relationship of the chemistry of rocks, soils and water and the human body, and the subsequent geographical distribution of diseases.

The interest in the connection between geographical conditions and human activities is, like biometeorology[1], very old. Hippocrates refers to it, and in the 11th century for instance Alî Ibn Ridwan comments on the hazards of air and water pollution for human health in Old Cairo[8]. A most exhaustive work, which became a classic, was written in 1883 by A. Hirsch: 'Handbuch der Historisch-geographischen Pathologie'[4].

A vast amount of literature has been published in the twentieth century. Again it was S. W. Tromp, who in the fifties, together with J. C. Diehl, set the scene for future research with his statistical studies on the geographical and geological distribution of human diseases[3, 10, 11, 16].

Nowadays societies like the American Society for Environmental Geochemistry and Health and its British counterpart study health problems in connection with soil.

Appearing immediately after this introduction is a series of articles describing the physiological and pathological reactions to meteorological conditions; they are followed by the articles on the pathological influences of soil properties. I realise that the list of subjects covered is far from complete, partly because certain specialists in particular fields were not available, partly because some authors were forced to withdraw from the review. Nevertheless, I hope that the articles in this issue may help to eliminate the skepticism and may serve to stimulate future studies in two fascinating fields of research.

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A short history of human biometeorology

by J. J. S. H. J. W. Bouma

formerly: Assistant Director at the Biometeorological Research Centre, Leiden. Present address: Anemonenweg 10, NL-2241 XK Wassenaar (The Netherlands)

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The rainbow, they thought, was the net of the God Beghu Nadaoja, the procreator of "swamp disease", with which he caught his victims; the comets were stars to which evil spirits clung and spread diseases[13], and earthquakes and the beginning of the New Moon were unfavorable to human fertility[17].

We now know that malaria is caused by a plasmodium; that its transmitter is influenced by temperature and rainfall[14]; that many other microorganisms spread disease, their viability depending on air movement, temperature, and humidity[2]; and that human fertility shows a pronounced seasonality, with temperature and light affecting the production of sex hormones[16].

The notion that weather influences health and disease is as old as mankind, but conceptions of the nature of these influences and ideas about health and diseases have changed profoundly over the centuries. Whereas primitive man brought order to a multitude of confusing phenomena through belief, modern man produces order through knowledge. Between their belief and our knowledge, centuries have elapsed – the weather-gods have become weather bureaus, and the Beghu Nadaojas bacteriologists. Man has found that the atmosphere and the human body are highly complex systems and that understanding the interaction between the two is far more complicated than a simple establishment of observable facts.

It is not the individual weather elements, but their changes and interactions which cause alterations in the intricate structure of the human body which, in addition, is also subject to many other influences. The resulting complication makes it difficult to prove the effects of the atmospheric environment on the human body; this may have been the reason why interest in the question has fluctuated so much throughout the centuries. Nevertheless, from the perseverance of many investigators, the modern border science of biometerology has emerged.

In the course of the centuries many scientific theories have been proposed, and vigorously defended, but in the end abandoned. A few of them, however, have lingered on, as it were, sometimes banished into obscurity, sometimes discussed with renewed interest, and according to the common thinking of a given period, viewed from a different angle. They could not be substantiated until the tremendous growth of the sciences in our time and the subsequent expansion of specialized studies threw new light on the past.

One such theory is that the atmosphere and its changes affect the functioning of the human body. The Greeks were the first to describe such effects, but it was not until the twentieth century that their empirical findings and those of the intervening ages were given a firm scientific basis. It is not accidental that the Greeks produced the first treatises on the influences of the weather and the seasons on the human body, as meteorology and medicine, like all natural sciences, originate from the same source: early Greek philosophy.

In their quest to disclose the secrets of nature and the universe, the Greek philosophers scrutinized every phenomenon between earth and sky. Their theories were a mixture of philosophy – based on pure logic (logos), and highly speculative – and practical – science. They speculated on the primary element or *Urstoff,* made astronomical observations for the sake of navigation and discussed the nature of man, and did it all without making any clear distinction between their various activities[5]. Conform to their associative ideas was the conviction that the human body is not an entity in itself but that its functioning is inseparable from the natural environment, and that this environment must be considered in matters of health and disease. In itself this was not new; earlier civilizations had related health and disease to the natural environment. However, that connection had mainly been confined to cosmic events, i.e. astrology. The Greeks did not reject astrology, but they were also keenly aware of their direct physical environment.

Undoubtedly they derived their knowledge from the skippers of boats, who were confronted during their commercial sea travels with problems of navigation, with the winds and other phenomena; from the philosophers who traveled and brought back climatological details, and not least from the itinerant physicians who noticed differences in climate and the occurrence of certain diseases in certain places.

When the medical profession gradually drifted away from pure philosophy, the study of the environment remained an integral part of its studies. It is not surprising, then, that Hippocrates (circa 460–375 BC), who marks the culmination of Greek medicine and is still called the Father of Medicine, emphasized the effects of climate and the seasons in the etiology and curing of diseases.

His arguments, summarized in W. F. Petersen's 'The Patient and the Weather', vol I[18] can be paraphrased as follows:

1. All diseases are fundamentally due to interference with the supply of air (oxygen) to the tissues (a generalized or regional anoxemia).
2. This being the case, diseases will occur more commonly when the air is most disturbed, particularly at the 'change of the seasons'.
3. Every meteorological disturbance alters the tissues, with a restorative period that requires approximately ten days.
4. Greece, and Europe in general, which have a cyclonic circulation of the atmosphere ('the hot winds and the cold, but especially those that are universal') will be the site of diseases different than those in countries like Egypt and those of Asia Minor, where the climatic conditions are more stable.
5. The developing embryo will be affected by the atmospheric alterations of the time. 'Generation, too, varies in the coagulation of the seed and is not the same for the same seed in summer as in winter, nor in rain as in drought'.
6. As a consequence of this, and the effect of postnatal atmospheric environment, the races of man developed and differentiated, becoming hard or soft, tall or squat, intelligent or stupid, leptosome or pyknic, to use the modern terms for antipodal types.
7. The human and animal species of a region will ultimately come to adapt to the environment in which they are reared.

Although many of his ideas may be refutable, and many of his conclusions may be speculative, his sound observations and rational thoughts were sufficient to arrest the attention of the learned for generations to come, until in the twentieth century the essence of his observations could be confirmed scientifically. His treatise 'Air, Water, Places' belongs to the most interesting, as do 'Epidemics I and II' and the 'Aphorisms'. Apart from paving the way to Western medical thought, Hippocrates contributed largely to climatology. The elementary principles for the study of climatology originate from his studies[20].

The first attempts to elucidate the physical phenomena of the environment originate from Aristotle (circa 384–322 BC). In his main work 'Meteorologica' ('Discussions on the Atmosphere') he explained meteorological occurrences in a systematic way. His studies also reflect the general conviction about the interaction of man and his physical environment. For example, he explained epidemics as being caused by germs transported in the wind.

The actual weather forecast developed in Greece as well. Theophrastus (circa 380–285 BC), a pupil of Aristotle and author of 'Book on Signs', gives us through this book, a good idea of the high level of meteorology as an empirical science in Greece[20]. Theophrastus discussed the importance of observing the rising and setting of the moon; he stated that when the moon is a complete circle, it will be stormy until the middle of the month; when autumn is clear and bright, the coming spring will be cold. He observed the changes in the environment itself, but he also recognized differences in animal behavior prior to weather changes.

The influence of Hippocrates and Aristotle was profound, and when the intellectual center of the world moved to Alexandria and later to Rome, Greek learning was gradually adapted. Important in this progress was the 'Naturalis Historia' of Pliny (circa 23–78 BC), an encyclopaedia of the whole of Greek science. Poseidonius (134–51 BC) further spread the theories on meteorology, and Galen of Pergamon (circa 129–199 BC) became the main representative of Hippocratic medicine. From the time of Galen, however, science and philosophy began to decline, and by the fifth century religion had established its dominance in daily life. Philosophy and science were only valued in so far as they endorsed the doctrines of the Church and the Scriptures; fanaticism and superstition prevailed. Meteorology was studied only within the context of the Bible – Creation itself being a subject for discussion – and diseases were God's punishments for sins dictated by Satan. The glories of Greek learning were translated, and disappeared in monastic libraries.

However, the spirit of Greek learning lived on in the East. In the ninth century, Hippocrates and Galen were translated by influential scholars like Hunain and Abu al-Kindi (800–870). Medical matters and the physical environment were also intertwined in their studies. Al-Kindi, the most important philosopher of the Arabic world, wrote a treatise consisting of 20 books on medical matters including Hippocratic medicine, and on physical subjects, one of which lent itself to a very interesting book on optics. Other famous scholars, like Avicenna (980–1037) and Averoes (12th century), wrote on medical and physical matters. Yet, valuable as these men were for the preservation of Hippocratic ideas, they did not contribute any fundamentally new points of view. The only exception is the Persian Abu Bakr-al-Rāzī, who proposed interesting theories on climatic influences on the spreading of smallpox and measles[15].

Via North Africa and Spain, Greek knowledge came back to the West. As a consequence of reforms within the clergy, the monasteries had lost their position as centers of learning. The study of Greek philosophy and science continued, but now in centers of learning – 'schools' – and the Scholastic Movement developed. The main characteristic of this movement was a strong belief in dialectic and syllologic reasoning[19]; the theories and conclusions were of a strictly academic character and led to a rigidity which paralyzed further progress in science. There was an active interest in the Greeks, and, indeed, the importance attached to logic concurred with their views; however, their empiricism was neglected. Additionally, the authority of the Church was still dominant, and learned ideas were subject to its scrutiny. Moreover, theology was the 'scientia universalis' and the natural sciences and medicine were subordinated to it.

Nevertheless, this period created a matrix for the intellectual progress still to come. The first signs of this progress were marked by the Renaissance. This period of transition heralded a revival of science. The scholastic movement disintegrated under the influence of a new generation of scholars who rejected the uncritical admiration of Greek logic derived mainly from translations and commentaries of the early church fathers and the Arabs. They insisted on studying the original Greek texts, and combined this study with independence in observing, thinking and experimenting. Yet this new approach did not so much produce new ideas as it created a mental atmosphere which came near to that of the best Greek traditions[19].

As for the relationship between the natural sciences and medicine, in the preceding centuries little attention had been paid to it. However, in the sixteenth century the interest revived, in particular in connection with epidemics. Contrasting with the splendor and elegance of the Renaissance was the filthiness of the towns, a fertile soil for the spreading of disease. Gerilano Fracastoro from Verona (1484–1553) made contributions to the etiology of communicable diseases which were based on Hippocrates 'Epidemics'; his findings were later confirmed when bacteriology developed. Guillaume de Baillou (1538–1616) applied the epidemiological theories of Hippocrates in his studies on whooping cough, and the famous Theophrastus von Hohenheim or Paracelsus (1490–1541) presented theories on weather and on geologically determined diseases which were interesting for that time. In the latter studies he applied the preliminaries of chemistry, which were then beginning to emerge from the older alchemy.

However, by the end of the sixteenth century the connection between meteorology and medicine lost its prominence almost completely. Resistance to traditional philosophy and science grew. The initial breakthrough in the intellectual outlook was undoubtedly achieved by the theories of Copernicus (1543). His heliocentric hypothesis replaced the prevailing geocentric theories of Aristotle. In theological and psychological respects this disqualification of the earth as center of the universe was far-reaching. It began to be recognized that what had been believed since antiquity might be false, and that the task of scientific truth should be the collection of facts, combined with hypotheses as to laws binding these facts together[19].

This axiom induced a valuation of Reason as the fundamental source for all knowledge, excluding imagination and the senses. The doctrines of philosophy, whose early representative was René Descartes (1596–1650), taught that the abstract approach based on facts alone can reveal the truth and that this will ultimately enable man to master nature. Mathematical order was to play a dominant role in the interpretation of results obtained from conscientious observations, and in the seventeenth century the need for exact scientific observations stimulated the invention of new instruments. The combination of advanced mathematics, the invention of instruments and the philosophical viewpoint that pure knowledge is a prerequisite for progress established the spectacular triumph of science in the seventeenth century.

The eagerness to unravel the secrets of nature and its laws accelerated progress in medicine and the natural sciences. The pursuit of knowledge in each branch of science provided a multitude of facts; however, at the same time it blocked the way to associative virtuosity concerning man himself. Man was but a tiny part of the universe, a mechanical subject the functioning of which was the main interest for study and experiment. Consequently, the study of the influences of man's natural environment on his well-being retreated into the background. The only substantial contributions came from Thomas Sydenham (1624–1689). He pointed to the seasonal dependence of health problems and collected data on diseases and environment to correlate their relationship.

Yet, the tremendous discoveries made during this period in meteorology and medicine were later to stimulate a new interest in the possible relationship between the weather and diseases. This interest was partly the result of the accumulation of meteorological measurements made possible by the invention of instruments like thermometers, barometers and hygrometers. The founder of the first observational network was Ferdinand II of Tuscany (1610–1670). He initiated simultaneous measurements in Florence, Pisa, Bologna, Parma and Milan[8,20] and founded the Academia del Cimento. Under pressure from the Church he had to stop these activities in 1667. Such observations were, however, continued in France, Germany, England and The Netherlands. The Dutch Academy of Science regularly offered prizes for the best essays on a particular subject. In 1777 the subject was the possible influence of weather on diseases. The 'Natuur- en Geneeskundige Correspondentie Sociëteit' (1779–1793) was the result of this competition, its objectives being the collecting of data on weather observations and correlated diseases. The Société Royale de Médecine in France (1776–1793) subsequently stimulated its members to collect similar data, as did the Royal Academy in England and the Societas Meteorologica Palatina (1780–1795) in Germany. These data were mutually exchanged[8]. The standardization of the measurements and instruments of these organizations, which was a precondition for participation, together with the exchange of meteorological data, contributed to the development of Synoptic Meteorology which provided knowledge of the weather over large areas.

The emergence of the Romantic Movement at the end of the eighteenth century undoubtedly contributed to a renewed interest in the functioning of man in the surrounding world. The Romantics, preferring passion to calculation[19], allowed subjective perception, sentiments and imagination, in contrast to the extreme rationality and pure reason of the recent past. They admired vigor and grand effects, and the sometimes violent and destructive forces of nature certainly appealed to this general mood. Initiated by Jean Jacques Rousseau (1712–1778), this movement originated in France but was, at first, centered mainly in Germany. It had a profound effect on science in Germany, where the universities taught a hybrid natural philosophy[6] based on doubtful and romantic assumptions. This may be a reason why so many studies on weather and diseases originated in Germany. Most of these studies were vague, with an undertone of mystique – qualities which did not help to foster ideas which were basically sound. However, remarkable results of sensible observations also appeared.

Alexander von Humboldt (1769–1859) wrote in his study, 'Kosmos': 'Climate comprises all atmospheric changes which clearly excite our organs'[3], while Hoffmann (in 1746), Finke (1795) and Schnurren (1813) carried out the first statistical studies on the relation of diseases to particular climates[25]. Hufeland (1762–1836) published studies on weather and morbidity; Carus (1789–1869) demonstrated this influence of weather and climate on the organism. Schönlein (1793–1864) described the influence of atmospheric factors on man, as did Wunderlich (1815–1878) in his handbook 'Handbuch der Pathologie und Therapie'.

To the later studies belongs a detailed work by Ackermann[1] (1810–1873): 'Das Wetter und die Krankheiten'. Of special interest are the groundwater theories of Von Pettenkofer[24] (1818–1901).

Despite the wealth of information, the study of the effects of weather and climate stagnated, partly because the mechanisms of many bodily actions were yet unknown, and partly because the mechanisms of the weather were largely a mystery. Indeed, the results especially of synoptic meteorology had made clear that the structure of the atmosphere is far more complicated than its outcome – weather and climate – alone, and this implied that for a deeper understanding of the atmosphere as a whole, detailed studies of every single weather element were prerequisite.

Pioneering work had been done by scientists such as Gay Lussac with observations from free balloons, Von Humboldt (1769–1859) on isotherms, Dove (1803–1879) and Brandes (1777–1834). Fourier (1768–1830) and August (1795–1870) worked on atmospheric temperatures and Poisson (1781–1840) on gases; together with the studies of Carnot (1796–1832), these studies were forerunners of what would later be known as the thermodynamics of the atmosphere. Espy (1768–1830) published his important study 'The philosophy of storms', Loomis (1811–1889) worked on cyclonic circulation and Hann (1839–1921) on thunderstorms. All these studies resulted in what would become known as dynamic meteorology, its most well-known representative being V. Bjerkness (1862–1951) with his studies on the dynamic principles of the atmospheric circulations and his polar-front theory[20]. And so a better understanding of the atmospheric mechanisms gradually emerged which was to be enlarged in later years with the developments in physical meteorology.

During the second half of the nineteenth century, science became international through the facilities of transport which increased personal intercourse, and the publication of scientific periodicals which brought new results of scientific endeavors to the attention of a broad audience. Substantial contributions came from the USA[4]. The various branches of medicine grew, not least because of the developments in laboratory medicine[6]. Not only in medicine, but also in the sciences, the establishment of laboratories became essential for further advancements. They provided the opportunities for thorough studies of each subject separately. The subsequently increased specialization accelerated the tremendous progress in the twentieth century, and the time when one scientist could cover various branches of science was past forever.

With regard to the study of the influences of the physical environment on man, the last studies made by one expert only were those of Petersen[18] (1887–1950): 'The Patient and the Weather' and De Rudder[7]: 'Grundrisse einer Meteorobiologie des Menschen'. Of special interest are the studies of Huntington[9,10] from the USA on the climatological influences on race and civilization. His studies gave the impetus to several American scientists in the first half of the twentieth century.

The achievements in the field of human physiology (*and* the allied fields of biophysics and biochemistry, especially in the Anglo-Saxon countries) and in the atmospheric sciences just before and after the Second World War, proved beyond doubt that the study of the correlation between two highly complex systems demanded an interdisciplinary approach. However, the counter-effects of expert studies were, and still are, twofold. Both had a detrimental effect on further studies of the influence of weather and climate on man. Specialization hampered the communication between the different branches of sciences and it created a stern skepticism about all theories that were not based on reproducible results and well-defined facts. It jeopardized the power of imagination which, if sensibly applied, is an essential part of true learning.

And while so much basic knowledge had been obtained, after the war further progress in specific studies of meteorological influences on man had reached a deadlock. It was Tromp[21] (1909–1983), a creative and intellectual scientist who realized in the fifties that future progress in the study of the influences of the physical environment on man (and also on plants and animals) could only be effected through an interdisciplinary approach. He launched the idea of founding an international organization where scientists could join together and tackle the fascinating problems of man and weather[11]. Supported by Ungeheuer, Head of the Medizin-Meteorologische Forschungsstelle at Bad Tölz, Bavaria, he founded in 1956 the International Society of Biometeorology which was soon joined by scientists from several countries throughout the world; in 1957 the first issue of the International Journal of Biometeorology appeared[12]. But it was really the publication in 1963 of 'Medical Biometeorology'[22] with its 4382 references that showed how the big yield of various fields of research had helped in obtaining a deeper understanding, now that it had been put in its proper setting. Moreover, this publication was a stimulus not only for progress in human biometeorology, but also for animal and plant biometeorology[23].

When, in 1970, biometeorology was given its final definition as being 'the study of the direct and indirect effects (of an irregular, fluctuating or rhythmic nature) of the physical, chemical and physicochemical micro- and macro-environments, of both the earth's atmosphere and of similar extra-terrestrial environments, on physicochemical systems in general and on living organisms (plants, animals and man) in particular', it was an established leading environmental science.

It has been a long journey from the superstitions via Hippocrates to present-day biometeorology. We know indeed that germs are airborne, not as passengers on board comets, but rather carried by the wind! And if we cannot rule the winds and whims of the atmosphere, we are learning at least how these rule us.

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