A REPORT TO THE COUNCIL OF THE BIOPHYSICAL SOCIETY

Biophysical Research in the People's Republic of China

INTRODUCTION

In spring 1971, the visit of the United States table tennis team to the People's Republic of China opened up the possibilities of travel and exchange between the two countries. This event was soon followed by the now well known Shanghai Communiqué of February 27, 1972, issued jointly by the United States and the People's Republic of China which included an agreement to facilitate the development of scientific, technological, and cultural exchanges and communication. In the spirit of the Shanghai Communiqué, the People's Republic of China sent its first multidisciplinary scientific delegation to visit the United States in response to invitations from the Federation of American Scientists and the Committee on Scholarly Communication with the People's Republic of China—a committee founded jointly by the U.S. National Academy of Sciences, the American Council of Learned Societies, and the Social Science Research Council.

Heading the seven-scientist delegation to visit the United States in November 1972 was Dr. Pei Shih-chang, director of the Institute of Biophysics of the Chinese Academy of Sciences in Peking. Since I had received a visa to go to China in 1973, I wrote to Dr. Pei expressing my desire to see the Institute of Biophysics. A cordial invitation was extended to me by Dr. Pei in February 1973. With enthusiastic support from Frederic M. Richards (president of the Biophysical Society, 1972) and Peter H. von Hippel (president, 1973), as well as the endorsement of the Biophysical Society Council at its March 2, 1973 meeting, I visited not only the Institute of Biophysics but also a number of other research institutes and universities as well, as an official representative of the Biophysical Society. What follows are some of my impressions, observations, and conclusions.

THE INSTITUTE OF BIOPHYSICS

The Institute of Biophysics was established in 1958 under the auspices of the Chinese Academy of Sciences (CAS). The older Institute of Physiology and Biochemistry in Shanghai was divided into three separate units: Institute of Physiology and the Institute of Biochemistry, which remained in Shanghai, and the Institute of Biophysics, which was moved to Peking. (Coincidentally, that year also saw the formal founding of the Biophysical Society in the United States.)

In the Institute of Biophysics, there are 220 persons of whom about 150 are directly engaged in research. The overall organization of the Institute consists of five research sections, a machine and electronics shop, and a glass-blowing shop. The two workshops I saw, located in two different buildings, appeared to be adequately equipped and comparable to those one sees at large universities in the United States.

Before describing the research sections, let me make a few remarks about the director of the Institute. A serene and soft-spoken person, Director Pei Shih-chang is over 70 years old. He appeared in excellent health and was very energetic. Dr. Pei, an experimental biologist (Ph.D., University of Tübingen, 1928), at various times served as director of the Institute of Experimental Biology; dean, College of Sciences, Chekiang University; deputy, Third National People's Congress; member of the Standing Committee, National People's Congress; assistant editor of *Science Bulletin* and *Scientia Sinica;* member of editorial board of *Acta Zoologica Sinica.*

Section on Cells and Cell Organelles. There are three groups in this section. The primary interest of the first group is the structure and function of mitochondria, and in particular the swelling and contraction phenomena during oxidative phosphorylation. The leading person in the group is Young Fu-yu, an articulate and alert scientist in his forties. Young's group, comprising eight researchers, has just completed a study on comparative volume changes of rat liver mitochondria induced by LiCl, NaCl, and KCl in the presence of EDTA. The second group is concerned with biogenesis of yeast mitochondria using certain membrane-bound enzymes isolated from snails. The ultrastructural change of the oocytes during the sex reversal of *Chirocephalus nankingensis* (a kind of crustacea) is the research area of the third group. All the laboratories I saw were neat and equipped with instruments of both foreign and Chinese manufacture. Also, I was shown a homemade polarograph whose Hg electrode was ingeniously attached to an electric hair-cutter. The vibration of the hair-cutter at 50 cps, I was told, aided uniform drop formation and gave very reproducible results. While visiting the labs, I was welcome to look around and free to take as many pictures as I wished. There were many specialized books in the labs. For example, in one lab, I saw a copy of *Current Topics in Bioenergetics* (Vol. 4).

Section on Molecular Biology. This is a relatively new section formed in 1970. The section is divided into three groups. In the first group, Dr. Tsou Chen-lu (Ph.D., Cambridge University, 1951) is one of the prominent members. This group is particularly interested in the mechanisms of enzyme action and the kinetics of irreversible modification of enzyme activity. The second group is investigating the structure and function of RNA at the molecular level. This group is also working on other biopolymers. The third group is concerned with the structure and organization of biocompounds. Members of the third group have collaborated with researchers in the Institute of Physics of the CAS and Peking University. The most notable achievement of this group has been the determination of the spatial structure of crystalline pig insulin using X-ray diffraction technique at a resolution of 1.8 Å.

Section on Radiation Biology. Professor Hsu Feng-chao (educated in Belgium in the late 1930s) is the responsible person in this section. There are four groups: external radiation, internal radiation, dosimetry, and isotopic tracer methodology. Each has four to six researchers. This section operates a 30,000 Ci cobalt-60 source and five small Co-60 sources (8 Ci each). These high energy sources are used by the external radiation group for experiments on monkeys and rats. The group is concerned with long-term radiation effects and is investigating the action of ionizing radiation on chromosomes.

Section on Sensory Receptors. At present, there are two groups in this section. One group, headed by Researcher Chang Cheng-lien, is working on vibratory receptors (Herbst body) of the pigeon. The other group, just started, is engaged in research on the structure and function of the retina. Researcher Tan Man-chi is the leader of the new group.

Section on Instrumentation and Techniques. This section is responsible for the development and design of the instruments and their proper applications throughout the Institute. There are two groups of which one specializes in the equipment used in radiation biology. Instrumentation other than for radiation use is the responsibility of the second group. I was shown a number of instruments such as nuclear magnetic resonance, electron spin resonance, and liquid scintillation spectrometers, an electron microscope and apparatus for fluorescence spectroscopy. Lu I-wan (a woman), Tao Shan-lin (Shantung University), and Yeh Shih-xun (Institute of Industrial Technology) were introduced to me as responsible persons in the section.

OTHER INSTITUTIONS

In addition to the Institute of Biophysics, I also visited a number of other institutes of the Chinese Academy of Sciences as well as science departments in the universities. There are over

1,600 research, development, and higher education institutions in the People's Republic of China, of which some 170 research institutes are under the supervision of the CAS. Since the available facts on biophysical research and science education are still very few, a brief description of some of these centers of research and of higher learning may be informative and provide additional glimpses of scientific activities in China since the Cultural Revolution.

Institute of Plant Research (Peking). The Institute was established in 1953 with Professors Lin Jung and Tang Pei-sung as its deputy directors. At present, like all other organizations, the Institute is run by a Revolutionary Committee. Professor Lin (Sc.D., University of Paris, 1930) told me that the Institute has 350 workers, including 250 technical personnel; the majority of them are university graduates. The past accomplishments of the Institute include the discovery of a plant containing a high percentage of corticoid hormones, the collection of many species of wild herbs, and the demonstration of a plant growth regulating drug called Tao-Mai-Li which produced effects on wheat. There are five scientific sections: taxonomy, ecology, paleobotany, morphology and cytology, and plant physiology.

The Taxonomy Section has a large herbarium with more than one million specimens. Tang Yen-chen, the section head, told me that there are 60 persons in his group, which is engaged in the preparation of a major publication entitled *Icongraphia Cormophytorium Sinicorum* with the first section comprising some 10 volumes. This mammoth undertaking, with the first two volumes already totaling 2,469 pages (published in 1972 and 1973), will eventually have detailed drawings for each of the 30,000 entries of Chinese plants. Wu Chen-shun (Tung-chi University, Shanghai), leader of the plant chemistry group of the Taxonomy Section, showed me an experiment in progress. They were extracting an ingredient from *Ledum palustre* which was said to be useful in treating asthma and other respiratory diseases.

In the Section on Paleobotany, I talked with Hsu Jen and Chang Hsing-tan (B.S., Amoy University) who specialized in higher plants. Hsu, the Section Head, showed me some plant fossils from the Devonian period in Yun-nan Province, which were used in identifying the stratigraphic sequence.

Professor Tsui Cheng (Ph.D., University of Michigan, 1947), secretary-general of the Chinese Society of Plant Physiology, accompanied me to see some laboratories belonging to the Morphology and Cytology Section. This section, begun in 1971, has about 20 researchers. I was given a reprint of a paper on cell differentiation of embryos in the pollen grains of *Triticale* and *Capsicum annum* by Chien Nan-feng and co-workers, which appeared in the first issue of *Scientia Sinica* (1973) since the Cultural Revolution.

The Section on Plant Physiology, the largest unit of the Institute, has over 80 technical workers and consists of four groups: photosynthesis, growth hormones, produce and fruit storage, and herbicides. The Photosynthesis laboratory is directed by Kuang Ting-yun, a woman who had done postgraduate work at Moscow State University in the Soviet Union. This very articulate scientist told me that there are 26 researchers working on a wide range of both experimental and theoretical problems such as photophosphorylation, oxygen evolution, isolation of reaction center of photosystem II, and the ultrastructure of chloroplasts. In addition, the group works in close collaboration with a local factory in producing ATP for drug uses. The laboratories I saw were equipped with assorted instruments including an ESR spectrometer made in Tientsin during the Cultural Revolution (1967–68). In another laboratory, I was shown an electron microscope made by Peking Scientific Instruments Factory in 1969. The microscope is capable of 30,000 × magnification with a resolution of 12 Å. The electron microscope unit worked closely with the Photosynthesis Group. The Growth Hormones Group has extracted a growth hormone from water chestnuts which, unlike the well-known gibberellin, stimulates the growth of callus tissue cultures and generates buds in such cultures. The Produce and Fruit Storage Group has found conditions (O_2 and CO_2 concentrations) conducive for storage of tomatoes and other produce; I was told that polyphenol oxidases may be involved. The Herbicide Group has done extensive work on the use of DCPA (3,4-dichlorobenzenepropionamide) in rice fields. This compound was said to be very beneficial to the work of poor and lower-middle peasants.

Institute of Physiology (Shanghai). Before the Cultural Revolution, the Institute had a wide range of research activities in basic physiology of the central nervous system, human electroretinogram, tissue cultures of adult human brain cells, analysis of single unit activity in the lateral geniculate body of the cat, the influence of drugs on gastric pepsin secretion in pigs, and biochemistry of tropomysoins of proteins of connective tissue and of various enzyme systems. The Institute's biological electronics laboratory, in cooperation with Twilight Radio Equipment Plant in Kwangchow had made trail production of a highly sensitive electrometer useful in biological research.

The Institute now consists of five sections: (1) general physiology of the central nervous system and neuromuscular system, including systems analysis physiology; (2) acupuncture anesthesia; (3) sensory organs, visual and auditory; (4) physiology at high altitude; and (5) reproductive physiology including birth control. The Institute has 290 workers of whom 160 are research scientists. The Institute is under the direction of Dr. Feng Te-pei (M.S., University of Chicago, 1929, and Ph.D., University of London, 1933). Among the other scientists I met during a brief tour were Fan Shih-pan and Wen Yeh-shao (working on muscle contraction), Sun I-an and Mu Wang-yuan (electrophysiology), and Chou Tai-sen and Chu Pei-hung (physiology).

Institute of Plant Physiology (Shanghai). The Institute of Plant Physiology of the Chinese Academy of Sciences began in 1950 as a plant physiology laboratory of the Institute of Experimental Biology and became a separate unit in 1954 with Ying Hung-chang as deputy director. Before the Cultural Revolution, the Institute had engaged in a wide range of investigations including research on the physiology and biochemistry of microorganisms (such as actinomycetes and actinophage); effects of gibberellin on vegetable crops; ecology of wheat; resistance of agricultural plants to salinity, flooding, and drought; biosynthesis of starch in rice; antibiotics; biosynthesis of riboflavin; photosynthesis, particularly in relation to the life conditions of agricultural plants; and functions of microorganisms in the rhizosphere of cultivated plants. At the time of my visit, the Institute was being moved to a new building.

The Institute of Plant Physiology now has six research sections: (1) photosynthesis (under Professor Shen Yun-kang), (2) nitrogen fixation, (3) plant hormones, (4) agricultural microbiology, (5) tissue culture, and (6) enzymes. According to Dr. Ying (Ph.D., California Institute of Technology, 1937), the Institute has about 350 workers. Some of the prominent members are Wei Chia-mien, Ma Mun-ren, and Lee You-tse. They are now working on more practical problems closely related to agriculture; for example, the effect of gibberellins and other new microbiological products on plant growth, photophosphorylation, oxygen evolution, effects of uncouplers, and quantum requirement and the intermediate steps of photophosphorylation. Significantly, according to Professor A. Jagendorf of Cornell University, a group of researchers (Shen Yun-kang, G. M. Shen, and Ying Hung-chang) of this Institute had independently and simultaneously discovered in 1962 that, in isolated spinach chloroplasts, ATP can be formed after illumination under certain conditions.

Chung-shan University (Kwangchow). Formerly known as Canton University in 1924, and at one time a part of Lingnan University, the name was changed to Chung-shan (another name of Dr. Sun Yat-sen) University in honor of Dr. Sun after his death in 1926. Before the Cultural Revolution, the University had the usual science departments and a semiconductor laboratory. In 1964, the University had 4,000 students. The University was closed during the Cultural Revolution (1966–69). Both staff and students went to the countryside and factories to receive reeducation from peasants and workers. The University reopened in 1970, admitting 540 new students and 780 more students in 1972. Now the University has 11 departments and a school of library science.

The two science departments I saw were biology and chemistry. In the insect ecology laboratory, Lin Fu-sen told me that they were working on a problem of controlling the litchi wasp with insect parasites and testing them at nearby communes. In the physiology laboratory, I met Liu Hseuh-kao who had studied at New York University in the early 1950s. While I was there, they were doing an acupuncture anesthesia experiment on a rat. Researcher Liu said that they hope to understand the underlying physiological mechanism for the manner in which acupuncture works. In the chemistry department, I was shown the high polymer laboratory where Professor Lee Man-fu was in charge. The laboratory was well equipped with both Chinese and foreign-made instruments.

Wu-han University (Wu-chang). The University was established in 1913. There were 5,000 students and 2,000 faculty before the Cultural Revolution and now there are 2,000 students and the same number of faculty. Present at the reception during my visit were Chen You-ching (responsible person of the University's revolutionary committee), Professor Sun Hsiang-chung (studied at University of Edinburgh, Scotland in the late 1930s), and Professor Wu Yu-ching (Ph.D., Harvard, 1947). Besides the traditional science departments, there are four factories attached to the University for students to gain practical experience. I was only able to see two laboratories in the biology department. In one laboratory, I met Liu Lien-tsui (Wu-han University, 1936). She has isolated particles of 300–500 Å and 1,100–1,200 Å from breast cancer cells and is interested in their origin. In the second laboratory, Researchers Cheng Chen-quo (Wu-han University, 1960) and Ho Hai-ping (Wu-han University, 1947) have been doing experiments on liquid crystals and their application to cancer diagnosis.

Central China Normal University (Wu-han). This University is the largest in Central China in training secondary school teachers. I talked with Lee Chung-cha, head of the biology department (Ph.D., Cornell University, 1938) and Ning Yuan-mo, head of the chemistry department. The biology department started readmitting students in 1971 and had 125 students and 69 faculty, including 10 assistants during the time of my visit. Formal instruction has been reduced from four to three years and the students spend 50% of their time in self-study. The students spend two days per month in physical labor either on a farm or in a factory. The chemistry department is a bit larger with 190 students and about 70 professors (distribution: inorganic, 20; organic, 20; analytical, 10; physical, 10; and chemical engineering, 10). Besides the usual chemistry courses, the student has to take one year of physics, mathematics through differential equations, competency in one foreign language (usually English), political science, and physical education. Before the Cultural Revolution, a course in educational methodology was required. At present, the course has not been reintroduced pending further discussion, Professor Ning said. In addition, the student spends two days a month working on a commune. One interesting feature about the department was that the students and chemistry faculty operate a small workshop making reagent grade ferric chloride as a part of laboratory work. The use of "waste" products was stressed. I was shown cartons of finished products ready for shipment.

Peking University. Of all universities in China, Peking University stands out not only for its academic excellence but also for its revolutionary tradition dating back to the famous May 4th student movement in 1919 in which Mao Tse-tung participated. Forty-seven years later the students of Peking University started another movement, which has become known as the Great Proletarian Cultural Revolution. I visited Peking University on two separate occasions and saw the colloid science laboratory in the chemistry department and a biophysics laboratory in the biology department. I talked with Professor Fu Ying (Ph.D., University of Michigan, 1928), head of the colloid science laboratory and a vice-president of Peking University before the Cultural Revolution. They are now working on problems with a practical application such as understanding the mechanism of wax deposit in oil pipes and devising means for the prevention of its occurrence. The laboratory was equipped with a new IR spectrometer and other standard instruments. I met many researchers (Chao Quo-she, Professor Fu's assistant) in the laboratory who were former students of Professor Fu. Before touring the biophysics laboratory of the biology department, I had brief conversations with two departmental representatives: Wu Hsiang-yu (Catholic University, Peking, 1947) and Mei Cheng-an (University of Illinois, 1947–56) who was a former graduate student of the late Dr. R. Emerson. In the biophysics laboratory I was introduced to its leader, Chou Pei-ai (Peking University) who told me that the laboratory has a staff of 10 and is divided into two groups. The first group concentrates its effort on instrumentation and the second on acupuncture anesthesia. They work closely with the City Health Department of Peking and Peking Medical College. I was told, for example, they help to train technical cadres in the use of small computers specially designed for medical applications. I saw a few people working on a variety of electronic instruments and was shown a large Faraday chamber capable of accommodating a patient lying down. The chamber had all sorts of instruments attached to it including an apparatus for measuring blood flow in the brain.

THE EFFECTS OF THE CULTURAL REVOLUTION ON SCIENTIFIC RESEARCH

The Great Proletarian Cultural Revolution, which is also known simply as the Cultural Revolution, began with an uprising of students at Peking University and lasted from 1966 to 1969. During this time, everyday business at educational and other intellectual institutions was suspended, while basic principles were reevaluated. Methods, organizational structures, and goals were criticized and brought into line with socialist ideals.

On one occasion I met Professor Feng Yu-lan, the famed philosopher, who was reportedly purged during the Cultural Revolution. Professor Feng was active in the May 4th movement of 1919. He rejected Confucianism and called it a reactionary philosophy. In response to a question that he was brainwashed during the Cultural Revolution, he said "What's wrong with that! People regularly wash their faces and take a bath so as to keep clean. Why should not a person cleanse his mind of filth?"

The Chinese Academy of Sciences. The Chinese Academy of Sciences, China's national science organization, was modeled after the Soviet Union after the establishment of the People's Republic, which consisted of a bureaucratized system of research with a powerful, central academy of sciences playing the leading role. It was essentially an elitist approach stressing the results of "pure" research. By nature, the adoption of the Soviet model involved the importation of science and technology from developed countries. This bureaucratized approach to science and its award system, etc., did not go very well with many scientists. By about 1957, the Soviet model proved unsatisfactory and was abandoned in favor of the "Yen-an approach." The Yen-an approach was actually developed in a small village named Yen-an in Shensi Province during the period from the 1930s to 40s. It stressed close contact between the leader and the masses and de-emphasized the role of professional and academic science.

The Chinese Academy of Sciences is not a purely administrative and organizational superstructure. Unlike the U.S. Academy of Sciences, the CAS before the Cultural Revolution was composed of five science departments: physical, life, earth, technical, and social. Under each department numerous research institutes were operated. For example, the Institute of Biophysics was under the Department of Life Sciences. There were more than 35 other institutes affiliated with the Department of Life Sciences such as the Institute of Physiology, the Institute of Plant Physiology, the Institute of Plant Research. In the provinces and municipalities (Peking, Shanghai, and Tientsin), the CAS also operated branch academies, which were established in 1958 as a part of the Great Leap Forward. The branch academies were then charged with the task of correlating research and developments and of helping to promote "mass science." Mass

Science meant that, among other things, experienced workers and peasants were invited to serve as "research fellows" in the scientific institutions. In agriculture, for example, a large number of experimental stations were set up in rural areas throughout the country. It was reported that ordinary peasants were encouraged to take part in scientific experiments with the guidance and cooperation of scientific workers from the cities. At present, the CAS is being reorganized; some of its institutes will be placed under the control of government industrial ministries or municipal (provincial) bureaus of science and technology.

Before the Cultural Revolution, the CAS did, and presumably still does, receive guidance directly from the State Council (the equivalent of the Cabinet in the United States).

The Institute of Biophysics. Before the Cultural Revolution, a research institute like the Institute of Biophysics had one director who made all important decisions in consultation with the Communist party secretary concerning the research and development of projects undertaken at the Institute. The scientific staff was divided into four categories: researcher, associate researcher, assistant researcher, and research assistant. These positions were equivalent to professor, associate professor, lecturer and assistant in a university. Persons who occupied these positions were almost all university graduates belonging to a "privileged" class. It was basically a hierarchical system with increasing autocratic and bureaucratic manifestations, not unlike the system in operation before 1949. Researchers and associate researchers, usually section heads and group leaders, who were in the highest income bracket, frequently pursued either personal research interests or duplicated the findings of others with little originality. They did "research for research's sake" ignoring the needs of the country. In other words, "bourgeois" intellectuals still operated in the old way regarding knowledge as private property, theoretical work as the only work worth pursuing, or seeking personal fame and fortune, or doing things with comprador mentality (meaning, for example, trailing behind the western science at a snail's pace).

Just before these outmoded ways of thinking and old ways of doing things had become firmly entrenched came the explosion of the Great Proletarian Cultural Revolution. This Cultural Revolution of 1966–69 was the most extraordinary politico-socio-economical phenomenon since the founding of the PRC. During the Cultural Revolution research activities at the Institute were either completely interrupted or greatly curtailed. Members of the Institute including the senior scientists spent some time in the "May 7" cadre schools (established throughout the country in response to Chairman Mao Tse-tung's directive issued on May 7, 1966), in factories, or in Peoples' Communes participating in manual labor. The Cultural Revolution, for science and education, meant the wider participation of the masses, implementing the policy of "walking on two legs" (i.e., relying on one's own efforts in the simultaneous development of agriculture and industry, at both national and local levels; large and small enterprises using all available methods both modern and indigenous), carrying out the principle of uniting theory and practice to serve socialist construction, and research should be closely tied to actual production. Most important of all, the question of "whom to serve and how to serve" was heatedly debated. The formation of the Revolutionary Committees at universities, factories, communes, provincial and municipal governments, were the earliest fruits of the Cultural Revolution. At the Institute of Biophysics, a Revolutionary Committee was also established. The Institute's Revolutionary Committee is made up of leading cadres, scientific and technical staff, and workers. This is known as a "three-in-one" participation. However, there is another aspect of "three-in-one" participation in terms of age groups in selecting the members serving on the Revolutionary Committee. The Revolutionary Committee must have representation from the old (senior scientists and workers, for example), the middle-aged, and the young (recent graduates). In theory, equal representation by women on the Revolutionary Committee must also be observed. At the Institute of Biophysics, the percentage of women serving on the Revolutionary Committee is still very low (probably not more than 20%).

Currently, initiation and decision of a scientific project are no longer solely in the hands of the group leader or section heads. Instead, any member of the Institute can initiate a project which must be discussed openly at each level (group, section, and institute). The supreme decision-making body is the Institute's Revolutionary Committee under Party leadership. When a project is initiated and before the approval is given, a thorough literature search is conducted, both to gather source materials and to avoid duplication. Once approved, a "three-in-one" group, formed on the principles outlined above, is set up to see that the project is properly carried out. Does it work? It is too early to pass any judgment.

Since the establishment of the Institute of Biophysics, there has been one conference on biophysics sponsored by the Chinese Society of Physiology in August 1964, held in Dairen in Liaoning Province, in Northeastern China. Abstracts of the conference are not available, however.

Research results of the Institutes before the Cultural Revolution were usually published in scholarly journals such as *Scientia Sinica, Acta Biochimica et Biophysica Sinica, Science Bulletin,* and *Acta Biochimica Sinica.* Publications of these journals were suspended during the Cultural Revolution. *Scientia Sinica* and *Science Bulletin* have already resumed publication. Dr. Pei indicated that *Acta Biochimica et Biophysica Sinica* would resume publication within the year. The problem of authorship has been discussed. Should articles be signed collectively or only by the individual(s) doing the work? Apparently many scientists do not want journal publications to serve mainly as a way of enhancing their own prestige. In this connection it is interesting to note that an examination of *Scientia Sinica* (No. 1, 1973) published in February 1973 shows that one-third of the articles give only the names of laboratories.

Training of Biophysicists. At the outset Dr. Pei indicated that he could only talk about the biophysics program at universities before the Cultural Revolution (1966), since at the present time education and science were still in a fluid state. The enrollment of new students at many universities was resumed in 1970.

Before the Cultural Revolution, biophysics curricula were offered at the following universities: Fu-Tan University (Shanghai), Nanking University, Shan-tung University (Tsingtao), Peking University, Chinese University of Science and Technology (formerly at Peking, now in Hofei, Anhwei Province), Medical University of China (Peking), and Shanghai University of Science and Technology. In general, the curriculum required, in addition to basic courses, three specialized courses: radiation biology, general biophysics, and cell biology. In general biophysics, among the topics covered were thermodynamics, mechanics, and bioenergetics. In cell biology, the structure and function of biological membranes were studied. At the end of four years of study, the student had to pass a final examination (written). No formal degree was awarded, however. My impression was that the training which the student received would be equivalent to that of a M.S. student in the United States.

Things certainly will not be the same after the Cultural Revolution. There have been many reforms and innovations introduced. Most salient are the standards and methods of selecting students being admitted to the universities. Briefly, in addition to the usual moral, intellectual, and physical qualifications, the students are selected on the basis of the following two categories: (1) high school graduates at least 20 years old with a minimum of two years of practical experience in factory, commune, or the PLA (People's Liberation Army), and (2) in the case of workers, poor and lower-middle peasants, and revolutionary cadres who have more than eight years of working experience or who have inventions or innovations to their credit. Methods of selection are: self-application, recommendation by one's peers, approval by the leadership, and an entrance examination (noncompetitive) set by the university concerned. The purpose of the examination, I was told, is to ascertain whether the student has achieved a level of education at least the equivalent of a junior middle school graduate.

As of the fall of 1973, about 353,000 students have enrolled in the institutes of higher learning.

The Views of Scientists. From the talks I had with scientists both at the Institute and elsewhere, my impression was that the Cultural Revolution has had many profound effects. For instance, elitism in science is no longer stressed. Many scientists feel that for the first time in their lives the idea of "serving the people" has taken on real and concrete meaning.

One of the most interesting aspects of my visit was a discussion in Shanghai with four representatives of the younger generation of scientific workers; they were Ma Mun-ren (Nankai University), Lee You-tse (Szechwan University), Shen Yun-kang (Chekiang University), and Wei Chia-mian (Nanking University). They all came from the Institute of Plant Physiology, had more than ten years of working experience as researchers, and were in their thirties. In the course of our conversation I asked them what difference they experienced, if any, before and after the Cultural Revolution. They all agreed that a tremendous upsurge has taken place at the Institute and in themselves as a result of the Cultural Revolution. The Institute is now governed by a "three-in-one" group (Revolutionary Committee). In themselves, these scientists felt that they have acquired a new world outlook of serving the people. In the past they say that the old world outlook of intellectuals often found expression in their professional work, most notably in separating theoretical knowledge from practical work and separating politics (political consciousness) from professional endeavor. They argue that, if one accept's Chairman Mao's dialectics that "the correctness or incorrectness of the ideaological and political line" is the deciding factor in everything, then clearly one must be involved politically.

What this younger generation of scientists said was very revealing. There must have been a heated debate and struggle during the years of the Cultural Revolution. A little pamphlet entitled "Strive to Build a Socialist University of Science and Engineering" (Foreign Language Press, Peking, 1972), which I picked up in a bookstore in Nanking echoes much of what they said to me. The booklet also contains a summary of the *Forum on the Revolution in Education in Shanghai Colleges of Science and Engineering* held on June 2, 1970. Among the many problems involved in transforming education, the Forum singles out that *it is the teachers who are the main problem.*

Dr. Feng Te-pei of the Institute of Physiology said that there had been fundamental changes since the Cultural Revolution, both in the style of work and attitude. In addition, he said that the Cultural Revolution is not an "all-or-none phenomenon" but a continuing process of "struggle-criticism-transformation" and will require years, if not decades, for completion.

In Peking, several times in the course of our conversations, Dr. Pei and others reiterated that many things have not been settled yet, and they are still in a transitional period. But one thing seemed clear—that theory and practice must be combined with productive labor as the universal guiding principle of the working style. There were three phases of the Cultural Revolution: struggle, criticism, and transformation. They are now in the last phase. The results are not yet in. But from all indications, they are confident that the outcome will be successful.

CONCLUDING REMARKS

In concluding this report, I would like to offer some thoughts on the value of scientific exchange with the People's Republic of China. From my observations during my two and one-half months' visit, it appears that the scientific work being done in the PRC is of very high quality. My general impression of the laboratories I saw at the Institute of Biophysics and elsewhere is that they are staffed by dedicated and hardworking scientists and technicians. In terms of hardware, one has the feeling that technology in China has reached the point that the Chinese can manufacture almost anything needed for carrying out advanced research. As concrete examples, many special scientific instruments made in China were on display at Industrial Exhibit Hall in

Shanghai. These include a 400,000 × electron microscope with a 7 Å resolution, a 2 m grating spectrometer with a range of 200–1,000 nm, a 44 ps risetime sampling oscilloscope, a mass spectrograph with a resolution of $M/\Delta M$ of 1,000 and a sensitivity of 10^{-9}, and a 100 MHz electronic counter. Recently it was reported that China has made an electronic computer with integrated circuit. The computer has a word length of 45 bits and a storage capacity of 130,000 words and is capable of one million operations per second. On the basis of technological products I saw, which included most research instruments I could think of, I am of the opinion that scientific and technological training in China must be of high caliber and very broadly based.

Furthermore, familiarity with recent scientific developments (in my specialty at least) is not limited to the few specialists trained abroad. For instance, during my visit to the Institute of Biophysics, I gave a lecture, in Chinese, dealing with the use of bilayer lipid membranes as experimental models of biological membranes. The audience was responsive and appeared to be receptive. During the lecture, I was rescued quite a few times when I came to technical terms such as exciton, spin-labeling, uncoupler, thylakoid, etc., which I did not have time to look up in Chinese. There was always more than one person in the audience who could readily provide the Chinese equivalents. It was evident during the question-and-answer period following my talk that the Chinese investigators were quite up to date with the latest research in membrane biophysics done abroad.

As described in the section on the Cultural Revolution, ideology seems to be having a profound impact on science in China, giving it a new orientation. It is my opinion that it would be difficult to understand the People's Republic without first of all having some understanding of the thought of Mao Tse-tung, which seems to articulate with great force the spirit of the new China. Everywhere I went, I saw portraits of Chairman Mao Tse-tung, his sayings, and the reproductions of his poems. Also, there were numerous slogans either inspired by or originated from Mao Tse-tung. Of these, ones most often heard were "SERVING THE PEOPLE" and "BE SELF-RELIANT." These two slogans, in many ways, summarize the uniqueness of the present Chinese society. The way China uses science and technology for social purposes cannot be appraised apart from the ideological, political, and economic settings. The Chinese I talked with acknowledge that they have much to learn in areas of science and technology from the developed countries. In other areas such as medical care and health delivery, social organization, and the role of science and technology in society, I feel, they may have much to teach us.

Since the establishment of the People's Republic of China in 1949, there had been almost no contacts between U.S. and Chinese scientists until about three years ago. Thus, in a discussion with Dr. Pei Shih-chang, the director of the Institute of Biophysics, I raised the question of future scientific contacts and exchanges between U.S. and Chinese biophysicists. As a positive step in this direction, I mentioned the possibility of their sending a few representatives to our next annual meeting. I also said that the Biophysical Society is interested in journal exchanges. Dr. Pei said that the Institute would be pleased to accept the *Biophysical Journal* and other publications of the Society. In return, they would send reprints of their work after journal publications have been resumed. On the question of scholarly exchanges, the main obstacle it seems is political because of the unresolved Taiwan question. However, Dr. Pei expressed the view that he saw no difficulty once the process of normalizing relations between China and the United States has been completed. It is interesting to note here that, back in 1964 when a scientific group from the Royal Society (London) visited China, the CAS indicated that biophysics was one of the three fields of most immediate interest for Chinese scientists, the other two being geology and meteorology (high energy physics, molecular biology, and cardiovascular surgery were second in priority). Although this list was drawn up before the Cultural Revolution, it remains to be seen whether the CAS has changed its priorities.

Throughout my visit at the Institute of Biophysics and elsewhere, I was cordially received. It is my feeling, and that of many others as well, that the reestablishment of scientific contacts will be of mutual benefit to the United States and China. To conclude this report, I would like to quote the words of Dr. Pei Shih-chang, at the conclusion of his visit as the head of the first Scientists' Delegation from the People's Republic of China to the United States in November 1972: "With the common efforts of the two peoples, the new seeds of friendship which have been sown between them are sure to grow well and bear rich fruit."

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