China's Institute of Biophysics and Other Scientific Institutions

H. Ti Tien

Institute of Biophysics

The sky was heavy with dark clouds. Rain was predicted for the day. That was Monday, July 2, 1973 in Peking. By prior arrangements, that day and the next I was to visit the Institute of Biophysics of the Chinese Academy of Sciences, as the official representative of the Biophysical Society. The programme of my visit included three separate events: (1) in the morning of the first day, I was to meet with the staff of the Institute and to be given a tour of its facilities; (2) in the afternoon, I was to give a lecture on my specialty (bilayer lipid membranes); and (3) a seminar on biophysics in the United States and China was to be held in the morning of the second day.

Everything went according to the plan. Thanks to the efficiency and unfailing courtesy of Comrades Yang Fu-yu, Hsing Nei, and the staff of the Institute, my visit was a memorable one and has enabled me to report the following.

At about 8:30 a.m. I was met at the hotel by Comrades Yang and Hsing, and we left immediately for the Institute of Biophysics which is situated in the northwest part of Peking. On the way, we drove through many streets with tall trees, frequently several rows deep, and lining both sides of the road. Comrade Hsing, a dignified woman in her 40's, told me, in response to my query, that she had studied chemistry at Peking University and was now a political cadre doing administrative work. Presently, our car, after passing through a gate, stopped in front of a large 5-story building. I was greeted immediately at the entrance by Dr Pei Shih-chang, who is the Director of the Institute, and others. Among these, I learned later were members of the Institute's Revolutionary Committee.

In a pleasantly furnished reception room, with a portrait of Chairman Mao Tsetung and enlarged copies of his poems decorating its walls, tea was served. Director Pei introduced me to the following responsible persons at the Institute:

Chang Cheng-lien, a biophysicist specializing in receptor organs;
Hsing Nei, an administrator (woman), a graduate of Peking University;
Hsu Feng-chao, a radiation biologist who had studied in Belgium in the 1930's;
Huang Fen, a biochemist (woman);

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Lu I-wan, a specialist in liquid scintillation spectroscopy (woman);
Tan Man-chi, a sensory organ physiologist;
Tien Yeh, a tall man with greyish-white hair, a leading member of the Revolutionary Committee;
Tsou Chen-lu, an enzymologist who had studied biochemistry in England from 1947 to 1951, with a Ph.D. from Cambridge University;
Yang Fu-yu, a specialist in mitochondria, a graduate of Chekiang University.

After the introduction, Director Pei proceeded to outline the history and the organization of the Institute of Biophysics. First, let me make a few remarks about Dr Pei Shih-chang, before describing the Institute, based on what I saw and on information I gathered elsewhere.

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, received his Ph.D. from the University of Tübingen, Germany, in 1928. At various times, Dr Pei served as Director of the Institute of Experimental Biology, Chinese Academy of Sciences; Dean, College of Sciences, Chekiang University; board member, Department of Biology, Chinese Academy of Sciences; committee member, State Scientific and Technological Commission, State Council; 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.* Further, Dr Pei also served as the head of the first multi-disciplinary scientific delegation from the People's Republic of China to the United States in November 1972. The delegation came to the US in response to invitations from the Federation of American Scientists and the Committee on Scholarly Communication with the PRC —a committee formed jointly by the US National Academy of Sciences, the American Council of Learned Societies and the Social Science Research Council.

In 1958, a number of remarkable events took place in China; among these were the launching of the Great Leap Forward, the formation of the People's Communes, and the establishment of the Institute of Biophysics under the auspices of the Chinese Academy of Sciences. (Coincidentally, that year also saw the formal founding of the Biophysical Society in the US.) The Chinese Institute of Biophysics formerly was a part of the Institute of Experimental Biology and the Institute of Physiology and Biochemistry of the Academy in Shanghai. Before 1950 the latter was known as the Institute of Medicine. In 1958, the Institute of Physiology and Biochemistry was divided into three separate units: Institute of Physiology, Institute of Biochemistry, and Institute of Biophysics, with the first two remaining in Shanghai, while the Institute of Biophysics was moved to Peking.

At present, the Institute of Biophysics does not have its own building. Its facilities are scattered in several buildings in the park-like compound housing a number of other Institutes of the Academy of Sciences. However, Director Pei said that plans are being made and the present facilities will be housed under a new roof very soon. It may be noted that, when the word 'Chinese' appears in official titles of organizations, it indicates that they are national in scope. There are three such academies. Besides the Academy of Sciences, the other two are the Chinese Academy of Medical Sciences and the Chinese Academy of Agricultural Sciences. Here a few words about the Chinese Academy of Sciences are in order.

First, before the Great Proletarian Cultural Revolution which is also known simply as the Cultural Revolution, the Academy of Sciences did, and presumably still does, receive guidance directly from the State Council. Second, the Academy of Sciences is not a purely administrative and organizational superstructure. But unlike

the US Academy of Sciences, it is comprised of five science departments (physical, life, earth, technical, and social). Under each department numerous research institutes are operated. For example, the Institute of Biophysics is under the Department of Life Sciences. There are 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. (The afore-mentioned institutes, two of which as well as a number of science departments in the universities I also visited, will be briefly described at the end of this paper.) In the provinces and municipalities (Peking, Shanghai and Tientsin), the Academy of Sciences also operates 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 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 secientific 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 cities. At present, the Academy of Sciences 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.

In the Institute of Biophysics of the Academy of Sciences, there are 220 persons of whom about 150 are directly engaged in research. The overall organization of the Institute, according to Director Pei, 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 US.

I was given a tour of a number of laboratories in the five research sections of the Institute. A description is given below.

Section on Cells and Cell Organelles

There are three groups in this section. The primary interest of the first group is on the structure and function of mitochondria, and in particular the swelling and contraction phenomena during oxidative phosphorylation. The leading person in the group is Yang Fu-yu, an articulate and alert scientist in his 40's. Yang'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 nankinensis* (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 home-made 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). In Yang's lab, I was introduced to two scientists, Chao Yun-Jian and Hsu Sho-chang. Both were biophysics majors and graduated before the Cultural Revolution. The former (woman) was from Nankai University in

Tientsin and the latter from University of Science and Technology in Peking.

Section on Molecular Biology

This is a relatively new section formed in 1970. The section is divided into three groups. In the enzyme group, Dr Tsou is one of the prominent members. Dr Tsou and his associates are 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 Academy of Sciences 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 is the responsible person in this section. There are four groups: external radiation, internal radiation, dosimetry, and isotopic tracer methodology. Each has 4 to 6 researchers. This section operates a 30,000 curie cobalt-60 source and five small Co-60 source (8 curies 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 has completed a study of 36 months duration at the height of the Cultural Revolution (1968). In this study 30 monkeys from south-western China (Yunan and Kweichow provinces) were subjected to whole-body irradiation with the dose rate at 2.5 roentgens/day. At present, they are investigating the action of ionizing radiation on rat chromosomes. The facilities I saw for these experiments were quite impressive. The internal radiation group, where I met researcher Lee Sun-pei, is concerned with the radiation effects on organs, membranes and cells using dogs and rats.

Section on Sensory Receptors

At present, there are two groups in this section; one group is working on vibratory receptors (Herbst body) of the pigeon and the other group, just started, is engaged in research on the structure and function of the retina. Besides researchers Chang Cheng-lien and Tan Man-chi, whom I have already mentioned, I chatted briefly with Cheng Guo-chang, a specialist in electrophysiology, who had studied in Switzerland in 1947 and in Mexico in the 1950's. I was also introduced to Ying Chun-yang, a graduate of Nanking University in 1964, who majored in Biophysics. Researcher Ying told me there were about 20 biophysics majors in the biology department which at the time had about 150 students.

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 NMR, ESR, a liquid scintillation spectrometer, an electron microscope and apparatus for fluorescence spectroscopy. Some of the researchers in this section I met, in addition to Lu I-wan, were Tao Shan-lin (Biophysics major, a graduate of Shantung University in Tsingtao), Yeh Shih-xun (graduate of the Institute of Industrial Technology in Peking) and Tsou Chia-yu (a graduate of the School

of Technology in Peking). Both Yeh and Tsou had studied radio electronics. I was introduced also to researcher Wan Lien, who is in charge of nuclear magnetic resonance instrumentation. He is a graduate of Yunan University in Kunming, and his two associates Chen Han-yun (electrical instrumentation, Institute of Technology in Shanghai) and Hsing Lu-lien, a 1959 graduate of Peking University with a major in radio electronics.

My general impression of the laboratories I saw at the Institute of Biophysics and elsewhere is that they are staffed by dedicated and hard-working scientists and technicians. 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. 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 calibre and very broadly based.

Afternoon, Monday, July 2, 1973

The daily working schedule in China calls for a rest period in mid-day lasting from 11:30 a.m. to 2:30 p.m., during which time the main meal of the day is eaten and many people go home to take a nap, a custom which I readily adopted while I was in China. However, I was not able to have my siesta that day because my lecture had been scheduled at 3:00 p.m. and I needed time to look over my notes. Earlier, when arrangements were being made, Yang Fu-yu said I could give my talk either in English or in Chinese with the latter definitely preferred. I therefore decided to use Chinese although I had not had opportunities to use it for more than 20 years. I told Yang that there were many technical terms I was not acquainted with. He told me not to worry and assured me that this would not be a problem for I could simply say or write the terms on the blackboard in English. Besides, Yang said, there would be scientists in the audience who would help me out, if necessary.

The sky by now had further darkened and the predicted rain was pouring. Promptly at 3:00 p.m. I was ushered into a large lecture hall and introduced to an audience of about 250. Later, I was told that, in addition to scientists and technicians of the institutes, many had come from other institutes of the Academy of Sciences and near-by universities. I spoke on 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-labelling, 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 provide readily the Chinese equivalents. In this connection, Professor Tang Pei-sung was particularly helpful. Several days later I met him again at the Institute of Plant Research of the Academy of Sciences, where a seminar on the current status of photosynthesis research was held. Professor Tang, who received his Ph.D. from Johns Hopkins University in 1930, is about 70 years old. He is very energetic and well informed on the recent advances in photosynthesis and related fields. It may be noted that familiarity with recent scientific developments (in my specialty at least) is not limited to the few specialists trained abroad. This was very evident during the question-and-answer period following my talk. Perhaps, it can be best illustrated by reproducing some of the questions asked:

> Q: Under the electron microscope the thickness of certain biological membranes appears to be the same both before and after removing more than 90 per cent of their phospholipids. How can this phenomenon be explained in terms of the bilayer lipid model in which the importance of lipids is

strongly emphasized?

Q: It is known that proteins play many essential roles in organelle membranes. For example, in mitochondrial membranes many enzymes are involved in the complex process of energy transduction. How useful is the bilayer lipid membrane, devoid of proteins, as a model for the biological membranes?

Q: It has been recently reported that Calvin and his co-workers constructed a photoelectric cell using chlorophyll and ZnO and estimated that in the near future 1000 kw power could be generated from 10 m^2 area. Technically, how does one proceed to produce this type of membrane with an area of this size?

Q: Can one arrange different lipid molecules on the opposite sides of a bilayer lipid membrane, for example, with phosphatidyl choline and sphingomyelin on one surface and with phosphatidyl ethanolamine and phosphatidyl serine on the other? The reason I ask this question is that, according to a recent paper, there is experimental evidence indicating that the plasma membrane of red blood cells may be arranged in this fashion.

One comment can be made with regard to the above. Investigators in the field of biological membranes can readily appreciate the topical nature of these questions and the Chinese scientists' awareness of very recently published journal articles.

Tuesday, July 3, 1973

In the morning of my second day at the Institute of Biophysics, the sky was still heavily overcast but rain had stopped. A rectangular-table discussion on 'biophysics' was held at about 9:00 a.m. During the first part of the discussion, lasting more than one hour, about 25 persons were present, including Dr Pei, members of the Institute's revolutionary committee, senior scientists, representatives of technicians and workers. After we were all seated, tea was served as usual. Dr Pei made a few brief introductory remarks. This was followed by my giving a short account of the Biophysical Society, its aims, purposes, organization, and its various activities both past and present. I also described briefly the current biophysical research activities in the US. I prefaced my presentation by conveying the greetings of Dr Peter H. von Hippel (our President) on behalf of the members of the Biophysical Society to biophysicist colleagues in China. The greetings were graciously received. Dr Pei Shih-chang responded by sending his best wishes on behalf of the Institute of Biophysics of the Academy of Sciences to all biophysical workers in the US.

In the ensuing two hours, the following main topics were discussed: the operation of the Institute of Biophysics, the activities of the Institute, the training of biophysicists in China, and the exchanges of information and biophysical scientists between the two countries.

The Operation of the Institute of Biophysics

In China, 'proletarian politics' are in command. I had a better understanding of this concept after Dr Pei described the operation of the Institute in response to my question concerning the Institute's revolutionary committee.

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 un-

like 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 trailing behind the Western science at a snail's pace).

Just before these out-moded thinking and old ways of doing things became firmly entrenched, came the explosion of the Great Proletarian Cultural Revolution. This Cultural Revolution was the most extraordinary politico-socio-economical phenomenon since the founding of the People's Republic. 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 Tsetung's directive issued on May 7, 1966), in factories, or in peoples' communes participating in manual labour. The Cultural Revolution, for science and education, meant that 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. I was told that 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 per cent).

Currently, I was told, initiation and decision of a scientific project are no longer solely in the hands of the group leader or section heads. Instead, any member in the Institute can initiate a project which must be discussed openly at each level (group, section, and institute). The supreme desicion-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. From the talks I had with scientists both at the Institute and elsewhere (Peking University, Wuhan University, Nankai University, Chungshan University, Institute of Physiology, etc.), my impression was that the Cultural Revolution had many profound effects. For

instance, élitism 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.

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 labour as the universal guiding principle of the working style. I was further told that 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. At this point, our conversation moved on to a discussion of the other activities of the Institute.

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 Talien in Liaoning province, in North-eastern 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*, *Science Bulletin*, and *Acta Biochemica Sinica*. Publications of these journals were suspended during the Cultural Revolution. At this writing (October 1973), *Scientia Sinica* and *Science Bulletin* have already resumed publication. Dr Pei indicated that *Acta Biochemica et Biophysica* 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 the laboratories.

Training of Biophysicists in China

At the outset Dr Pei indicated that he could only talk about the biophysics programme 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: Futan University (Shanghai), Nanking University, Shantung 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. Only at Shanghai University of Science and Technology was biophysics organized as a department. In all others, biophysics was offered as a specialty in the departments of biology. In either case, the training required was four years. In general, the curriculum required, in addition to basic courses (chemistry, physics, biology and mathematics), three specialized courses. These were 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 US.

Things certainly will not be the same after the Cultural Revolution and what

I have described above may be of historical interest only. There are 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 plus a minimum of two years of practical experience in factory, commune, or the 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 (non-competitive) 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 autumn 1973, about 353,000 students have enrolled in the institutes of higher learning. Presumably they have all been selected on the basis of the principles outlined above.

How will this new approach in education affect the training programme in biophysics? It is hard to answer, but it is of interest to note that implicit in the 'struggle, criticism, and transformation' of the Cultural Revolution, trial by experience and modification when necessary are the working rules.

Scientific Exchanges

Since the establishment of the People's Republic in 1949, there had been almost no contacts between US and Chinese scientists until about two years ago. Up to March of 1972, fewer than 10 scientists from the US had visited China. That, it should be noted, is about the same as the number of Americans who had been to the moon. Thus, towards the end of our discussion I raised the question of future scientific contacts and exchanges between US 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 in Minneapolis in June 1974. Also I 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 two other issues, Dr Pei expressed the view that he saw no difficulty once the process of normalizing relations between China and the US 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 Academy of Sciences 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 Academy of Sciences has changed its priorities.

Institute of Plant Research (Peking)

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. These included the Institute of Plant Research in Peking, the Institute of Physiology and the Institute of Plant Physiology, both in Shanghai, Chungshan University in Kwangchow, Kwangtung province, Wuhan University and Central China Normal University, both in Wuhan, Hupeh province, and Peking University. Since the

available facts on biophysical research and science education are still very few, a brief description 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.

The Institute of Plant Research is located near the Peking Zoo, on the outskirts of the city. I spent the entire day at the Institute on July 6, 1973, there talking with its staff and touring its facilities. The Institute was established in 1953 with Professors Lin Jung and Tang Pei-sung as its deputy directors. 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 such as an increase in output, a shorter and stouter stem.

At present, like all other organizations, the Institute is run by a revolutionary committee. Upon my arrival at the Institute, I was met by Professor Lin Jung, Professor Tsui Cheng, and Hsiao Shun, a responsible person of the revolutionary committee. Professor Lin, who is about seventy and received his Sc. D. from the University of Paris in 1930, told me that the Institute has 350 workers, including 250 technical personnel; the majority of them are university graduates. There are five scientific sections: taxonomy, ecology, paleobotany, morphology and cytology, and plant physiology. I was given a quick tour of the Institute's laboratories located in several buildings scattered in a well-tended garden-like compound. The taxonomy section has a large herbarium with more than one million specimens. The collection was actually started long before Liberation (i.e., before 1949). 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. I was shown the first two volumes which had already been published in 1972 and 1973, and Volume 3 is in the press. This mammoth undertaking with the first two volumes already totaling 2,469 pages will eventually have detailed drawings for each of the 30,000 entries of Chinese plants. The volumes I saw have indexes and headings in both Chinese and Latin. The taxonomy section was also doing a number of other experimental investigations. Wu Chen-shun, leader of the plant chemistry group and a graduate of Tungchi University in Shanghai, 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. The latter specialized in higher plants and was a graduate of Amoy University in Hsiamen, Fukien province in the early 1950's. Comrade Hsu, the section head, showed me some plant fossils from the Devonian period in Yunnan province, which were used in identifying the stratigraphic sequence. The section on plant physiology, the largest unit of the Institute, has over 80 technical workers and consists of four groups: photosynthesis, growth hormones, herbicides, and produce and fruit storage. In one of the laboratories, I was shown an electron microscope made by Peking Scientific Instruments Factory in 1969. I was told by Dr Tuan Hsu-chuan that the Institute acquired the instrument only recently. The electron microscope is capable of 30,000 X magnification with a resolution of 12 Å. Dr Tuan, who served as group leader, received a Ph.D. from Stanford University in 1927 and afterwards worked for a number of years at the University of Pennsylvania. The three individuals I met who were working on the electron microscope were Tso Shih-yu (Szechwan University, Chengtu), Hsia Chun-lun

(Chungshan University, Kwangchow), and Chao King (Technical Cadre School, Peking). They all had about ten or more years of experience. The electron microscope unit worked closely with the photosynthesis group.

The leader of the growth hormones group is Shao Li-mei. She specialized in botany and graduated from Nanking University in 1953. This group had 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. In charge of the produce and fruit storage group is a woman named Chang King-lan who graduated from North-western Agricultural College, Wukung, Shensi province, with more than 20 years of experience. This group had found conditions conducive for storage of tomatoes and other produce, namely at low oxygen concentration (2-4 per cent) and/or at high CO_2 concentration (6-8 per cent) but harmful when the CO_2 concentration is greater than 20 per cent. I was told that polyphenol oxidases may be involved. The herbicide group, under the leadership of Lee Quo-feng (Szechwan University, 1956) had done extensive work on the use of DCPA (3,4 dichlorobenzene-propionamide) in rice fields. This compound was said to be very beneficial to poor and lower-middle peasants. In the photosynthesis laboratory I again met Professor Tang Pei-sung, who attended my lecture at the Institute of Biophysics as mentioned earlier. The laboratory is directed by Kwang Ting-yun, a woman scientist who had done post-graduate 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 centre 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. (I was told that ATP is effective in the treatment of certain liver diseases and ear-ringing.) The laboratories I saw were equipped with assorted instruments including an ESR spectrometer made in Tientsin during the Cultural Revolution. I was introduced to a woman scientist named Chou Pei-jen, specializing in photophosphorylation, and Shih Ting-chi, a graduate of Peking University in charge of the ESR instrument. After a delicious lunch with Professor Lin Jung, Professor Tsui Cheng and Comrade Hsiao at Peking Exhibition Centre near the Institute of Plant Research, I was taken by Professor Tsui to see some laboratories belonging to the morphology and cytology section. Incidentally, Professor Tsui received a Ph. D. from the University of Michigan in 1947 and did his dissertation on the role of zinc in auxin synthesis in the tomato plant. He was secretary-general of the Chinese Society of Plant Physiology. The morphology and cytology section, begun in 1971, has about 20 researchers. I was introduced to Chien Ying-ching (Futan University, 1954), Ko Chung-shun (Amoy University), and Chien Nan-feng (Futan University, 1949). I was given a reprint of a paper on cell differentiation of embryos in the pollen grains of *Triticale* and *Capsicum annuum* by Chien Nan-feng and co-workers, which appeared in the first issue of *Scientia Sinica* (1973) since the Cultural Revolution.

Institute of Physiology (Shanghai)

As mentioned earlier, the Institute of Physiology was established as a separate unit in 1958. Before the Cultural Revolution, the Institute, under the direction of Dr Feng Te-pei, had a wide range of research activities in areas of 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, and the influence of drugs on gastric pepsin secretion in pigs, and bio-

chemistry 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 trial production of a highly sensitive electrometer useful in biological research. I visited the Institute on August 17, 1973 and was received by Dr Feng, a very friendly person with greying hair who received a M.S. from the University of Chicago in 1929 and a Ph.D. from the University of London, England in 1933. Dr Feng told me that the Institute now consists of 5 sections: (1) general physiology of the CNS and neuromuscular system, including systems analysis physiology; (2) acupuncture anaesthesia; (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. Later, I met some of them during a brief tour. Among these were Fan Shih-pan (Chiaotung University, 1950, muscle contraction), Wen Yeh-Shao (Futan University, 1963, muscle contraction), Sun I-an (Peking University, 1950, electrophysiology), Mu Wang-yuan (Honan University, 1951, electrophysiology), Chou Tai-sen (Shanghai University of Science and Technology, 1963, physiology), and Chu Pei-hung (Chinese University of Science and Technology, 1965, physiology). In response to my question concerning the impact of the Cultural Revolution, Dr Feng said that there had been fundamental changes both in the style of work and attitude, confirming what I had learned at the Institute of Biophysics. In addition, Dr Feng 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. He made this statement as a matter of fact and full of optimism. I detected no trace of cynicism either in his voice or expression. On the contrary, I felt that he meant every word of what he said.

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 Lo Tsung-lo and Ying Hung-chang as director and deputy director, respectively. Before the Cultural Revolution, the Institute had engaged in a wide range of investigations including research on the physiology and biochemistry of micro-organisms (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 micro-organisms in the rhizosphere of cultivated plants. At the time of my visit (August 17, 1973), the Institute was being moved to a new building. I was not able to see its facilities but I did talk with Dr Ying Hung-chang and his colleagues at the Institute of Physiology during my visit with Dr Feng Te-pei described in the preceding section.

The Institute of Plant Physiology now has six research sections: (1) photosynthesis, (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, with the overwhelming majority having received their training after Liberation. Because of my interest, our conversation was centred mainly on photosynthesis. Dr Ying said that they are now working on more practical problems closely related to agriculture. For example, workers in the hormone section are studying the effect of gibberellins and other new microbiologi-

cal products on plant growth. Dr Ying said that they are also working on such problems as photophosphorylation, oxygen evolution, effects of uncouplers, and quantum requirement and the intermediate steps of photophosphorylation. It is worth noting that, according to Jagendorf of Cornell University, an authority on photosynthesis, a group of researchers of this Institute had independently and simultaneously discovered in 1962 that, in isolated spinach chloroplasts, ATP can be formed after illumination under certain conditions.

The most interesting aspect of my visit was a discussion held later with four representatives of the younger generation of scientific workers together with Dr Ying Hung-chang and Dr Feng Te-pei participating. The four representatives, who all came from the Institute of Plant Physiology, were Ma Mun-ren (a graduate of Nankai University), Lee You-tse (a graduate of Szechwan University), Shen Yun-kang (a graduate of Chekiang University who participated in the photophosphorylation work mentioned above), and Wei Chia-mian (a graduate of Nanking University). They all had more than 10 years of working experience as researchers and were in their middle 30's. In the course of our conversation I asked them what difference they experienced, if any, before and after the Cultural Revolution. Rather than giving their individual responses, I have put together a composite of their views.

Most important of all, they all agreed that a tremendous upsurge has taken place in 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) selected on the principles described earlier. 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/or separating politics (political consciousness) from professional endeavor. They argue that, if one accepts Chairman Mao's dialectics that 'the correctness or incorrectness of the ideological and political line' is the deciding factor in everything, then clearly one must be involved politically. Lee You-tse was particularly articulate on the problem of how to integrate with the masses. How could one share the feelings of the working class if one is not involved with them, say, in a factory?

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 Languages 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.

Chungshan University (Kwangchow)

I visited two science departments of Chungshan University in Kwangchow on June 13, 1973. Formerly known as Canton University in 1924, and at one time a part of Lingnan University, the name was changed to Chungshan (another name of Dr Sun Yat-sen) University in honour of Dr Sun after his death in 1926. Before the Cultural Revolution, the University's science departments included biology, botany, chemistry, geography, geology, mathematics, mathematical mechanics, oceanography, physics, zoology and a semi-conductor laboratory. In 1964, the University had 4,000 stu-

dents. The University was closed during the Cultural Revolution. Both staff and students went to the countryside and factories to receive re-education from peasants and workers. The University had since re-opened in 1970 and admitted 540 new students in 1970, none in 1971, and 780 students in 1972. About 25 per cent of these students were women. The total administrative personnel, teaching staff and workers was 2,000. Of these, 1,000 were faculty. Now the University has 11 departments (Chinese, history, philosophy, economics, foreign languages, biology, chemistry, physics [electronics], metallurgy, mechanics, dynamics). There is also a school (department) of library science. I was told the above by Hsu Mo-ching, a responsible person of the 28-member revolutionary committee. Comrade Hsu stressed a couple of times that they are still in an experimental stage in organizing the University. The two science departments I saw were biology and chemistry. I was guided on my visit in the biology department by Huang I-ming, who studied for three-and-a-half years in Leningrad, Chen Shun-hwa, a woman chemist who graduated from Chungshan University, Tso Hsiug-sen, a woman who had taught inorganic chemistry for more than 20 years, and Wong Eng-xian, a member of the Biology Department. In the insect ecology laboratory, Liu Fu-sen told me that they were working on a problem of controlling the *litchi* wasp with insect parasites and testing them at near-by communes. In the physiology laboratory, I met Liu Hseuh-kao, who had studied at New York University in the early 1950's, and his two associates, Yang Sze-kiang and Hsu Shih-po. While I was there, they were doing an acupuncture anaesthesia 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. Professor Lee told me that there were 40 students admitted in 1970 since the Cultural Revolution and they were expecting to enroll about 60 students in the autumn of 1973. The duration of training was tentatively set for three years.

Wuhan University (Wuhan)

In the tri-cities of Wuhan, often called the Chicago of China, in Hupeh province, I visited two universities: Wuhan and Central China Normal. First a brief description of my visit to Wuhan University will be given.

The University was established in 1913. Before the Cultural Revolution, science departments included biology, chemistry, mathematics and physics. Present at the reception during my visit were Chen You-ching (responsible member of the University's revolutionary committee), Professor Sun Chiang-shung (studied at University of Edinburgh, Scotland in the late 1930's), Professor Wu Yu-ching (head of History Department, Ph.D. Harvard, 1947) and two students from the Foreign Languages Department. There were 5,000 students and 2,000 in faculty before the Cultural Revolution and now 2,000 students with the same number of faculty (June 1973). Besides the traditional science departments mentioned above, 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, a graduate of Wuhan University in 1936. She told me that she has isolated particles of 300-500Å and 1000-1200Å from breast cancer cells and is interested in their origin. In the second laboratory, Researchers Cheng Chen-quo (Wuhan University, 1960) and Ho Hai-ping (Wuhan

University, 1947) have been doing experiments on liquid crystals and their application to cancer diagnosis. Though I was totally ignorant of the field and did not understand what they were saying, I was nevertheless impressed by a number of coloured photographs of cancerous cells to which certain liquid crystals had apparently lent their service.

Central China Normal University (Wuhan)

This University, which I visited on June 18, 1973, is the largest in Central China in training secondary school teachers. In particular, 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. Professor Ning gave me a tour of the chemistry building. The Biology Department started re-admitting 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 4 to 3 years and the students spent 50 per cent of their time in self-study. The students spent two days per month in physical labour 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 re-introduced pending further discussion, Professor Ning said. In addition, the student spent two days a month working on a commune. One interesting feature about the department was that the students and chemistry faculty operate a small factory making reagent grade ferric chloride as a part of laboratory work. The two principal starting materials for the process were iron and chlorine gas. The latter was obtained by electrolyzing the brine. The source of iron was discarded iron turnings from near-by factories. 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 Tsetung participated. Forty-seven years later the students of Peking University started another movement, which has become known as the Great Proletarian Cultural Revolution. Its impacts are still being felt today on all aspects of Chinese life. 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. Professor Fu Ying, head of the colloid science laboratory with a Ph.D. from the University of Michigan in 1928 and a vice-president of Peking University before the Cultural Revolution, together with his assistant, Chao Quo-she (a graduate of Tsinghua University in 1949) escorted me around the laboratory. Professor Fu told me that 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 in the laboratory who were former students of Professor Fu. Two days later after my visit, a seminar was held in the hotel's reception

room where I was staying, with 18 scientists from the colloid science laboratory. We talked about the state of colloid science in the US and China. All the scientists who came to the seminar, except one, were graduates of leading universities in China. The exception was Lee Yu-feng. She had only a junior high school education and was sent to Peking University by the famed Taching Oil Works in North-east China, where she worked as a technician. Before touring the biophysics laboratory of the Biology Department, I had brief conversations with two departmental representatives: Wu Hsiang-yu, a graduate of Catholic University in Peking in 1947 and Mei Cheng-an, a former graduate student of the late Dr R. Emerson. Mei Cheng-an studied at the University of Illinois from 1947 to 1956. In the biophysics laboratory I was introduced to Chou Pei-ai, who majored in biophysics and was a graduate of Peking University. Researcher Chou told me that the biophysics laboratory has a staff of ten and is divided into two groups. The first group concentrates its effort on instrumentation and the second on acupuncture anaesthesia. 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.

Concluding Remarks

The descriptions above are based on my two-and-a-half months' visit to the People's Republic of China in June, July and August of 1973 and my reading on the country in preparation for the trip. There are over 1,600 research, development and higher education institutions in China, of which some 170 research institute are under the supervision of the Academy of Sciences. The number of institutions I visited is less than 1 per cent. Therefore, I did not conduct a survey of the field and most certainly am not qualified to be an expert on any part of Chinese science. In this article, I have attempted to give my observations, impressions and interpretations. In concluding this report, I would like to offer some of my impressions of the country that I left more than a quarter of a century ago.

During the ten-week sojourn in China, accompanied by my wife and two daughters, I visited 21 cities and towns in 14 provinces and municipalities, covering some 6,000 miles. My impressions and views of the people and the country can be summarized as follows:

(1) The people we came in contact with were business-like, friendly, helpful, dignified, and curious. I can also add a number of other adjectives such as polite, honest, and non-obsequious. Most important of all, I noticed that the age-old concern of 'face' appeared to have gone out of style, especially among the intellectuals.

(2) The streets in the cities and towns were crowded but clean and orderly. Although most of the streets were quite dark at night owing to a shortage of electricity, they were safe and we walked in them without fear, as did many Chinese. There was no evidence of crime or theft.

(3) Everywhere we went, we saw portraits of Chairman Mao Tsetung, his sayings, and the reproductions of his poems. It is my personal feeling that it would be difficult to understand China today without first of all having some understanding of the thought of Mao Tsetung, which seems to articulate with great force the spirit of the new China.

Throughout my visit at the Institute of Biophysics and elsewhere, I was cor-

dially received. It is my feeling, and that of many others as well, that the re-establishment of scientific contacts will be of mutual benefit to the US and China. To conclude this section, 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 US 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.'