Scientific Relations with China

President Carter’s decision to normalize relations with China has met a mixed public response. However, in scientific and educational circles the reaction is more favorable. There one finds awareness and appreciation of the intellectual potentials of the Chinese, of the great inventive contributions during past millennia, and a feeling that the United States should be on friendly terms with a nation that includes one-fourth of the world’s population. U.S. scientists are disposed to give Chinese visiting scholars a warm welcome and many are eager to spend some time in China. The extent of interchange and cooperation will be determined by the Chinese rather than by reluctance here.

Current official attitudes of the Chinese toward interaction are in sharp contrast to those that prevailed only a few years ago. From 1948 to 1971 there were few contacts. Then a gradual change occurred in which science and technology had a major role. A pivotal moment was the Nixon visit to China in 1972. But even before that, scholarly groups here were trying to foster relationships. In 1966 a Committee on Scholarly Communication with Mainland China was formed to explore and pursue opportunities to facilitate scientific and other scholarly communication. The Committee included four major sectors of American scholarly activities—the American Council of Learned Societies, the National Academy of Engineering, the National Academy of Sciences, and the Social Science Research Council.

Early efforts to achieve a working relationship with China were not fruitful, but in 1972 the Committee, renamed the Committee on Scholarly Communication with the People’s Republic of China, became a major factor in exchanges. From 1972 through 1978 the Committee and its staff served as hosts to 37 Chinese scientific delegations to the United States. Since the spring of 1973 the Committee has sent 30 American scholarly delegations to China, selecting the exchange topics and participants.

This organized effort was supplemented by private groups and individuals. Notably effective were Chinese-Americans, some of whom prepared trip reports that were published. The various visits made clear to the Chinese that a good and friendly climate for interchange existed.

In July 1978 President Carter sent his science adviser, Frank Press, and a delegation of heads of science and technology-related government agencies to China. Their mission was to investigate the possibility of cooperation going beyond the survey trips. Press had earlier served as chairman of the Committee on Scholarly Communication with the People’s Republic of China and he had been a member of an American visiting delegation. This background was helpful in discussions leading to opening the way for serious scholarly cooperation. The Press mission probably had a significance that went beyond scholarship. When two major powers make an agreement, many factors are involved. But in the normalization of relations, considerations of scientific and technological interchange surely were an important factor.

With the resumption of diplomatic relations between the United States and China, interchange will occur through other mechanisms such as commercial relationships and exchanges between universities. To obtain information to better formulate a cooperative program, most of the members of the Board of Directors of AAAS visited China from 14 November to 3 December 1978. The delegation was able to examine a broad cross section of Chinese life, education, and science and technology. In the course of the visit, many hundreds of photographs were taken both on film and in the mind. In this issue there are a few pictures and impressions of changing scenes in China in late 1978. What is presented is somewhat different, less euphoric than the views of earlier visitors. In turn, it is to be expected that what will be reported a few years hence will differ from the present portrayal, for the vast energy of China is being channeled in new directions and change for better or worse is inevitable.—PHILIP H. ABELSON
AAAS Board Visit to China—
A Brief Report

The Board of Directors made a 3-week visit to the People’s Republic of China (13 November to 3 December) as a AAAS international science initiative. Cities visited included Peking, Shanghai, Kweilin, and Canton. The visit was arranged through an exchange of letters which culminated in an invitation from the Scientific and Technical Association of the People’s Republic of China (PRC). All Board members participated except Drs. Gifford, Mosteller, and Yang. The China initiative was in accord with the recommendations of the Committee on Future Directions concerning the importance of a wider role for AAAS in international science. It was the first time the Board of Directors, as a body, has participated in a new program initiative.

The Board substantially fulfilled its expectations for the visit to China.

1. The primary purpose of the trip was to develop a workable basis for cooperative exchanges between AAAS and its counterpart association in the PRC. The Scientific and Technical Association of the People’s Republic of China (STAPRC) is a federation of some 64 scientific societies which is beginning again to hold annual and disciplinary meetings, publish scientific journals, and work toward the “popularization” of science. The visit was successful in producing a framework for such exchanges and agreement was reached on initial areas for cooperation in 1979 and 1980. The undertakings on AAAS’s part reflect objectives in the AAAS Constitution, that is, to further the work of scientists, to facilitate cooperation among them, and to increase the public understanding of science.

At a special audience with Vice Premier Fang Yi (chairman of the State Commission for Science and Technology), a high-level approval was given to the principle of cooperative relationships on a people-to-people basis. We invited the Chinese to make a return visit to the United States, and they will send a substantial delegation here in May or June 1979. We offered to share AAAS publications and symposium reports and to include the Chinese as observers or participants in our annual meetings. The
Chinese asked AAAS to take a central role in persuading U.S. experts from academia and industry to go to China for extended lecture visits and in generating a cooperative project in the area of popularizing science and technology. Other possibilities to be pursued by correspondence include some joint activity in science education and a possible Sino-American symposium at the 1980 annual meeting.

2. The Board sought meetings with key figures in the PRC in areas of science, technology, and government to clarify China’s intentions and priorities in modernizing science and technology. This was accomplished with in-depth meetings with such leaders as Fang Yi, Professor Chou Pei-yuan (acting head of STAPRC and president of Peking University), top officials of the Ministry of Education and the Academy of Sciences, and heads of universities and institutes concerned with basic and applied science.

All contacts and meetings with officials and scientists were extremely cordial; the Chinese were disarmingly frank in assessing the damage visited upon education and science between 1965 and 1975. Equally clear was the government’s and Party’s solid commitment to recovery and modernization of science, technology, and education and for a strong Western connection to help bring them about. While a mere 3 weeks spent in a society as complex as China’s is too short a time to produce strong conclusions, the evidence available indicated a decisive turn in China’s internal and external policies for science, technology, and development.

3. The Board tried to get a clear understanding of institutional arrangements for policy-making in science and technology. The answers came in bits, for the most part. In important ways, the policy structure reflects the residual influence of the former Soviet presence with an interlocking apparatus in which the Party, the State Commission, the Academy, the ministries, and the provincial organs are all involved. Despite many signs of liberalization, the Party organs still provide the direction over research institutes, and scientists are required to be, in the words of Party Vice-Chairman Teng, “both red and expert.” While the values of basic science are acknowledged at every level, expectations for benefits to defense, industry, and agriculture are very high. This may reflect a tilt in the early years toward emphasis on applied science and technological innovation.

4. We sought a broad and mixed view of the state of basic and applied research. It is very clear that the Chinese have pragmatic reasons for reentering the larger world of science and rebuilding both their laboratory competence and their science information resources. With occasional exceptions, the general impression was that both basic research and applied research must overcome a decade of neglect and disruption. The “needs” cover the whole spectrum: modern instruments, new equipment, replacement of facilities, contact with overseas scholarship and literature, higher standards of undergraduate and postgraduate education, replenishment of faculty, and foreign language capability. Where the Chinese appear to have an advantage is in combining traditional Chinese science with Western approaches to science, notably in such areas as health care and preventive strategies. With this, China has an impressive cohort of zealous and resourceful younger scientists who are now doing good work under Spartan conditions. As they get opportunities to study abroad, the prospect is that China may be less than one generation away from putting on a very good scientific show.

5. Because the education system is critical to the four modernizations (industry, agriculture, defense, and science
and technology), and especially to progress in science, the Board made special efforts to look into this area. What we found was a universal recognition by the Chinese of the predicament confronting them in education. Universities had been shut down, postgraduate study stopped, libraries vandalized, and professors farmed out to hard labor in factories and the countryside. Foreign language teaching had been proscribed, and the flow of foreign literature and especially foreign communication had been effectively shut off. Today, the universities are reopened and students are being tested before admission. The quality of appointees to key university administrative and academic positions is impressive, and many of them are alumni and alumnæ of American universities. Emphasis is being given to importing foreign experts for extended lecture tours and to arranging student exchanges. Language training is being speeded up, with emphasis on English. An impressive expansion program is in the works to multiply the number of universities while at the same time decentralizing science education to the factories and communes through what we would call outreach programs. Technical and vocational schools are on the drawing boards, and the plans envisage 2-year community colleges as well. In short, there is an explosive movement toward the creation of the infrastructure for development, limited in practical terms by problems of teacher quality and student quality. To fill these gaps, the Chinese are looking to overseas training to supplement domestic crash programs. Education in China at this point is a very serious business.

6. The Board members went to China expecting to be asked to give lectures. The Chinese had a great appetite for these lectures, and they were given to audiences varying in size from 50 to 300. The lectures traversed the gamut from industrial management and the U.S. science policy system to medical information networks, technology assessment, energy policy choices, scientific journal management, social sciences, the biological sciences, sociology of medicine, and roles of private hospitals in health care delivery. What were expected to be short lectures always took a full half-day as the Chinese pressed questions.

As evidenced by the responses generated by our lectures, throughout China Board members were struck by the keen interest in questions of science. It is obvious the Chinese have a long way to go to recoup the time and talent lost between 1965 and 1975, but the desire and determination to reach parity in matters of science and technology are also clear.

Prognosis is risky, considering the modern history of the revolutionary movement in China, but on the evidence of a brief and strenuous visit it appears that the changes under way are widely supported by both policy and public opinion, and that in the decade ahead Chinese science will give a very good account of itself.

The cooperative arrangements agreed to by STAPRC and AAAS represent one step in many that the Chinese will take as normalization proceeds and the People's Republic of China goes about rebuilding its scientific capabilities.

William D. Carey
Executive Officer

Fourth Annual
R&D Policy Colloquium

The fourth annual AAAS Research and Development Policy Colloquium will be held 19-20 June 1979 at the Mayflower Hotel in Washington, D.C. In addition to topics related to federal R&D, the FY 1980 budget, and R&D in industry and the economy, the program will include international aspects of R&D policy.

Research and Development:
AAAS Report IV will be available in book form in time for the June 1979 Colloquium.

For further information, write to R&D Budget Project, Office of Public Sector Programs, at the AAAS address.

AAAS Introduces New
Life Insurance Program

This year AAAS is introducing a new membership benefit—a program of group term life insurance that has been developed especially for AAAS members and their families. The benefit is being offered in response to the expressed interest on the part of many AAAS members, who over the last several years have inquired about the availability of life insurance at attractive low group rates.

Some 2 years ago, the Board of Directors authorized an investigation into the possibility of making such a program available to members. After determining at an early stage that the services of a professional independent insurance administrator would prove essential in helping to provide this type of membership service, AAAS carefully examined more than a dozen administrators and interviewed some eight of them. Based on their experience, reputation, and client references, AAAS selected Association Consultants, Inc., of Chicago, to help develop and administer the program. They are operating under the general supervision of the AAAS Board, an insurance committee of the Board, and AAAS staff.

Also, as a part of this process, AAAS conducted a survey of a cross section of members, in which they were asked to indicate their professional interests, preferences about Science, comments on the annual meeting, and possible membership benefits that AAAS could offer in the future, including insurance protection. The response provided valuable information that will help in setting future editorial and management policies. In addition, it helped to determine just what type of insurance program would best suit members' interests and needs.

Using the information gained from the survey, AAAS developed specifications for the proposed insurance program and invited several of the major insurance carriers to submit proposals. After reviewing proposals from several insurance carriers, AAAS selected the program underwritten by Northwestern National Life Insurance Company and their subsidiary, the North Atlantic Life Insurance Company of America. Established in 1885, Northwestern National ranks in the top 2 percent by size of the more than 1800 U.S. life insurance companies.

The new Group Term Life Insurance Plan for AAAS members is uncomplicated and designed to accommodate the needs of the majority of the membership.

Benefits of the program include:
- During the Open Charter Enrollment Period, all members under age 70 can apply for up to $100,000 coverage.
- Also, during the Open Charter Enrollment Period, all eligible members under age 50 are guaranteed $10,000 or $20,000 coverage.
- Members can elect to insure their spouses for up to the same amount that they select for themselves.
- All dependent children between 14 days and 23 years of age may be insured for $5000 each.
- At age 70 all insured members qualify for a paid-up benefit.

AAAS has established a special group

9 FEBRUARY 1979
China in Transition

This issue includes accounts of a 3-week visit to the People’s Republic of China by the AAAS Board of Directors. The aims of the visit and some cooperative arrangements that were made between AAAS and the Chinese Scientific and Technical Association are outlined on page 533. The following three articles are personal impressions of the editor of Science, the executive officer of AAAS, and the then president of the Board of Directors.

Education, Science, and Technology in China

Philip H. Abelson

President Carter’s decision to normalize relations with the People’s Republic of China has fostered expanded scientific interchange between the two countries. In consequence, the visit to China by a delegation from the AAAS from 14 November to 3 December 1978 was particularly timely.

In one sense, the delegates were following a well-trodden path. Numerous U.S. scientific groups have visited China during the past 6 years, some private, but many under the sponsorship of the Committee on Scholarly Communication with the People’s Republic of China. However, in general they have concentrated on specific areas of science such as solid-state physics. The AAAS delegation was unusual in its broad representation of disciplines and consequently in its broad outlook. It was comprised of people who had knowledge of university and medical education, libraries, medicine, the natural sciences, economics, sociology, technology, management, and politics.

Members were fascinated with what they learned about all levels of education. They tried to estimate the status of scientific research in the various fields. They were alert to discover whether and how research would be applied to societal needs. Questions about policy and management were frequent.

After a visit such as ours, participants are tempted to become instant experts. It is too easy to generalize from limited data. Beyond that, our hosts set much of the agenda. But there are factors that lend confidence in the validity of our observations. One is that we could check with groups who had been there before us (1). A second factor is that we asked many questions of many people. Some of our questions and comments were tough, even imperant. Responses were such that we felt we were dealing with honest and forthcoming people.

One of the major questions about China that over the years has puzzled me is, “Why hasn’t China developed faster and more extensively?” The country has substantial resources of coal, oil, hydropower, minerals, and agricultural land. Most of its area lies within the temperate zone. It has tremendous human resources. In the United States, Chinese scientists have performed admirably. In New York City youths of Chinese extraction do exceptionally well in the city-wide mathematics competition.

The problems of modernizing a large, populous country are enormous and complex, and so I return from China with my question not fully answered. However, I have no doubt that ideology has had a dominant role in influencing the development of education, science, and technology.

After Chairman Mao and his colleagues triumphed in 1948, a decade of remarkable progress followed. Chairman Mao’s leadership and teachings were crucial in unifying China and in the achievement of great national goals. Education was fostered; literacy was increased from 20 to more than 95 percent. Higher education was expanded. Many research institutes were created and their personnel greatly increased. Infectious disease, including venereal disease, was practically eliminated, as were prostitution and traffic in drugs. Production of many chemicals and pharmaceuticals was initiated. China became essentially self-sufficient with respect to antibiotics. In the last two decades there have been advances, but progress has been uneven, largely because of repeated twists and turns in ideology. One of the ideological twists with broad relevance to future scientific exchanges was the Cultural Revolution (1966 to 1976), which had a great impact on education and research.

Impact on Education

At virtually every university or institute that the AAAS group visited, the briefings included a denunciation of the Gang of Four. This was a small ingroup headed by Mao’s wife. For many years they controlled the major propaganda organs and the Ministry of Education. The Gang of Four were blamed for the severe disruptions of education and research that occurred during the Cultural Revolution. Worst hit was education. The universities were closed in 1966, and classes were resumed only on a limited basis in 1970. At that time a poorly qualified group of students were admitted who
had been selected on the basis of ideological considerations. In contrast, earlier students were chosen on the basis of nationwide examinations.

But the damage to education went even deeper than that. Prior to 1966, primary and middle school covered 12 years. This was cut to 10 years and before students could attend universities, they were required to spend 2 years in the countryside or in factories. Attendance at universities was diminished to 3 years, with much of the time devoted to ideological and other nonacademic matters. From 1966 to 1978 graduate school training was practically nonexistent. The study and use of foreign languages were discouraged.

Medical education and research were also hit. Medical schools were closed from 1966 to 1970. When they were reopened, the 4- to 7-year course was cut to 3 years. Students were selected from the army, communes, and factories on the basis of ideology. In general, their previous training did not go beyond the secondary school level. During the Cultural Revolution most medical research was discontinued, professionals were transferred to the provinces, and the Chinese Academy of Medicine was forced to move to a remote village.

Following the death of Chairman Mao and the arrest of the Gang of Four in late 1976, drastic shifts in policy occurred. The new ideological line emphasized the four modernizations—agriculture, industry, defense, and science and technology. Correspondingly, the official attitude toward education and research changed and new policies were quickly implemented. University curricula have been restored. Graduate training has been resumed. Students young and old will be sent abroad. Foreign schools and lecturers will be invited to China.

Today, training in the middle schools is heavily oriented toward the natural sciences and mathematics. The best students want to become physicists. Training in foreign languages begins in primary schools and continues through middle school.

Student bodies at universities have not yet been restored to their 1966 enrollment of 900,000, but the intention is that by 1985 the number will rise to 3 million. Most of them are expected to become scientists and engineers. Were these policies to be implemented, China would then be producing more technically trained graduates than the United States.

Impact on Research

Although research activities in the universities and institutes were not disrupted so severely as education, the impact of the Cultural Revolution was extensive. In China most research is carried out at institutes affiliated with the Chinese Academy of Sciences. A lesser amount is conducted at universities. During the Cultural Revolution, fundamental research was largely interrupted, although some applied work continued. The institutes fared relatively better, but they also had difficulties. We were told that in 1966 there were 100 research institutes, but that in 1976 only 40 remained. We were also told that during that 10-year interval few new research instruments were procured, and much existing equipment was damaged.

Some of the institutes came through the Cultural Revolution much better than others. For example, the Institute of Sili- cate Research in Shanghai has achieved significant results that could only have been reached by sustained effort over a period of many years. My impression, which has been reinforced by those of other groups, is that members of institutes and universities around Shanghai fared better in general than those in Peking. A possible explanation is that the Gang of Four came from Shanghai.

At all the universities and research institutes we were impressed with the people we met. They were informed about their subject fields, aware of relevant material that had appeared in the literature, and enthusiastic and energetic in their approach to science. We met and talked with more older staff members than with younger ones. The proportion of high-level women scientists in China appears to be greater than in the United States.

For the present and for the next several years, scientific leadership in China will rest with foreign-trained Chinese. Those educated in the United States are particularly prominent. Most of them came here between 1932 and 1949. Their memories of the United States are many and warm. In 1950 to 1960 a number of Chinese were trained in the Soviet Union, but only a small fraction were scientists. Their role is minimal.

In the ideological turmoils of the past two decades U.S.-trained scientists encountered difficulties, but perhaps not as great difficulties as are generally believed. True, they were special targets for abuse and "reeducation" because they were privileged, lived in urban settings, had usually come from wealthy families, and had foreign connections. True, most of them spent a year or more in the countryside or in factories. However, few were killed, their comparatively large salaries were maintained, and they were ultimately restored to their positions. To a large degree it is they who will provide a warm welcoming atmosphere for American scientists who accept invitations to lecture in China. A survey of reports from various scientific delegations indicates experiences similar to those of the AAAS group. We were most courteously received. Lectures given by members of our group were well attended by appreciative audiences who asked many good questions.

For the most part, the equipment with which the Chinese work is deficient in
quality and quantity. This is not surprising in view of the cost of such equipment and the restrictions against buying it that prevailed during the Cultural Revolution. Typical items are about 15 years behind the times, and even these are relatively few in number.

In leading U.S. laboratories one often sees equipment that has been developed locally and is more advanced than the usual state of the art. This is particularly true of some of our principal industrial research laboratories. In contrast, I saw no example in China of laboratory equipment that surpassed Western state of the art, and few pieces that even matched it.

In view of the handicaps under which Chinese scientists have worked, their accomplishments are fairly impressive, and one is led to believe that under more favorable conditions they would be remarkably creative. However, much of the work we saw was a duplication or modest variant of Western accomplishments. Some of the work was original and up to Western standards. I saw no instance in which the Chinese were notably ahead.

This view of Chinese research is broadly shared by the many visiting groups who have been drawn from every major branch of science. There is considerable variation in estimates about how far in years the Chinese are behind us. In this matter it appears that there are wide differences from field to field and within fields. The Chinese put emphasis on some areas, particularly those with quick applications, while not touching others. They are furthest behind and will find it hardest to catch up in areas of the physical sciences and computer technology where access to excellent equipment and instrumentation is essential. In some aspects of the biological sciences they are not far behind and indeed may have some lessons to teach us.

An example is their procedures for dealing with agricultural insect pests. Although they employ chemicals if necessary, they prefer to use biological controls. In any event, they refrain from overkill and treat only areas that are found to be substantially infested. They employ parasitic wasps, mites, and viruses and are developing additional biological agents.

Another example of work that merits continuing attention is Chinese studies of the incidence and etiology of cancer. Their cancer control program monitors the prevalence of the disease throughout the entire country. They find that in China 80 percent of cancers occur in the alimentary tract. The commonest sites are the stomach and the esophagus. The incidence of some tumors may be 100 times as great in one geographical area as in another. Such variations merit close studies, which the Chinese are making. They are sharing findings and specimens with Western medical scientists.

Most visiting experts from the United States agree that the Institute of Biochemistry in Shanghai is good. It is the site where the first chemical synthesis of insulin was carried out. Currently it is the scene of much activity in molecular biology, including research with recombinant DNA techniques. The Institute has carried out the tedious chore of isolating restriction enzymes. One recent visitor, an expert in DNA studies, was impressed with what he saw and the people he talked to. He believes that if the Institute enjoyed the kind of support in equipment and supplies that prevails in the United States, it would soon be among the world leaders. At present it is no more than a year or two behind. The AAAS group that visited the Institute was also favorably impressed.

Today, much of the frontier research in the United States is dependent on superb new equipment. Usually this instrumentation has as an essential component a mini- or microcomputer. Often the data obtained from the equipment are further processed in a larger computer. The use of large computers in research is commonplace, and many undergraduates as well as most graduate students in the physical sciences are familiar with computers and how they can be used.

In China we rarely saw instrumentation that included as a component a dedicated computer. The Chinese have no large computer whose capabilities approach those of large U.S. computers. We were told of only one that could process 2 million instructions per second, and most of the computers in China have about a tenth of this capability. There is very little training in the use of comput-

Diagram of a tokamak at the Institute of Physics, Peking. Beside the Chinese physicist are Edward E. David, Jr. (left), and Philip H. Abelson (right). [Photos from E. E. David, Jr.]
ers and only a few students program them.

In high-energy physics the Chinese do not have, nor could they have for a decade or more, equipment that might match that of advanced countries. Despite a lack of up-to-date equipment and computers the Chinese are succeeding in applying science to national needs. However, their problems in catching up with the West are enormous. The gap is great, and the target keeps moving ahead as advances in high technology continue.

In their research in the physical sciences the Chinese are active and knowledgeable in most of the fields currently worked in by Western scientists. Emphasis is on areas that are known to have practical applications. For example, in geophysics there are substantial efforts in earthquake prediction. In chemistry, much effort is devoted to petrochemicals, to natural products, and to polymers. In physics, lasers and a wide variety of solid-state devices are receiving much attention.

A useful insight into the level of Chinese applied science and technology can be obtained at their industrial exhibits. The AAAS delegation visited such an exhibit in Shanghai. There we saw about 1000 items whose preparation required a good level of competence in chemistry, biochemistry, metallurgy, physics, chemical engineering, and mechanical engineering. On display were many plastics, including synthetic rubber, Lucite, polystyrene, polyimide, and Teflon. Pharmaceuticals included a large number of antibiotics and drugs for hypertension, coronary disease, and nerve disorders. China produces ample steroid contraceptive drugs for domestic use as well as some for export.

Also on display were high-temperature alloys, titanium tubes, rare earth metals and salts, and semiconductor materials, including silicon crystals of 99.9999+ percent purity.

Essentially every consumer item that one could think of was there, including household goods, fabrics, musical instruments, radios, television sets, automobiles, and trucks. Production of automobiles is about 130,000 per year. The industrial exhibit also features some large machines, such as an automated milling machine with 48 cutting tools, a vertical lathe capable of machining an object 3 meters in diameter, and a machine for converting steel wire 15 millimeters in diameter into threaded bolts with hexagonal inserted sockets. The machinery appeared to be well engineered. However, many of the machines exhibited are not mass-produced, but one of a kind.

R & D Policy

Necessarily, in implementing the four modernizations, China will emphasize applied research. Average per capita annual income is about $340. In comparison to filling urgent present-day needs, a long-term unknown payoff cannot command priority. During our visit the delegation had an audience with Vice Premier Fang Yi. He is the person within the ruling group who sets policy in scientific and technological matters for China. During the conversations he said flatly, "If there is no application of research, then the research is worthless." This statement sounds familiar to Americans, who have repeatedly heard similar comments from some of their politicians. However, in China the comment is likely to have more weight than it would in the United States.

Our hosts told us repeatedly that the leadership in China is now determined to catch up with the advanced countries in science and technology. They hope to reach our current level by 1985 and to surpass us by 2000. These are inspiring goals but achieving them is problematic. As for getting to the first goal, one could scarcely devise a more unlikely springboard than the Cultural Revolution with its impact on the training of experts. Beyond that, the rulers of China apparently have little experience in the effective integration of advanced research and development into major industrial complexes.

In our contacts with directors of institutes and officials of the Chinese Academy of Sciences we repeatedly inquired about mechanisms for transfer of findings from research to applications. The standard response was to give an example of the use of improved seeds in the communes. Mechanisms for transferring results from the physical sciences to industry seem weak. At various places we were told that someone from a factory would occasionally visit an institute.

The current situation in China with respect to utilizing research is reminiscent of the attitudes of some U.S. companies during the 1950's. At that time it was the fashion to erect a beautiful laboratory off somewhere on a hill, staff it with the best scientists money could buy, and then wait expectantly for miracles. That era has long gone. The U.S. companies that maintain large research and development laboratories have made determined efforts to ensure that there is adequate interaction between research, patent counsel, development, engineering, production, quality control, marketing, and corporate management.

Competition in International Trade

In the recent past the economy of China has been little influenced by outside developments. But the new goals that have been outlined for the country will cause it to interact more strongly with the rest of the world. Enormous sums of money must be spent if China is to be modernized, amounting to as much as many hundreds of billions of dollars.

In part that money will be supplied by foreign investors, but they will provide funds only as long as they believe they will be paid back and make a profit. Oil is another possible source of money, but large reserves have not yet been found and substantial proceeds are distant at best. A more practical source of funds to pay off debts and for further investment is expanded sale of finished goods. But competing in world trade is a tough game. The goods must be attractively priced and of excellent quality. Before World War II the Japanese attempted to compete with price alone. At that time their shoddy merchandise was laughed at. Following World War II the Japanese instituted strict quality control which, coupled with cost-cutting, has made them wealthy, respected, and feared competitors.

Thus far Chinese industry has largely been oriented to produce for domestic customers. In a controlled economy costs are not always important or visible. For a customer in a socialist country to complain about the quality of a state-produced item borders on dissidence. The disciplining influence of the marketplace is absent.

I was first alerted to some of the problems that the Chinese will face by observing the quality of their bricks. There were many piles of them to be seen. I became sufficiently interested to look at thousands of bricks. They were comparatively fragile, and no two were alike.

Members of our group visited six places where various kinds of manufacturing were being conducted. These were small installations with simple, old machines. In general, the workplaces were dusty and poorly lighted. Despite the low wages paid to the workers, it was difficult to believe that low-cost high-quality products could be made in those locations.

Observations at a computer factory pointed to one of the problems the Chinese will encounter. In 1971 they assembled a computer based on integrated circuits on silicon chips. This admirable feat was accomplished with locally produced components. The small factory where the computer was assembled had
previously made door handles. In the interval since 1971 production has ranged up to ten computers of the same design per year. But in the same period great advances have been made in the United States and a U.S. computer costing a hundredth as much as the Chinese version can accomplish the same calculations at similar speed. The computer is not the best model the Chinese have produced, and the factory cited is not their most efficient one. However, the contrast in cost illustrates a problem that China will face when it engages in international competition.

If the Chinese are to compete in many of the items of international trade, they must bring to the undertaking more than cheap labor, patriotism, and self-discipline. Improving their capabilities in science and technology will help, but alone they will not be enough. Once truly committed to modernization, the Chinese may find themselves facing no end of changes, pressures, and social problems.

But the Chinese are an intelligent, energetic, and moral people. They have come far in the last 30 years. They will continue the development process. It is even possible that in spite of shifts in policies and direction that at times are destructive and self-defeating, they may yet arrive at a better, more livable social structure than others have thus far achieved.

The Chinese Scene

William D. Carey

Coming from Tokyo, the contrast on arrival at Peking could not be sharper. Peking is the fabled Xanadu, pleasure dome of Kubla Khan. But today very little pleasure is visible. The city is proletarian in all its features. The population fills the sidewalks, streets, and avenues: on foot, on bicycles, stacked in buses and open trucks. Rush hour sees streams of bicycles flowing, crowds queuing at bus stops, patiently and without shoving or pushing. There is a universal atmosphere of organized existence. There are no beggars, few loungers. Dress is simple, colorless, and drab, but clean. Facial expressions range from deadpan to the glowing joy of teenagers. This is by no means a sullen people. They eye Americans with curiosity and often with smiles and a stray word or phrase of English.

The AAAS group saw no signs of teenage hoodlumism. The bicycle brigades swept down the avenues in good order, the crowds on the streets were well-behaved, and the mornings dawned with the sight of hordes of young people running through the streets singing and exercising on the way to school. No police sirens ever sounded, day or night, and uniformed police were hard to find. On the other hand, who was a policeman?

When we were taken to see the Forbidden City or the Summer Palace, we noticed that as the proletariat crowded around us and listened to our guides, other proletarian-looking men would suddenly step forward and send them packing. And no back talk or sullen looks. The only sign of behavioral independence was jaywalking into the traffic stream or driving a bicycle or truck across the bows of a madly honking official car.

Work and Leisure

Although the populace appears to be in a constant state of motion, coming and going to nameless destinations on nameless errands in a permanent rhythm of organized futility, one senses beneath it all an explosive energy and power, a human machine in the process of being shaped, directed, controlled, and harnessed.

China is a nation of toilers. On any journey, short or long, one sees laborers at work, on farms or on the roads. Their work is backbreaking and powered largely by human muscle. A new road is laid by pick and shovel, with an ancient coal-burning steamroller waiting to smooth out and pack the stones. In the fields, water buffalo pull wooden plows steered by the peasants. Women do everything that men do, with no relief from the hardest kind of labor. A common sight from the window of the luxurious official limousine (the "Red Flag") is long lines of handcart loaded with bricks, pulled by women between the shafts and pushed by others at the rear, bent almost horizontal. At the foreign visitors’ hotels, guests’ bags are hauled up to the rooms by teen-age girls who do not seem to mind at all. Hundreds of millions of people are doing these things 6 days a week, taking a short break only to spoon a bowl of rice, vegetables, and bits of fish or meat. Nobody looks hungry or inadequately clothed.

On Sunday, Heroes’ Square is dense with silent and orderly regiments of people waiting by the hour to enter the massive mausoleum of Chairman Mao and glimpse the body as it lies in state with an honor guard of soldiers armed with bayonets. Once back in the streets, they pack the sidewalks and the shops, crowd around the ice-cream vendors, and stand 30 or 40 deep, reading the wall posters. They find pleasure in books, radio, museums, the arts, and the movies. Although they follow the Marxist line and emphasize pragmatism and realism, they turn to fantasy for entertainment. We were treated to movies and an operetta, all of which featured romantic fables out of the long ago, with lovers separated and then rejoined by the interventions of good fairies, bad fairies, magic, and dragons. The singing was haunting and the dancing exquisite, but the plots would not meet a Western standard of realism. But the cinemas are crowded and the people cannot get enough of them despite the poor quality of materials.
of the films, which were made more than 20 years ago. China is about to organize a film production industry from scratch, and it will be interesting to see what it comes up with. We saw a current documentary film of the reborn Music Conservatory in which a dozen young artists aged 8 to 15 demonstrated extraordinary musical proficiency and concentration, and the technical quality of the film was equal to anything New York could produce.

Another strong impression of China today came out of our visit to a “key” middle school in Shanghai and a kindergarten in Kwelín. The middle school provides 3 years at the junior high level and 2 years of high school, and the school we were told was obviously one of their best. It had 1600 students and 120 teachers. The courses covered literature, mathematics, chemistry, physics, foreign languages, biology, geography, music, Chinese history, and physical education. The aim of the school, we were told, is to raise the all-around development of the students on the moral, intellectual, and physical levels. Political education deals with the revolutionary idea and the approach of Communism. The teachers must keep up their studies of Marx, Lenin, and Mao’s thought, and both teachers and students are sent out to the countryside to learn labor from the peasants.

In the first classroom, an English language class, as we entered there was total silence. Sixty teenagers were sitting with their eyes closed, listening to a rhythmic chant from a tape recorder. Then the pitch changed, and all 60 pupils began to massage the upper bridge of their noses with thumb and index finger. Again the pitch changed, and the pupils (still with eyes closed and no one cheating to glimpse the Americans lined up along the walls) began massaging the eye muscles. A third change of pitch, and 60 heads dropped in unison onto folded arms. The tape stopped, and all eyes focused on the teacher. We learned that we had walked in on a “relaxation period” and that all the massaging was to relieve eye tension and prevent nearsightedness. This is a notion of Chinese medicine, and is related to acupuncture. The eerie aspect was the total concentration of the students, even in relaxation, and their self-control in avoiding distractions. We stayed for English and algebra sessions, and the performance was superb. Despite a dreadful street racket of honking trucks and traffic, to say nothing of 20 starring Americans, neither teachers nor students missed a beat. Later, we met with the faculty and two students, a boy and a girl. When we asked the girl what her ambition was (she was a science major), the answer came back, “to fulfill the four modernizations” (industry, agriculture, defense, and science and technology). Asked what they knew about America, for a moment they were stumped. “Very little,” said the girl. “Nothing,” said the boy. But after some fast thinking, the girl said, “Americans are friends of China, and they are very clever.”

The kindergarten at Kwelín was an eye-opener. There were several hundred children aged 3 to 6. They are taken at the age of 3, to relieve working parents, and for 6 days each week they live, eat, learn, play, and sleep at the school. On the seventh day they go home to their parents. The children were beautiful, clean, and exquisitely trained. Babies performed acrobatics for us, danced, and recited “poems of Chairman Mao.” The teachers were dedicated and very good with the children, who seemed to enjoy what they were doing. We went through the dormitories: 36 little beds in each, immaculate and without a wrinkle, clothes stacked in neat piles on shelves, and a bed in the corner for the teacher. The entire kindergarten operation seemed to follow a script, with the youngsters and the routines thoroughly programmed. Not a child cried, not one seemed distracted by the foreign visitors, nothing was out of place. The environment was one of total control, total order, and precision. We had to marvel at it; but more than one of us felt that it was as chilling as it was efficient.

Scholars and Scientists

The happiest people we found in China were the educated class who had studied in the United States in the 1940’s and 1950’s, before the Cultural Revolution. Their delight in being liberated was plain to see, and the alumni and alumnae from Berkeley, Harvard, MIT, Michigan, Columbia, Wisconsin, Yale, and Smith were radiant at the prospects for reunion with American colleagues. Most of them bore the wounds of the last 10 years, although they were discreet about their experiences. They have been recalled to fill key positions in the research institutes and universities, and without exception their minds are on the future instead of the past. Their resilience says a good deal about the Chinese capacity to absorb punishment and survive.

Our principal exposure was to these scholars, scientists, and interpreters as well as the leading officials. They were uniformly gracious, considerate almost to a fault, friendly, and likable. One had a strong sense (or illusion) of making fast friends. They recited the errors of the Gang of Four to the point of tedium, but not once was there criticism of the mistakes or excesses of Americans. They were discreet. They spoke repeatedly of their backwardness, but they made plain their intention not only of catching up but of “overtaking” us—a more polite term than the Soviet threat to bury us. As for the Russians, the bitterness of the Chinese toward them is never concealed. They blame the Russians almost as much as the Gang of Four.

Visiting their research institutes was a revealing experience. The buildings typically were run-down and without amenities. It was standard procedure to be greeted on the front steps by the institute head and his staff, bundled in hats and coats; go inside and climb several flights to a meeting room where tea and cigarettes were laid out; and conduct the exchange still wearing coats while our hands gradually froze. Heat (this was late November) was not programmed for some weeks to come. The same situation existed as we were shown laboratories, where the scientists briefed us in poorly lit rooms, wearing Mao caps and heavy clothing. In a word, the setting was Spartan. But the mood was something very different: upbeat, serious, confident, proud of what could be done under adversity.

They are frank in admitting backwardness, and direct in asking for any help or knowledge that we can share. They had no embarrassment in letting us see the poverty and austerity of their working environments. They could not have cared less. One had to like them, wish them luck, and want to help them. What we saw was the price China has paid for decades of the self-reliance theme. It has
The generally ruinous state of scientific research and technology in China was plain to see. Propaganda aside, there can be no doubt that science was savaged from the mid-1960's to the mid-1970's and is reemerging from a dark age. All the blame for this is heaped upon the Gang of Four. When questioned as to how this could be possible, the answers are that because the Cultural Revolution was cloaked in twisted interpretations of Chairman Mao's principles, even the intellectuals were confused to the point of "not knowing what was right from wrong." But this answer was not universal, as we found in south China from an aging but dynamic scientist who declared that she fought back and continued teaching and research all through the period, even making her students learn English and follow the English language scientific literature. Yet she was the exception. The others were bitter, but apparently had seen no way except to conform and wait it out. When we asked where Chou En-lai was during all this, the reply was that he recognized the errors but had to go very slowly in correcting them. Nobody pointed a finger at Chairman Mao himself. Indeed, at every briefing, the Chinese took care to say that China is now following the line laid down by Chairman Mao. Supposedly, they were attributing the rise of the Cultural Revolution to Mao's own prophecy that the socialist road would be beset by "contradictions." So there it is, a puzzle for the Western-trained mind. But we remember the stories of book burning, bombing, and arson at universities and the killing of faculty members of the Peking Conservatory of Music. Perhaps the most likely explanation for the overthrow of the Gang of Four was the one we heard near the end of the trip, that with the suppression of farmers' private plots and the prohibition against raising hens and chickens, the standards of living and income fell so far that the lid on the discontent finally blew off.

The goals of the four modernizations will be difficult to fulfill in the absence of a vast infusion of technical assistance from the outside and the creation, starting from almost zero, of exceptional capabilities from the inside. The risks for science are those that are typical for a developing country: massive preference for fast technological and industrial leaps and pressure for quick results from applied science. This means that higher education paired with scientific research will be promoted, but that modernization of laboratories and research institutes could come more slowly. If this view is more or less correct, it puts a double emphasis on the importance to Chinese science of student exchange with advanced countries, importation of Western experts for extended lecture tours, and getting foreign scientific literature to restock the libraries. Along with this, the Chinese must expand their foreign language instruction; it is noticeable that in the university libraries English language books are covered with dust and some have not been checked out for years.

But there is another obvious problem for the Chinese in forcing the pace of modernization. They do not yet seem to realize that as they approach a level of scale in industrialization and press for technological innovation and export markets, they will require skills in management. Even a socialist economy needs first-rate managers as it progresses toward development. Few Chinese leaders with whom we talked had any appreciation of this until we narrowed the lines of discussion to the problem of quality control. Then they came alive and said that it is one of their worst problems and that in some plants, such as textile factories, failures in quality control are penalized by taking the loss out of the pay of the managers. But there is not yet enough recognition that training in middle and upper management is a priority on which the four modernizations will depend. No central institute appears to be in existence for this purpose, and nobody seemed to know whether Chinese would be sent abroad to Western centers of management training and education. This was a point that the AAAS group raised repeatedly during the visit.

It is also clear that the gradual improvement of productivity through farm mechanization, improved fertilizers, and insect control programs will free millions from the communes and create social problems. The Chinese answer to this is that the workers will be absorbed by the parallel growth of light and heavy industry, transportation, and education. In short, an expanding economy will solve structural employment problems and, through a policy of industrial decentralization, keep the masses from crowding into the cities.

Because science education is crucial to China's modernization goals, the Board asked to meet with the Ministry of Education in Peking, even though the Chinese did not have it on our itinerary. This turned out to be a revealing meeting with the Vice Minister and several of his deputies. It began, as usual, with a speech about the four modernizations, but soon the point was made that science and technology are the keys, and education provides the foundation for all of it. If the four modernizations are to happen, China must train as many skilled people as possible and very quickly. China can buy technology abroad, but skills must be developed at home.
The Vice Minister went on to say that the problem is not simply to increase the number of students. It is to quickly improve the quality of education. The plans are to (i) get the 400 existing colleges and universities to absorb more students; (ii) open new colleges and universities, together with 2-year vocational or professional colleges; and (iii) develop television and correspondence courses along with “July 21st schools” for workers at the factories, to teach trades.

The goal for higher education is to increase the college and university student population from under 900,000 to 3 million by 1985, even though this is far too little for a country with China’s population. But the question of how to increase the number of teachers and improve their skills is a hard one. As of now, they are taking their best graduate students and preparing them for college teaching. On top of this, they have to raise the skills of the existing teachers, and they do it by running all-day courses taught by competent professors. Short courses are being given in locations where capable faculty are concentrated. Veteran teachers of good quality have the job of rapidly training new ones. And under the program to send “students” overseas for training, nearly half of those sent will be teachers in the next 2- or 3-year period. At the same time, China wants to bring in teachers from abroad—specialists and scholars who will give lectures on either a short-term or long-term basis. While all this is going on, China will have to modernize laboratories and bring in “machine literacy.”

Questions about the condition of libraries, the Vice Minister described them as badly damaged. Almost nothing was published during the Cultural Revolution, and little was allowed in from abroad. A conference was held in 1978 to evaluate textbooks to be introduced into China. Considering that there are about 20 “important” universities in the world (for instance, Massachusetts Institute of Technology, Harvard, Oxford, Cambridge, Tokyo, and Moscow), the Chinese want the textbooks they use and are beginning to bring them in. The Vice Minister added the hope that AAAS would help to provide textbooks and publications in science and technology, along with tapes, slides, and other aids to accompany the textbooks. When asked whether the Ministry has a translation capability, the answer was a brief “yes.”

The next question was on the foreign language training program, and this time a long answer was given. It turns out that this is a major bottleneck, again because of the Gang of Four. China realizes that language training is crucial, and besides English, which is being taught in many schools, they are launching programs to train people in French, Japanese, German, Spanish, and other languages. Students are asked to start foreign languages in the primary schools. Besides foreign language departments in the universities, there are a number of language institutes in Peking, Shanghai, Canton, and elsewhere. Foreign languages are also taught on television and radio.

AAAS and the Chinese Scientific and Technical Association shook hands on a flexible agreement to develop good mutual working relationships. A Chinese delegation will make a return visit for 3 weeks to AAAS in the spring. AAAS is sending Science magazine to a dozen or so centers in China. We are going to share other AAAS publications and symposium books with them, and make them welcome at our meetings. There has already been a significant exchange of books and documents between their Academy of Medicine and our National Library of Medicine, as a direct result of our trip. The Chinese have asked us to contact a long list of U.S. experts whom they wish to invite to give lectures for extended periods in China, and they want to develop a specific exchange with AAAS in the field of popularization of science and technology. Although it is not spelled out in the agreement, the prospects are also good for joint work related to strengthening science education, and for a substantial collaboration aimed at scaling up Chinese scholarship in the social sciences. Since our main purpose was to lay the cornerstone for increasing communication between the respective scientific communities through nongovernmental channels, that objective was accomplished.

China: Objectives, Contradictions, and Social Currents

E. E. David, Jr.

In Peking, the weather is chilly; there is ice on the ponds in the mornings and winter is coming. But there is the air of spring among scientists, teachers, and intellectuals. There is celebration at their release from the suppression of doctrine and dogma. Science and technology, and specialized advanced education, are now looked on as essential resources for national development, rather than as evils to be condemned and suppressed. Contacts between Chinese scientists and engineers and those outside are now encouraged. Universities are planning 100 percent or more expansion; admissions on merit rather than political acceptability have been restored. Graduate education will be resumed on a large scale. New research equipment has begun to arrive from the West, and research institutions are being similarly treated. Students will be sent abroad in large numbers and exchanges are contemplated. It is enough to gladden the heart of any partisan of science.

There is no doubt that these movements are genuine, as is the opening of China to importation of foreign technology and to joint enterprise with Western firms. Indeed, the promise is great, and the enthusiasm of those who see the rapid emergence of China as a world power based on its 1 billion people are understandable. Actually, I detected an element of euphoria both in Peking and among returning travelers. A sober assessment raises a number of doubts.

I think back to the time in 1972 when President Nixon and Dr. Kissinger returned triumphant from their visit to China. At the subsequent Cabinet briefing, President Nixon expressed his admiration for the Chinese leadership—Chou En-lai and Chairman Mao himself — and for their consistency and logic in their conduct of foreign policy. He also expressed awe at the intrinsic power of a
nation consisting of one-quarter of the world’s population. But what was their view of us? The President was clear on that point. They admired our accomplishments, but they questioned our resolve. They wondered if we could establish a foreign policy and have the will to sustain it to the point of effect. Perhaps the Chinese leadership is still waiting for its answer. But now we can raise the same question about their situation: how stable is it, how permanent is the turnaround, how far is it likely to go? Are they moving too fast, away from their revolutionary past and toward more conventional ideas for development of Chinese society? What social movements will be generated by the change from Chairman Mao’s continuing revolution to stability and the building of institutions and elites? What will be the reaction to the removal of long-standing societal symbols, the “little red book” and Chairman Mao himself as the omnipotent leader?

Of course, there are no firm answers to such questions. But the questions themselves suggest the uncertainty in the picture. Kenneth Boulding has said that “events are not as significant as you think.” Indeed, there is a large measure of randomness and happenstance in affairs. Events are not often the result of an explicit plan, carefully thought out and precisely executed. Events in China arise probably out of a mélange of influences in an unplanned way. Of one thing we can be sure: there are still elements in China that would prefer the traditional Maoist course to a Western-inspired modernization of their society. Despite such obvious sources of uncertainty, there do seem to be some fundamentals in the situation that make it more predictable than the questions above would indicate.

AAAS Visit

Perceiving those fundamentals and examining them in some detail were among the purposes of the recent visit by the AAAS Board to China. I doubt that we can add much that is new to the picture already available in sober quarters here. But the breadth of the delegation, covering engineering and the physical, life, medical, and social sciences as well as politics, was extraordinary. The congeniality of the group allowed a scholarly synthesis of comprehensive ideas. Many of these we shared and discussed with our Chinese hosts. We talked intimately with Chou Pei-yuan, president of Peking University and of the Chinese Scientific and Technical Association. We compared notes with Vice Premier Fang Yi, now also acting head of their Academy of Sciences.

Our Chinese hosts were very open in these discussions, and we were also, as soon as we became accustomed to the idea of a freewheeling exchange of views in a regimented society. I suspect that this relaxed interaction was possible because we were a nongovernmental organization without any official sanction or standing. The only times of tension occurred when someone on the Chinese side recognized that some of our delegates were government officials (such as Congressman Mike McCormack) and took the opportunity to lecture us on the necessity for normalization of relations. (The visit occurred before normalization was achieved.) The trip was largely privately financed and sponsored, although of course we kept the State Department informed, and we met with Ambassador Leonard Woodcock, head of our liaison office in Peking. Thus, we were free to speak our minds in Peking, and now in Washington and elsewhere.

Despite these advantages, I hasten to deny any special insights or expertise in the Chinese situation, which is immensely complex as Chinese scholars well know. Indeed, it is difficult to organize one’s thoughts after returning from the ferment that is China today. One important feature of the scene there is contradiction. For example, the Chinese are wary of the Soviets. They are actively opposed to the Soviet government and its way. They are concerned about the aggressive Soviet foreign policy. The Chinese have little sympathy for the Soviet Union’s adventurism or its accomplishments in science. Yet the Chinese organization of research is in the Soviet pattern. Research institutes are a part of the Academia Sinica. University research is under the Ministry of Education, while industrial research and development is carried out in industry itself. This fragmentation makes it difficult to integrate research and development efforts effectively, just as it is in the Soviet system.

Another contradiction is that Chinese science and technology are furthest advanced in areas of their least need. One physician put it well—he said, “We tend to emphasize the sensational; re-attaching severed arms and fingers when what we need most is an effective public health program.” One of China’s stated priorities is high-energy physics, hardly a technology of the people, and we saw good work in the synthesis of graded refraction optical fibers for information transmission where there is a clearly inadequate voice telephone service. Such paradoxes are not unique to China, of course. But the contradictory elements seem a significant part of their overall system.

Objectives for National Development

Still another instance involving contradiction stems from their stated objectives for national development and for science and technology as part of their vision of the future. These objectives were adopted and promulgated as national policy in well-publicized meetings held earlier this year in Peking. There, four modernizations were established as goals: agriculture, national defense, industrial production, and science and technology—the last being essential to the first three. A later conference defined eight priority science and technology subjects ranging from agriculture through energy and materials to genetic
engineering, computers, space science, lasers, and high-energy physics.

These choices show a certain sophistication, ranging as they do from the essential, agriculture, through development necessities to prestige fields aimed at rehabilitating their science and joining the international club. But these choices are coupled to very ambitious time scales. The Chinese aspire to attaining the level of late-1970's Western technology by 1985, and being "thoroughly modernized" by the end of the century. Yet there is little obvious planning, organization, or management aimed at achieving those goals. For example, in rebuilding their research and education, they are reinforcing the existing structure of institutes, educational activities, and industrial research separated by bureaucratic barriers. This structure is of Soviet origin, and now would seem to be a unique opportunity to change it to a more unitary system to encourage transfer of knowledge and technique from research to production. They may be missing a chance to make their innovation system much more effective by organizing it to remove the barriers so obvious in Soviet-style systems. Little thought has apparently been given to this possibility.

Clearly, modern planning and organization are difficult in a society that for almost 30 years has depended for achievement on collective resolve and the thoroughly puritanical little red book, and that has only a small cohort of technocrats as responsible managers. I was particularly taken with one question that was repeatedly asked: "Dr. David, how will we know when we have achieved a technologically advanced society? What are the indicators?" The question itself is poignant and does credit to the Chinese intellect, but it indicates the lack of well-defined goals.

Social science in China is highly underdeveloped. As members of their Academy of Social Sciences pointed out, they do not have the fields of sociology and anthropology yet. Social science there tends to encompass history, literature, and political science. The move toward a technologically advanced society will raise new social questions for China. For example, rapid development of technologically based industry will create an elite of scientists, engineers, and managers. Yet that is contrary to the Maoist ideology on which their society has been based since 1949. The new road is a drastic change and will have far-reaching social effects. What will be the internal reaction to encouragement of entrepreneurial tendencies after they have been suppressed for so long?* Traditionally the Chinese have been shrewd businessmen, but have 30 years of Maoism changed that? Overall, I believe there has been little thinking about the detailed effects of indigenous innovation and modernization on their society.

We found knowledgeable and sophisticated people in all of the research institutions we visited, many of them trained in the United States in the 1930's and 1940's and in Europe later. Yet there was little appreciation of what it takes to establish a computer industry, for example. We found no pressure for clean rooms in manufacturing, user education, or evangelism to turn computer skeptics to enthusiasts among the users, and of course marketing is a foreign concept. At the computer factory we visited, the development group showed that these ideas were not beyond their thinking, but are beyond the action stage at present. They do have plans to set up an equipment maintenance organization now that they have been making machines since 1973. The plant and its workers formerly made doorknobs and handles, so their present output represents quite a conversion.

Another contradiction is apparent in the grand marble mausoleum in Tienmen Square that holds the body of Chairman Mao. We visited the mausoleum and saw him lying in state. That structure and its contents are a monument that cannot be erased. Recall that the Soviets removed Stalin from the Red Square mausoleum when they repudiated him, but they had Lenin to fall back on. There is no such parallel in China (although one wonders about Chou En-lai). Yet there is clearly an ongoing attempt to repudiate Mao and Maoism as a rigid doctrine—and more importantly, as a guiding operational philosophy. That process is behind the posters, demonstrations, and statements in Peking, and does indeed seem to be a prerequisite to technologically based development. After all, one cannot learn to build computers from reading the little red book.

We found a strong attachment in Peking to Marxist economics. In many institutions and in the main square one sees posters of Marx, Engels, Lenin, Stalin, Mao, and Hua. Yet there are evidences of pragmatism in practice. The recent legitimization of joint ventures with Western enterprises is a particularly striking example.

I could go on with this list of contradictions. Another one is the ready availability of news from the foreign press in Peking. Printed in English, it is not in newspaper form but is given as a duplicated handout to foreigners every day. I found no drive to acquire these handouts among our Chinese intellectual friends, whereas there is a demand for any foreign news publication in Moscow. There seems to be less suppression of factual news in Peking, yet there is certainly not full freedom of opinion, despite the rather effective Chinese technique of using posters to express ideas.

Contradiction in practice is perhaps an important feature of Chinese style—a yin-yang effect much more compatible with the Chinese mind than with our own. Having duly noted this element of strangeness, let me go on to other elements. You will note some level of contradiction in all these matters as well.

I was fascinated by the central role of rhetoric in China. Rhetoric is a political tool in many countries, but the uniformity of theme in China is striking. We heard denunciations of the Gang of Four for past abuses from almost everyone. Their removal from power is said to be the most significant political event since the 1949 revolution. The Gang of Four and Lin Piao are clearly the current domestic villains, and they are blamed for the excesses of the Cultural Revolution and the suppression of modern development. It has been said that radical move-

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*Actually, there are signs that entrepreneurship survives in China. Along the back streets of Shanghai we saw small shops producing goods such as metallic washers, woven scarfs, specialty foods, and reed furniture. At least some of the output is sold on the spot. It is hard to believe that a part of this commerce is not outside the system.
ments thrive when some devil has been identified for condemnation. The Gang of Four certainly fills that role admirably and perhaps they will soon be joined by Chairman Mao, although I doubt his repudiation will go that far, given the Chinese respect for the past and their need for traditions. Who or what will be the next target? It will be well for adventurous enterprises and nations approaching China to be wary.

Economic and Political Prospects

There has been much enthusiastic comment here and in Europe about China's future role on the world scene as an economic power. It has been said that what China chooses to do, she can do. Actually, the picture is much hazier. China's industry is not modern, and productivity has not become a major economic objective. Where technology enters the picture, it is an empirical technology. For example, there is labor-intensive production of circuit breakers and steam turbines. Those products seem adequate for immediate needs. In one plant producing trucks the output is around 400 per day, again labor-intensive. Mass production with automated equipment is yet to appear, although it is clearly an objective in China's drive for industrial modernization. The implications of an industrial modernization policy go beyond the mere increase in gross Chinese product. Socialist societies traditionally are in need of labor; everyone works since the system demands it. China has the world's largest work force to accommodate. What will happen when industrial development reduces job availability? What will be the social impact of job elimination in a society where it seems against both doctrine and tradition? I believe that little thought has been given to such puzzles—after all, there are no sociologists to raise the issue. The paradox of a highly productive energy- and capital-intensive industry in a traditionally labor-intensive society will raise problems.

If China is to follow the path toward modernization, financing is a key question. We were told that there are ample reserves of hard currency for immediate projects. China has accumulated substantial currency reserves from its exports to Japan, and of course there has been no corresponding drain on its accounts. But to sustain the long march toward modernization, new sources of wealth will be required. One possible source frequently cited is oil. Currently identified Chinese oil reserves amount to perhaps 20 billion barrels—somewhat less than U.S. reserves. More important, the potential is largely unknown. Contrary to many stories, there is no indication that China will become oil-rich. There are interesting prospects for new fields offshore, but they are yet to be explored. Nevertheless, financing is not likely to be a limitation in the near future for Chinese development. Available credit seems to be more than adequate for the near term.

On the international scene, there are very strong long-term forces pushing China and the United States together. Perhaps the strongest lies in the international political-military realm. It is no secret that the United States and other Western nations do not feel able to parry Soviet thrusts in all parts of the world. The Chinese have said that the Soviet Union is the most imperialistic factor on the world scene. Regardless of the truth of that statement, China and the United States have a profound mutual interest in seeing that the Soviets do not dominate the Western Pacific and Southeast Asia. The Soviet moves toward Vietnam seem sinister. Thus, as one looks some years down the road, there are likely to be reasons for the United States and China (along with Japan) to consider an alliance, formal or informal. Will we see the sale of U.S. military hardware to China? Will we see the U.S. fleet in Shanghai harbor? It is not impossible, and so the United States clearly has a stake in the success of the Chinese efforts toward modernization.

Western Contributions

So far I have noted some of the contradictory elements in the Chinese situation, the paucity of management planning to reach ambitious goals, the sociological uncertainties raised by the trend to reject Maoism as an operational doctrine and to move toward a society that is more energy- and capital-intensive than labor-intensive, and finally the long-term forces pushing China and the United States together. If we try to assist China, what sorts of contributions should we consider? Certainly the Chinese will require modern technology and financing. But they will also need aid in management, planning, elements of marketing, and science and education. No matter what we do, there are likely to be steps forward, backward, and sideways as China proceeds along its chosen path.

We may worry that China will have problems such as we see in Iran today. In Iran, foreign influences brought in by the government have led to strife involving both traditional religious and modern liberal factions. Still another worry is the language problem. I am told that Chinese is a difficult language for precise communication such as that required in science and engineering. The many dialects in China present a difficulty too. It remains to be seen just how serious the difficulties of communication and documentation will be.

As we prepare to aid China, we must ask what the character of Chinese technology and products is likely to be 25 years hence, around the year 2000. Much of the technology we saw still shows the influence of China's earlier Soviet connection: automobiles, petroleum refineries, radios, and electrical equipment are examples. Looking ahead, however, perhaps our best clues come from Chinese art. The style of a nation's technology often seems akin to its artistic style: perhaps the connection is through engineering and manufacturing design. Chinese art of certain earlier eras was elegant and simple. However, the modern art we saw is not as fresh or graceful. Judging by that, we would not expect Chinese technology to have the simplicity or functionality of Japanese technology, the originality of U.S. products, or the ponderous character of Soviet design. Perhaps the Chinese will create their own style in the manner of the French, but to do so they will have to exhibit more originality than is evident today. I doubt, therefore, that indigenous Chinese products will be strong competitors on the international market soon. At least for a substantial time, the Chinese will compete in the fashion of South Korea, Taiwan, or Singapore, which use imported technology and principally foreign designs. So I return from China with mixed feelings. One cannot help but admire and respond positively to the smiling scientists and engineers one meets there. One is startled by the ambitious plans for modernization but dubious about their execution. One sees the common interests of China and the United States, but is concerned that a Chinese course can be held long enough to achieve common objectives. Beyond all this, however, there is no doubt that we have witnessed over the past 6 years a major change on the world scene—the opening of China to the West. The dimensions of the change are not yet fully apparent. As they emerge, we will find that there are new fundamentals. It is significant that the Chinese place science and technology in the forefront of these.