THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN CHINA: 1949-65

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INTRODUCTION

TECHNOLOGICAL DEVELOPMENT in China today has undergone a major transformation due largely to the impact of the Great Cultural Revolution.

Until recently, scientific and technical development was entrusted to the elaborate research establishment of the Academy of Sciences whose organized teams of scientists spurred the growth of research in key fields having a direct bearing on the economy and the national defense.

This particular approach to research was modelled along Soviet lines. During the Cultural Revolution, this line of development became associated with the Liu Shao-ch'i faction, and, suffering the fate of Liu and his followers, was severely condemned and discredited.

During the Great Leap Forward in 1958, a triple alliance was forged between workers, scientists, and administrators brought together to speed production in factories. After the Cultural Revolution, technological development took place within the context of this new alliance which replaced China's former dependence on specialized research institutions. Workers, scientists, and administrators, working together, made a concerted effort to develop an independent technology adapted to the specific conditions and particular technical and economic needs of China. This self-reliant approach affords a sharp contrast to past practices of importing the latest technological advances and expertise from other countries.

This paper was written in September 1966, before the conflict between the old and new approaches, identified respectively with the Liu Shao-ch'i and Mao Tse-tung factions, had become apparent.[1] My treatment of the growth of research and development in the People's Republic of China is based on the role played in that development by the Chinese Academy of Sciences. No mention is made, therefore, of the impact the new alliance has had on scientific and technological progress since the Cultural Revolution. However, I feel that the role of the Academy of Sciences in organizing and advancing research cannot be ignored

[1] I have discussed the worker-scientist-administrator alliance in another article entitled "Rōdō gijutsu ningen" [Labor, technology, human being], in *Kōza Chūgoku*, Vol. 4 (Tokyo: Chikuma shobō, 1967). The two conflicting approaches to the development of science and technology are analyzed in a later article, "Kōgyōka to kakumei" [Industrialization and revolution], *Tembō*, October 1968.

when attempting to assess the future development of science. The way in which the Academy has been incorporated into the new approach is equally important in understanding the future course of technology in that country. I have therefore left this paper in its original format in the hopes that it will offer the reader a perspective on the present state of scientific and technological research in China.[2]

I. PROBLEMS AND PROSPECTS OF THE CHINESE INTELLIGENTSIA IN 1956

Nineteen fifty-six was a year of unprecedented growth for science and technology in China. It was during this epoch-making year that an event of far-reaching importance for China's scientific establishment took place; the role of the intelligentsia[3] in constructing a new China was seriously discussed at a special conference sponsored by the Central Committee of the Chinese Communist Party (CCP). The party's motives for taking up this issue at this particular time are indicated in Chou En-lai's report on the growing importance of scientists and technicians in China and the special problems they posed:

> We are building up a Socialist economy, in a word, in order to satisfy to the maximum extent the constantly growing needs, material and cultural, of the whole society. To achieve this end, we must continually develop our social productive power, continually raise labor productivity, and continually register improvement on the foundation of high technique and in accordance with the continual increase of social production. For this reason, in this age of Socialism as compared with any previous age, there is the greater need for the fullest elevation of production technique, the greater need for the fullest development of science and utilization of scientific knowledge. . . . The different forms of construction we are now engaged in need the participation of intellectuals in ever growing numbers. [10, p. 129]

Chou En-lai's report deals primarily with problems arising in the natural sciences and the field of technology. Two basic issues are discussed at length in the report. The first issue concerns various problems stemming from the special nature of the intelligentsia itself:

> The fundamental question now is that the forces of our intelligentsia are insufficient in number, professional skills and political consciousness to meet the requirements of our rapid Socialist construction. Certain unreasonable features in our present employment and treatment of intellectuals and, in particular, certain sectarian attitudes among some of our comrades towards intellectuals outside the Party, have to some extent handicapped us in bringing the existing powers of the intelligentsia into full play. [10, p. 129]

The second issue Chou En-lai took up was the current state of science and technology in China, the specialized fields dominated by the intelligentsia.

> But as a whole, the state of China's science and technique is still very backward. We are still unable to acquire and put into use very many of the latest scientific achieve-

[2] This introduction was written in March 1969.
[3] Here, the term intelligentsia refers primarily to natural scientists and technical specialists.

ments of the world. We are also still unable to solve independently of the Soviet experts, many of the complex technical questions now arising in our work of construction. Yet till recently, we have failed to draw up comprehensive plans for raising our scientific and technical levels. We have even failed to make the fullest and most effective use of our existing forces. Our backwardness in technical science is inseparable from our weak foundations in scientific theory. It is precisely in scientific research that our strength is the less. [10, p. 132]

Chou En-lai later proposed a number of solutions to these problems. The description he has provided us with, however, speaks dramatically of the backward conditions China faced as it set about in earnest to develop a full-scale scientific technology backed by research. The subsequent growth of the sciences and technology followed the basic policy outlined by Chou's report. Before examining these developments in detail, however, I would first like to discuss some of the problems that surfaced in Chou En-lai's report and clarify the situation that existed at that time.

There were approximately a hundred thousand top-level intellectuals engaged in scientific research or involved in education, industrial technology, health, and cultural and artistic activities in 1956. Table I shows the occupational structure

TABLE I

OCCUPATIONAL DISTRIBUTION OF TOP-LEVEL INTELLECTUALS

Top-level Intellectuals	Approximate Number
Educators above the level of lecturer	31,000
Health officials, doctors and above (including traditional practitioners)	25,000
Researchers above the level of research assistant	3,000
Industrial technicians above the level of instructor	31,000
Intellectuals engaged in cultural and artistic activities	6,000
Other specialists	5,000
Total	101,000

Source: Kuo Mo-jo [26, p. 209].

for top-level intellectuals. Included in this category are specialists with creative skills in a particular field. For example, while university graduates are intellectuals by definition, only those capable of doing advanced research or teaching are considered top-level. Approximately 35 per cent of the specialists shown in Table I were budding intellectuals picked from 217,900 university graduates for further training during the six years that followed the 1949 Revolution.

The word intelligentsia as used in China denotes a much wider class of people than it normally does in Japan or the West. This is not surprising when one considers the generally low educational standards in China and the high rate of illiteracy which in March 1956 stood at 78 per cent. The intelligentsia may be divided into specialist or elite intellectuals and rank-and-file intellectuals. The latter number about 3,840,000. The number of rank-and-file intellectuals with university educations is exceptionally small.

Modern higher education in China began during the twenty-year period following the Northern Expedition. By 1949, 185,000 students had graduated from universities [12, p. 393]. These graduates together with students educated abroad during the same period form the nucleus of Chinese scientists today and became the primary group of specialists engaged in scientific and technical research after the Revolution.

Next let us turn our attention to university teachers and technicians. Table II

TABLE II
BREAKDOWN OF UNIVERSITY TEACHERS AND TECHNICIANS

University Teachers	(%)	Total	Technicians	(%)	Total
Professors and assistant professors	17.8	7,499	Engineers	32.8	31,000
Lecturers	24.0	10,095	Technicians (university graduates)	67.2	63,600
Assistants	58.2	24,472			
Total	100.0	42,066	Total	100.0	94,600

Sources: [10]. See also [26].

shows the breakdown for each category of teacher and technician. The large gap between teachers above the level of lecturer in Table II and educators above the same level in Table I should be noted. Based on Chou En-lai's statement that "some of the assistants have already taken up teaching work" [10, p. 131], we may assume that these assistants are top-level intellectuals. This brings the total number of assistants responsible for lectures to about 13,500.

> Excluding those over fifty years of age, the teachers at universities today consist mainly of lecturers and instructors in their twenties. There are extremely few professors between the ages of thirty and fifty. (Quoted from the June 1957 pronouncement by T'ao Mêng-ho) [20, p. 153]

In 1955, there were 194 institutions of higher learning in China including 14 universities, 42 technical schools, and 40 teachers' colleges.[4] This would place the average number of professors and assistant professors per institution at thirty-eight. Out of a population of 650 million people, then, this meant there were fewer than 1.5 technicians with education beyond the undergraduate level for every ten thousand inhabitants.

The Chinese Academy of Sciences stands at the center of all scientific and technical research in China. At the end of 1955, there were forty-one research institutes attached to the Academy employing a total of 2,483 researchers. Table III shows the breakdown of research specialists for the years 1952, 1955, and 1957. Research specialists, researchers, associate researchers, and assistants correspond generally to university professors, assistant professors, lecturers, and assistants in terms of skill and position within the institutional hierarchy. In 1955, each research institute was assigned an average of ten technicians above the level of associate researcher. During the same year, the departments of mathematics, physics, and chemistry; geology and biology; technical sciences; and social

[4] [17, 1957, p. 585]. A summary of these schools is found in the 1955 edition.

TABLE III
RESEARCH STAFF OF THE ACADEMY OF SCIENCES

Academy of Sciences and Research Staff	1952	1955	1957
Research institutes directly affiliated with the Academy	31	41	68
Total research personnel	1,292	2,483	5,506
Specialists and technicians	317	428	746
Research assistants	314	421	755
Research trainees	661	1,634	4,005

Sources: [17, 1956] [28].

science and philosophy were created in the Academy. A total of 233 scientists and other technical specialists were assigned as committee members to the new departments, 172 from the natural and technical sciences and 61 from the humanities and social sciences. These figures reflect more or less accurately the ratio of specialists holding positions in research institutes and universities in both areas.

These statistics point to a critical shortage of top-level scientists and specialists. Training specialists is a time-consuming process, however much time is devoted to this purpose, and only a limited number of trained specialists can be turned out during any given period, even under the best of conditions. As Table III indicates, the Academy of Sciences was augmented by the addition of 111 top-level research and technical personnel between 1952 and 1955 to help overcome this shortage of trained specialists. Ten new research institutes were also established at this time, however, and there was no absolute change in the average number of research personnel allotted to each faculty. Little had changed by 1957, and the average research staff still numbered less than eleven. In education, for example, progress in recruiting adequate numbers of trained teachers was made only within the framework of the long-range ten- and twenty-year plans. The most pressing problems inhibiting the development of science and technology, then, were actually problems relating to the intelligentsia; the most urgent need was a policy that would enable China to utilize its meager human resources to best advantage.

During this early period, there were a few intellectuals lost or changed their jobs, and a few teachers were not lecturing full-time in a university. In 1952, academic departments and curricula that had originally been modelled after the American pattern of higher education were reorganized along Soviet lines. At this time, the departments of the humanities and the social sciences, including sociology, political science, law, and foreign literature, were either greatly reduced in scope or abolished altogether. Approximately four thousand scholars in these disciplines lost their lectureships and were forced to take up other kinds of work [20, p. 154].

The natural and technical sciences were virtually unaffected by this reorientation and the ensuing changes in the nation's academic structure. However, even here, a man was not always placed in the most suitable position. Although a great deal of attention was ostensibly given to training capable researchers, in fact, scientists with the ability and the inclination to do advanced research were often assigned administrative positions or given responsibilities outside of their areas of competence. A survey of five light industrial units by the Fourth General Office of the State Council indicated that about 10 per cent of the scientists and other specialists working there were assigned to posts totally unrelated to their own fields. "This is a very serious loss. . . . specialists . . . [should be] placed in places where they are most needed" [10, p. 133].

Because of the demands made on them and the conditions under which they lived and worked, scientists were unable to make full use of their specialized knowledge and skills. There were too many obligatory conferences and administrative duties not related to their work. Only half of the specialists serving on faculty committees in the natural sciences could engage in full-time research activities, and even fewer specialists in the social sciences or humanities were able to spend time working in their own field. "The Central committee considers it essential to ensure that they have at least five-sixths of the working day (or 40 hours a week) available for their professional work" [10, p. 134].

By far the most irritating and serious disruptions to research were neither the excessive number of required meetings nor the extra administrative duties. Most scientists were annoyed by the feigned superiority, exclusiveness, hostility, and distrust openly displayed by party members toward specialists and their work. Party members generally lacked understanding or sympathy for research and the scientists remained a source of irritation. A closer look at the intelligentsia as a class reveals that they were, indeed, considerably different from the average party member in both background and outlook.

A detailed discussion of the social and class structure of imperial China is well beyond the scope of this paper. However, it should be pointed out that many scientists came from upper-class families and were the sons and daughters of former landholders and property owners. Table IV shows the number of undergraduates, graduates, and research students studying to become specialists under the Academy of Sciences' new training program as of September 1956 with proletarian or peasant backgrounds. Table IV also shows the ratio of students from proletarian and peasant classes among those who went to the U.S.S.R. for study

TABLE IV
CLASS BACKGROUND OF STUDENTS AND RESEARCH TRAINEES
(September 1956)

Classification of Students and Research Trainees	Proletarian or Peasant Background (%)
University:	
Undergraduates	34.29
Research trainees	17.46
Academy of Sciences:	
Research trainees	5.92
Students studying in the Soviet Union (1952–56)	30.10

Source: [25].

TABLE V

Research Trainees of Academy of Sciences	%
Landlord or capitalist class background	41.4
Non-party member Non-member Communist Youth League	37.9

Source: [25].

between 1952 and 1956. Table V shows the number of non-party research students and those from the landlord and capitalist classes in the Academy.

Research students become future scientists and technical specialists, and upon completion of four years of study, they receive the degree of Associate Doctor of the Academy of Sciences. Seven years after the 1949 Revolution, however, still less than 6 per cent of the research trainees slated to assume positions in Academy institutes were from proletarian or peasant backgrounds. The absolute number of students in 1956 is not known. However, in 1957 there were 340 students specializing in 147 major fields [17, 1958, p. 598]. Since a rapid increase in the total number of trainees over the previous year is unlikely, the number of students with proletarian or peasant backgrounds can be placed with some degree of accuracy at about twenty. These twenty students are probably the first proletarians and peasants to be trained as top-level scientists and technicians by the Academy of Sciences. If these figures are accurate, possibly 10 per cent of the scientists trained after the Revolution were of proletarian or peasant extraction; there were none before the Revolution.

According to a report by Liu Shao-ch'i delivered at the Eighth Party Congress held in September 1956, 10,730,000 people representing 1.6 per cent of China's 650 million inhabitants were party members. More than 60 per cent joined the party after the 1949 Revolution. Table VI shows the class background of party members [30, p. 197]. When one considers that 78 per cent of the population is illiterate, the 12 per cent party membership rate for intellectuals is quite high. Included in this figure are 33.5 per cent of the 3,840,000 rank-and-file intellectuals. The number of party members among top-level intellectuals is unknown, but the figure they represent is probably inconsequential. Although it is an oversimplification, one might take the view that the Chinese Communist Party struggled for thirty-five years to remove from power the very class from which many top-

TABLE VI
CLASS BACKGROUND OF PARTY MEMBERS

Class	(%)	Total
Total	100.0	10,730,000
Workers	14.0	1,492,200
Peasantry	69.0	7,403,700
Intellectuals	12.0	1,287,600
Other	5.0	536,500

Source: [30, p. 197].

level intellectuals emerged. Problems inherent in the bureaucratic structure apart, conflicting interests and outlooks between party members and scientists were aggravated considerably by differences in class background. The situation produced by the complex interplay of human factors can well be imagined.

To minimize these differences and remove the obstacles placed in the way of science and technology, party members were forced to reevaluate their attitudes toward scientists. Party members had to understand why specialists, who seemed so different, should be entitled to special treatment. A number of barriers to mutual understanding had to be torn down. Party members had to recognize that scientific research is an extravagant activity, more closely resembling play than real work. Scientists had to devour literally huge quantities of books and research data in the library where they spent much of their time, and unless they were provided with very expensive equipment and research facilities, the fruits of their labor were not readily apparent. Scientists also had to be accompanied by research assistants to accomplish their tasks. In matters relating to their professional competence, intellectuals were deferred to and wielded considerable influence; the party members had to hold back their ideas. Furthermore, scientists living in spacious quarters, required sufficient time to pursue their own interests and received high salaries. They enjoyed high status, academic titles, and received incentive pay. It was not easy for party members to readjust their attitudes toward scientists who lived so differently and cultivated such divergent interests. Chou En-lai devoted a considerable part of his report to this problem.

Nor was it particularly easy for scientists to make complementary adjustments to party members. The task of reexamining their own values and attitudes and then correcting them proved difficult. Later, during the days of the Hundred Flowers, one chemist confessed, "I never considered my own thinking wrong." About 40 per cent of the Chinese intelligentsia were politically active and supported the party and the government. Forty per cent were not politically active but still supported both party and government, and about 10 per cent were not politically reliable or were openly opposed to socialism. A few scientists were actually counterrevolutionary. Thought reform for scientists and other intellectuals grew out of this issue, and, as I have already written a great deal about this topic elsewhere, I will not take it up again here.

Next I would like to discuss present attitudes toward science and technology in China and explore the course of science's future development.

After summarizing the progress made in science and technology throughout the world during the last twenty to thirty years, Chou En-lai, noting the world's "progress which has thrown us far behind in the field of scientific development" [10, p. 139], stressed that:

> We must keep pace with this advanced scientific level of the world. We must bear in mind that while we are making headway, others are also advancing rapidly. . . . It is very hard at present to estimate accurately how long will be needed for our scientific achievements to catch up with the most advanced world levels. Yet we must chart our task now—and that is to bring our country's most vital scientific departments near to the most advanced world levels by the end of the third Five

> Year Plan so that we shall be able, by our own efforts, to achieve speedily whatever other countries may do in the way of up-to-date achievements. Having laid such a foundation, we should be able to deal more thoroughly with the question of catching up world levels. [10, p. 140]

"To fulfill this great task, we must first discard all servile thinking, which is a sign of lack of national self-confidence" [10, p. 140]. In the past, China depended on Soviet aid to save the day when China's own casual approach to the application of scientific technology led to serious difficulties. Chinese students sent to study in the Soviet Union were not scientists; most had only middle school or high school educations:

> The result would be to remain forever in a state of dependence and imitation, . . . impede the systematic, rapid development of our science. . . . [10, p. 140]

A new approach to the problem was called for:

> The other way is to make an overall plan that distinguishes between what is essential and urgent and what is not so essential and urgent and to systematically utilize the latest achievements of Soviet science so as to bring ourselves abreast of Soviet levels as quickly as possible. . . . We can thus make the most effective and reasonable use of Soviet assistance and promote the planned development of our science so that it will be possible to hasten establishing relations of mutual help between the scientific groups of our two countries. [10, p. 140]

In addition to the new spirit of cooperation with the Soviet Union, the importance of theoretical science to the growth of technology and applied science was recognized. Major efforts were made to insure the growth of the theoretical sciences.

> Without a definite amount of theoretical scientific research as the foundation, we shall not be able to register progress and transformation of a basic nature in our technique. But the growth of the forces for theoretical study must be slower than the growth of the forces of technical application, while the results of the theoretical work are generally indirect and cannot be readily recognized all at once. Precisely because of this, a tendency to short-sightedness still exists among many comrades who are not willing to employ the forces necessary for scientific research and constantly ask scientists to solve comparatively simple questions for them regarding technical application and production procedures. It is certainly unquestionable that theory must not be divorced from practice and we must fight against any theoretical study which is dissociated from practice. But the main tendency at present is the neglect of theoretical study. [10, pp. 140–41]

Six measures were proposed as "the most rapid and most effective course" of remedying this situation. First, it was proposed that outstanding scientists and university students be sent to the Soviet Union and other countries for one- and two-year advanced study programs. Upon their return they were to establish and develop scientific and technical programs in the Academy of Sciences and various governmental departments and train future scientists. Second, specialists from the Soviet Union and other countries were to come to China to help set up new research institutes and train researchers. Third, Soviet specialists already in China were not to be used as general laborers; they were to be used as teachers and advisors. Making optimum use of Soviet aid, Chinese technicians, working at factories (156 in all) set up with Soviet aid, were to be systematically reorganized to study and master new technical principles. Fourth, the best Chinese scientists and university graduates were to be used for advanced scientific research. They were to bolster the Academy of Sciences and form a corps of specialists that would instruct China's human resources in the latest scientific methods, thereby improving the standards of scientific and technical research throughout the nation. Fifth, scientists in the nation's universities, including most of the technical specialists of the Academy, were to expand the scope of their research activities and raise the educational standards in science to a respectable level. Sixth, in order to lighten somewhat the heavy duties borne by the Academy, research facilities were to be created in governmental bureaus and departments dealing with geology, industry, agriculture, water resources, transportation, national defense, and national hygiene.

The successful implementation of these measures depended in part on satisfying certain basic requirements such as insuring a complete collection of books, documents, periodicals, and other pertinent data; committing adequate funds to buy necessary books and import larger numbers of foreign periodicals and other publications; translating major foreign literary works into Chinese and expanding the scope of language training; systematically increasing student enrollment in Chinese universities; and improving the quality of training received by rank-and-file intellectuals who constitute a sort of "reserve army" of the intellectual elite.

Chou En-lai's speech on the role of the intelligentsia in the development of a modern technology and related problems was delivered on January 14, 1956 and dealt with these measures in detail. Since December 1955, however, many scientists had been working together to prepare a long-range plan for the future development of science and technology. The scientists signaled anew the shortsightedness of government and central committee officials and emphasized the importance of theoretical research. The scientific community also took an active interest in seeing the long-range plan put into effect. These measures had been repeatedly proposed by "Chinese and Soviet scientists" in the past who agreed that this "is the only correct way we should follow" [10, p. 140]. The last half of Chou En-lai's report is a testament to the influence of the scientific establishment whose recommendations created a new atmosphere of progress. It was in this spirit that Mao Tse-tung, also present at the conference, called for a "march on science" which heralded the beginning of the Hundred Flowers movement.

II. THE COLLAPSE AND REVIVAL OF SCIENTIFIC AND TECHNICAL RESEARCH

Little remained of China's former research establishments after the liberation of China in 1949 by the People's Liberation Army. More than ten years of constant warfare had thoroughly disrupted research activities in all parts of the country, and the situation inherited by the new government was far from encouraging. In November 1949, the government created the Chinese Academy of Sciences and began the long, arduous task of reconstructing its former research facilities.

Rather than merely rebuilding what had existed before the Revolution, the government founded an entirely new research institute. Before launching a discussion of research in the new China, however, a look at scientific and technical research in pre-revolutionary China may be of some help in understanding subsequent developments.

The establishment of the National Central Academy (Academia Sinica) in October 1928, inaugurated the first real research effort devoted to scientific and technical progress in China.

> In August 1929, the National Academy of Peiping was created. In September 1932, the National Institute of Translation was established in Nanking. As national research institutes were set up to facilitate expanding research activities, academic research in the cities was being actively promoted. In the mid-1930s, . . . elite groups, isolated from society and taking refuge in their ivory towers, began to appear. [34, p. 144]

Another means of assessing the extent of research activity is to look at the growth of academic societies. Among the earliest societies to be formed in China were the Medical Society established in 1914, the Geological Society formed in 1922, and the Meterological Society created in 1924. Later groups were the Pharmaceutical Society, 1928; the Paleontology Society, 1928; the Society of Plant Pathology, 1929; the Physical and Chemical societies, 1932; the Botanical and Geographical societies, 1933; and the Mathematical Society, 1936. During the 1920s, the Yellow Sea Research Institute of Chemical Industry, the Science Society's Biological Laboratory, and other private research organizations were set up with the help of funds provided by private foundations. Entering this century, the real value of modern science was first grasped and put to practical use during the period of interim stability that marked the Kuomintang rule after the May 4 movement. This development was no doubt due in part to the efforts of students returning to China from abroad with new ideas conducive to the growth of science.[5] Scientific research in China, however, did not really get under way until the Revolution of 1949.

This is no way lessens the quality or value of the research carried out in China

[5] A few examples will help illustrate the relatively backward conditions of scientific research in China during this early period. At the National Academy of Peiping and the Academia Sinica, nineteen research institutes were eventually created. These included the institutes of Physics, Radium, Chemistry, Engineering, Geology, Astronomy, Meterology, Pharmacy, the Humanities, and Social Sciences. In 1936, the annual expenses of both research bodies amounted to 4 million yuan. Specifically, US$200 in foreign currency was allotted to the Institute of Radium, National Academy of Peiping. This sum, however, was not nearly sufficient to cover the expense of books, instruments, test pharmaceuticals, testing materials, and other equipment. No more than ten personnel were assigned to a given research institute, and in some cases there were only two or three researchers per faculty. Three chemistry laboratoies were assigned forty research personnel (these were the chemistry institutes of the Academia Sinica and the National Academy of Peiping and the Institute of Pharmacy attached to the latter). The library of the Institute of Chemistry attached to the National Academy of Peiping contained little over one thousand volumes and subscribed to only thirty-four periodicals [19, 1957, Nos. 14 & 15; 1959, Nos. 17 & 19]. In general, equipment, funds, and personnel in China's main research institutions during this period were minimal.

during the early and mid-1930s. Many important discoveries were made in broad fields such as geology and biology, areas usually requiring a high degree of specialization. Furthermore, the generation of researchers and students trained during the 1930s formed the corps of specialists engaged in scientific research after the Revolution. By the time China had become embroiled in war with Japan ten years later, the small elitist groups of scientists and intellectuals formed earlier had almost completely disappeared, research activities were disbanded, and most of those engaged in research had either disappeared or fled the country. Within a period of twelve years, five thousand specialists fled to the United States and three thousand to Europe according to T'ao Mêng-ho, who was involved in the movement to repatriate Chinese intellectuals in exile abroad [20, p. 162]. Most exiles were probably top-level intellectuals and students.

One of the first tasks of the newly established Academy of Sciences was to locate China's dispersed intellectuals, scientists, and technical specialists. In 1950, the Academy's Planning Bureau compiled a directory that included 865 senior scientists. These scientists were invited to serve as specialist representatives attached to the Academy of Sciences. Approximately 20 per cent of these scientists (171) were residing in foreign countries other than Taiwan at the time and represented major fields in the basic sciences. Many of China's natural scientists were in exile. For example, fifteen out of forty-three physicists (34.88 per cent), seven out of twenty-one astronomers (30 per cent), and twenty-four out of eighty-one mathematicians (29.63 per cent) were living outside the country at the time of the Planning Bureau survey [19, May 1950]. Among the scientists who responded to the invitation to return home were Li Ssŭ-kuang (Geology), Hua Lo-kêng (Mathematics), Chao Chung-yao (Nuclear Physics), Ko T'ing-sui (Metallurgy), Ts'ao Jih-ch'ang (Psychology), and later, Ch'ien Hsüeh-sên (Physics) [19, Apr. 1951]. The return of Chao Chung-yao in 1950 was a particularly important event in China. One hundred and fourteen Chinese intellectuals returned from the United States on the same ship [19, Oct. 1951]. The total number of intellectuals and scientists who eventually returned to their homeland, however, is unknown.

As we have seen, the Chinese Academy of Sciences was created in November 1949, incorporating the former Academia Sinica and the National Academy of Peiping.

Between 1949 and 1955, the basic groundwork was laid for developing a comprehensive research establishment, and acquisition of the necessary research facilities and personnel was given first priority. The reconstruction program included the task of outfitting each research institute with the required equipment, bringing together scientists, consolidating research facilities, and expanding the system of higher education. Furthermore, research institutes were created in government bureaus concerned with production, and natural science societies were reorganized into a formal association [38].

A few words on the Academy are perhaps in order before closing our discussion of the reorganization of scientific research after the 1949 Revolution. Table VII shows the organizational structure of the Academy as of May 1950.

TABLE VII

(A) FORMER RESEARCH ESTABLISHMENTS IN CHINA

Research Institutes		Field	
In central China	11	Natural sciences	19
In northern China	9	Technical sciences	1
Educational	2	Humanities and the social sciences	3
Independent	1		
Total	23	Total	23

(B) ACADEMY OF SCIENCES

Research Institutes		Field	
Integrated with former research establishments	15	Natural sciences	
		already established	11
Newly established	1	planning stage	2
In planning stage	2	being considered	1
Being considered	1	Technical sciences	
		already established	1
		planning stage	1
		Humanities and the social sciences	
		already established	4
Total	16	Total	16

Source: [19, May 1950].

Most of the institutes are located in Peking, Nanking, or Shanghai. There were 259 research personnel attached to the institutes when they were set up. This figure includes 82 researchers, 30 associate researchers, 62 assistant researchers, and 85 assistants. As of 1950, the Academy had not yet initiated exchanges with Soviet scientists, and the only contacts being considered at that time were the mutual exchange of publications and related items. The influence of the Korean War on China drastically reduced research allocations, and total research expenditures in 1952 only amounted to 0.07 per cent of the annual budget [33].

III. THE TWELVE-YEAR SCIENCE PLAN

At the first plenary session of the Academy of Sciences held in June 1950, President Kuo Mo-jo had the following to say regarding the future development of scientific research.

> Placing primary emphasis on planning and the corporate nature of scientific research, we will strengthen the functional interrelationship between fields in which scientific research is being conducted. [22]

From its inception, the Academy placed particular importance on the role of planning in research activities, and after 1950, each research institute was required to draft projected research plans for the following year. Although the beginnings of planned research were halting, steady progress was made, and planning became more effective and better organized as time went by. Similar developments, no doubt, also took place in government research organs at the municipal, provincial, and national levels. A broad, long-term perspective was not adopted, however, nor was any significant attempt made to coordinate or adjust research activities having similar or complementary objectives. In March 1951, the government directed all research institutions to forward annual plans for projected research in line with the Academy's ongoing programs. The Academy was already occupied with organizing and consolidating its own research institutes and personnel, and how effective the government's program was is doubtful.

Comprehensive planning was not begun seriously by the Academy until late 1952. This was done in preparation for the government's First Five-Year Plan scheduled to begin in 1953. The Academy, however, had already been reorganized by this time and for the past two-and-a-half years, each research institute had been actively gathering the data required to prepare a comprehensive, integrated research strategy. In addition to the research plan for 1952, preparation of a five-year plan for scientific research was begun. This plan, however, ran into opposition from the CCP and the central government because it threatened to interfere with their own designs. In October 1952, a conference on scientific planning for 1953 was held at the Academy's Northeast Branch. Wu Hêng, CCP member responsible for the administration of scientific research and Vice-President of the Academy, delivered a scathing attack on the proposed plan listing eight major shortcomings. Wu charged that the idea of national construction was being misinterpreted and that without adequate information, the actual conditions prevailing in China could not be known. He criticized the plan as too ambitious and having the emphasis in the wrong place. He further charged that too many different projects were included in the plan and that the period of time required to implement it was too long. Wu criticized the proposal as placing too much faith in the scientific establishments of capitalist countries, ignoring the achievements of Soviet science, and underplaying the possibility of learning from Soviet scientists. Wu further noted the lack of communications and contacts with other research organizations throughout the country. In concluding, Wu charged that the funding of the proposal was not realistic and that the amount of money allocated for the establishment of middle-range experimental stations was excessive; he felt that middle-range experiments were being promoted for their own sake and at considerable expense, much as research was often undertaken as an end in itself instead of a means [40]. Judging from Wu's comments, the scientists' proposal apparently placed considerable emphasis on basic, theoretical research aimed at encompassing the whole range of modern science and technology. Their plan was as prudent as it was ambitious and stressed the use of intermediate experimentation as an important means of improving production through applied science. A number of sources confirm that this approach was intended to enable China to catch up with the advanced scientific level of the world after 1950 [22]. Whether this was actually possible or not cannot be easily determined. The CCP, however, wanted research that would lead directly to increased production at less cost and in a shorter period of time. The scientists' proposals were revised around this theme, and research projects for 1953 and 1954 were limited to those directly effecting national economic growth and industrial output.[6] Although conditions had improved substantially by 1955, about 60 per cent of the eight hundred projected research topics submitted for approval corresponded with the actual needs of government organizations and industry [19, Jan. 1956].

The concentration of scientific efforts in research was aimed to benefit the production process directly; however, it also led scientists to an awareness of the backwardness of theoretical research in China. The Soviet Union aided China in all phases of the First Five-Year Plan (1953–57). Between 1953 and 1954, the Soviet Union began the construction of 156 industrial plants. Contact with Soviet technicians and Soviet technology stimulated Chinese interest in long-term planning, and it soon became apparent to Chinese scientists that basic surveys of China's natural resources and the natural environment were inadequate, even in the areas of mining, agriculture, and the conservation of water resources. The lack of effective leadership in scientific research and the glaring defects present in China's foremost research institutions became apparent at this time. At a conference of Academy chairmen held in October 1953, the importance of adequate leadership training and the need to study Soviet theory and methods were recognized. Kuo Mo-jo unveiled a series of proposals to correct the deficiencies in China's research establishment in a report presented to the State Supreme Council of the central government in January 1954. Kuo stressed the need for a clear understanding of the capabilities of scientific research being conducted at that time and pointed out the necessity of practical construction and developmental planning suitable for their own use. Kuo urged the development of heavy industry as a secondary goal and stressed the importance of conducting thorough surveys of natural and environmental resources. Kuo further indicated the need to develop those basic sciences that did not yet exist in China and strengthen those that were only partially developed. At the same time, he proposed that a system be adopted by the Academy to train students to assume the country's leadership in science and technology. The major departments were to be the department of mathematics, physics, and chemistry, the department of biology and geology, the department of science and technology, and the department of philosophy and the social sciences [23]. The latter two proposals were adopted and implemented a year-and-a-half later in June 1956.

The First Five-Year Plan brought the scientific communities of both China and the Soviet Union into closer contact. Until then, there had been exchanges of important literature and personnel in some areas, but these exchanges were neither large-scale nor well coordinated. In early 1953, the science academies of both countries began to exchange scientific publications and information on a large-scale, and in October 1954, the Accord for Technical and Scientific Cooperation was concluded in Peking. The free exchange of technical resources was agreed to, including technical and scientific reports, technical specialists,

[6] [14, p. 550]. Related articles are found in the 1953 and 1954 issues of the *K'ohsüeh t'ungpao*.

technical aid, and information on recent advances in scientific and technical fields [17, 1955, p. 299]. Soviet advisors were probably assigned to the staff of the Academy at this time. Beginning in 1954, however, the number of Soviet scientists dispatched to universities and research institutions throughout China increased significantly. For example, thirteen Russian specialists were invited to Peking University [17, 1955, p. 203]. In April 1955, the Atomic Energy Accord was concluded, and the Chinese built a nuclear research reactor and cyclotron with Russian aid. The visiting Soviet scientists no doubt convinced Chinese scientists of the importance of long-range planning during their stay in China. This fact is reflected in Chou En-lai's report which notes, "[a long-term plan for scientific research] is one repeatedly suggested by Chinese and Soviet scientists . . ." [10, p. 140]. After surveying the research facilities and activities in each region, advisors from the Soviet Academy of Sciences proposed a long-term plan for science and technology in China during the June 1955 conference held in Peking. Difficulties encountered during the implementation of the Five-Year Plan convinced the CCP and the central government of the need for such a plan. This turning point was reached at the Academy's Conference on the Establishment of Academic Departments convened to consider Kuo Mo-jo's recommendations.

The conference was held in Peking from June 1 through June 10, 1955. A draft entitled "Prospectus for the First Five-Year Plan of the Academy of Sciences" was presented at this time. An alternate plan, "Proposed Major Revisions," was also presented to the conference. The actual content of these revisions is not known for sure, but the revisions most likely comprised one section of a long-range fifteen-year plan for science broken down into three separate five-year plans. These revisions are not thought to have been designed to alter the prospectus for the original five-year proposal set forth at the conference, and the resolutions adopted by the conference seem to indicate this:

> The Academy of Sciences should design, without delay, a long-range fifteen-year developmental plan for science and should complete the draft for the plan within one year. Furthermore, plans for nationwide scientific activities should be designed to assure the cooperation of pertinent government bureaus, in particular the Ministry of Higher Education, State Planning Commission. [19, July 1955]

On September 15, 1955, the Academy announced a series of measures designed to lead to the creation of a fifteen-year plan [19, Nov. 1955]. Preparatory work to draft the plan started in December and involved the participation of hundreds of scientists who were to survey existing conditions and recommend the direction best suited for the further development of science and technology in China. A number of proposals were presented and discussed at this time [19, Jan.–Apr. 1956]. The Soviet Academy of Sciences sent a number of specialists including two chemists and five physicists to help draft the plan. They participated in numerous surveys and discussions, supplied valuable information and data on a wide variety of topics, and gave much-needed technical advice to Chinese scientists during the two months of preliminary planning [42] [3]. More than six months were required to draft the plan, and it was probably not completed until June 1956. Because the plan was originally to have begun in 1953, it was renamed the Long-term Twelve-Year Plan for the Development of Science and Technology. Chou En-lai's report was supported by these scientists, and it is assumed that all of the suggestions in his report were contained in the plan. Unfortunately, the plan was never made public, and its exact content must remain a mystery. Other sources, however, suggest some of the probable content.

The Twelve-Year Science Plan had three main goals. The first concerned research in basic theory, the second dealt with establishing and developing entirely new fields of research, and the third goal was to develop general research such as surveys of the environment and natural resources. More specifically, the implementation of fifty-seven important tasks was agreed to. The most pressing of these tasks are the following: to develop research in the fields of atomic energy, semi-conductors, electronics, computer science, automation, high-speed fluids, and turbine propulsion. The overall objective of the Twelve-Year Science Plan was to reach the international level of scientific standards set in the most advanced fields of science by 1967 [24]. A major change, then, had clearly taken place. The utilitarianism of the 1953–55 period had given way to the realization that basic research in the theoretical sciences was essential to make use of China's substantial power in the major fields of science and technology upon completion of the Twelve-Year Plan.

Drafting a plan, of course, does not necessarily insure the results. In March 1956, the Scientific Planning Committee was set up under the State Supreme Council, integrating scientific and technical planning with administrative management. Chen Yi was appointed first chairman of the committee and was later succeeded by Nieh Jung-chên. From late 1956 through 1957, all possible efforts were exerted to make the plan operable. The cooperation of the Soviet Union was an essential factor in the development of a new technology. A few examples from the development of research in physics may be useful here.

Two Soviet experts were sent to help the Chinese implement the Twelve-Year Plan in electronics. Upon their arrival, they presented a proposal based on their work at the Institute of Electronics at the Soviet Academy of Sciences. Their plan provided that a team of scientists from the Chinese Academy be sent to the Soviet Union in early 1957. The Chinese scientists received training at the U.S.S.R. Institute of Electronics and other advanced research institutions, and upon their return to China, took the lead in future planning and research activities at the institute in the same field. A set of machine parts and equipment used in microwave research were sent from the Russian electronics institute to their counterparts in China. Russian specialists were sent to several universities and put to work educating students, training research personnel, and building a base for the future growth of research. Before the Revolution of 1949, semi-conductor physics was an unknown field in China. Earlier, in 1953, an Academy team returned from the Soviet Union with the news that Soviet advances in semi-conductor physics stemmed directly from advanced theoretical research conducted in solid state physics. Chinese specialists, however, failed to fully appreciate the importance of research to development. Without Russian aid, the expansion of research activities was inhibited, and research did not pick up again until late

1956. When the original plan was set up in 1956, the Soviet Union sent one specialist to China to provide leadership and chart the course for future research. One of the major programs created by the plan was to send Academy scientists to the Soviet Union to inspect eight research institutes, three factories, and other research related organizations and to attend lectures for a period of two months. Six months after the team returned, they succeeded in extracting germanium crystals and in test producing germanium diodes and triodes. It was also in 1956 that the Soviet specialist joined the faculty of Peking University's physics department. Soviet aid was used to help develop physics, vital to quality control of industrial goods, in the years following the Revolution. Although aid was begun in 1954 to develop education and research in metallurgical physics needed for production purposes, teaching and research in other new fields was not begun until 1956 [42]. Before 1956, poor research conditions were apparent in every field of science. In 1957, the Chinese and Soviet academies agreed to cooperate in the development of science and technology on eighty-nine problems. Under the provisions of the accord that was signed, 288 top-level Russian scientists were sent to China [28].

Although the extent of Soviet cooperation was significant, its importance should not be exaggerated, nor should the considerable talents and ability of the Chinese scientists be underestimated. Ch'ien Hsüeh-sên, a graduate of Massachusetts Institute of Technology, was one of these able scientists. Ch'ien returned to China in 1955, as we mentioned earlier, and set up the Institute of Mechanics becoming research director. His considerable ability and accomplishments are quite apparent in a paper written after his return entitled "Lun chishuk'ohsüeh" [Of technical science]. The following is a summary of this paper [7].

Until the beginning of the twentieth century, the natural sciences and technology were separate fields. With the development that took place in all areas of twentieth century science, however, science became for the first time the foundation upon which technology could develop. From the practical applications of science, a new technology was born. Forty years ago at MIT, technology was taught as a classroom subject for the first time based on the assumption that the natural sciences could be practically applied to technical problems. This was a revolution in technical education. Receiving training in the natural sciences before doing advanced work, a new type of technical specialist appeared who could solve problems by applying scientific principles. Since then, this system of education has come into wide use in many countries, but it is doubtful whether its full potential has been fully exploited. There is too wide a gap between training in the natural sciences and later specialization. There are too many instances where the natural sciences are taught without benefit of instruction in their application.

This situation occurs because science and technology are essentially separate entities. Science does not attempt to understand natural objects in themselves. Rather it seeks to turn these objects into abstractions and generalize about them. The main characteristics of science are simplification, classification, and categorization. We cannot determine by inference or deduction, the nature of an object by theory alone. There is, in other words, far more to the application of scientific theories to technical problems than mere inference or deductive reasoning. Under the present system of education, it is difficult to teach this to students in less than four years. These students have thoroughly confused science and technology in their minds. A new system is called for, one that teaches technical theory well-grounded in theoretical science. I suggest the new discipline be named "technical science."

Technical science is intimately related to both the natural sciences and technology, but it employs methods that are quite different from either. By acquiring skills in this new discipline, it is possible to become at the same time natural scientists, technician, and technician-scientist.

Mathematics is the tool of the technician-scientist. Since the technician-scientist uses mathematics more than the natural scientist, he must be thoroughly versed in the methodology of mathematical computation and analysis. Technician-scientists must also be trained in the use of computers. In the future, a technician-scientist not familiar with the computer will be hard to imagine. The tool par excellence of the technician-scientist is certainly mathematical computation and analysis. However, the key to technical science and its unique methodology is the *model.* When a problem has been formulated and the necessary data obtained, a model is constructed which embodies all the major elements of the original problem. This model is a miniature image of the whole, an abstracted pattern, and a product of the mind; it is not the phenomenon itself. When the model has been completed, the next step is to analyze it and determine the relationship between its parts. This is done in accordance with certain prescribed principles and the methodology of mathematical analysis. The model and accompanying mathematical operations will yield theoretical results that, for the first time, can be compared with actual fact.

The fields that make up technical science are chemical fluid mechanics, physical dynamics, electromagnetic fluid dynamics, rheology, geodynamics, nuclear reactor theory, control engineering, computer technology, spectrology, and operations research. Ch'ien Hsüeh-sên also dealt with the relationship between the natural sciences and various technical fields, research in these areas, and the practical applications of these research activities. A discussion of these points is unfortunately outside the scope of this paper. Ch'ien's detailed discussion of economic measurement, however, is of considerable interest. This involved the practical application of advances in technical science to various fields of economies including the problems changing from economic planning in industry to national economic planning. Ch'ien Hsüeh-sên's dramatic return was an event of great importance for China. Before resuming our earlier discussion, a look at the training of research personnel is in order.

In August 1955, a system was devised by the Academy to turn out first rate technical specialists and scientists. The following qualifications were required for admittance to the program: at least two years experience in research in the candidate's degree field or a closely related field and superior ratings in the candidate's major field; scholastic ability on a par with others in the same field; and demonstrated ability to conduct advanced research. Entrance examinations were conducted, and the period of study was set at four years. Students were to be affiliated with a research institute and, under a teacher's guidance, would receive training in one or two major fields. Students were expected to demonstrate proficiency in Russian and one other foreign language [17, 1955]. This system of training researchers within the framework of a research institution is worthy of note. A similar system was used with excellent results in India [1]. The results of this type of training, however, will not be felt in China for another ten or twenty years, but the influence of the program is expected to be considerable. Table VIII shows the distribution of university graduates in 1956 by academic

TABLE VIII
DISTRIBUTION OF UNIVERSITY GRADUATES: 1956

Field	Total	(%)	Remarks
Students in foreign coutries; research students of the Academy of Sciences, 3rd Geology Bureau, and the Department of Technical Sciences; university researchers and instructors	15,163	24.31	4,932 graduate engineers (22.7% of all graduate engineers)
Heavy industry	15,438	24.74	11,412 graduate engineers (52.71% of all graduate engineers)
Light industry, transportation, agriculture, forestry, water resources, finance, culture	8,706	13.36	
People's Liberation Army, etc.	1,651	2.65	
Provinces, autonomous provinces, cities under direct control	21,425	34.34	
Total	62,383	100.00	

Source: [11].

field in line with the Twelve-Year Science Plan. Special note should be taken of the large number of students entering research institutes.

IV. "LET A HUNDRED SCHOOLS OF THOUGHT CONTEND"

A. *Science and Ideology*

On May 26, 1956, as preparations for the Twelve-Year Plan for the Development of Science and Technology were nearing completion, Lu Ting-yi delivered his now famous injunction, "Paihuach'ifang paichiachêngming" [Let a hundred flowers blossom, a hundred schools of thought contend]. Although the plan was nearly completed, before it could become operative, a number of technological and scientific problems had to be resolved. Lu Ting-yi's speech touched on many of these problems.

Much has been written concerning the beginning, dramatic denouement, and tragic finale of the Hundred Flowers campaign. Despite the urgings of the CCP to debate openly, intellectuals at first remained silent for fear of the reprisals they felt sure were to follow. Not until May of the following year did they begin to speak freely and publicly; until then, few thought "contended" and few flowers "blossomed together." Although intellectuals in general refused to speak openly, from the movement's inception, natural scientists began to discuss events among themselves, and before long, they were well on their way toward resolving the conflict between science and ideology.

Lu Ting-yi made the following statement in his speech:

> Every scientist has his own political viewpoint, although natural science itself has no class character. [31]

Natural science has no class character. The meaning of this statement was immediately obvious to natural scientists. As natural scientists began to speak out, the *Kuangming jihpao*, organ of the Democratic Party faction, offered its pages as a forum for their opinions. It was their reliance on fact that enabled the natural scientists to take the lead in broaching many important issues, and they spoke up louder and clearer than any other group of intellectuals.

When the People's Republic of China was established in 1949, scientific theories such as Einstein's theory of relativity, Pauling's work on resonance, theoretical mathematics, the Mendel-Morgan laws of heredity, and other advances in science were discredited by the Soviet Union. The "natural dialecticians" controlled scientific thought in biology, geology, economic geography, and other fields. The force of the Soviet arguments brushed all opposition aside and spread to China. A number of critical ideas and theories were translated from Russian and introduced to China where they quickly became gospel. Scholars with differing viewpoints were silenced, and books expressing contrary views were barred from publication [5]. The scientists' silence, however, should not be taken as a sign of their defeat. Despite the natural dialecticians' and philosophers' criticisms, Soviet scientists continued their research sticking close to scientific fact. The computer demonstrated the validity of theoretical mathematics, and the cyclotron verified the theory of relativity. Chinese scientists also laid down a barrage of irrefutable fact which led to the entrapment and eventual demise of the dialectical theoreticians.

The only dialectical theory that took root in China during this period was biology with its direct applications to agricultural production. A Michurin Study Society was organized at the Academy of Agricultural Sciences, Huapei University in 1948. After the Revolution this society established branches throughout China. The Michurin-Lysenko school opposed the work of Mendel and Morgan, and their denunciation of the Mendel-Morgan body of theory reached the peak of its intensity in 1955. In a special "Michurin" edition published by the Academy of Sciences' organ, *K'ohsüeh t'ungpao* [19, Dec. 1955], the overthrow of the Mendel-Morgan faction was urged. This was accomplished virtually without debate or opposition. Mendal and Morgan were condemned as reactionary, idealists imbued with bourgeois thought [18].

Later developments in science and technology in fields other than genetics, showed these criticisms to be without foundation. Research in other fields of science confirmed this. In late 1955, a new trend became discernible. "Reflections on the Theory of Relativity" by the Polish physicist Infelt, who visited

China at that time, was published in the *K'ohsüeh t'ungpao* [16]. The implementation of the Twelve-Year Science Plan compelled Chinese scientists to make amends with the past. During the early stages of the plan, the *Jênmin jihpao*, official organ of the CCP, published a paper by the well-known mathematician Hu Shih-hua entitled "Theoretical Mathematics: A Science Worthy of Particular Note" (June 9, 1956). Hu's paper urged scientists to take a positive attitude to break away from past errors. In fact, the number of Chinese scientists seriously influenced by Soviet ideological arguments was surprisingly small. Nonetheless, more than a year-and-a-half was required to put research in genetics on a sound footing again. In August 1956, the Academy and the Ministry of Higher Education sponsored a round-table discussion on genetics which lasted fifteen days. Heated arguments from both schools were aired. Further discussion was brought to an end, however, in December 1957, when the research projects designed to accompany the Twelve-Year Science Plan were revealed at a meeting of the Genetics Society. The result was a complete victory for the Mendel-Morgan faction [13] [19, 1958, No. 1].

The principle that the natural sciences have no class character was frequently invoked later as events dictated.

> There is no class character in the natural sciences nor in the field of technology. Generally speaking, varying technical and scholarly opinions in these fields are expressions of the conflict of ideas that leads to understanding. They are not expressions of the conflict of class interests. [6]

This principle assumes significance in terms of China's struggle to liberate itself from dependence on the Soviet Union, to stop imitating Soviet methods, and to be free of Russia's ideological control. This desire for independence may be glimpsed in Chou En-lai's report on the intellectuals, but it does not become an open issue until the Hundred Flowers campaign. A *K'ohsüe t'ungpao* editorial written about this time mentioned scientists who disagreed with Soviet theories, remained silent, and did not offer their own interpretations of experimental results. The editorial severely criticized the fact that "not a few" scientists, from start to finish, simply parroted Soviet scientists and theories. The editorial took to task those who did not think independently and became lost in the debates between different Soviet academic societies. The editorial attacked those who felt that by refraining from expressing one's own opinion, one merely follows the lead of others. Finally, the editorial emphasized that today's Soviet theories may well be disproved and forgotten tomorrow and suggested that the advances in science and technology made in capitalist countries are also deserving of serious consideration [19, June 1956].

While Chinese specialists were studying Soviet theories and methods, a full-scale attempt was being made to speed up the Twelve-Year Plan in order to establish as early as possible a solid base for the further development of science and technology. Chinese scientists were beginning to look for a means of lessening their dependence on Soviet science and easing its pervasive influence. At the fifth meeting of the State Council's Scientific and Technological Commission held in March 1958, Kuo Mo-jo made the following statement:

> It is our never ending principle to attain success by self-reliance, overcoming difficulties in science and technology. However, Soviet aid is still necessary. [27]

B. *Scientific Development and the Needs of the State*

The Hundred Flowers campaign reached a new peak of intensity in May 1957, and a host of new problems were unearthed in the scientific community. During this period, the Central Committee of the Chinese Democratic Alliance, the political organization of the intelligentsia, set up the "Problems in Scientific Planning" research seminar, the first of four such groups to be established. This move opened a number of debates and stimulated research into the problem of the intellectuals. The Problem in Scientific Planning group soon issued a joint statement expressing their views. The five authors of the document were Tsêng Chao-lun (Chemistry), Ch'ien Chia-chü (Economics), Hua Lo-kêng (Mathematics), T'ung Ti-chou (Biology), and Ch'ien Wei-ch'ang (Physics). The statement was published in the June 9, 1957 edition of *Kuangming jihpao* and entitled "Several Views on China's Scientific Establishment."

The scientists' statement dealt for the most part with the same problems treated by Chou En-lai in his report on the intelligentsia and discussed in detail the obstacles preventing a thorough reform of advanced research in China. The statement urged that the reform be carried through to a successful conclusion and noted scientists' preferences. For instance, scientists wished to be relieved of the obligation to greet and host foreign dignitaries.

The joint report touched on two critical issues, academic freedom and national security. The statement read in part:

> With the exception of a few areas where joint research is necessitated, scientific research options should be left open and the "personal preferences" of the researcher should be taken into account. Researchers should be able to select their own topics. . . . The impetus to provide good technical leadership and conduct relevant research should come from the work itself. It is not necessary to designate special leaders in advance or motivate researchers apart from their work. . . . The security system is too stringent and is one of the major barriers to all scientific research. . . . We propose that, except in the area of military and foreign affairs and where new inventions are concerned, the present security arrangements required to protect important information should not apply to scientists and professors.

The statement was immediately denounced as an instrument of the Chang-Lo alliance (Chang Po-chün and Lo Lung-chi) and an attempted return to capitalism. The denunciation was made as CCP policy began to shift perceptibly from the freedom of debate encouraged during the Hundred Flowers to accusations of the right-wing backlash [25]. All five authors were members of faculties in the Academy. Because the authors had also participated in designing the Twelve-Year Plan, the Academy convened a special conference to criticize the report. The conference was held from June 14 to 15 and again from June 22 to 25, 1957. The five scientists admitted during the conference that they had charted a course that would lead ultimately to the restoration of capitalism and each delivered a self-criticism [19, 1957, Nos. 15 & 16].

These five scientists were most likely not interested in reinstating capitalism.

The Academy's condemnation of the scientists reflected the growing conflict between "science and the state," and it is to this cause that we must look for an explanation of their behavior. After World War II, answers to this basic problem were actively being sought even by advanced capitalist countries. The conflicts between the needs of the state and the needs of science were seen more clearly in China which became a socialist state relatively late. Scientists depended on the state for funds to finance their research. The state, on the other hand, depended on scientists to adapt and exploit the technological revolution to best advantage. The issues of national security and planned research arise from this mutual dependence. Research, however, requires a considerable degree of freedom since the outcome of research cannot be assessed beforehand. Just how tight national security should be in light of the present state of technology is a difficult decision for the government of a modern state, and each country today continues to search for a suitable balance between the needs of the state and those of science. The joint statement issued by the five Chinese scientists expressed their nostalgia for the conditions that obtained during the prewar era. Although fully accustomed to the current level of scientific and technological development and committed to research, these scientists nonetheless longed for the absolute academic freedom they once enjoyed from their ivory towers and wished to benefit once again from minimal ties with the state.

During the Academy conference, scholars in the humanities and social sciences consistently levelled charges of anti-party, anti-socialist, and neo-capitalist against the authors of the joint statement. The natural scientists, however, understood the crux of the problem. Regarding the issue of national security and defense research, Ch'ien Hsüeh-sên noted: "This is an industrialized age, not one of petty artisans. Modern research without planning is an impossibility." Ch'ien was supported by Lu Hsüeh-shan of the Institute of Applied Physics. Whatever the outcome of the Hundred Flowers campaign, the statement would most likely have drawn hostile criticism even then. In an underdeveloped country such as China, modern levels of scientific development cannot be achieved without a high degree of planning and coordination and without full backing from the state in matters relating to research in science and technology.

The Oppenheimer incident, however, puts the issue in a somewhat different perspective. Oppenheimer and others refused to cooperate with the United States Government in developing the hydrogen bomb justifying their refusal on the grounds that the project would lead to the destruction of mankind. If the rights of the individual are identified with the rights of mankind, then the principle of state supremacy is negated. Oppenheimer's colleague, Teller, however, took the opposite view and cooperated with the state in developing the bomb. Teller did this in the name of academic freedom, the right to pursue one's own research. The statement issued by the five Chinese scientists, then, posed a problem of a different magnitude; here, both sides implicitly recognized the principle of state supremacy and national interest. The problem in China was one of degree.

Begging the reader's indulgence, I would like to digress slightly and make a few comments about the nature of science in relation to the state. It is difficult to completely exclude a man's values in the field of humanities and social sciences, however much he may be induced to criticize himself and reflect on his own behavior. The natural sciences and the field of technology, however, develop in a way quite different from the social sciences and the humanities. If the natural sciences and technology, a steady supply of resources are made available to the scientist, and the scientist and technical specialist are normally protected by the state as a matter of policy; if political interference with scientific theory is kept to a minimum, substantial progress is almost guaranteed; science and technology, then, can develop under any political system providing certain minimum requirements, such as those mentioned above, are met. Because science is a value-free discipline, it is relatively innocuous in a political sense and therefore of very limited value as an ideological weapon, whence the Chinese assertion that science has no class character.

After the round-table discussions sponsored by the Academy of Sciences in response to the joint statement by the five scientists, research institutes and universities began a rigorous program of self-criticism. As a result of these conferences, Chinese scientists reportedly acknowledged the necessity of leadership and planning in the future development of science and technology [19, 1958, No. 4].

Between 1956 and 1957, a number of important events cleared the way for the uninhibited growth of science and technology. The role of the intelligentsia was thoroughly reexamined, the Twelve-Year Science Plan was drafted, the principle was established that science and technology have no class character, the importance of planning in research was reaffirmed, and preparations were made for the implementation of the Science Plan for more than a year-and-a-half. The Second Five-Year Plan (1958–62) was begun in 1958 without a flaw. Storms were brewing in the outside world, however, and, inside China itself, the apparent calm was about to be disturbed by the Great Leap Forward.

V. SCIENTISTS AND THE GREAT LEAP FORWARD

The scientific community faced the prospect of the Great Leap Forward, scheduled to begin after the autumn harvest of 1957, with few apprehensions. Scientific projects and preparations for the Leap Forward were discussed by research directors of the Academy of Sciences during a three-day meeting held from February 13, 1958. Most scientists felt that the Twelve-Year Science Plan would be science's contribution to the Great Leap Forward. Kung Tsu-t'ung, Deputy Director, Institute of Optical and Precision Instruments, attracted notice when he proposed that the Twelve-Year Plan be shortened to eight years. Ch'ien Hsüeh-sên's proposals, however, show the most insight:

> We must look beyond our immediate preoccupations. We must consider not only present national needs and priorities, but we must also look to the next ten years and beyond, to the even longer range needs of science and technology. The forty tasks listed in the draft program for agricultural development may be accomplished earlier than originally planned. However, our operational scientists should be more concerned about developing agriculture after present goals have been achieved. The subsequent development of agriculture, then, will not depend on mechanization,

> electrification, and the manufacture of chemical fertilizers. Rather, this development will come about through the practical application of technical processes to agriculture. Agricultural products will be produced like goods in a factory, i.e., production will be accomplished in a controlled environment. Agriculture, in other words, would be industrialized.
>
> Furthermore, our main source of energy at present is coke; coal is also used to smelt iron. Recent advances in science and technology seem to indicate that in the future, energy will be derived mainly from hydroelectric sources, atomic fission, or atomic fusion, methods now being researched. Although we cannot stop using coal and other fuels altogether, other methods of producing electricity must be carefully considered.

Ch'ien further emphasized that:

> Now is the time to extend the academic boundaries of new departments in the Academy of Sciences. For example, physics has been incorporated as an integral part of several different disciplines such as biophysics, etc. Since interdepartmental disciplines are common in the natural and technical sciences, the natural and technical sciences should likewise be applied to social sciences. Mathematical statistics could be profitably introduced to the social sciences as well as the field of industrial economics which involves engineering technology. Mutual exchanges between disciplines will produce new and important fields of inquiry. [8]

While the Great Leap Forward was still gathering momentum, Kuo Mo-jo delivered an address at the fifth meeting of the Scientific and Technological Commission held from March 5 through 12. The address read in part:

> It has taken two years to complete preparations for our twelve-year mission. We agree unanimously on how to achieve this goal completely. We recognize the tremendous potential of the scientific leap forward. We are confident because we have laid our plans with the greatest of care. [28]

Although, scientists could not remain entirely aloof from events. Before long, that part of the scientific establishment having the closest ties to production was drawn into the maelstrom of the Great Leap Forward. In early March 1958, the Institute of Petroleum announced it would achieve international standards of performance in petroleum science within five to seven years. At the same time, all laboratories at the Institute of Geology announced they would narrow the gap between international scientific standards and their own within six to eight years. The research laboratories of the Institute of Entomology pledged to complete their ten-year program in seven years. In mid-March, the cellulose chemistry laboratories of the Institute of Applied Chemistry announced they would complete their program to attain international standards of performance within three to five years, and all research projects in the inorganic chemistry laboratories were to be completed within three to seven years. The Institute of Physical Chemistry was to attain the same results within three to five years. The Institute of Optical and Precision Instruments hoped to reach international levels within six years, and the micro-organism laboratory of the Institute of Forestry and Pedology announced it would complete its four-year project in one year [19, 1958, Nos. 7 & 8].

The implications were clear. The plan that had taken hundreds of specialists more than six months to draft and a year-and-a-half of meticulous preparation to implement had gone for naught. No one could slow the momentum generated by the Great Leap Forward.

In early June, Chang Chin-fu, Vice-President of the Academy of Sciences, urged scientists to comply with the following guidelines: join the leftist faction at work; destroy academism and support the views of the masses; solve problems by yourself, build self-confidence; study the advances made in foreign countries and strive to develop creativity anew; do not hesitate to use young people [2]. From that time on, the Leap Forward was actively promoted in all research institutes. In early June, the Academy held the Peking regional conference on the Great Leap Forward. Sixty-four representatives made declarations of their determination to see the movement successfully implemented and carried out. It was agreed to push the original plan toward completion within two years and to complete it fully within three [35].

At the thirty-seventh anniversary of the founding of the Chinese Communist Party, July 1, 1958, specialists from each research institute attached to the Academy of Sciences reported to the party on the results obtained in each field durnig the Leap Forward in science. The Institute of Atomic Energy reported the completion of a cyclotron and nuclear research reactor built with Soviet aid and the successful completion of a small-scale cyclotron of its own design. In just twenty days, the Institute of Applied Physics was able to complete a crash program to build the "world's most efficient transistor." The Institute of Zoology completed a report on the animals of northeast China in thirty-five days, a survey normally requiring one year. The Pedological Survey Group finished a 1 : 100,000 scale map of the Gobi Desert in Inner Mongolia working five days and five nights [36].

The following is an excerpt from a report published in July:

> All party committees in the Institute of Metallurgy and the Institute of Forestry and Pedology . . . have organized a Leap Forward movement. On June 21, a joint meeting was held at which both institutes pledged to support the Great Leap Forward. The campaign aroused wide interest, kindled fierce enthusiasm, and sparked a burst of activity reminding one of an atomic explosion. Factories and laboratories worked day and night to achieve new results which were obtained ten days later and reported to the party. [39]

The editorial staff of the *K'ohsüeh t'ungpao*, the official publication of the Academy of Sciences, was completely reshuffled in July. Among the editorial staff, top scientists were gradually replaced by non-scientists such as party committees and secretaries in the universities and research institutes, deputy research directors of research institutes who were dispatched from the party, and party members of all government production bureaus and enterprises.

The July anniversary of the CCP was the first hurdle the scientists had to clear; the October 1 National Day celebrations were the second. Party committees in each research institute continued to push ahead with their work in order to present the party with outstanding achievements on the occasion of the October National Day celebrations [29].

In September, the Central Committee of the CCP made major revisions in the

Long-term Plan for Science and Technology. On September 25, 1958, the Chinese Scientific and Technological Association held its first national congress. At the congress Nieh Jung-chên, Vice-Premier of the State Supreme Council, Central Committee member, Director of the Science and Technology Administration,[7] and Chairman of the Scientific and Technological Commission from 1956 made the following statement:

> Present conditions make it possible to move the Twelve-Year Plan for the Development of Science and Technology, implemented in 1956, ahead five years and complete it early. Part of the plan can be completed in seven years. Part of the plan has already been completed.

Research organs were created in each province, city, people's commune, and factory. "A high level of scientific performance is being achieved by the party and the people." The objectives of the Second Five-Year Plan were to overtake the scientifically advanced countries in the field of industrial science and technology.

> We will endeavor to achieve this goal in three years in spite of all obstacles. We will renovate science and technology in China in order to attain the highest standards of scientific and technical development in the world. We should complete the Twelve-Year Science Plan by 1962. [32]

The possibility of completing the Third Five-Year Plan within the time allotted for the Second Five-Year Plan naturally raised a number of questions. Modern science approaches problems in the following way: when a research project was selected, relevant literature pertaining to the proposed project was carefully studied to discover who had already dealt with similar problems, the difficulties they encountered, and the results they obtained. However, for scientists, participating in the Leap Forward, although this procedure is doubtless necessary in many instances, it was not considered indispensable for each research project.

> If all relevant source materials are consulted thoroughly each time, research will be prolonged indefinitely. If we do not first look to reality for the key to a given problem, then we will be buried by tons of waste paper and totally immobilized. The logical solution to this situation is to begin by confronting the actual problems encountered in production and refer to the literature when a solution to concrete problems is required. When this approach is used boldly and imaginatively, research will proceed smoothly and quickly. Research in support of the Great Leap Forward will be completed in a short period of time once old research methods are abandoned. [41]

The inability of political leaders to grasp fully the complexities of scientific research is not typical of the situation in China alone. The difference between China and the advanced countries here is only one of degree. Given the political environment of China, however, this difference of degree proved fatal to the Leap Forward in science.

[7] The Association was formed from the All-China Federation of Natural Science Societies and the All-China Association for the Dissemination of Scientific and Technical Knowledge in September 1958. The Association was under the Scientific and Technological Commission.

A report from the Chemistry Department of Wuhan University indicates who was behind science's great leap forward. In March, 125 chemistry students left Wuhan to begin on-the-job training in factories. Teachers were opposed to this training on the grounds that students should stay and complete research in progress. The students, however, rejected their teachers' advice and willingly joined the factory production groups. There they lived and worked side-by-side with the laborers and conducted a total of seventy-eight research experiments. Forty-three experiments were successful, and more than half of the projects were adapted directly to production needs. The students insisted that their research related immediately to the needs of production, and their graduation theses were decided along these lines. The CCP concurred wholeheartedly. Again there was a fierce theoretical dispute among teachers who asserted the special task of the university is to broaden the scope and theory of science. They warned against being entrapped by a narrow pragmatism. Most younger teachers and some senior teachers sided with the students, however, and went along with party policy. Almost all graduation theses (sixty-four) dealt with topics related to the students' exposure to production. For example, twelve students, five younger teachers, and one senior teacher studying analytical chemistry formed six research teams in an attempt to discover a way of speeding up the measurement of tungsten in high-speed metals. The fastest recorded time reported in a foreign country was fifty minutes. Using methods developed at the Tayeh Steel Mill, a speed of thirty minutes was recorded. Other factories reported times of sixteen minutes. Various production facilities were asked to bring the time under ten minutes. After two months of effort, three kinds of means was discovered to shorten the time to between four and seven minutes. The methods developed on a trial-and-error basis for practical use were later verified experimentally in the laboratory. Another example of students' support for the movement is seen in the analysis and criticism of teachers' lectures by their students. Students found 25 irrefutable errors in one of the "old" professors' lecture notes. They uncovered on further examination 56 ideologically incorrect assertions, 68 incomprehensible statements, 130 errors in experimental procedures, and a total of 102 topics either unrelated to production or contemptuous of the Soviet Union. In all, 408 items were found to be highly questionable or wrong altogether. A total of 4,700 objectionable items were discovered in twenty different subjects [4].

On September 20, 1958, the University of Science and Technology was created in the Academy of Sciences to train a new type of scientist and technician. The new university stressed the interrelationship between physical labor and academic training. A one-year course was instituted that included eight months of academic work, three months of first hand training in production, and a one-month vacation. A small factory was set up in each department, and a large factory was constructed to serve the entire school. The university was divided into thirteen departments. These were the departments of nuclear physics and engineering, technical physics, electronic physics, automation, high-polymer chemistry and physics, applied mathematics and computer technology, and biophysics. The new university was reportedly a "university of communism" [19, 1958, No. 19].

The Academy of Sciences met on October 4 in Peking to commemorate National Day. Ten-thousand scientists were present to announce to the party the outstanding achievements made by the scientific community. The results achieved during the Great Leap Forward in science were highly praised at this time. Of the 2,152 different science displays prepared for the occasion, 167 met world scientific standards, and 66 surpassed world standards [19, 1958, No. 19]. Of the 7,401 exhibits displayed at the National Exhibition of the Technical Revolution in Medicine and Hygiene, 578 met approved international standards, 368 surpassed these standards, and 578 displays were unique to China and therefore could not be compared [19, 1958, No. 22]. This latter category no doubt included advances made in indigenous Chinese medicine. The Chinese scientists had accomplished veritable miracles in the four months since June.

Unfortunately, however, scientists and technical specialists, who are expected to understand the significance of research, refused to believe the miraculous claims. Scientists maintained their silence and continued conducting tests and analyzing the products and data accumulated during the Leap Forward in science. The movement yielded a sizeable set of data. As the data accumulated, however, the discouragement of party committees in research institutes and the researchers who had followed the party's lead grew. The data overwhelmingly declared the Great Leap Forward in science to be an unqualified failure in terms of the objectives it set out to achieve.

VI. BEYOND THE GREAT LEAP FORWARD

By 1958, China's scientific establishment had been restored to a sound footing. The events set in motion during 1958, however, set the scientists back a good deal in their efforts to improve the standing of Chinese science in the world. The agricultural and earth sciences were an exception. At a conference held in November 1958, scientists pursuing research in these fields reported that through the use of organic fertilizers, deep plowing, intensive cultivation, and irrigation, the latent productivity of the soil could be tapped and developed indefinitely. Their report was published in early 1959 [19, 1959, No. 1]. A number of developments appeared to confirm their hypothesis. Because harvest schedules were being changed continually, the predicted yields for the 1958 harvest increased almost daily. Many agricultural scientists, of course, refused to believe these estimates. They continued conducting tests on deep plowing and intensive cultivation. Unlike tests on industrial products, however, these tests had to allow ample time for the plants being tested to grow, and the experiments took a good deal of time.

By late 1958, China's scientific community had once again restored some semblance of order and resumed research activities. In early 1959, the staff of the *K'ohsüeh t'ungpao* was reshuffled a second time. Scientists who had remained quiet during the Great Leap Forward once again began to write and express their ideas openly. Vice-President of the Academy of Sciences, Chang Chin-fu, presented a paper entitled, "Push the Leap Forward in Science One Step Further," which was published as a feature article in the first issue of the *K'ohsüeh t'ungpao* for 1959. Chang's paper voiced the first substantive criticism heard since the leap forward movement began. He stressed that there is theoretical work in science not directly related to actual conditions and theoretical work that proceeds from trial and error. The importance of this type of work should not be forgotten. On the other hand, Chang emphasized that just because concrete results are obtained does not mean scientists should be satisfied. Science must continually redouble its efforts to expand the scope of theory. A positive attitude is required, but it must be combined with planning and a long-term perspective capable of unifying theory with reality. The Great Leap Forward taught China many lessons, Chang said. For example, the Academy's Institute of Physics tested transistors sent from various plants. The Institute's reports on the purity of the silicon and germanium, however, were at variance with the reports sent from the manufacturers. Most items were found to be of a much lower purity than had been reported. The Institute of Computer Technology forged ahead and produced a computer (China's first home-produced product) during the months of June and July. After several months of use, the performance of the computer declined substantially. Finally it was decided to correct the faulty construction and rebuild the machine.

The miraculous results attributed to the Great Leap Forward, designed to place Chinese science on a par with world standards, were debunked within a short period of time. Scientists started to criticize the movement or simply ignored its results. Most scientists, in other words, discussed problems in science and technology as though they had never heard of the "results" of the Great Leap Forward.

Eventually, however, criticism was directed to all phases of production. The following examples are indicative of the view top-level scientists and technical specialists took of the leap forward in science. Fang Yu-hsüan, Deputy Director of the Science and Technology Commission, briefly mentioned the Leap Forward in a discussion of technical standards in the machine industry.

> Since the Great Leap Forward, many people have made innovations in the construction of machines, particularly construction machinery. These innovations have been made in response to the actual conditions obtaining in China. The structure of machine products has been fundamentally revolutionized, and a number of imaginative results have been obtained. However, we must wake up and draw some hard lessons from our past experiences. Most of these innovations have been nothing more than mere simplifications of already existing products, and fundamental restructuring has not occurred. [19, 1959, No. 4]

Wang Chih-hsi of the Metallurgical Industries Section of the Academy discussed the simplification of indigenous blast furnaces in a general survey of major problems confronting the metals industry. He noted that the analytical results of quality tests done on iron and the coke and fire-brick used in furnaces and obtained by indigenous techniques showed these products to be unfit for use [19, 1959, No. 5].

A broad critique of the leap forward in science was delivered at an April 7 conference of the directors of Academy research institutes [37]. The policy that had been set forth at the beginning of 1959 by Chang Chin-fu was interpreted to mean a return to the original Twelve-Year Science Plan. The implementation of this plan was to receive top priority for 1959.

In November, the final results of research on deep cultivation and intensive planting were announced by the Institute of Plant Physiology. The test data showed that the optimum depth for planting and cultivation was only slightly deeper than traditional methods indicated [21].

The conference of the National Scientific Planning Committee held in Peking in December revoked the policies set during late September 1958 and publicly announced a return to the original Twelve-Year Science Plan. From the point of view of the Chinese scientific community, the Great Leap Forward was a violent typhoon whose gale-force winds created disorder and confusion throughout the period from June to November 1958.

Here, a clear distinction should be made between the results achieved in science and technology through research and the results of science's "leap forward." It was an epochal year for Chinese science, the most important since the 1949 Revolution. Although world scientific standards were not obtained, China nonetheless succeeded in furthering scientific activities, in developing a large quantity of new test goods, and in completing a number of significant research projects. It was in 1958 that the Twelve-Year Science Plan which had taken two years to prepare and implement bore first fruit through the efforts of scientists and technicians who were not involved in the Great Leap Forward. During this period, then, science and technology developed even in spite of the upheaval caused by the Great Leap Forward.

VII. THE 1960S: SCIENTIFIC RESEARCH TAKES ROOT

The political leadership of China and the many scientists and students who supported this leadership learned a great deal from the failure of the Great Leap Forward.

In the first place, it was learned that scientific research is not to be tampered with and bent to political ends. For example, one of the primary functions of the *K'ohsüeh t'ungpao* was to publicize the government's policies in science and technology. After 1961, this publication became an ordinary science journal, and only rarely have topics dealing with planning and policy-making for science been printed in the *Hungch'i*, the official organ of the CCP.

Second, officials and scientists learned that scientific research requires patience and perseverance. The new attitude is evident in the *tuntien* ("crouching") or intensive research undertaken in the agricultural sciences after 1960. Recognizing their defeat in the Great Leap Forward, agricultural scientists reorganized old methods of research and immediately employed new ones. People's communes appropriate for research purposes were selected, small research teams were organized which lived in the communes with the people, and work was begun. Surveys were conducted of the natural surroundings, local conditions, and the experience of the farmers in the area. The surveys were analyzed and became the basis for pilot projects to improve productivity. Scientists began first with small-scale test paddies, expanded their study to medium-sized fields and finally proceed to test large-scale paddies. If the results were satisfactory, they would be imitated and adapted to production purposes by the commune. This is, of course, normal procedure in ordinary research, but such procedures were not widely employed in China until the 1960s. The first results of this *tuntien* research were reported in the May 25 issue of *Jênmin jihpao*, 1963, and between 1964 and 1965, the number of successes increased considerably. The general revival of agricultural production is no doubt due in large measure to the efforts of scientists and the use of established research procedures.

Third, it was finally recognized that the development of advanced and basic research and the general increase in national standards of science are two different problems with very different dimensions. Confusing these two problems was one of the primary factors leading to the rise and fall of the Great Leap Forward. Where scientific and technical planning and management were concerned, greater weight was attached to the opinions of top scientists like Ch'ien Hsüeh-sên.

Fourth, the importance of basic and theoretical research was clearly understood at last. The inability of political leaders to fully appreciate the significance of the Twelve-Year Science Plan led to the ultimate defeat of the Great Leap Forward. Scientists, not political leaders, insisted on the importance of the plan, drafted it, and strove to implement it. The withdrawal of Soviet technicians and the loss of technical aid also brought home to the Chinese leadership the hard lesson that the development of science and technology is not possible without basic research and without nurturing the theoretical sciences.[8] The effort China has since devoted to developing the basic and theoretical sciences and encouraging education in the sciences will most likely pay large dividends in the ten to twenty years. By that time, China's production technology and the level of basic planned technology should be greatly improved and approach world standards. China still needs a great deal of experience, however, before world standards in the production of commodity goods are achieved.

The fifth point is directly related to point four. The Chinese began to appreciate the importance of adequate funding and investment in scientific research. In 1960, when the last statistics appeared, 1,081 million yuan ($441 million) or 1.54 per cent of the national budget was allocated to scientific research [33].

The development of research in science and technology did not really take firm root in China until the 1960s. The course of that development has not

[8] Of particular interest here is the excellent paper, referred to earlier, by the Indian scientist Bhabha, appearing in the February 1966 issue of *Science*. Bhabha discusses the problems of scientific and technical development in India. Although India had the potential for self-development in the field of atomic energy where consistent efforts had been made to train specialists and develop basic research, a satisfactory degree of self-reliance was never achieved in the steel industry and other areas. If foreign aid were discontinued, fatal defects would be exposed and even their strong programs would flounder. Bhabha emphasizes that the independent development of Indian industry depends on the growth of science and technology within the country [1].

been smooth as we have seen. By the time Chinese leaders finally recognized the importance of research, it was already late, and the country had begun preparing to meet the economic crisis that followed in the wake of bad political decisions and the series of natural disasters that struck China soon thereafter. The loss of Soviet technical aid at the same time must have been an additional shock. Cooperation between China and the Soviet Union was not totally disrupted, however, and formal relations were still maintained. The transition from a policy of "heavy industry first" to "agriculture first" must inevitably have caused sweeping changes in the Twelve-Year Science Plan and disrupted other programs as well. After 1960, I have heard less and less about planned research.[9]

A *Hungch'i* editorial appearing in 1962 called for a positive examination of technical policies and active supporting research to back the policies up [15]. After 1962, research planning reappears in reports and these submitted in major research fields. This would seem to confirm the existence of research plans in research institutions.

An important source of information here is the paper written by Ch'ien Hsüeh-sên published in 1963 in the *Hungch'i* and entitled "K'ohsüehchishu-tê-tsuchih kuanli kungtso" [The task of building organizational management for science and technology] [9]. The paper deals with the unique features of modern science and the need to construct an organizational management to administer it. If research in science and technology is of foremost importance, then organizational management is a close second. Uniting management with research assures the progress of science. Ch'ien discussed the measures needed to institute planning for annual and long-term research in each field. He also discussed how planning should be organized and how research results should be applied to the task of national construction. After examining these points in detail, he proposed that courses be created in universities to train specialists in the field of organizational management. Reading between the lines of Ch'ien's report, we can see that in China management operations and development planning have again become important and that scientists have once again gained influence in this area.

In December 1964, at the National People's Congress, Chou En-lai revealed the existence of a "Development Plan for Science and Technology" [17, 1965, p. 11]. This would seem to indicate that a new comprehensive science plan was drafted and implemented in 1964. Compared with the earlier Twelve-Year Plan, the new plan appears to stress development in the life sciences rather than physics. Information on science and technology for the 1960s from written sources is very limited. We can only hope that specialists in each active field of research and, in particular, foreign specialists who visit China, will keep us accurately informed of the progress being made in science and technology in China today. Hopefully, we will have more than impressions to go on in the future.

9 This may be due simply to a lack of adequate source materials for the period in question.

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