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SCIENCE IN CHINA AND U.S.–CHINA SCIENTIFIC EXCHANGES: ASSESSMENT AND PROSPECTS

SCIENCE AND TECHNOLOGY IN THE PEOPLE'S REPUBLIC OF CHINA
BACKGROUND STUDY NO. 2

PREPARED FOR THE

SUBCOMMITTEE ON
DOMESTIC AND INTERNATIONAL
SCIENTIFIC PLANNING AND ANALYSIS

OF THE

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SCIENCE AND TECHNOLOGY
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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., November 24, 1976.

Hon. OLIN E. TEAGUE,
Chairman, Committee on Science and Technology, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am glad to transmit to you a study entitled "Science in China and U.S.–China Scientific Exchange: Assessment and Prospects." This study is a review of the results obtained from the exchanges of scientific delegations between the United States and China and includes, as well, a brief assessment of the changing science policies of the Chinese government.

Although the United States and China are countries with vast differences in history, political systems, and industrial development, we have in recent years seen a gradual broadening in scientific and technological exchanges between our two countries. Beginning with the visit of the President of the United States to the People's Republic of China in February 1972, American and Chinese scientists and engineers have increasingly visited each other's countries. To fully understand the impact on American science and on the future relations between our two countries, we must understand more about science and technology in China. This study, which is the second in a series of background studies of science and technology in China, will, I hope, contribute toward this end.

The study was prepared for the Committee by Mr. Leo A. Orleans, China Specialist at the Library of Congress, who visited China in 1973 as a member of the American Medical delegation. Mr. Orleans performed the study under the auspices of the Congressional Research Service.

It is my hope that this study may be useful to you and to those members of the Committee on Science and Technology and the House who have an interest in the development of science and technology in China.

Sincerely yours,

RAY THORNTON, *Chairman,*
Subcommittee on Domestic and International Scientific Planning and Analysis.

CONTENTS

	Page
Letter of Transmittal	III
Contents	V
Introduction	1
Characteristics of China's Science—A Review	2
Politics in Command	2
Utilitarianism and Self-Reliance	4
"Walking on Two Legs"	5
Learning About China's Science	9
First Two Decades	9
Opening the Curtain	10
State-of-the-Art	13
Some views and verdicts	13
Some conclusions	21
Scientific Exchanges	23
Constraints	23
Prospects	25
Appendix A: Research Institutes in China	31
Appendix B: Exchange Programs of the Committee on Scholarly Communications with the Peoples' Republic of China	37

INTRODUCTION

After a generation of isolation and hostility, the United States and the People's Republic of China have come to the conclusion that despite persisting differences, it would be to the mutual advantage of both to initiate steps that would facilitate a variety of contacts between the two countries. The necessary groundwork was laid and the dramatic breakthrough came about with the visit of President Nixon to China in February 1972. At the conclusion of this visit a joint communique was issued in Shanghai which outlined a number of agreed principles designed to serve as a framework for future relations. Included in the communique was the following statement:

> The two sides agreed that it is desirable to broaden the understanding between the two peoples. To this end, they discussed specific areas in such fields as science, technology, culture, sports and journalism, in which people-to-people contacts and exchanges would be mutually beneficial. Each side undertakes to facilitate the further development of such contacts and exchanges.[1]

Of all the principles agreed to in Shanghai, this one had the most immediate visible effect as an ever increasing number of American citizens, individually and in groups, began to tour China's cities and countryside and to write and speak about their impressions of the country. With the possible exception of commercial representatives at the Canton Fair (held twice annually since 1957), scientists and engineers undoubtedly out-number all other American professionals on recent visits to China.

This report will highlight some of China's policies and programs relating to science and technology and the role they play in the country's development; it will review the changes that have occurred in the way we observe and evaluate China's scientific progress; and finally, it will summarize some of the reactions of visiting American scientists and comment on the past and future of scientific exchanges between the United States and China. It should be noted that sometimes the word "science" will be used in its Chinese connotation, to include both "science" and "technology."

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[1] *New York Times*, February 28, 1972.

Characteristics of China's Science—A Review

The importance of science and technology to the advancement of China's economic, military and social goals was clearly recognized by many leaders of the new Communist regime when it took over the country in 1949. As in the case of other developmental processes, however, China has not always followed the Western experience, but rather has attempted numerous innovations and experiments that more closely reflected Mao Tse-tung's philosophy on how a new society should be built. There are a number of Mao's tenets for achieving given goals that have been translated into principles or policies which dominate China's whole developmental process. The story of China's science and technology since 1949 can be highlighted by considering just three basic "realities" of China's unique approach to development—all of them intimately interrelated.

POLITICS IN COMMAND

Over the past 25 years virtually all of China's attitudes and policies, whether toward economic development, or education, or science, have undergone major changes. The main reason for these shifts has been the degree to which the "politics in command" principle, the first "reality," has been adhered to during given years. In the more radical periods, such as the Great Leap Forward in 1958 and the Great Proletarian Cultural Revolution in 1966, the role of politics was overwhelming. During the less volatile periods, somewhat more practical considerations tended to play a greater role in decision making and policy formulation. Even then, it was only a question of degree, because for the highly politicized Chinese population, politics is never entirely absent. The political cycles from liberal to radical reflect an almost perpetual tug-of-war between Mao's revolutionary values which stress mass mobilization and participation even in science and technology, and the forces that would attempt to achieve economic development and modernization by making much fuller use of foreign technological models and foreign know-how.[2]

There evolved an obvious dilemma or, as Mao would say, a contradiction. Most of China's scientific elite had been trained either in the West or by Western-trained professors. They valued academic training, foreign experience and contacts, and independent research for the sake of increasing knowledge. Consequently the Western-trained scientists, as well as those trained in the Soviet Union in the 1950's, found it difficult, for example, to sympathize with the value Mao places on the native intelligence and initiative of the masses or to accept the notion that the primary function of science is in the service of pro-

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[2] For a detailed discussion of cycles as they relate to science, see Richard P. Suttmeier, "Science Policy Shifts, Organizational Change and China's Development," *The China Quarterly*, June 1975, p. 207.

duction. Nevertheless, in the early years China's "march on science" had no choice but to rely on the scientists who, in close but not necessarily friendly cooperation with their Soviet counterparts, were in the process of producing the Twelve-Year Science Plan, with its twelve priority categories, designed to place the country on par with the advanced world.[3] Gradually, however, first by creating the Science Planning Commission in 1956 and later by strengthening it and expanding its functions as the State Scientific and Technological Commission, the regime began taking a variety of steps to wrest primary control over science from the Academy of Sciences which, until then, had been the chief policymaker and performer in the science area. During the 1960's and certainly after the Cultural Revolution, Peking's control over the scientific community was such that scientists were not very likely to stray from research related to the state economic plans. In order to further assure goal-oriented science, China managed to shift many of the scientific activities from the universities and academically oriented institutes of the Chinese Academy of Sciences to the practical environment of the plants, factories and farms. As a result, the number of institutes under the Academy's jurisdiction was drastically reduced after the Cultural Revolution. What is more significant, however, is that in mid-1976 70 institutes were again identified as functioning. A similar trend is evident in the number of institutes of the Academy of Agricultural Sciences (now the Academy of Agriculture and Forestry Sciences) and the Academy of Medical Sciences (see Appendix A).

This recent trend to increase again the number of scientific institutes is still another indication of the love/hate relationship between the Chinese leadership and the scientists. Periodic attacks notwithstanding, the people who make China's policies know all too well the extent to which the achievement of the country's goals continues to depend on the foreign-trained scientific and technical personnel, so that these specialists still constitute the elite in the country—a contention that would be vehemently denied by the Chinese. But this elitism is relative, and there is no doubt that changes have occurred in the attitudes of the old scientists, while the new generation of scientists is even more amenable to some of the policies promulgated since the Cultural Revolution. The young professionals are more likely to be imbued with a new spirit, so frequently mentioned by visitors, and to accept political leadership than were the scientists ten or twenty years earlier. In general, inequalities have not been eliminated in China, but if you "have it," you no longer flaunt it.[4]

When discussing the role of politics in China's scientific and technological program, it is important to consider another factor. Whereas at one time Western observers were almost unanimous in their judgment that political disruptions such as the Great Leap and the Cul-

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[3] The specific priority areas identified by the twelve year plan were: (1) peaceful uses of atomic energy, (2) radio electronics, (3) jet propulsion, (4) automation and remote control, (5) petroleum and scarce mineral exploration, (6) metallurgy, (7) fuel technology, (8) power equipment and heavy machinery, (9) problems relating to harnessing the Yellow and Yangtze Rivers, (10) chemical fertilizers and mechanization of agriculture, (11) prevention and eradication of detrimental diseases, (12 problems of basic theory in natural science.

[4] For an excellent article on this subject see Martin King Whyte, "Inequality and Stratification in China," *The China Quarterly*, No. 64, December, 1975, p. 684.

tural Revolution were also disruptive to the economy and the scientific establishment, there is a growing body of opinion that these massive campaigns are a prerequisite to generating political will for Mao-style development and that even occasional visits to the countryside where scientists must work and mingle with the peasants may not have seriously affected their performance—and in some cases have enhanced it. In other words, in science and technology, as elsewhere, politics do, in fact, determine the role, the goal and the performance of individuals.

UTILITARIANISM AND SELF-RELIANCE

China has a rich history in science that goes back to the pre-Christian era. Characteristically, however, most of China's scientific progress was based on observation, description and practical trials, more than on experimentation and rigorous demonstration leading to the development of theory which was the foundation for the Western scientific revolution. In a sense, China's present utilitarian views of how science and technology should assist the development of the country (the second "reality") reflect these traditional antecedents that have been adapted to meet contemporary goals. Science (and, of course, technology) must serve economic construction, it must be able to insure China's military needs and, through widespread dissemination and popularization, science must change the attitudes of the masses and help transform the society.

Self-reliance and self-sufficiency are deeply rooted in Mao's ideology of expediency. Slogans exhort the Chinese people at every administrative level, from the village to the province, to "do it yourself" and to utilize every local resource, skill and capability, the better to provide for their own physical and economic needs and relieve the national government, as much as possible, from such responsibilities. Self-reliance dovetails nicely with Chairman Mao's belief in the importance of indigenous development and the need for mass participation even in science and technology, where great emphasis is placed on technical innovation by workers and peasants. This campaign for self-reliance is designed to draw out the latent ingenuity of the masses in every type of production effort. Considering the many thousands of specific innovations that have been reported by urban and rural production units throughout the country, some undoubtedly must have improved technological efficiency. But even if, on balance, it may be economically costly for millions of workers to double as their own efficiency experts, the campaign for innovation does have social advantages. Innovation builds confidence among the workers, gives them a sense of participation in the nation's economic and social goals, and is a valuable learning process. Furthermore, through innovation the masses learn that scientific and technical knowledge is not the exclusive possession of the professional elites, but that it can also originate from common people.

The encouragement of utilitarianism and self-reliance among bona fide professionals in science and technology is also clearly a part of the national policy. As early as 1952 the members of the Chinese Academy of Sciences were warned that "research work must serve definite purposes and lead to the solution of important problems of mass character"—that all the emphasis must be on applied science

rather than on basic research. How closely the Western-trained scientists (who, we are told, have an inherent tendency to stray into research that is not problem oriented) heeded this admonition again depended on the cyclical length of the leash that was controlled by the Communist Party. For the most part, the Chinese scientists have been problem oriented and have concentrated on adapting available knowledge to Chinese needs rather than on spending limited resources for much more expensive basic research which may or may not result in practical achievements. At the same time we know that basic, non-directed research was not entirely absent and that members of the Chinese Academy of Sciences have been credited with a number of scientific accomplishments. Almost inevitably, however, the focus of such research has been compatible with China's national priorities.

Notwithstanding the limited capital and relatively scarce scientific manpower, the Chinese insist that they will achieve their goal of modernization through "self-reliance," with minimum technological dependence on foreign countries. The need for such independence was brought home by the serious differences between China and the Soviet Union, generated by Mao's Great Leap policies in 1958. The progressive deterioration of relations finally culminated in 1960 with the withdrawal by the Soviet Union of all technical personnel and assistance. Thus, it was not until 1961 that China began to stress technological (and political) self-sufficiency as a pressing national goal. But although the call for self-sufficiency in science and higher technology was useful as a face-saving ploy ("We never needed your help anyway" flourish) and served to control importation of expensive foreign equipment and limit undesirable scientific contact with foreign specialists, China has never ceased to be keenly aware of her needs for advanced industrial technology nor did she ever really become a technologically isolated nation. This somewhat schizophrenic attitude has been reflected in the content of some of the rhetoric. One year Peking's propaganda can turn out a continuous stream of abuse directed at everything foreign, warning against the "unbridled quest for imports of foreign industrial equipment and technology"; next year (or, sometimes, even simultaneously!) the line will be that "self-reliance in no way means shutting one's doors to sincere and effective international aid." And China never shut the doors. The volume of imports fluctuated but she never completely stopped purchasing significant quantities of technology from Western Europe and Japan and, after 1972, from the United States. Her scientists and engineers also continued to receive (except during the height of the Cultural Revolution) all the latest scientific and technical publications and reports which kept them informed of advances in the outside world. In other words, practical considerations prevailed; China received the technology she required, but frugality combined with the push for self-sufficiency undoubtedly controlled the flow of this technology to carefully selected priority areas.

"WALKING ON TWO LEGS"

The third "reality" of China's scientific and technological development is uniquely Chinese and is expressed in the "walking on two legs" slogan. In a sense, it is a compromise of all the contradictions discussed above and a summary of China's broad policies.

The almost constant political tug-of-war between advocates of "redness" (political purity) and "expertness" (technical proficiency), or (since the Cultural Revolution) between the Maoist and Liuist approach to development, is resolved by "walking on two legs." It is a practical compromise between alternative developmental strategies which recognizes that, given the scarcity of capital and skilled manpower, China's quest for modernization will require advanced technology as well as more traditional, labor intensive methods. Thus China encourages both modern and indigenous methods of industrial production and pushes for agricultural mechanization along with improvements in traditional farming. She builds large industrial complexes and small local industries. She "walks on two legs" in education, in public health and in numerous other economic and social programs. Science and technology, which must provide the population with food, shelter, clothing and other essential consumer goods and at the same time develop an economic base that would make it possible for China to pursue a strong and independent foreign policy, must also "walk on two legs."

China's fundamental policy is to encourage simultaneously science for technological advancement and science for the people—and to assure maximum flexibility in the development of both. Consequently, while in areas of high priority every effort is made to provide the Chinese scientists and engineers with facilities, equipment and foreign know-how necessary to meet China's needs in advanced science, a different but equally important effort is made at the mass level to transform the basic but somewhat abstract national virtue, "love of science," into a more practical economic asset. Through education and practice the Chinese are gradually introducing simple technology into the rural areas. Furthermore, to encourage the "unity of theory and practice," the two "legs" are drawn closer together, particularly since the Cultural Revolution, by insuring more frequent contacts between the workers and peasants and the scientists—the latter being required to spend a given period of time each year on the farm or in a factory.

China is "walking on two legs" as she relies on her own scientists and engineers to develop new technologies at the same time that she is selectively importing advanced technology from abroad. International science clearly recognizes such achievements of China's scientists as the synthesis of insulin and, at a different level, there is also respect for some of the work that has been done in high energy physics, in plasma physics, in high polymer chemistry, in laser research and in the significant technological progress that has been made in many processes within the industrial sector of the economy. At the same time China has been astutely selecting for import foreign technology, including scientific instruments, machinery, transportation equipment and scores of whole plants.[5] So, by "walking on both legs" China is

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[5] The number and types of high technology equipment sold to the Chinese by U.S. firms has been growing. In addition to the well-publicized sale of ten Boeing aircraft and eight ammonia plants sold by M. W. Kellogg, a general appreciation of the nature of China's purchases can be obtained from a partial list from the testimony of Christopher H. Phillips, President of the National Council for U.S.-China Trade, before the Subcommitee on Investigations of the Committee on International Relations, U.S. House of Representatives (Dec. 8, 1975):

> RCA Global Communications, Western Union International, and Comtech Laboratories, Inc. have sold China satellite communications equipment. Clarke Equipment and International Harvester have sold China towing tractors for use at airports. Bucyrus-Erie has sold China $20 million worth of blast hole bits and power shovels. Caterpillar has sold China $3.8 milion worth of medium size pipe-laying equipment. Rucker has sold blow-out preventor stacks to control oil well pressure; Gleason Works—automobile gear and axle producing machines; Picker Corporation—a scanning system for the detection of radio active pharmaceuticals.

developing her own technology, and, when necessary, importing more sophisticated technology for immediate use and adaption to China's specific needs.

Finally, China is "walking on two legs" in her approach to scientific and technical education. Before the Cultural Revolution, China maintained a two-track system in education. Well aware that the nation could neither provide quality education for the whole school-age population nor absorb into a developing economy unlimited numbers of highly trained specialists, the educational system produced graduates at many different levels of competence, from low-grade technicians to highly trained scientists. The Cultural Revolution had a drastic effect on the system, which Mao considered to be too elitist and discriminatory against the children of workers and peasants. All schools were closed from at least 2 years at the primary level to 4 or more years at the college level. When they reopened, the curriculum at all educational levels was shortened, all study was integrated with productive labor, most examinations were abolished and many more students from worker and peasant families were admitted into both secondary and higher educational levels.

A curious feature of the present educational system is China's reluctance to emphasize some of its positive aspects. Because the prerequisites for the new educational system are prescribed by ideology, the view presented to the outside world is of an education for the masses which is oriented toward political orthodoxy and production. Actually, there is adequate evidence, both from Chinese sources and from recent visitors, that the leadership knows very well that some special provisions must be made in order to meet the national requirements for high-level scientific manpower. To accommodate these needs, China has been gradually reverting to a two-track system—to "walking on two legs"—in education. Although many of the post Cultural Revolution innovations in education remain, most of the primary schools in large cities are back to six years, while middle schools have a three or four-year curriculum. At the higher educational level there is continued demand for the integration of education with production and most, though not all, of the students still spend two to three years in the countryside or factories before being admitted to an institution of higher learning. But while much publicity is given the factory-run colleges which follow the principle of "practice, knowledge, again practice, again knowledge," the old established universities are quietly incorporating more theory into the studies and increasing the number of years required to complete the education in some of the more specialized fields of science and technology. The periodic post-Cultural Revolution tremors in the field of education are becoming less frequent and of shorter duration, and only serve to support the belief that there is a gradual and selective drift toward quality education. In other words, China has recognized that while she must educate and train as many people as possible to fit quickly into production, she also must have scientists and engineers with superior academic training not only for sophisticated research but even for the adaption of high level Western technology.

It seems quite evident that in science and technology the "walking on two legs" approach meets China's practical requirements. There is no doubt that sometimes one leg supports the other and occasionally one may trip the other, but if there is validity in Mao's long-term

view of how China should develop, then there is validity in the "two-leg" approach. The theoretical goal of making all scientists workers and all workers scientists may never be achieved, but at the same time it would appear that the continuous striving toward that end may not have been quite as damaging to bona fide science as originally assumed. In the process, the masses should gradually gain the kind of confidence that will make it possible for them to more easily accept and participate in technical advances in the factory and the countryside.

Learning About China's Science

THE FIRST TWO DECADES

The preceding thumbnail sketch of China's policies and characteristics relating to science and technology gives no hint of the relatively voluminous data on the subject that have been published by the Chinese over the years. As a matter of fact, in this field Chinese writings have probably been more revealing than in many others, although in the publishing sector, as in everything else, politics is in command. The quality and quantity of published materials fluctuate with the political tenor of the time, and that is why the greatest volume of books, monographs and periodicals were published in the mid-1950's and the mid-1960's. But even in the intervening years literature relating to science and technology was ample enough to provide a fairly clear picture of the major policies pursued by Peking, the problems that the regime encountered in implementing such policies and the broad trends in science and technology, particularly as they related to economic development. This type of information was available from a great variety of newspaper articles, both general and specialized (but nonscientific) journals and daily radio broadcasts which were thoroughly analyzed by individuals and organizations concerned with China's economic progress.

The situation has been much less satisfactory vis-a-vis state of the art evaluations in the various sciences. The reason is not related to a lack of published scientific materials. When the publication peak was reached in the late 1950's, as many as 500 serials in science and technology were published by the national and provincial organs, institutes, and universities, while the Science Press of the Chinese Academy of Sciences was annually publishing thousands of scientific and technical books and monographs of various degrees of sophistication. The number of these publications decreased sharply in the early 1960's, picked up again in the mid-1960's, and then dropped to zero during the Cultural Revolution. Since then, there has been a slow but steady resumption in the flow of published materials on science and technology. Although some of the books and journals were not for public sale and not all available publications necessarily found their way to the United States, during most of the past quarter century the volume of Chinese scientific and technical materials in this country has been adequate for a reasonably confident evaluation of the state of the art in most scientific fields. And yet, outside the intelligence community, there has been virtually no effort devoted specifically to this subject.

There are two basic reasons why, until 1972, so little has been done in evaluating China's position in the sciences. First, China remained closed to most of the world and certainly to the United States. American scientists could not enter the country, observe the facilities and

the laboratories, or talk to their Chinese counterparts. The few scientists from Western Europe, Canada and Australia who managed to get into China in the 1950's and 1960's brought back some useful impressions, but they had little opportunity to view in depth any aspect of Chinese science and quickly abandoned their often transient interest in China to resume their own activities.

The second reason for the gap in assessing China's scientific developments is even more important and relates to the simple question: Who? There are few scientists who have all the necessary or desirable prerequisites: an interest in China, adequate time to devote to this interest, a useful (not necessarily imperative) competence in the Chinese language, and a willingness to pursue this interest without any prospects for a field trip. The numerous American scientists of Chinese extraction—the most likely candidates for such an endeavor—have naturally been too occupied with their own academic and professional interests. By default, then, most of the analysis of scientific developments in China has been left to social scientists specializing in the People's Republic of China—individuals with little or no competence in the hard sciences.

One significant exception was a 1960 symposium on Chinese science, held at the meeting of the American Association for the Advancement of Science and jointly sponsored by the National Science Foundation, the Social Science Research Council, and nine American scientific societies and institutions. In that case, recognized scientists, many of Chinese extraction, were provided with an estimated total of 200,000 pages of reproduced materials dealing with the various sciences, and were asked to write state of the art papers. These were then published in 1961 in one volume: *Sciences in Communist China*.[6] It was the first and last exercise of this kind, and it was and still is useful for the period it covers—but it is, of course, obsolete.

OPENING THE CURTAIN

Since 1971 there has been a drastic change in the approach to the study of China's science and technology.

In the spring of 1971 the American table tennis team accepted an invitation to visit China, initiating what the Chinese refer to as "people's diplomacy" and opening the possibilities of travel and exchange between China and the United States. Since then there has been a noticeable and understandable change in both the interest in China's science and the mode of studying it. Whereas China's science had been of concern to a relatively few individuals and organizations—and much of that concern was generated by China's military threat potential—the accelerated rate of scholarly exchanges in the past 5 years between the two countries has resulted in China being "discovered" by more and more scientists. After visiting China, American scientists come away intrigued by what they have seen and, many of them, with a desire to learn more about the country and about the state of the art in their respective fields of specialization. Some of their published reports have had a snowball effect, stimulating the interest of thousands of other scientists, scholars, and laymen.

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[6] Sidney H. Gould (Ed.), *Sciences in Communist China*, American Association for the Advancement of Science, Washington, D.C., 1961.

The recognition by American industry of China as a possible trade market has also provoked considerable interest in China's science and especially in her technological achievements and goals, as evidenced by the large number of engineers and scientists visiting the mainland on behalf of various corporations. All in all, during the past few years there has been a quantum leap in the number of people who would like to know more about China's science and technology, where it is, and where it is likely to go.

With the accelerated interest came a change in the type of evaluation that is now preferred. While prior to 1971 analysis of China's science was based essentially on Chinese published sources with all too little input by the American scientific community, since then everyone with an interest in Chinese science and technology has been looking almost exclusively to the scientist who visited the country and talked with his Chinese counterparts in the scientific institutes, and to the engineer who has had first hand impressions of China's technological development. Now there is an extremely limited use of published Chinese materials in most writings on Chinese science. In other words, there has been a methodological flip-flop.

No one knows exactly how many Americans have visited the People's Republic of China since the spring of 1971, but it is estimated that their number has by now exceeded 10,000 with perhaps more than two-thirds of Chinese-American origin. The professional composition of this group is also difficult to estimate. It started with a trickle of newsmen, scientists, athletes, politicians and businessmen, and has increased to a modest stream of visitor representing a fairly broad cross-section of American society. There are large numbers of business representatives who either are involved in or have a longing for trade with China and therefore make periodic pilgrimages to the Canton fair; the National Council for U.S.-China Trade is involved in facilitating trade missions to China; the National Committee on United States-China Relations sponsors and assists exchanges of a variety of specialized delegations; there are groups sponsored by the U.S.-China People's Friendship Association, consisting of "leaders of broad-based community organizations"—primarily individuals favorable to China's point of view; and there are numerous independently organized visits by groups and individuals.

What proportion of the visitors to China have been scientists (excluding social sciences) and engineers is also not known, but their number is believed to be quite large—perhaps as many as 600 to 800. There are several reasons why scientists were among the first to glimpse what has been transpiring behind the bamboo curtain and why they continue to dominate at least the scholarly exchanges. Although scientists may be as politically conscious as anyone else, natural and medical sciences deal in general truths and general laws which do not change with ideology, thus making scientists ideal intermediaries for establishing communications with a highly politicized society. Because China has made significant progress in some fields of science, she naturally feels she can put her best foot forward by showing her accomplishments. On the other hand, China's interest in areas of science where she is lagging behind the world level and her pressing need for advanced technology have also moved the leadership to extend invitations to certain types of specialists. From the American perspective, in addition to the novelty

and curiosity associated with a visit to China, there is genuine interest in some of the unique ways in which science and technology is used to modernize and industrialize the country and raise the practical awareness of the masses. Furthermore, there is widespread belief that even if at present there is little that American scientists can learn from the Chinese, China bears watching (and visiting) because in the not too distant future her science and technology may well be competing on advanced world levels.

The American organization serving as a focal point for scientific exchanges with the People's Republic of China is the Committee on Scholarly Communication with the People's Republic of China (CSCPRC), which was formed jointly in 1966 by the National Academy of Sciences, the Social Science Research Council and the American Council of Learned Societies. Chartered to explore and encourage communication between Chinese and American scholars in the natural and medical sciences, social sciences, and the humanities, the Commitee maintained a holding operation until after the Cultural Revolution. Following the 1972 Shanghai Communique, however, the CSCPRC has become the organization responsible for all official ("government-facilitated") scientific exchanges between the two countries, playing a much more significant role than the number of exchange delegations might suggest. As a result of negotiated agreements with the Chinese Scientific and Technical Association, 21 American scientific groups visited China (3 of them funded but not sponsored by the CSCPRC) and 26 Chinese groups visited the United States, as of the end of 1976; 1977 will probably see another 10 or 12 groups exchanging visits (see Appendix B).

Because of the CSCPRC exchanges and privately organized science-oriented visits, some of America's top scientists have had an opportunity to view Chinese science first hand, and it is probably safe to say that each of them has written at least one report or article describing his experiences. Although there is no bibliography of all their writings, in preparing this report an effort was made to review a fairly comprehensive sampling and to extract the essence of some of their conclusions, particularly as they pertain to the state of the art in specific scientific fields.

State-of-the-Art

SOME VIEWS AND VERDICTS

The articles and reports written by scientists upon their return from China usually describe in some detail the institutions and facilities they visited, the research activities they observed and the conversations they had with Chinese scientists. Although much can be deduced from the content of these reports, most visitors seem to be very cautious about setting down in writing any generalized judgments about the state of the art—albeit, the more recent observers seem to be less reluctant to do so. The year of the visit is also important because China has undergone some significant changes during the years since the scientific exchanges were initiated, so that individuals who visited China in 1972 might return with somewhat different impressions if they had another opportunity to travel to China. It is therefore important to stress once again that although the views and verdicts that follow are, hopefully, representative, they are only a sampling and in no sense exhaustive. Furthermore, to avoid giving the reader an impression that he will find definitive evaluations of the various sciences, sub-headings are omitted in favor of a running commentary.[7]

It is easy to understand why there has been more written on Chinese agriculture and health than on any other aspect of China's development. Both are, of course, primary determinants of China's future. In addition, however, the apparent availability of food and the healthy look of the population has been a surprise to many early visitors and in sharp contrast to the image of the old China they took with them. Because of the importance of agriculture and medicine and because of the very legitimate pride the Chinese take in their accomplishments in these fields, medical scientists, and to a lesser degree agricultural scientists, have constituted a disproportionate number of academic visitors.

There seems to be a general concensus among scientists about China's agriculture. Most would probably agree with Sterling Wortman, Vice-President of the Rockefeller Foundation and head of the CSCPRC-sponsored plant studies delegation. He was "inclined to accept" China's assertion that self-sufficiency in food was achieved in 1971, concluding that "given a continuation of the present aggressive and coordinated effort it seems that China will be able to achieve substantial increases in agricultural production over the next decade."[8] The most common reservations about China's agriculture relate to the longer future, and specifically to the nature of agricultural research as pursued since

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[7] I would like to thank Anne Keatley, Staff Director of the CSCPRC, for letting me browse through the Commitee's excellent files of published and unpublished trip reports.

[8] Sterling Wortman, "Agriculture in China," *Scientific America,* Vol. 232, No. 6, June 1975, p. 21. For an excellent review of science in China's agriculture, the reader is referred to the full report of this delegation: *Plant Studies in the People's Rcpublic of China,* National Academy of Sciences, Washington, D.C., 1975.

the Cultural Revolution. Scientists tend to feel that the Chinese may not be prudent in emphasizing applied research at the local level conducted primarily by people with practical farming experience, rather than concentrating on basic scientific investigation without reference to the immediate problems of production and conducted by members of the scientific community. For example, G. F. Sprague, professor of agronomy and another member of the plant studies delegation, comments that "the current agricultural research in China is more nearly self-contained than is true of any other area of the world" and that "longer-term increases in productivity would appear to require a great emphasis on supportive basic research." [9] In other words, although China's agriculture is already more sophisticated than that of other developing countries and despite China's surprising successes (for a rural, underdeveloped country) in population control,[10] most agricultural specialists express some concern about that country's long-term food-population balance.

Considering the large number of physicians who have visited China during the past 4 years, there are inevitable differences in some of the evaluations of the medical care that is available to the Chinese people. Almost all would agree, however, that through massive sanitation efforts and improvisations in the health delivery system, the Chinese have achieved a minor health miracle. E. Grey Dimond, Provost for Health Sciences at the University of Missouri, writes that ". . . all will be struck by the fresh and original approaches being tried in many health fields." He also brings out a point that is relevant not only to the medical sciences but to all sciences and China's development in general: "To appreciate New China, the westerner must look with not only a scientific eye, but equally with an awareness that the largest social experiment in the history of man is being carried out." [11]

Physicians are impressed with China's health delivery system and the close to universal accessibility of primary health care. They think it is reasonable for China to emphasize preventive medicine and to fully utilize paraprofessionals—although some draw the line at the ubiquitous barefoot doctors. There is less concurrence on the efficiency of China's curative medicine. Certainly many would disagree with the conclusion of T. O. Cheng, a prominent cardiovascular specialist at the George Washington University Medical Center, that "Despite the twenty-three years of isolation, medicine in China is as modern as that in the United States, and physicians still speak the same language." [12] It is not to denigrate China's achievements to point out as did Martin Cherkasky, Director of New York's Montefiore Hospital and Medical Center, that "There was an impression that there might be inordinate delays for people with some serious medical conditions for whom prompt diagnosis and definitive therapy might be of great importance." [13] Or to comment, as did Eugene A. Stead,

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[9] G. F. Sprague, "Agriculture in China," *Science*, Vol. 188, May 9, 1975, p. 551.
[10] See, for example, Leo A. Orleans, "China's Experience in Population Control: The Elusive Model," *World Development*, Vol. 3, Nos. 7 & 8, July-August 1975.
[11] E. Grey Dimond, Foreword to *China Medicine as We Saw it*, (Joseph R. Quinn, Ed.), National Institutes of Health, Washington, D.C., 1974.
[12] T. O. Cheng, "Medicine in Modern China," *Journal of American Geriatrics Society*, July 1973.
[13] Martin Cherkasky, "Health Care Organization and Health Policy Issues," *Report of the Medical Delegation to the People's Republic of China*, Institute of Medicine, National Academy of Sciencies, Washington, D.C., 1973, p. 39.

Professor of Medicine at Duke University, that "The pace of the wards appeared slow. Diagnostic procedures were not tightly scheduled and the time between diagnosis and surgery was prolonged by our standards. The average stay of patients appeared to reflect this more leisurely approach."[14] Stead also commented on the more primitive medical facilities in the rural areas which serve four-fifths of the country's population: "The health stations and the commune and factory hospitals had very limited diagnostic facilities, and therapy at that level was primarily symptomatic and was carried out without the establishment of a definitive diagnosis." Many other physicians have also commented on the disparity in urban and rural health care—a problem that is recognized by the Chinese authorities and one they are attempting to cope with.

American medical personnel have shown great interest in China's drug industry. The country's claim of self-sufficiency in the production of essential modern drugs is generally accepted and frequently pointed to as a significant accomplishment.

Philip R. Lee, Director of the Health Policy Center of the University of California in San Francisco, is a little more cautious in his reaction when he writes that:

> . . . it is impossible to provide a detailed or definitive evaluation of modern drugs and pharmaceutical manufacturing in the People's Republic of China at the present time. In two fields at least, animicrobial and oral contraceptive drugs, the performance in production, distribution and effective use has been outstanding."[15]

Yang-ming Chu, Professor of Microbiology at George Washington University, also comments on China's antibiotics industry:

> In view of the scarcity of trained microbiologists and the lack of adequate equipment, the mere fact that China could build up her antibiotic industry from 'nothing' is a great achievement . . . It is no small matter for China to become self-sufficient in antibiotics for domestic needs.[16]

Despite some skepticism, American scientists have shown even greater interest in herbal medicines that are so widely used in China. They usually leave China without losing either their interest or their skepticism. Interest is maintained because of their knowledge that a large proportion of modern drugs are also derived from crude plant materials or plant extracts. Skepticism is not eliminated because the uncontrolled and individualistic way in which the multiple traditional drugs are used by the Chinese medical profession "drives Western scientists to distraction." Thus, while they lament the absence of laboratory research and placebo-controlled trials of the medications, most pharmacologists and physicians would probably agree with Samuel D. J. Yeh of Cornell University Medical College, that ". . . some of the treasures of healing arts gradually accumulated

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[14] Eugene A. Stead, Jr., "Patterns of Disease," *Ibid.*, p. 53.
[15] Philip R. Lee, "Drugs and Pharmaceutical Manufacturing in the People's Republic of China," *Ibid.*, p. 123.
[16] Yang-ming Chu, "Achievements in Applied Microbiology," in *China Medicine as We Saw it* (Joseph R. Quinn, Ed.), John E. Fogarty International Center, National Institutes of Health, Washington, D.C., 1974, p. 388.

over centuries by the Chinese and their ancestors, based on millions or billions of human experimentations may be useful and must be carefully and objectively evaluated." [17]

A conclusion of the American Herbal Pharmacology Delegation would also probably be seconded by a large proportion of all medical professionals who visited China:

> Perhaps the most significant impact felt by the scientific members of the delegation came from the challenge to basic assumptions long held by our own society. What we saw of acupuncture analgesia; Chinese orthopedic practices; their nonoperative approach to kidney stones, appendicitis, and cataract surgery; burn treatment; their methods of dispensing drugs; and the respect for the opinions and experience of both patients and physicians was extremely provocative and suggested a need for Western scientists to reexamine some of their favorite dogmas.[18]

Emil L. Smith, Chairman of the Biological Chemistry Department of the UCLA Medical School, expressed a few tentative views of the status of biochemistry in China. In his overall impressions, following a 1973 visit, Dr. Smith found that practical work is strongly emphasized but that some fundamental work has been initiated; that the overall support for the three institutes he visited was fair to poor—especially in the quality of electronics and instrumentation—but improving; that scientists at the institutes were well-acquainted with some of the work done in the West from the available literature, but have not observed at first-hand modern techniques and instruments; and, that there is little research activity in biochemistry in medical schools or universities as compared to the institutes.[19]

In reporting on biophysical research in China, H. Ti Tien of Michigan State summarizes his experience as follows:

> From my observation during my two and a half month visit, it appears that scientific work being done in the PRC is of very high quality. My general impression of the laboratories I saw at the Institute of Biophysics and elsewhere is that they are staffed by dedicated and hardworking scientists and technicians. In terms of hardware, one has the feeling that technology in China has reached the point that the Chinese can manufacture almost anything needed for carrying out advanced research.[20]

Since such an evaluation may depend on one's discipline, as well as on what one happened to see and hear during the stay in China, it is natural that other visitors would take exception with Professor Tien's optimistic assessment. For example, after visiting five universities

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[17] Samuel D. J. Yeh, "Experimental and Clinical Oncology in the People's Republic of China," *American Journal of Chinese Medicine,* Vol. 1, No. 2, 1973, p. 219.

[18] A Trip Report of the American Herbal Pharmacology Delegation, *Herbal Pharmacology in the People's Republic of China,* National Academy of Sciences, Washington, D.C., 1975, p. 80.

[19] Emil L. Smith, "Impressions on the Status of Biochemistry in China," unpublished report, 1973.

[20] H. Ti Tien, "Biophysical Research in the People's Republic of China," *Biophysical Journal,* Vol. 15, 1975, p. 329.

Brian J. Skinner, Professor of Geology and Geophysics at Yale, concluded that:

> . . . the state of geology can only be described as poor. The faculty are largely unaware of what has happened in the last decade, and although reprinted Western journals of the last two years are on the library shelves I could not find much evidence that they were read.[21]

He felt that the primary goal of geological education in China was to produce people who could work on engineering projects and in prospecting.

Another member of the Yale delegation, Clement L. Market, Professor of Biology, was in general agreement with Skinner:

> Research and teaching in the biological sciences in China—as seen at the universities of Canton, Shanghai, Sian and Peking—is at a very low level. The research laboratories are primitively equipped and appear to be largely unused at the present time. What little research is done appears to be directed to very practical ends.[22]

It may be worth noting, editorally, that the Yale group apparently concentrated their visit on the institutions of higher education—not the best vantage point for viewing scientific research in China.

Henry Abarbanel, whose specialty is the theory of high energy physics, is very enthusiastic about China and the value of U.S.-China exchanges, but he too has some reservations about the state of the art in physics:

> My impression of the physics laboratories we visited is one of vigor, enthusiasm, and high-quality personnel, but rather unsophisticated equipment and very little in the way of concrete results. . . . The major scientific work in Chinese physics (aside from, one must suppose, weapons research) seems to have been applied research and development of useful things.[23]

The importance of chemistry in China may be judged by the numerous publications and the large number of institutes of the Academy of Sciences that are related to the broad field of chemistry, as well as, of course, the rapid progress that has been made in this field. Jesse C. H. Hwa, Manager of Research Planning at the Stauffer Chemical Company, had some interesting comments to make about the advances in China's plastics industry. The specialists he met in China were:

> interested in learning about recent developments in such applied areas as jumbo PVC reactors, bulk PVC polymerization, clean reactors, water desalination, engineering plastics, etc. They were not as familiar with some other U.S. develop-

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[21] Brian J. Skinner, "Geology and Geochemistry," *in* "Impressions of China," *Yale Alumni Magazine,* Vol. XXXVIII, No. 1, October 1974, p. 25.
[22] Clement L. Market, *ibid.,* p. 26.
[23] Henry Abarbanel, "New China Hands—American Scientists Visit the People's Republic," *Engineering and Science,* Vol. XXXVII, No. 4, February 1974.

> ments such as soft lenses, powder coating and flame retardance. They seemed to have a good knowledge of patent literature.[24]

On the other hand, Herman Mark, Director of Polymer Research Institute of the New York Polytechnic Institute, while also impressed with much of what he saw and the people he talked with on his 1972 visit, concluded that at least in polymer science "their equipment is not up to date and the literature of the last 3 or 4 years is almost unknown."[25] It should be pointed out, however, that, in part, the different impressions may be due to the fact that Hwa was primarily concerned with practical aspects of production, while Mark may have been more interested in research in general. This type of distinction is likely to affect the conclusions of all scientists.

Observational and theoretical meteorology in China has a tradition that goes back many hundreds of years, and even in the late 1950's, in terms of the number of weather stations, her meteorological network ranked fourth among the meteorological services of the world. According to a very comprehensive report by a four-member delegation representing The American Meteorological Society, China continues to make good progress in this field, although it is undoubtedly constrained by a lack of computer capability. The delegation concluded that the:

> operational weather prediction in China is capable of meeting the needs of the People's Republic of China in most respects. Synoptic and climatological weather observations of good quality are being gathered from a dense network of stations. Satellite pictures are being received and utilized regularly at a number of locations. . . . Weather radars are in use, though to a lesser degree than in some of the more developed nations. The state of the art in numerical prediction is behind that in many nations, but the capability of many operational predictions has been demonstrated.[26]

Like so many scientists in other fields, the meteorologists also had the feeling that the very important research and development in weather prediction is less than adequate.

The CSCPRC sponsored American seismological delegation also had a very productive visit in late 1974, as evidenced by their report on earthquake research in China.[27] The seismologists fully appreciate the role that has been assigned to science and scientists in transforming the Chinese society and the effect of the shifting priorities of China's leadership on future developments. The delegates believe that due to China's relatively strong background in basic geological research and apparent commitment from high authority, "the effort over the last 5 years has built a steady growing momentum." Many of the problems in seismology, however, are similar to those in other scien-

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[24] Jesse C. H. Hwa, an interview, *in Chemtech*, February 1973, p. 83.
[25] Herman Mark, "Notes on a Visit to China," *Chemtech*, February 1973, p. 85.
[26] William Kellog, et al., "Visit to the People's Republic of China: a report from the AMS delegation," *Bulletin of American Meteorological Society*, Vol. 85, November 1974, p. 1309.
[27] Report of the American Seismology Delegation, "Earthquake Research in China," *EOS* (Transactions of the American Geophysical Union), Vol. 56, November 1975.

tific fields and have to do with such factors as quality control, incentives and training. The group concluded that in many ways the hesitancy of the earthquake program:

> is a mirror of the uncertainty about most aspects of Chinese society today. Many would like to see the program move to raise standards of achievement, to increase the level of training, to strengthen the discipline of leadership at the national level. But many others seem unconcerned that the time has come, and words, "groping" and "experimentation" came often to the lips of our hosts, as though to say the final decisions are yet to be made. Whether the Chinese will be the first to predict earthquake on a large scale successfully may hinge directly on the outcome of this discussion.

Actually, since the visit of the seismological delegation, China's record has been mixed. Her scientists successfully predicted the Liaoning earthquake in February 1975 and perhaps several earthquakes in Yunnan in the summer of 1976; they did not anticipate the disastrous earthquake that hit the Tangshan-Fengnan area (affecting Tientsin and Peking) at the end of July 1976. Not surprisingly, however, the interest in China's seismological research continues.

Because of China's obvious interest in Western computer technology, there have been quite a few computer science groups visiting the country. Although China's rapid development in this area makes it likely that some of the statements made two or three years ago—especially in relation to specific equipment—may not necessarily hold now, the general conclusion of one distinguished group of scientists is just as true today as it was in 1972:

> While China is clearly not the equal of the United States in computing . . . the Chinese have demonstrated the ability to reach very high levels of technology in very short time. The state of technical and scientific knowledge is expanding rapidly. Much will depend on present and future national priorities in China and on the broadening base of interaction with the Western world.[28]

All visitors would also agree with the observation that the Chinese use their computers almost exclusively for scientific and engineering calculations and that they give no evidence of having invested much effort in other application areas such as information retrieval.

Bohdan O. Szuprowicz, who has been following China's computer developments closely since his trip in 1972 and who is involved in studying China's market for high technology, believes that "China is adopting a catching up strategy similar to the Japanese, and will copy advanced products for the next 10 to 15 years until electronics industries are only 2 or 3 years behind those of the United States." He agrees with the Cheatham group that:

> The people who design and operate Chinese computers scrupulously read most of the western technical and trade

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[28] Thomas E. Cheatham, et. al., "Computing in China: A Travel Report," *Science*, Vol. 182, No. 4108, October 12, 1973.

> publications. Thus they are extremely up to date on recent developments in the world computer industry and are familiar with numerous advanced application areas.[29]

He does comment, however, as do some of the other computer scientists, that "China's computer technology appears to be weakest in the area of peripheral and input-output devices."

Obviously missing from all the visitors' reports are references to the highly sensitive area of space and nuclear science, except, in a few instances, to express the common assumption that some of China's top scientists and most advanced research is being conducted in these priority fields. The assumption is reasonable. In September 1976 China carried out her 18th nuclear test since October 1964. In December 1975 she launched her fifth earth satellite since April 1970, giving rise to speculation that manned space flight may be a distinct possibility for China in the not too distant future. The Chinese naturally say very little about any of these activities, but it is no secret that all this work is done under military control and that although satellites have important political significance and great scientific potential, it is their military value that provided the necessary priority for development. It is not surprising that the New China News Agency inevitably reports that satellites are launched in support of "preparedness against war," because the same rockets that send them into space also launch intermediate range and intercontinental ballistic missiles, and because it is widely assumed that although at present China may not yet have electronic and photographic systems for sophisticated reconnaissance, this is the ultimate goal she has in mind.[30]

Probably most of the research and development activities related to nuclear weapons and rockets (missiles) is done under the direction and coordination of the National Defense Science and Technology Commission under the Ministry of National Defense. Some of China's best scientists must indeed be involved in this sophisticated research and development, such as American-trained Dr. Tsien Hsueh-shen, who is given much of the credit for China's successes in space. The priority nature of the work also suggests that the Commission can probably go outside its own institutions and defense-industrial ministries to draft special talent and capabilities wherever they may be. Certainly institutes of the Chinese Academy of Sciences must support a variety of defense projects. As a matter of fact, there has been conjecture that in order to shield priority military/space programs from the turmoil of the Cultural Revolution, many top scientists from the Academy of Sciences, as well as certain "civilian" research and industrial facilities, were placed under temporary military control, thus explaining, perhaps, the apparent spurt in China's nuclear/space technology during the late 1960's.

One of the few visitors to comment directly on China's space program was Fan Chang-yun, professor of space science and astronomy at the University of Arizona. After a visit to China he reported that

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[29] Bohdan O. Szuprowicz, "Computers in Mao's China," *New Scientist,* March 15, 1973, p. 599.

[30] *Aviation Week & Space Technology* (October 20, 1975, p. 9), for example, reported that a modified version of the 3,500-mile range Chinese CSS–X3 ICBM was used on July 26, 1975 to launch China's third satellite, believed to be on an Earth photography mission.

within 5 to 10 years China will make rapid advances in its space program and will rank among the world's more advanced nations.[31]

As one moves away from science into industrial technology, which is more visible and more accessible, there is greater likelihood that the outsider's observations will be based on more solid foundations. One general view of China's technology is provided by James Hillier, Executive Vice President of Research and Engineering at the RCA Corporation. He believes that "the PRC is behind the U.S. in every technology" with which he has had any contact. The most advanced work he saw was in the Semiconductor Research Institute which he judged to be 5 years behind, while "production technologies for mechanical equipment seemed to be lagging by as much as thirty years." Furthermore, he did not see any original research, but rather a duplication of known accomplishments of western research.[32] Also, it would appear, that David Scott's comment that China's automotive industry "could benefit from a high-powered team of American consulting production engineers" [33] is applicable to most of China's industries.

These may well be reasonable evaluations, but it should be remembered that China's technology is "walking on two legs" and that there is great diversity in the level of modernization, not only among various industrial sectors, but also regionally, within the same sector.

SOME CONCLUSIONS

It is impossible to measure the degree of enthusiasm or misgiving, expressed in the above samples or in the broader literature reviewed for this report, about the state of science in China today, but there is enough of both. The contradictions in some of the conclusions usually reflect the uneven progress within the various fields of science, the professional perspective of the observer and even the "ideology" (if we may borrow a term from the Chinese) of the reporting scientist. But despite the absence of unanimity, there are a few generalizations that can be suggested with relative confidence. To a greater or lesser degree almost everyone is impressed with the scientific advances that China has made in the past quarter of a century, and there is a feeling among many American scientists that, given the priorities and funds, the Western- and Soviet-trained Chinese still have the necessary knowledge and talent to successfully compete and perform in many branches of advanced science. It is policies dictated by political considerations that tend to limit this type of work. The most frequent reservations pertain to the virtual absence of basic research and to the educational system which, as it is presently constituted, does not seem to be capable of educating scientists of world stature. Both reservations are more pertinent to China's future than to her present and raise questions about her ability to continue the past rate of scientific progress.

Finally, a few risky generalizations of my own—not about China's science, but about the observers of China's science. We all pride ourselves on our objectivity, but once we move from the precision of mathematics or pure science into the softer realm of social observations

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[31] *Aerospace Daily,* October 29, 1975, p. 317.
[32] James Hilier, Electronics Industries Association, Unpublished Trip Report.
[33] David Scott, "China Opens Doors for Rare View of Automotive Production," *Automotive Engineering,* August 1974, p. 30.

our objectivity becomes more personal than universal. Thus, the broader the scientist's outlook, the more interest he has outside his specific discipline, and the more understanding he has of the social experiment that is being conducted in China—the more likely he is to reflect a favorable image, not only of China, but of her science and technology. And there is another related observation pertaining to scientists of Chinese extraction. Whether because of the better basis they have for judging changes in China, or because language does not represent a handicap in communicating and learning, or because of their understandable ethnic pride in China's accomplishments (and completely irrespective of their political sympathies), or, perhaps, even because of possible concern for the welfare of their relatives who are still in China, Chinese Americans tend to give China's science and technology a better mark then do other American scientists.

Scientific Exchanges

CONSTRAINTS

It is no secret that the typical (emphasizing the "typical") 3- to 4- week tour of China is pleasant and even informative, but yet quite superficial. There have been some American scholars who have had an opportunity to visit China more than once and spend longer periods of time in the country; this is particularly true of scientists of Chinese origin, a few of whom have been permitted by Peking to stay for several months and even collaborate on research with their Chinese colleagues. It is important, however, to appreciate some of the constraints with which the typical scientific delegation has to cope. About a month is spent in visiting Canton, Peking, Shanghai, and perhaps three or four other cities usually selected from among Hangchow, Sian, Wuhan, Shenyang, Nanking and Tientsin, and supplemented by visits to two or three rural communes outside these cities. Much time is taken up by sightseeing (Great Wall, museums, parks, etc.), by viewing performances and hearing recitals (from kindergarten skits to revolutionary ballets), and by listening to briefings about various aspects of life in China and especially about the changes that have taken place since the Cultural Revolution. These experiences are by no means a waste of time, for in China, more so than in any other country, before one can understand and judge the developments in any field, it is necessary to understand the changes that have taken place in the society as a whole. The Chinese do everything possible to provide the visitor with an awareness of the new society, but it does take time.

Beyond these tourist aspects of the trip, opportunities are provided to visit scientific and educational institutions, factories and other facilities of special interest to the visitors. Scientists meet the best known and the most influential individuals in each field, are briefed by them. and quite frequently manage to have informal chats about subjects of mutual interest. When they want to, the Chinese can be gracious hosts and virtually everyone leaves with a "good feeling" about China and the Chinese people.

But what does one learn about China's science? Visitors hear about current policies and the philosophy of Chinese science, with much emphasis on science for the masses, the role of innovation and applied research, the importance of self-reliance, "open door research" and the value of correct political thinking, the new prerequisites for entrance into the institutions of higher education and so forth. It is extremely difficult to obtain detailed responses to questions concerning administration of science, research priorities, how responsibility is designated and shared by the Chinese Academy of Sciences, the factory and the university, scientific activities below the national level and, most important, about the state of the arts in the various sciences.

Nevertheless, there is no doubt that our scientists return with a certain appreciation of "where China is" in their own fields of specialization and in terms of world development. Survey visits do provide information that cannot be obtained in other ways. At the same time it is probably fair to say that because of the limited time, overscheduling, the inability to communicate without an interpreter, and restricted mobility, most visitors are professionally frustrated. There are, of course, exceptions. The American scientists of Chinese extraction, for example, able to spend longer periods of time in China and to communicate with their colleagues without the language handicap, obviously have been in the best position to gain special insights into China's science. Delegations with a more specialized focus (e.g., meteorology, seismology, herbal pharmacology, plant studies), especially in fields where the Chinese have made original advances, seem to return with more useful information, as evidenced by the CSCPRC-sponsored groups. Engineers with more applied interests in areas in which the Chinese are seeking information and assistance often get a more in-depth view of some segment of China's industry and science. Finally, a few individual scientists, because of their specialty, their sympathy or their tenacity, have managed to dip below the surface of China's science and technology. Quite understandably, however, even they are constrained by what the Chinese are willing to show and tell.

Early in 1975, the CSCPRC conducted a survey of scientists and other professionals interested in furthering scholarly communications with China, asking them to react to the ongoing exchanges and to make suggestions as to the direction the exchanges should take in the future. Several major areas of concern emerged—concern that pretty much coincides with both written and oral comments made by most visitors participating in scholarly exchanges.

The first concern is with the duration of the China visits. Although many who have not visited China and whose fields have not been significantly represented in exchanges are willing to accept short-term survey visits, the majority of those who have visited the People's Republic feel that we have now passed the get-acquainted period and that in the future scholarly communication must place greater emphasis on more substantive exchanges. There should be an effort to arrange seminars, conferences, work-shops and other more thorough discussion with the Chinese.

Many scientists feel that there has been and, if changes are not made, will continue to be an imbalance in the interests served by academic exchanges—that there is not enough reciprocity and that thus far exchanges have been more beneficial to the Chinese than to the Americans. This view is particularly prevalent among engineers and scientists involved in applied fields of high technology, who believe that given China's technological level, there is very little practical knowledge that can be gained through scholarly exchanges with China and that all the know-how moves in one direction—toward China. Conversely, there are some groups of scientists who believe that there is indeed something to be learned from the Chinese. In this category are individuals whose interests coincide with current Chinese priorities: there are many medical scientists, some agricultural scien-

tists, as well as other specialists who tend to look at China from a somewhat broader perspective—not just in terms of America's interests, but also as a social experiment and a possible "model" for some developing countries. Neither group, however, questions the principle that exchanges must be of mutual value.

Yet another disappointment with scholarly exchanges relates to the obvious inability or unwillingness of the Chinese scientists and scientific institutions to maintain a continuity in the relationships with their American colleagues. There is a reasonable expectation among our scientists that once an acquaintance has been established, this professional relationship must be fostered through correspondence and the exchange of scientific publications and materials. Despite inevitable exceptions, in general this has not been the case. Letters by American scientists to their Chinese colleagues are only seldom answered and, if they are, in most instances the replies are cursory and limited in substance. There is no doubt that the Chinese leadership continues to be suspicious of person-to-person contacts between their nationals and foreigners, so that continuity of relationships between scientists will have to wait for some change in China's political climate.

By way of consolation or further aggravation—depending on one's perspective—it may be worth noting that after some 19 years of maintaining Academy-to-Academy scientific exchanges with the Soviet Union and five years of government-to-government cooperation as a result of the signing of the U.S.-Soviet Agreement in Scientific and Technical Cooperation, many of the questions that are now being asked in the United States about this relationship are almost identical to those being asked with regard to exchanges with China. For example, is most of the cooperation in areas where the United States has a superior capability; what tangible, visible results have been obtained through these activities; if the United States has a superior capability in most of the areas of cooperation, is the net result inevitably to be one where the gains to Soviet research result in losses to the United States; can the United States be assured of balance in the research agreements, and so forth. The great difference in the nature of the exchanges and the considerations that are involved in dealing with the Soviet Union and China only seem to make the similarities in the questions more striking.[34]

PROSPECTS

Predicting China's behavior is akin to fortune telling, but a few guesses about exchanges will be ventured.

"Symbolic" is the word that surfaces most frequently in connection with U.S.–P.R.C. scholarly exchanges—they symbolize the desire of both countries to initiate and pursue contacts. In his speech to the U.N. General Assembly on September 22, 1975, Secretary of State Kissinger stated that "There is no relationship to which the United States assigns greater significance than its new ties with the People's Republic of China." Since exchanges which evolved from political considerations now represent the national policy of both China and the

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[34] U.S. House of Representatives, Committee on Science and Astronautics, Subcommittee on Domestic and International Scientific Planning and Analysis, "Background Materials on U.S.-U.S.S.R. Cooperative Agreements in Science and Technology," Washington, November 1975.

United States, in a symbolic sense, a reciprocal visit of basketball teams is just as important as an exchange of scientific delegations. This does not mean that efforts to move from symbol to substance in scientific exchanges do not represent worthwhile goals. The problem, however, is that while American scientists are able and anxious to expand their contacts with China beyond the token stage, it would be premature to extrapolate China's demonstrated interests into a reciprocal and concrete relationship. China's true intentions—at least as evidenced by her temperament in negotiations—are still vague and perplexing. It is also ill-advised to subscribe to the widespread belief that scholarly exchanges will take a "leap forward" if a solution is found to the Taiwan issue and the People's Republic is officially recognized by the United States. Indeed, politics is preeminent in China and the absence of recognition is an important stumbling block to the normalization of a variety of relations, but recognition will not necessarily improve the qualitative aspects of scholarly exchanges, as evidenced by China's contacts with nations which have accorded recognition.

The primary reason why China will continue to be cautious in pursuing scholarly exchanges is, I think, related to a combination of national pride and insecurity which, in a sense, tend to reinforce each other. Despite China's impressive accomplishments and the general display of bravado in much of her publications—especially those directed at foreign audiences—the Chinese are quite insecure in their relations with scientists from technologically advanced nations. Perhaps, as a compensation, they exhibit intense national pride and great sensitivity to criticism. They will inevitably ask for "criticisms and suggestions," but if at all possible, will usually avoid showing the visitor areas of weakness—where criticism and suggestions would potentially be most valuable. Unfortunately, the Chinese do not seem to recognize the fact that the overwhelming majority of foreign visitors are understanding of past obstacles that China has had to overcome, and very sensitive and sympathetic to the problems that remain. Under these circumstances, the difficulty in finding scientific and technical subjects agreeable to the Chinese, greatly limits the type and number of delegations the Chinese will accept.

Priorities in industry and technology force China to accept foreign engineers and technicians employed by American Corporations for prolonged stays (e.g., Boeing, M. W. Kellog, RCA Global Communications), but inevitably they live in some type of restricted residence or compound, where they are isolated from the people except during working hours. Such conditions would be extremely difficult to impose on individual foreign scientists, who would, furthermore, require the services of a full-time interpreter—another serious impediment to collaboration.[35] Foreigners are still suspect to China and although there are a few exceptions, it is unlikely that China will be willing to expose her scientific establishment and her societal "innards" to American academicians while they conduct prolonged research and

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[35] It is also possible to conjecture—and this may seem to be a contradiction—that the knowledge of the Chinese language might well be a hinderance rather than an asset. True, there are many other reasons why the Chinese are extremely reluctant to permit scholars interested in the economic, social, political and cultural aspects of Chinese society to participate in exchanges, but perhaps one reason may be that social scientists specializing in China are much more likely to know Chinese and communicate directly with the people they meet.

field work in close contact with China's own scientists. It is therefore my opinion that when it comes to Chinese science, Americans, just as other foreigners, will continue to "view flowers from horseback" for some time to come. This does not mean that efforts should not continue to further develop exchanges in science and technology; they may, yet, be more symbolic than substantive, but they represent an important link to any future improvement in relations between China and the United States.

In the meantime, if the interest in the need to stay abreast of China's scientific developments can be taken as a given, while prospects for meaningful scientific exchanges are relatively dim, we must, seek alternatives. Perhaps, while we await some breakthroughs in collaborative scientific research with China, an effort could be made to establish closer collaborative research between American scientists and American specialists working on contemporary China. In other words, rather than pursuing the either/or approach described above—an almost complete dependence on publications before 1972 and reliance on visitor reports since then—we must strive for an integrated, planned collaborative effort. Full use must be made of the great volume of information now available in Chinese scientific publications, as well as of the experience of our China specialists in interpreting policies and developments and in the important art of reading between the lines. But to be of value, this must be done in close collaboration with scientists who would be willing and able to contribute beyond their post-China-visit report. It should be possible to involve some American scientists in a long-term team effort to study Chinese science, and to support financially their labor and the labor of a few China specialists in an integrated analysis of China's scientific publications and science policies. If this were done, even the standard four-week visit to China by scientists intimately familiar with Chinese data, would become a much more meaningful and useful experience.

As usual, however, the "what" of a problem is much easier to address than the "how," and the "how" exceeds the scope of this report.

APPENDIX A

Research Institutes in China

Appendix A

RESEARCH INSTITUTE OF THE CHINESE ACADEMY OF SCIENCES

Applied Chemistry Institute of Kirin, Changchun*
Archaeology Institute, Peking
Astronomical Observatory, Peking
Astronomical Observatory, Shanghai*
Astronomical Observatory, Purple Mountain, Nanking*
Atmospheric Physics Institute, Peking
Atomic Energy Institute, Peking*
Automation Energy Institute, Peking*
Biochemistry Institute, Peking*
Biophysics Institute, Peking
Botany Institute, Peking*
Botany Institute of Kwangtung, Canton*
Chemical Engineering and Metallurgy Institute, Peking*
Chemical Physics Institute, Lanchow*
Chemical Physics Institute, Luta*
Chemistry Institute, Peking*
Chemistry Institute, Tsinan*
Chemistry Institute South Central, Canton*
Computer Technology Institute, Shanghai*
Computer Technology Institute, Shenyang
Economics Institute, Peking
Electrical Engineering Institute, Peking*
Electron Optics Institute, Shanghai*
Engineering Mechanics Institute, Harbin*
Entomology Institute of Kwangtung, Canton*
Entomology Institute, Shanghai*
Environmental Chemistry Institute, Peking
Experimental Biology Institute, Shanghai*
Genetics Institute, Peking
Geochemistry Institute, Kweiyang*
Geography Institute, Peking
Geology Institute, Peking
Geology Paleontology Institute, Nanking*
Geophysics Institute, Peking
Glaciology, Permafrost and Deserts Institute, Lanchow*
High Energy Physics Institute, Peking
History Institute No. 1 (Ancient History), Peking
History Institute No. 3 (Modern History), Peking
Hydrobiology Institute, Wuhan*
Linguistics and Philology Institute, Peking
Literature Institute, Peking
Materia Medica Institute, Shanghai*

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*Known or presumed to be dually subordinate to the Chinese Adacemy of Sciences and to municipal or provincial units defined only as local authorities.

Mathematics Institute, Peking
Mechanics Institute, Peking*
Metallurgy Institute, Shanghai*
Metrology Institute, Peking
Nuclear Physics Institute, Shanghai*
Oceanography of the South Seas Institute, Canton*
Oceanography Institute, Tsingtao*
Optics and Precision Instruments Institute, Changchun*
Optics and Precision Instruments Institute, Shanghai*
Organic Chemistry Institute, Shanghai*
Pedology Institute, Nanking*
Physics Institute, Peking
Physiology Institute, Shanghai*
Plant Physiology Institute, Shanghai*
Plateau Atmospheric Physics Institute, Lanchow*
Physiology Institute, Peking
Radio Engineering and Electronics Institute, Peking
Rock Soil Mechanics Institute, Wuhan*
Saline Lakes Research Institute, Sining*
Scientific and Technical Information Institute, Peking
Semiconductors Institute, Peking
Silicate Chemistry Technology Institute, Shanghai*
Structure of Matter Institute of Fukien, Foochow*
Technical Physics Institute, Shanghai*
Vertebrate Paleontology and Paleo-Anthropology Institute, Peking
Zoology Institute, Peking*

RESEARCH INSTITUTES OF THE CHINESE ACADEMY OF AGRICULTURE AND FORESTRY SCIENCES

Agriculture Institute, Peking
Atomic Energy Utilization in Agriculture Research Institute, Peking
Bee Institute of Kiangsi, Nanchang
Citrus Fruit Research Institute, Chungking
Cotton Institute, Peking
Crop Breeding and Cultivation Institute, Peking
Olericulture Institute, Tientsin
Plant Protection Institute, Peking
Sericulture Institute of Kiangsu, Chenchiang
Soil Fertilizer Institute, Techow
Tea Institute, Hangchow
Tobacco Institute, Tsinan

RESEARCH INSTITUTE OF THE ACADEMY OF MEDICAL SCIENCES

Antibiotics Institute, Peking
Cardiovascular Diseases Institute, Peking
Dermatology Venerology Institute, Peking
Epidemiology Institute, Peking
Experimental Medicine Institute, Peking
Hermatology Institute, Tientsin

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*Known or presumed to be dually subordinate to the Chinese Academy of Sciences and to municipal or provincial units defined only as local authorities.

Hypertension Institute, Shanghai
Materia Medica Institute, Peking
Oncology Research Institute, Peking
Parasitology Institute, Shanghai
Traumatology Institute, Shanghai
Tuberculosis Research Institute, Peking

RESEARCH INSTITUTES OF THE ACADEMY OF CHINESE TRADITIONAL MEDICINE

Acupuncture and Moxibustion Institute, Peking
Chinese Medicine Research Institute, Peking

Source: *Current Scene,* June 1976, Vol. XIV, No. 6, pp. 17–21. Some analysts, however, question the functional existence of all the institutes in the above list. For example, during his visit to the United States in the summer of 1975, Chou Pei-yuan, Vice Chairman of the Scientific and Technical Association of the PRC, reported that there were only 36 institutes under the Chinese Academy of Sciences, 17 under its direct jurisdiction of Academia Sinica and the province of municipality.

APPENDIX B

Exchange Programs of the Committee on Scholarly Communication With the People's Republic of China

Appendix B

EXCHANGE PROGRAMS OF THE COMMITTEE ON SCHOLARLY COMMUNICATION WITH THE PEOPLE'S REPUBLIC OF CHINA

CHINESE DELEGATIONS TO THE UNITED STATES

1972

Medicine	October.
Science (interdisciplinary)	November.

1973

Hydrotechnology	April.
High Energy Physics	May.
Insect Hormone	June.
Librarians	September.
Computer Science	October.
Biomedical Engineering and Physiology of Pain	November.
Language Teaching	November.

1974

Seismology	April.
Laser Research	June.
Agriculture	August.
Pharmacology	November.
Plant Photosynthesis	November.

1975

Solid State Physics	March.
Molecular Biology	May.
Communications Techniques	June.
Petrochemical Industry	August.
Scientific and Technical Association	September.
Industrial Automation	November.

1976

Earthquake Engineering	April.
Tumor Immunology	May.
Agricultural Mechanization	September.
Environmental Sciences	September.
Astronomy	November.

AMERICAN DELEGATIONS TO THE PRC

1972

Computer Science	July.
Medicine	October.

1973

CSCPRC (interdisciplinary)	May.
Medicine (interdisciplinary)	June.
Physicists	July.
Art and Archeology	November.
Early Childhood Education	November.

1974

Acupuncture Anesthesia	May.
Herbal Pharmacology	June.
Plant Studies	August.
Seismology	October.
Linguistics	October.

1975

Schistosomiasis	April.
Paleoanthropology	May.
Rural Small Scale Industry	June.
Insect Control	August.
Solid State Physics	September.

1976

Pure and Applied Mathematics	May.
Wheat	May.
Liaoning Earthquake Prediction	June.
Steroid Chemistry and Biochemistry	October.

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