

REPORT TO HIS EXCELLENCY
PRESIDENT AND GENERALISSIMO
C H I A N G K A I - S H E K
on

The Position and Prospects
of Science and Technology in China.

The Necessity of Increased Government Support for Science.

The Necessity for Increasing the Prestige of Chinese Science.

The Necessity for Finding Political Leaders with an Understanding of the Function and Importance of Science in the National Welfare.

A Special Ministry for Science and Technology ?

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Scientific Societies and other Organisations.

Industrial Organisations and Industrial Welfare.

Wartime Science of China and Britain in Retrospect.

International Scientific Relations.

Chungking

Winter, 1945

SUMMARY OF RECOMMENDATIONS

It is recommended:

- (1) That the Government should embark on a great investment policy by subsidising the leading Chinese scientific institutions (pure as well as applied) on a scale very much greater than heretofore. These include:-

Academia Sinica
The Peiping Academy
The Fukien and other Provincial Academies, if any
National Geological Survey and Provincial Geological and Meteorological Surveys
National Industrial Research Bureau and other research activities of the Ministry of Economics
National Agricultural Research Bureau and other research activities of the Ministry of Agriculture and Forestry
National Institute of Health, National Epidemics Prevention Bureau, and other research activities of the National Health Administration
Army Ordnance Administration research activities
Army Medical Administration research activities
Air Force Research Bureau
The Provincial Science Institutes
The Science Departments of the Universities, including the University of Communications
Huanghai Research Institute and similar institutes.

There are special reasons for greatly increasing the support given to the:-

National Institute of Compilation and Translation

Substantial government grants should also be given to:-

Science Society of China
Natural Science Society of China
and all the specialised scientific societies.

This list is in no way exclusive or exhaustive, but only indicative.

- (2) That means should be developed for increasing the prestige of Science and Technology in China, perhaps by the foundation of new Orders and Decorations, accompanied by suitable publicity; by stricter registration of qualified men; or other methods as may be found good.
- (3) That great efforts be made to encourage political leaders with a real knowledge and understanding of Science and Technology in order to reduce the inhibiting factors which retard the industrialisation and modernisation of the country.
- (4) That the Ministry of Education be strengthened on the scientific side.
- (5) That since science cannot flourish except in a democratic and liberal atmosphere, steps be taken to ensure variety and freedom of thought and expression in the universities.
- (6) That the policy of sending the maximum number possible of scholars, students, and foreman-apprentices abroad for study, in the interests of the industrialisation and modernisation of the country, be vigorously proceeded with, and that western scholars and students be invited to China also.
- (7) That careful thought be given to the ways in which China's industrialisation might profitably differ from that which was historically gone through by the western countries, e.g. in the use of non-ferrous metals, plastics, plant products and chemurgic processes.
- (8) That special care be taken to ensure sound workers' welfare practice during industrialisation, in so far as the situation permits approximation to western standards.
- (9) That thought be given to the problem of the provision of scientific advisory bodies at all levels of government, and to the participation of scientific men in the foreign relations of the country.
- (10) That China continue her policy of demanding a United Nations Cultural Organisation capable of fulfilling the functions of an international science cooperation service, and that the Chinese scientific movement be strengthened as soon as possible by the arranging of one or more International Scientific Congresses in China.

Your Excellency:

When we met in the summer of 1943 you did me the honour of asking me to prepare for you, before I finally left China on completion of my wartime assignment, a Report on the Position and Prospects of Chinese Science and Technology. This I now submit in the form of a letter.[⊕] During the intervening period, I have travelled widely through the country, from the borders of Sinkiang in the Northwest to Fukien and Fuchow in the Southeast and the Salween in the Southwest, visiting nearly every university and scientific laboratory in Free China, and a large number of factories and arsenals. At the conclusion of this letter I shall have a few words to say about the Sino-British Science Cooperation Office, which I organised and directed, and which is now continuing in slightly modified form in peacetime.

I remember that at our interview you asked me for my criticisms on the shortcomings of Chinese science and technology. These I shall summarise below, but first of all I want to express my genuinely felt and truly unfeigned admiration for what the main body of Chinese scientists and technologists have accomplished during the war period, under the inspired leadership

(⊕) It emanates from me, of course, in my private capacity as a scientist, irrespective of any position I held under the British Government, which naturally has no responsibility for my views. My opinions are also not necessarily identical with those of any other persons who have been or may be concerned with Sino-British cultural interchanges.

of such men as Dr. Won Wên-Hao and Gen. Yu Ta-Wei. Chinese scientists have kept university training in the sciences going under conditions which would have daunted any European or American scientist; Chinese technologists have created new factories in West China where before there was nothing but wild land or ricefields. I well remember one plant in Szechuan (under the National Resources Commission) for the dry distillation of wood, where the chief engineer told me that the whole thing had been set up by men of no specialised experience, having no blueprints, and depending entirely on textbook descriptions. This required initiative and talent for improvisation of a very high order, and my experience is that Chinese engineers are second to none in possessing it. Evidence is available from many sources as to the excellence of Chinese construction works, such as the Hsiang-Kuei Railway Bridges, built by graduates of Tangshan Engineering College, and found very difficult to destroy by those who had to blow them up during the Japanese advance into Kuangsi at the end of 1944.

Again, on the purely scientific side, the geologists Ting Wên-Chiang and Li Sse-Kuang have been world-famous. The eminent physicists P.M.S. Blackett and Max Born considered Hu Chien-Shan and H.H. Pêng respectively among their most brilliant collaborators; the famous mathematician G.H. Hardy holds Hua Lo-Kêng in similar esteem. The world-renowned physiologists A.V. Hill and R.W. Gerard have likewise a very

high opinion of their colleagues Fêng Teh-Pei and Tang Pei-Sung. The industrial chemist Hou Teh-Pang achieved classical improvements on the Solvay process; Tung Ti-Chou and Chuang Hsiao-Hui have done outstanding work in experimental morphology. Wu Hsien produced the now generally accepted theory of protein denaturation seven years before his colleagues in the West, and Chen Ko-Kuei isolated ephedrine from the traditional drug ma huang. Great advances in our knowledge of pneumonic plague came from the work of Wu Nien-Teh, and Li Chen-Pin (with Goodpasture) was the first to cultivate viruses in tissue-culture, a method which is still the only one by which yellow-fever vaccine can be prepared. Lim Boon-Kêng, the father of the eminent Edinburgh and Peiping physiologist Ling Ko-Hsing (Robert Lim) collaborated fifty years ago with W.B. Hardy in pioneer work on the physical chemistry of the proteins. But I need not multiply examples, I could give hundreds of them, and the public statements I have frequently made concerning the high quality of Chinese scientific and technical work have been in no way flattering propaganda, but real statements of observed fact.

The Necessity of Increased Government Support for Science

If then, firm foundations for future Chinese science and technology have been laid, as I believe they have, and quantity rather than quality is lacking, what is the most important thing required for building up science in China? It is, in a

word, financial support on the part of the Government. The proper attitude of government towards science is to realise that science, pure and applied, is the most important single factor in the raising of the standard of life of the people, the "people's livelihood" of Sun Chung-Shan, up from the mediaeval standards of the present, to the modern standards of the most advanced parts of the world. Government must absolutely avoid the "miraculous" attitude towards science, in which science is regarded as something magic which can produce miracles. Government officials, having systematically starved scientific institutions of research funds for years, suddenly hear of something new and important, such as synthetic rubber, and immediately order the scientists to produce this within a few months. When they cannot do so, they are considered no good. Not in this way have the powerful modern countries built up their scientific organisations. It was recently estimated that the United Kingdom spends a tenth of one per cent of the whole national income on scientific research, the United States about half of one per cent, and the Soviet Union just under one per cent. The point is that these are investments which bring enormous returns. The crowning example of the release of intra-atomic energy over Hiroshima and Nagasaki, which shortened the agony of China perhaps by several years, and which has such enormous possibilities for peaceful use in the future, should suffice to indicate whether profound investment in science is worth while or not.

Moreover, it is most important that no distinction should be made between pure and applied science. The former is the life-blood of the latter. To take the atomic bomb again, nothing would have been possible without the purely academic researches of Becquerel and the Curies in France at the beginning of the present century, and of Rutherford, Cockcroft and Walton at Cambridge in the years after the first world war. The only distinction between pure and applied science is that the latter is likely to have applications for human welfare in the near future, while the former may not do so for perhaps a hundred years. But, as I shall point out later, since there may be in China a tendency on the part of thoughtless people to wish to adopt the technology of the west without the science, "pure" science should be strongly emphasised henceforward in China.

I recommend, therefore, that the post-war budget of both Academia Sinica and the Peiping Academy of Sciences should be raised to at least one hundred times what it was before the war². If science in China is supported on this scale, there is nothing to prevent her becoming a leading scientific country in 25 years. Such a budget would allow of the encouragement of special sciences, such as biophysics, nuclear physics, and experimental medicine, which have in recent years made great strides but are as yet little represented in China. The same very great

(2) I refer, of course, to actual purchasing power, irrespective of monetary denominations.

increases in endowments should be made with respect to the scientific laboratories of the universities, and it should be understood (as it has long been in England) that every science professor and lecturer should carry out individual researches in addition to his teaching as a matter of course.

The Academia Sinica, which follows the pattern of the Soviet Academy of Sciences rather than that of the Royal Society or the National Academy at Washington in having a series of laboratories of its own, is, in my opinion, well planned. There is no reason, when a country is of continental size, as China is, why there should not be two Academies, and the Peiping Academy's standards are in most cases equally high. The Academia Sinica should be expected to expand - it could take over, for example, if necessary, the excellent Sericultural Institute at Tsunyi and the Geographical Institute at Beipei (hitherto supported by the British Indemnity Board of Trustees). It might well also have some closer connections with the National Institute of Industrial Research, with its seventeen departments, just as the Royal Society is connected with the British National Chemical and Physical Laboratories. This Institute, too, needs very great financial strengthening.

The same applies to (a) the National Institute of Health (Medical Research) and all research activities of the National Health Administration, and (b) the National Institute of Agricultural Research, which is doing excellent work, and to

all the research activities of the Ministry of Agriculture and Forestry. Here in particular I should like to mention certain enterprises. The Chinling Mountains Forest Preservation Service, centered in Chouchih-hsien, Shensi, is doing an excellent work of protection, afforestation and education. In many other regions such as Fukien, the great natural wealth of China's forests should be scientifically exploited and not allowed to go to waste. Even more important is the problem of preventing soil erosion, in the loess country for instance. Daily the great rivers carry away millions of tons of good land to the sea. At Tienshui, Kansu, a Soil Conservation Experiment Station has been set up and it is doing excellent work. This is the kind of institution which should receive a thousand (rather than a hundred) times the financial support which it is actually getting, if China's welfare is, as it must be, the first consideration.

I shall return later to the question of the ordinary universities; here I would like to refer to some other institutions which deserve support on a lavish scale. I have been much impressed by the work of all the sections of the University of Communications, in both its Tangshan and Shanghai sections, which for more than 40 years have been training engineers for China, and every financial support should be given to them. In the field of technological research again, the Huanghai

Industrial Research Institute, though not a government organisation, has done and is doing excellent work, and there is no reason why it should not be aided by substantial government grants. I would also like to mention as especially needing support the National Institute of Compilation and Translation. This institute has long been responsible for the preparation of glossaries of standard equivalents for the technical terms used by western scientists and technologists. Such standard technical terms are an absolute necessity for a vigorous development of science in China. But owing to lack of funds the time taken in their preparation has been rather long, so that in some cases the terms have already been obsolete by the time the glossary was published - it is therefore essential to increase the budget of this institute also by a very large amount.

I hope I shall not be expected, in this brief account, to mention all the scientific organisations which urgently need greatly increased national support. But one is indeed obvious enough, the National Geological Survey, founded by Dr V.K. Ting, and perhaps China's most internationally well-known scientific body. Although support for it has hitherto been fairly reasonable by ordinary standards, one has only to compare it with the wonderful effort made by the Soviet Union to see that the Chinese Geological Survey has really been starved. The Soviet Union embarked upon a training program which provided no less

than two thousand geologists. Working in hundreds of expeditions they have scoured the vast expanse of the Soviet Union for new minerals and previously unknown sources of old minerals, with the result that the Union has been enriched a millionfold in wealth. Indeed it is now able to boast that it contains within its borders economic sources of every element in the Periodic Table. I think it would be a great mistake if confidence were reposed in the sometimes pessimistic estimate of China's mineral wealth. It would be much more reasonable to devote funds to increasing the activities of the present Geological Survey by at least a hundred times, in the firm belief that the investment would be an excellent one.

In sum, therefore, one of the most essential things to be done if China is to take her rightful place in the modern world, is to devote at least one half of one per cent of the national income to scientific and technological research.

The Necessity for Increasing the Prestige of Chinese Science.

One of the greatest essentials in post-war Chinese science is to take some measures for increasing its prestige in the nation. We in England are in this respect fortunately situated, since the Royal Society, the oldest and probably the most famous of all scientific societies in the world, includes in its fellowship nearly all British Scientific workers of any considerable achievement, and while conferring upon them a

distinction as high as that to be obtained in any other walk of English life, is itself in a position to be consulted if necessary on all important affairs of State in which science plays a part. In my opinion the prestige of science is not yet high enough in China. A distinguished Chinese engineer remarked to me once that in the United States technical men had their reward in money, while in the Soviet Union they had it in prestige, but that in China there was neither money nor prestige for the technical man. I am aware that there are prizes given by the Ministries of Education and Economic Affairs, and that there is a "People's Livelihood Medal"; but I wonder whether it would not be desirable to institute a new "order of chivalry", citations to which should be given by the Government itself, say, through the Executive Yuan, to the most outstanding Chinese scientists. Thus for technologists and engineers there might be an Order of the Tribute of Yü, for agricultural scientists an Order of Shen Nung, and for scientists in general an Order of the Dream Pool (after the "Dream Pool Essays" of Shen Kua, probably the greatest scientific book of the Sung Dynasty). Such new orders should be accompanied by considerable publicity, and every mark of official approbation for the scientists chosen to receive them. The Chinese Ministry of Information has been rather backward in publicising the work of Chinese scientists, though on occasion it has done so, as in the case of the excellent work at Kuangsi University on natural crop rubbers -

this should be remedied in the future, and better publicity given by whatever organisation succeeds the Ministry of Information.

These measures should not be confined to pure science alone. It would be quite feasible, and very easy, to institute decorations which could be won by whole factories (as in the Soviet Union and the United States), and it would be highly desirable to make more use of industrial medals for men of the shop-foreman class, on which the running of an efficient industry so greatly depends. Some of the best enterprises I have seen in China, such as the National Epidemic Prevention Bureau's Vaccine Institute in Kunming, obviously have a good esprit de corps and this should be by all means encouraged throughout the industrial world.

Conversely, some more attention might be paid to raising standards generally by setting up registers of qualified medical men (based no doubt on that begun by the Chinese Medical Association), of qualified engineers, and of qualified scientists. Great care should be taken to scrutinise the academic qualifications of those who are appointed to posts such as technical advisory member etc. of the various Ministries.

eastern science, but only one universal human science, of which the Chinese are the inheritors equally with the west, it being but a historical accident (as I think can be proved) that modern science originated in Western Europe, China herself having previously contributed many fundamental discoveries to world civilisation.

I might mention several psychological reasons for the failure of the scholars, gentry, and bankers to appreciate science. Since science has had the effect of greatly raising the standard of life of western (or modern) countries, the idea arose in China that its main purpose was to contribute to comforts and luxuries, and hence in wartime was a luxury which would have to be done without. To this group of ideas traditional Confucianism contributed, though old-time Confucian austerity was little more than a psychological rationalisation of the poverty of an agricultural pre-industrial civilisation. How short-sighted this was I considered in my mind when I was examining the defences of Hêngyang and Kweilin before the Japanese offensive at the end of 1944, and noted that in no case had steel plates been used to strengthen the system of pillboxes and strong points. Yet a steel industry had been built up at great pains and cost in West China. Steel is not a luxury for such purposes as the national defence.

But the psychological failure of many of the officials, gentry and bankers to appreciate science springs from much

deeper historical factors. In traditional Chinese economy, the acquisition of wealth was the outcome of high official position in the bureaucracy, and the traditional way of using wealth was to invest it in land or buildings, or to lend it out at interest. The capitalist form of investment in productive industrial enterprises was not practised. This therefore needs all the more encouragement today.

I am not one of those westerners who pass moral judgments upon the "corruption" and "squeeze" so common in Chinese economic life. Westerners who do so are unconsciously affected, in my opinion, by the historical association between capitalism and puritanism in European history. On the contrary, my reading of Chinese history is that this was the way the system worked through two thousand years of imperial bureaucracy. Since the taxes had to be collected largely in kind, and since the state of communications made it impossible to remit everything to the capital city and later receive sufficient funds to cover local government expenses, the practice necessarily grew up of deducting enough for these purposes before sending the taxes up to the imperial treasury. Hence there developed the custom, universal through all ranks of Chinese society, of everyone sequestering a certain sum in every financial transaction, and it could only be expected from human nature that everyone should make it as large as was possible without causing unpleasant social consequences. There was really nothing wrong

with this system as long as everyone did it, and as long as quantitative accounting was unnecessary. But in the modern world the dollar has to be equated with the therm and the erg. There has to be intercourse with other countries which have fully adopted the quantitative accounting of capitalism or socialism.

Presumably so far as the probity of officials is concerned, there is only one obvious solution. The new system, unlike the old, must pay them in all cases a living wage, and then pursue those who still engage in the former practices with all the rigour of the law. This will be a hard transition, but it is absolutely essential for the welfare of China. At any rate, one can see why the old-fashioned minds do not care for science and technology. In designing a radio valve, the electrons cannot be cheated out of their just demands; in constructing roads and bridges you cannot be content with inferior work, for next summer's rains will find you out. If ten inches is the minimum safe thickness for the refractory bricks of a steel furnace, it cannot be persuaded to accept eight - if one tries, it will have its revenge and that quickly. In other words, the world of Nature with which science and industry deal is a world quite different from that world of slow agricultural yields and purely social and personal relations in which Confucianism flourished. It is therefore not surprising that minds of the traditional type should fail to understand the new world.

Moreover, from the standpoint of the man of wealth, who in any society is primarily interested in acquiring more, science is only one of the ways in which profits may be increased, and often not the easiest way. Under capitalism, the intensive advertising of an inferior product may be much cheaper than any scientific improvement of its quality, while under contemporary Chinese society, investment in land or the setting up of new banks (very prominent in some Chinese cities during the war) may be easier ways of making money than truly productive industrial enterprises. The government, therefore, should have a program for the fostering of science and the industrialization of the country based on a broad recognition of the human needs of the people and the safety of the nation, and it should be prepared to exert some pressure on the wealth-owning groups to induce them to participate in the program.

This is not the place for an analysis of the causes for the terrible decay of heavy industry in Free China during the later stages of the war (even if I were capable of making it) - doubtless it was due to the monetary inflation, and could not have been avoided. But there can be no doubt that it was very bad for the morale of the Chinese technologists, who had given all possible skill and hard work towards building up industry in the western provinces, only to see it wither in the bud to 30% of its production capacity or less. What is much more worrying is the fear that the recovery of all industry throughout China will be delayed or indefinitely postponed unless

modern-minded, industrially-minded, men are placed in control. And moreover, unless this is done, the large industrial accessions which the circumstances of the ending of the war have mercifully brought intact into Chinese hands, will not be properly exploited.

The exact economic structure which China ought to aim at is of course a very great problem which is rather outside the scope of this report. I often question, however, whether it is necessary for China to retrace all the steps in the weary road of the development of capitalism in Western Europe. The proposals of Sun Chung-Shan that heavy industry, mining, power production and all communications should be owned and operated by the State, while light industry should be left for individual enterprise, seem to be an excellent compromise. Under the new Labour Government in England, we are coming to a somewhat similar compromise ourselves.

If China is suffering, as I suggest, from a traditionalistic psychology on the part of many politicians and officials who do not appreciate or understand the sciences and industry, this is not a phenomenon peculiar to China. Even in western Europe and in England, we also have long suffered from a ruling class trained wholly in classical learning and out of touch with the changes which science was bringing to the people's livelihood. The problem is no doubt graver in China, since capitalism is a much more recent growth, and the former system of bureaucratic feudalism so old and deep-rooted.

During the war I have noticed a number of instances which indicated a failure of the government to appreciate the needs of technology. There were many things which could probably not have been avoided. Thus the planning for the production of motor fuel substitutes, involving the operation of a number of low temperature coal and lignite carbonisation plants, was as a whole excellent, and if we had not one single high temperature carbonisation plant in the country, this was doubtless due to a loss of the equipment at Hanoi and Rangoon successively. Yet the case of the Academia Sinica's small hard-glass plant was one which showed lack of appreciation of the needs of science and technology even engaged purely on war work. This plant was the only one in China which could make Pyrex and Jena glass, a substance absolutely essential in chemical analysis; from Shanghai it was evacuated to Kunming and then after being bombed, to the country near Anning. But it still worked. It did not close down until forced to do so for financial reasons in the winter of 1943-4. Yet this was a key industry, very small, but essential for the functioning of the sciences both pure and applied.

I cannot feel that there are, in the most important Ministries concerned with Science and Technology, enough technically trained men; or else, for some reason, they have much less influence than their bureaucratic colleagues. For example, the Lunghai Railway locomotive repair shops at Baochi

have done a wonderful job in keeping the railway running during five years of isolation; fighting the water which eats away the staybolts, the sulphur-containing coal which eats away the fire-boxes, and the vegetable oil which deposits large lumps of carbon in the cylinders. They have been lacking in all normal supplies. For making their Babbitt metal they have been forced to buy old kettles from the town and melt them down in order to obtain the necessary tin. But how is it that this can happen in China, one of the greatest tin-producing countries in the world? I have seen thousands of ingots in Yunnan and Kuangsi, only one of which would have sufficed for the needs of the repair shops in Shensi. Yet in spite of repeated applications to the Ministry no tin was ever forthcoming.

A comment which is made by every technical expert who visits China is that all Chinese organisations are overstaffed with bureaucratic personnel, unskilled labourers, business staff, and the like. River steamers carry crews much larger than necessary. Universities and hospitals are burdened with needless officials. Thus the National Central Medical School in Chêngtu has 300 employees, but only 80 of these are scientific and technical (30 professors and 50 assistants of excellent quality); the balance is made up by secretarial staff. Thus in the attached Hospital the Cashier has 4 assistants, the Treasurer 5 and the Secretary 6. This may be a method of disguised unemployment benefit for refugees and others. Or it

may be considered a relic of the family system. While it will doubtless disappear as the processes of industrialisation and opening up of new natural resources go on, it imposes at present a severe strain on scientific institutions which need every dollar for equipment and apparatus. Measures ought to be taken to shield scientific and technical organisations from this burden.

Numerous are the ways in which a backward-looking and timid political mentality injures the growth of science in China. In the first place there is the question of mass education and mass enthusiasm. Party politicians seem unduly nervous of mass education, yet I remember an old and eminent American engineer, who had had close personal experience of the Russian Revolution, telling me that one of the outstanding features of the Soviet industrialisation process had been the enthusiasm of the mass of the people for it. Of anything similar he saw now little trace in China. The mass education movement indeed gives the impression of a force which has burnt itself out. In my travels, having occasion sometimes to stay a few nights in some small town, I have examined the Popular Education Hall in some old temple, with racks for newspapers, but no newspapers on them, a library but no books in it, etc. etc. It does not seem that the Ministry of Education's war-time adult education program has been very successful either. Young teachers have not been able to inspire old farmers, and

funds have been lacking. I suggest, therefore, that mass education in science and technology, with a view to interesting the people in the industrialisation program, should receive much more government attention than hitherto, and that any political hesitations should be overruled.

Within the universities also there are undesirable political interferences with science. The government should take a lenient view of the case if the social opinions of some good scientists should be found to be unorthodox. This is our practice in England, and I think China can much less well afford to throw away a good scientist than England can. Dismissal of scientific professors for causes nothing to do with science is a suicidal policy for any government which wishes to encourage science in China.^(*) The same applies, of course, to students. Indeed, it must be said that there is a direct connection between science and democratic freedom of thought. This is seen throughout the history of science, and nowhere better than throughout the course of World War II. The Nazis and Fascists started the war with a much more highly developed application of science to warfare than the Democracies; they had perfected

(*) There have even been cases in China (and one quite recently near Chungking) where high-ranking scholars have been arrested and held incommunicado for long periods by the police on quite inadequate grounds; doubtless without the knowledge or approval of the highest organs of government. Such "disappearing professors" produce the most lamentable impression abroad. One must remember that policemen are proverbially stupid, and the less they have to justify their actions to the public in open courts of law, the more stupid in carrying out their instructions they are likely to be.

the use of tanks and bombers, and had introduced such devices as the magnetic mine. But the more the war went on, the more they were overhauled and finally passed by the scientists of the Democracies. It was not the Axis powers which developed radiolocation (radar), penicillin, shaped plastic explosives the Norden bombsight, the Leigh light, the Bailey bridge, the proximity fuse, but the use of magnesium in airplane alloys, and finally, crowning instance, the intra-atomic energy bomb. It has, in fact, recently been revealed in the testimony before the Senate Committee (U.S.) on Science Legislation, that the Germans abandoned all basic scientific research between 1940 and 1942 because they thought they were winning easily without it. From this terrible mistake they never recovered, in spite of considerable developments in submarine technology and in the indecisive field of rocket weapons. The Chinese government will be well-advised to prepare henceforward for a considerable measure of freedom of thought in the Chinese universities, for only in such an atmosphere can science and technology flourish.

Minor causes of damage to science from political quarters may be seen in the "capture" of certain specific scientific posts by specific political groups. A man may thereupon be introduced to such a post, not because his scientific training qualifies him for it, but because that particular group had been responsible for financing his study abroad. Or for reasons

which are quite non-scientific, a new institute may be created, though the funds available are quite insufficient either for staffing or equipping it. This leads to the vice of "sign-boardism"; gates with important-looking inscriptions on them and very little within; institutes existing mainly on paper.

One of the most extraordinary bureaucratic capers which I have come across is the practice, which I understand is fairly widespread in the smaller organisations, of packing up the entire equipment of a laboratory into crates when a change of directors is taking place so that the incoming official will not be able, without great difficulty, to take note of any losses, breakages, or deviations from the inventory. Such a procedure, with its consequent interruption of scientific work, would be unthinkable in any modern country.

Finally, I might refer to the intrusion of misplaced national feeling into sciences such as pharmacology. The facts are that modern medicine is a system based on modern science, and that the traditional Chinese medicine (like all traditional empirical arts) is very inferior to it, and very unreliable. Nevertheless there are undoubtedly some valuable things in traditional Chinese medicine which have not yet received scientific explanations. Probably one in twenty of the drugs in the Pên Tsao have true pharmacological activity, and one in forty ought to have a place in the world pharmacopoeia. But a misguided nationalism seen in some Chinese officials

desires us to believe that the traditional system is overall better than modern medicine, and employs scientists to prove that the traditional drugs are efficacious. If they do not, so much the worse for them.

It must also be said that a contemptuous attitude towards science is found in the army as well as among politicians. I have no difficulty in finding instances. The Kweichow Science Institute at Kweiyang was wrecked, not by the Japanese, but by the quartering of Chinese troops in it. The Shensi Provincial Industrial Chemical Laboratory was forced to vacate its well-planned and equipped building to accommodate American troops and interpreters, but when they recently left, Chinese troops took it over, although the war had ended, and all protestations through the Provincial Government and its Bureau of Reconstruction, were of no avail. Similarly, also in Sian, the First Branch of the Army Medical College was forced to accept buildings of an extremely poor and mean description, and there in the small room serving as a Physics Laboratory I saw how the professor had to have a hand-turned dynamo supplying current, while the bacteriologists were unable to use their centrifuge and incubator, although every petty merchant's store and tea-shop in the city had electric light. This is not the way to make China a great nation.

From this criticism of a military attitude often seen I exempt the Chinese Air Force. I have been deeply impressed by

the Experiment Station of their Research Bureau at Chêngtu.

I consider that it did magnificent work throughout the war.

There is a further consideration of great importance on the borderline of political life and science. Many of the most important benefits which applied science can confer on the Chinese people can only come as the result of a strong and sustained government policy operated over a considerable period of time. I have in mind the whole soil conservation program, for instance, to which so much has been contributed by Dr W.C. Lowdermilk; the staunching of that continual drain of China's soils down the great rivers which gives its name to the Yellow Sea. Great works of afforestation, such as have been conducted by others in Manchuria and Korea, great works of water-catchment and irrigation, such as could be made at the foot of the Nan Shan, require for success a political stability, one of the contributory causes of which would be a true appreciation of the worth of these works themselves. There are many other such plans on foot. There is the question of strengthening the dairy husbandry of China. Nutritionists are agreed as to the value of the addition of milk and milk products to the Chinese diet, and agriculturists know how vast the areas are in Kansu, Chinghai, Sikang, and Kweichow which would be suitable for this kind of farming - but everything depends on stable conditions in which planned development may proceed. So also with the great

possibilities of S. Shensi and S. Kansu as fruit growing and canning areas.

A Special Ministry for Science and Technology

What has just been said about the necessity of political stability for planned development leads to the question of whether there could not be a special Ministry set up to take care of all governmentally organised research.

What I have in mind is the following. In the United Kingdom the principal research organisations of the government are independent of their corresponding ministries. Thus the Medical Research Council is not a part of the Ministry of Health; the Agricultural Research Council is not a part of the Ministry of Agriculture and Fisheries; and the Department of Scientific and Industrial Research has nothing to do with any Ministry. They all have the status of sub-committees of the Privy Council, a body with a long history which was originally the meeting of the King's counsellors, and they are responsible to Parliament not through any ordinary cabinet minister but through the Lord President of the Council. This system has the very great advantage that long-term research projects are not subject to political interference which might result from short-term political changes. While in the United States the government research organisations have to a large extent been safeguarded from the "spoils system", the British plan renders their continuity more effectual still.

One wonders whether the planning of science in China could derive any help from this. Suppose that a special ministry or commission for scientific and technological development were to be set up. Under it would come the National Agricultural Research Bureau and all provincial agricultural research activities, the National Bureau of Industrial Research and all similar work, the National Geological Survey, the National Institute of Medical Research, the National Institute of Compilation and Translation, etc. etc. It would have to work in very close connection with the universities through the Ministry of Education, and with the two National Academies. In order to ensure its isolation from ever-changing politics, it might conceivably stem, not like all other ministries and commissions from the Executive Yuan, but from one of the other four Yuan. I hesitate very much to make any concrete suggestion here, but the Examination Yuan must have had historically a close connection with learning and scholarship, so that the requisite conditions might be forthcoming from an association with that. This suggestion may, of course, be impracticable.

In any case, the main point is that some machinery might well be considered which would amount to a "Ministry of Scientific and Technological Development", so arranged as to be independent of all fundamentally executive departments, and therefore able to carry out long-term research without danger of political interruptions.

The Ministry of Education and the Overseas Study Program.

The next subject on which I wish to touch is the Ministry of Education. Such an organisation may be a necessity in China, but I think the feeling on the part of most of the British scholars who have visited China in recent years has been one of thankfulness that no such organisation is necessary in England. Even without in any way wishing to do so, such an organisation can hardly but exert a blighting influence on the variety and freedom of thought in the universities. However, the only specific criticism which I have of the Ministry is that it does not seem to have a sufficient staff of first-rate scientists who understand the needs of science in the universities. I would recommend that some attention should be given to this point as part of the general program for the furtherance of science in China during the reconstruction period. For example, those who are not themselves scientists cannot appreciate the needs of university laboratories for equipment. Even in the best universities such as the National Southwest Associated University this has been in recent years very poor, and in the more remote ones, such as the Nat. Northwestern University or the National Kweichow University almost non-existent.

I understand that the Ministry also exercises a censorship function on scholarly works produced by university professors. During the war this may have been desirable as a safeguard against the publication of second-class work, but I consider

that it is much to be deprecated in normal times. It is, in my opinion, much better to let university professors publish quite freely. Afterwards, through the medium of the book-reviews in the scholarly and scientific journals, justice is done upon scholars by their peers, and every work, whether good or bad, finds its own level. Government censorship, even in the interests of learning, is open to grave abuses and should be discontinued.

The question of the relations between the Ministry, the National Universities, and the Private ("Christian", or "missionary") Universities, hardly comes into the field of this Report. If I were to say anything on this subject, it would be that while I have no particular interest in the specifically religious side of these private foundations, I must state that some of them, particularly Yenching University, Fukien United University, and formerly Lingnan University, were (and doubtless again will be) of a distinctly high level scientifically, and that West China Union University has done a great deal for medical science in West China. From the scientific point of view, therefore, they should not be neglected or ignored by the government. On the general principle of state vs. private universities, I am of opinion that it is very desirable to have a certain number of private universities, just as is the case in the United States, where California has both the State University of Berkeley, and the Private

University of Stanford. This acts as a safeguard against undue political interference which might occasionally occur, and tends towards greater variety and freedom of thinking. Fortunately, in England, our universities (anciently religious foundations) are neither "private" nor "state". While the Government exercises no day to day control over their activities, such as a Ministry of Education would, it furnishes them with large funds annually, administered through a special Government Grant Committee. The real control occurs only every twenty years or so, when a Royal Commission on University Education is formed, and proceeds to visit each university in turn, taking evidence on all relevant subjects. Finally it promulgates its findings, and its decisions subsequently have to be adhered to. It would be a matter for thought whether in China also some such system of more remote control might not be advantageously substituted for day to day control, since it permits of longer periods in which the running of this or that piece of machinery or policy can be studied.

It may be said that in England we do have a Board of Education and that its name has recently been changed to Ministry. This is true, but one must remember that the main function of the British Education Board is that of supervising and inspecting schools, not universities; lower education, not higher. It preserves standards by approving textbooks and teachers. But it does not even have the right of election and

dismissal; this is held by the decentralised Education Committees of every town and county, and they may emphasise any political complexion so long as the academic standing of the teachers is up to the Board's requirement. Still less does the Board (and therefore the government) have any voice in the appointment of university professors; this is accomplished by Boards of Electors set up by the University in question and constituted largely of the leading scholars of the subject in question, many of whom may be professors of the same subject in other universities. In general a university is self-governed by a Senate elected from among the whole teaching faculty, and this in effect appoints a President. The Board of Education is not concerned.

I think it would be very worth while for a small group of Chinese educationalists to go to England specifically to study our democratic university system, the details of which are rather complex, and it would then be well worth considering carefully what steps could be taken in China towards the freeing of the Chinese universities from bureaucratic dead weight. Such a mission would, I am sure, be most warmly welcomed, and I would do my best to give it all the aid in my power.

Before passing on to the question of foreign study for advanced and post-graduate students, I would say a word on the question of the health of boys and girls at school and of students in the universities. This is, of course, only one

aspect of the general level of health in the country. According to my experience, it is extremely low. Preventable diseases such as trachoma, scabies, and various affections of the skin and scalp are almost universal. Tuberculosis takes a very heavy toll of university students, while the army is riddled with nutritional oedema and dysentery. Elephantiasis and every kind of parasitic infestation is found. On such a basis how is it possible to obtain good education and good scholars? In spite of all that the National Health Administration has been able to do through the war years, the fringe of the problem is hardly yet touched. And all this is at a time when even such dreaded diseases as bubonic plague and cerebro-spinal meningitis, to say nothing of septicaemia, cholera and typhoid, have been completely conquered by the sulpha-drugs and the newer anti-biotics prepared from moulds, such as penicillin. It should therefore be one of the first concerns of the Chinese Government to set up large-scale factories in the best-industrialised areas for making sulpha-drugs and antibiotics on a scale commensurate with the vast needs of China's great country. These medical aids should then be distributed to the people through an improved network of government health stations, of which there should be at least one in every hsien city. A Ministry of Education may well meditate upon the untold losses of potential talent through disease in childhood and adolescence.

With the policy of the Ministries of Education, Communications and Economic Affairs of sending large numbers of students abroad for periods of study I am, of course, in the most cordial agreement. The numbers of these should be counted in thousands rather than hundreds, up to the highest limits which the western countries can be persuaded to take. The outgoing personnel is, of course, and should continue to be, of many kinds, e.g. professors revisiting the west for refresh-er periods of research, young research workers going to complete their research experience and gain the Ph.D. degree, young technologists going to obtain works practice, and last but not least, the very important group of superior foreman types. This last group deserves particular attention, for China is even more deficient in shop foremen than in trained engineers. Here the language difficulty is acute, for such men can hardly be expected to have had sufficient education in foreign languages. Provision should therefore rather be made for intensive training of such men within China by specially invited foreign technical training experts, who can lecture and demonstrate through the medium of interpreters.

Returning to the higher academic groups, it will, in general, be better to send young scientists to be the pupils of great men individually, rather than to cultivate special sciences in the abstract. The great scientific traditions of

the west have generally been handed down personally from one generation to another, and the results have usually been best in my experience, where Chinese scientists have been the inheritors of specific personal traditions, such as those of Rutherford in physics, Conrady in optics, Spemann in embryology, or Morgan in genetics. From time to time also, some of the most eminent western scientists should be invited to spend a period of work in China.

I suppose it is understood that after the war there will be a big drive to improve the foreign language, especially English teaching in the Chinese schools, I understand that before the war the standard of this teaching was much higher than it was when I had the opportunity to observe it. It cannot be too much emphasised that the industrialisation and modernisation of China depends upon that manifold intercourse with the rest of the world which only a thorough knowledge of at least one other language besides Chinese can give. The part which the simplified "Basic English" can play here as an international language is not quite clear, but deserves attention, and I should also like to refer to another, more recently proposed, international language, "Interglossa", which is composed entirely of Greek and Latin roots (so well and widely known as the basis of all scientific technical terms) and Chinese grammar. In this connection, I consider that an urgent need for the Chinese student is a handy glossary of the most

important Greek and Latin roots with their equivalents in Chinese. This would reduce the strain on the memory. One can see from typescripts made by Chinese that they usually have no idea of the origin of Technical terms derived from Greek and Latin because they do not know where to insert the hyphen when dividing a word at the end of a line.

I think I need hardly say that the plan, believed to be entertained by some politicians, of despatching to each western country an official explicitly or implicitly charged with watching over the political ideas of the students sent to that country, will not prove acceptable to those western countries whose assistance is desired. A university dean once said to me "The Government does not want to train good scientists able to think for themselves, nor even good technologists; it only wants party followers with a technical smattering." I am sure he was being much too pessimistic. In politics it is just as it is in theology. I remember years ago arguments in England as to whether theological colleges should be located within the great free-thinking universities or not. The best conclusion was that the man who has carefully considered all the other possible systems of theological or political belief, and still adheres to his own, is the only ultimately reliable supporter of that system. If the great party of Sun Chung-Shan wants keen and faithful supporters, it will not get them by the methods of fear, but only by free enquiry and rational conviction.

It is to be hoped that China will not have to bear alone the whole financial burden of the training of the thousands of scientists and technologists which she needs. I am glad that during the past two or three years, the British Council has invited about five professors and forty students annually, and that besides these fellowships, there have been others given by the Federation of British Industries and ad hoc bodies such as the group of British pharmaceutical firms which recently gave eight special travelling fellowships. No suspicion of "educational imperialism" now attaches to such help. If formerly it was thought that Ruritania-trained students would, on returning to China, insist on using only Ruritanian products; the situation now is very different when it is agreed on all hands that China must instal, and be assisted to instal at the earliest possible moment, all the equipment necessary for making the products of modern civilisation herself.

The American State Department and other institutions such as the Rockefeller Foundation are participating in the training program on a large scale. Now that the Sino-Soviet Treaty has been approved it is much to be hoped that many Chinese scientists and engineers will be sent, and will be invited, to the Soviet Union, which in the vast extent and grandeur of its industrialisation has much to offer which cannot be obtained from either the United Kingdom or the United States. In view of the long common frontier with the Soviet Union, and the

complementary nature of Soviet and Chinese economies, there should be a complete reversal of the suppressive policy towards Russian language teaching which has prevailed in recent years,² and a big effort should be made to encourage it. One might also suggest that more use should be made of the Dominions in the British Commonwealth. There are great experiments on drought and forest areas, and in mining, in Canada, while in Australia an exceptionally striking participation of science in all phases of the national life has been necessitated by the special difficulties of agriculture in that country. India also has much help to give to China, and from my personal acquaintance with Indian scientists I know how willing they will be to give it.

The whole question of sending men abroad to bring back knowledge and experience for the modernisation of China involves consequences almost philosophical which require mention. A rather common conception is that embodied in the following quotation from a speech made by an eminent Chinese politician:-

"The civilisations of China and the West are different in their origins and different in their achievements. In no sense is Chinese civilisation generally inferior to that of the West; it merely happens that at the present moment we are deficient in natural science and the making of machinery; that is to say, in material culture; it is in this respect alone that others are ahead of us, and consequently it is

(2) I knew personally of a case in which a young scientist associated with one of the best Chinese Universities, was imprisoned because he had a Russian dictionary sent to him through the post. Though ultimately released, he did not get his dictionary back, nor could the police be made to apologise.

upon these matters that the emphasis should be laid when determining the object of sending students abroad. We have to repair our own deficiencies by acquiring the strong points of others. As regards spiritual culture, what we possess is already far superior to that of other people, and there can be no question of our going to study theirs, nor must we bring theirs back here and try to apply it in China. In so far as we learn from them on the non-material side, we must confine ourselves to those methods of scientific control which lead to the development and progress of industry, in order to be guided by them ourselves. These are the major premises that we must have in mind."

I find myself in complete disagreement with this conception. It assumes, as I said above, that science can be accepted by China, not as the supreme transformer of man's whole world-outlook, but as the mythology accompanying a useful set of techniques. This idea is untenable. Moreover, modern science cannot be fully understood without understanding the social setting of European civilisation in which it took its rise. It necessitates, therefore, some understanding of Greek philosophy and Roman law. To fail to see this is to make just as big a mistake as the Westerners who firmly believe that China's purely agricultural civilisation was a product of the people rather than the environment, and that the Chinese never made, indeed were incapable of making, any contributions to the history of human discovery and invention. How absurd this is, the facts of the discovery of gunpowder, printing, and the compass may show. These three discoveries were most appealed to at the time of the Renaissance in support of the developing idea of Progress, of the view that the Moderns were better than the

Ancients. Yet these three discoveries were all Chinese, not European. Conversely, the idea that Confucian social philosophy is a full and sufficient doctrine for China, having little relevance outside her borders, is also an illusion. Confucian social philosophy, introduced to Europe through the Latin translations of the seventeenth century Jesuits, deeply affected European social thought, especially by its Pelagian belief in fundamental human goodness, and by its Mencian statement of the people's right to rebel against tyrants. Incorporated in the social philosophy of the Encyclopaedist and Enlightenment periods, it paved the way for the French Revolution, and hence became one of the foundation stones of that body of progressive and democratic social thought which the Axis in our time wished to destroy but could not.

The fact is that despite all narrow nationalisms mankind forms one family. Euro-American social philosophy (for is there not a direct line of descent from Aristotle to Jefferson and from Anaxagoras to Paine ?) can be no monopoly of the Euro-American peoples, and Chinese social philosophy is no preserve of the Chinese. All peoples of the earth have the right to participate in the whole human heritage. Hence, as I think, the Chinese Government would do well to encourage the more socially relevant forms of Sinology in the West, when opportunity arises, in order that knowledge of Chinese achievements in the history of thought may be more widespread. And far

from trying to use modern science as a tool without regard for the social setting in which it grew up, the Government should encourage Chinese students to acquaint themselves as fully as they can with the whole history of thought in the West.

Scientific Societies and other Organisations

I have now spoken both of the great research institutions and of the universities; it remains to say something about other organisations which are quite important for the growth of the sciences and technology in China. I do not feel that the specific Scientific Societies have so far been sufficiently supported and encouraged. Yet in the west they have been powerful instruments in the development of science. In China they have already reached high standards, and have published journals of high quality, such as the Chinese Journal of Physiology, edited by Gen. Robert Lim. During the war, the quality of publications such as Sinensia (the Journal of Zoology edited by Academia Sinica), Science Record, the Journal of the Chinese Chemical Society, and the Meteorological Magazine, has been remarkable having regard to the difficult conditions of their preparation.

These societies urgently need accommodation for central offices, meeting rooms, and libraries, such as the British Chemical Society has in London, and a government wishing to encourage science would pay attention to the question of

assistance in providing them. Government grants of funds to help them in the reconstruction period would be highly desirable.

It is most important that the regular publications of these societies (as also of the universities) should be sent abroad systematically. In the past there has been too great a modesty on the part of Chinese scientists in this matter. Even when the journal is published wholly in Chinese, the presence of Chinese students in the West affords plenty of opportunities for having any articles of special importance translated into Western languages. However, it is greatly to be hoped that the practice of publishing a journal entirely in Chinese will cease as soon as possible. A scientific or learned journal ought at the very least to have a translation of its title, and the tabulated list of contents, on the front page. If possible, each contribution should also have a summary in one or other of the Western languages. During the war, the omission of all translations of titles has been excused on the ground that there were not enough printers in Free China who could set alphabetical type - in peacetime there will be no excuse. To publish in a language which the main body of the scientific world cannot understand is a contradiction in terms and the very stultification of nationalism. At the same time, I am in favour of the wider use of Chinese as one of the great world languages, as was done in the versions of the United Nations

Charter, and consider that steps should be taken to have Chinese abstracts prepared and published by international scientific organisations and congresses. The statement of this view will suffice to indicate that I see nothing wrong with the Chinese language as a logical instrument for the presentation of scientific statements (always providing that the necessary support is given, as advocated above, to the Nat. Institute for Compilation and Translation).

Besides the societies so far mentioned, there are some, such as the Science Society of China, and the Chinese Natural Science Society, which have interested themselves in spreading the knowledge of science along broader popular lines, and these should be very greatly encouraged, by substantial government grants or otherwise. Like the famous British Association for the Advancement of Science, they have played, and should increasingly play, a most important part in the development of science.

Here we have touched on scientific and technical popular education, as I did further back in connection with the mass movement for industrialisation. I have been very pleased with the general idea behind the several Provincial Science Institutes. These institutes forward popular education by wall newspapers and by the preparation of museums and exhibitions, and they embody workshops where scientific apparatus is made for schools

and colleges. The Kansu one at Lanchow seemed to hold the greatest potentialities, the Kuangsi one at Kweilin made the best apparatus, and the Kweichow one at Kweiyang had (until its destruction by quartering of Chinese troops at the end of 1944) the best and most instructive exhibitions. Unfortunately I failed to see the Fukien one at Shahsien. I recommend that every effort should be made to assure the expanded functioning of these institutes, of which there should be at least one in every province.

This brings up the question of provincial activities in science generally. I was deeply impressed by the progress made in Fukien province, where, under the earlier guidance of Gov. Chen Yi, a special Provincial Academy of Sciences had been set up. Although at the time of my visit it had been starved of funds, and was only just managing to get along, the idea was quite sound, and this was apparently the only province which had made such an initiative. Naturally, what I said above concerning the enhanced support which Academia Sinica and the Peiping Academy ought to receive, is also applicable to this and to any other Provincial Academies which may be founded. I was also impressed in Fukien by the excellence of the Provincial Meteorological Service (the best I have seen in China), the Provincial Geological and Soils Survey, and the Provincial Pinewood Root Oil Motor Fuel Cracking Factories (a most outstanding achievement of wartime improvisation).

Other provincial activities which especially impressed me were the Bureau of Reconstruction of Kansu province; the Bureau of Education of Szechuan province, with its excellent scientific apparatus factory at Supochiao near Chengtu; and the provincial Agricultural Experiment Station of Kuangsi at Shatang near Liuchow.

Lastly I wish to say a few words about a matter which could naturally not have a high priority during the long years of war, but to which serious attention should now be given. I refer to the preservation of ancient monuments. No country in the world has a more magnificent inheritance of evidences of antiquity than China. Yet little or no interest is taken in them. When I visited Tunhuang's famous painted cave-temples at Chienfotung in 1943 I found that nothing was being done to preserve them; Tang tiles were scattered everywhere and used for improper purposes, the painted plaster was falling down in large pieces and not being collected in the museum, and anyone who came was allowed to roam at will while the policemen made a meagre living by taking rubbings of inscribed stones for sale. I reported to Minister Chen Li-Fu accordingly, but the last news I had was that even the temple which his Ministry maintained there as a "research institute" had been closed. Other famous sites such as Yunkang are believed to be no better off.

But it is not only famous sites about which I feel concerned. Every hsien city of this great country has a Confucian

temple which enshrines the greatest of Chinese intellectual traditions. I remember particularly the beauty of those at Chienkung in Yunnan and Yungchang in Kansu. But everywhere they are decaying and mouldering. At Sian itself, the Tang capital of Changan, the Confucian temple has been wrecked by the quartering of soldiers, and the terraces of the central shrine of the sage itself, with all its beautiful carving, are today polluted with ordure. This is a disgrace to the nation.

The remedy is not difficult. Let a National Commission for the Preservation of Ancient Monuments be established as soon as possible, in close connection with Academia Sinica. Let it be staffed with archaeologists and scholars, not politicians, and provided with both adequate funds and publicity. Within a few years excellent results will accrue. One should not forget that under quiet conditions China could work up an important tourist traffic. Why should travellers visit the pyramids or temples of Egypt when they could visit the Nestorian Stone at Sian or the carved Buddhas of Yünkang?

Similarly liberal financial support should be given to the National Museum, now still languishing in its evacuation retreat at Lichuang. No one would dispute the justice of the view that the Tunhuang manuscripts, bought by Sir Aurel Stein long ago when the Hanlin Academy was dead and Academia Sinica not yet born, should ultimately be returned from the British Museum to Chinese keeping. But western scholars will be more

ready to agree to such a transfer when the Chinese Government shows by its actions a genuine and sincere regard for the welfare of its own great monuments of antiquity.

Moreover, if the as yet undiscovered antiquities of China are not to remain for ever hidden, if Chinese archaeologists are to take the place they deserve among the archaeologists of the world, Academia Sinica must as soon as possible be furnished with sufficient funds and facilities to undertake again extensive excavations. The Anyang investigations deeply affected our knowledge of world history. But why has no systematic investigation of the prehistoric sites in Kansu been made, or of the Han city of Changan, or of the Chou tombs near Hysienyang and the Sui tombs near Wugung? The importance of Chinese archaeology for world history is so great that the Chinese archaeologists ought to receive the fullest support of their government. Moreover, all those who have served as Chinese Ambassadors in western countries will bear me out regarding the prestige which China gains from her art and archaeology.

Industrial Organisations and Industrial Welfare

In the industrial field my experience of the factories under the National Resources Commission and the arsenals under the Army Ordnance Administration has been uniformly excellent. Often have I been amazed at the continued effort which has been

devoted to constructing and operating a highly complicated plant in some remote part of the country, a task frequently rendered more difficult than ever by the necessity of conducting so much of the work in underground air-raid protection tunnels. I found that one could always depend upon finding good organisation in such factories and arsenals, and as high a level of technique as the situation permitted. The fine work of the Kansu Petroleum Administration also deserves a special mention.

I was deeply gratified to find that in your book "China's Destiny" you expressed yourself as determined to put into practice as soon as possible the bold plans of Sun Chung-Shan for the improvement of communications, especially railways. It may be a commonplace observation, but I have been deeply impressed by the difference which even one railway makes to the atmosphere of an entire province - one may compare Hunan and Kuangsi for instance, with Szechuan and Kweichow. It is obviously imperative that all the western provinces be linked up in the general railway system at the earliest possible moment. This means completing the Kunming-Kweiyang-Chungking-Chêngtu line, and constructing a line from Chêngtu by Kuangyuen to Lanchow, linking with the Lunghai Railway at Tienshui just as the former line will link with the Chienkuei Railway at Kweiyang. I am looking forward very much to returning to China twenty years

from now and travelling all over west China by rail. If the Lashio-Yunnanyi-Kunming railway is completed, as I trust it will be, it will be possible to travel from India or at least from Burma to Peiping by rail. No doubt the through-passenger function of these railways will, in the coming days of air travel, be restricted enough, but the important point is that until rail communications cover west China, the operation of the factories and the exploitation of the economic minerals in these provinces cannot be profitably carried on.

It ought to be possible to utilise the water-power of the western rivers, such as the Mekong and the Salween, and it would be desirable to erect beside the power stations plants of considerable size for atmospheric nitrogen fixation, so that fertiliser would be available for the fields of the Szechuan basin and further north from a source much nearer than the coast. I think all opinions agree as to the necessity of abundant fertilisers for Chinese agriculture, which, by raising the productivity per man power, will release a portion of the population for industry, and hence for payment for imports.

The Savage scheme for the damming of the Yangtze in the gorges has fired the imagination of the technical world, and it is greatly to be hoped that means may be found for financing this enterprise which would give China the largest electric power plant yet built, provided that other more evenly spread items of industrialisation were not starved of capital thereby.

It is a great question how far Chinese industrialisation need follow the characteristic Western patterns based primarily on the iron and steel industries. Historically, English stocks of coal and iron were very large relative to the size of our island and its population, and later the stocks of coal, iron and oil available in the United States were found to be enormous. But though China has iron and coal of inferior quality scattered in relatively small amounts in every province, her only really large coal deposits are the as yet unworked ones in Shansi. Nearly $\frac{4}{5}$ of China's potential coal resources are in Shansi, adjacent to parts of Honan and Shensi. The Shansi coal-field is one of the greatest in the world and contains both anthracite and bituminous coal of good quality. The Manchurian supplies (principally round Fushun) are much more developed, owing to historical circumstances, but are relatively small. The iron-ore of Manchuria, on the other hand, is abundant, though not of very good quality and the adjacent part of Inner Mongolia (Chahan) has also extensive supplies. Nevertheless, in relation to the total area and population of the sub-continent, the supplies are probably less than those of Europe and the New World.

This position, however, is not nearly so serious today as it might have been fifty years ago. At the present time, aluminium and magnesium have become almost as important as iron and steel, owing to the rising dominance of air transport; and

for a great variety of uses plastics (some of which have tensile strength equivalent to that of steel) may advantageously be substituted for the ferrous metals. Recent researches show that China has large reserves of aluminium (bauxite) in Yunnan and Kweichow, and Manchuria has been the world's third greatest magnesium producer. Plastics, again, may be manufactured from all kinds of agricultural products and even waste, and are therefore particularly suitable for potentially vast Chinese industries.

In this connection great care should be taken to utilise to the full the natural products of the country, and here mention may be made of the work done during the war by the Chinese Air Force Research Bureau Experiment Station, which, making use of the extraordinarily high tensile strength of bamboo, has built powered airplanes of bamboo to 80% by weight, and gliders to 95% by weight. While methods of this kind would probably not suffice to produce large freight transport or passenger planes, they might well produce large numbers of small passenger planes or seaplanes suitable for short flights linking up the country in a network of airlines. In the same category comes the soyabean as a raw material for the plastics industry.

A special word "chemurgy", has been invented for chemical industries dependent on the growing of special crops. The most outstanding example of this is the production of rubber from

crop plants and not from the rubber tree, which has been very successful in the Soviet Union and the United States, and has been pioneered in India and China. But there are many others. China's predominantly agricultural background should strongly favour a transition to industrialism along these entirely new lines.

Some processes, of course, which were prominent features of Euro-American industrialisation, must also form part of that in China. Such, for instance, is the coal tar industry, the high temperature distillation of coal or lignite, without which there can be no benzene, and hence no basis for a great organic chemical industry.

Advantage will naturally be taken of the high position occupied by China in the production of certain minerals (highest world producer for tungsten and antimony, second highest for tale and fourth highest for brine products and tin). There are, moreover, many promising resources hardly as yet at all exploited with modern techniques, such as Sikang gold and mica, Yunnan copper and lignite, Kweichow mercury, Chinghai borax, and Kansu and Szechuan oil.

While in general I adhere to the usual concepts of planned centralised industrial development, I think also that there should be for a long time to come some scope for the activities of the Chinese Industrial Cooperatives, an organisation which does not seem to have had all the support it might have had

during the past few years. The remoter areas can thus be supplied with consumers' goods in such a manner as to utilise all available local talent, and in conformity with the family system. In border areas, too, where the Chinese agricultural meets the nomadic pastoral economy, cooperatives would be particularly helpful. The Baillie Schools (technical schools) of the C.I.C. have impressed me as among the best examples of technical education which I have seen in China, ranking equally with the Agricultural Vocational (Extension Teachers') Training School at Shatang near Liuchow, and deserve strong support coupled with freedom to experiment along their own lines.

It should be put on record that in most cases the welfare of the workers (so far as my wartime experience goes) has been comparatively well looked after in the government factories and arsenals. In certain places, such as the Tzuchung Power Alcohol Factory near Neichiang, Szechuan, this compares favourably (having regard to the generally prevailing lower standard of life) with advanced workers' welfare in Europe. There have been some cases, however, for example in low temperature coal carbonisation plants not owned and operated by the government, in which I considered that industrial diseases, such as lung affections due to gases and vapours, or cancer due to unrestricted contact of the skin with tars and oils, were not being properly guarded against. Moreover, the reliance on child, or

at least adolescent, labour in the Shensi cotton mills and the Yunnan tin mines (to take only two obvious examples) is unsatisfactory and not in the best interests of the nation. I understand (though I personally was not in China before the war) that the conditions of the workers in the industrial regions of Shanghai were notoriously bad. This is something against which the Chinese government must in the future be on its guard. The industrialisation of China will be watched very closely by the working masses of Britain, now ruling in its first powerful Labour government; by the working people of the Soviet Union, whose standard of life has been so much raised in recent years; and by those of the United States whose labour unions are not without power. In order to retain world sympathy and support, the Chinese government must see to it that industrialisation does not proceed in an unregulated way injurious to the mass of the working people, and must show that the low standard of life at which the Chinese people are bound to have to live for some time to come, does not necessarily involve the additional evils of preventable disease and improper working conditions.

Wartime Science of China and Britain in Retrospect.

Looking back at the part played by scientists during the past World War II, I consider that they have deserved very well of their country. Leaving their comparatively well-equipped laboratories (some of which were destroyed before their eyes) in the eastern provinces, they journeyed to the western part

of the country, and maintained the life of research and technological production under extraordinary difficulties. Long endurance of such difficulties deserves some reward.

Discussing the situation many times both with government officials and with academic scientists, I found that the latter generally strongly emphasised the importance of pure science, even under conditions when the monthly funds available for even an important research institute of Academia Sinica amounted to no more than would purchase sufficient fuel for the month. They knew that applied science could never flourish without pure science, and they were right. No one can ever say what vast consequences may flow from experiments that seem completely academic. Government officials, emphasising, also rightly, the importance of technical training for students, sometimes spoke of a reluctance on the part of scientists to enter government service and take up war work. This can only have been very partially true. The Physics Institute of the Peiping Academy did a most remarkable job of manufacturing microscopes and providing quartz crystals for radio sets; the Chinghua University General Physiology Research Institute tackled many problems of agricultural importance; and many laboratories did what they could towards isolating the active principles of some of the traditionally used drugs, such as the anti-malarials. In so far as it was true, it can certainly not have been due to the old distinction between degrading manual work on the one hand

and the clean work of the scholar on the other. I have been very pleased to meet young university graduates working as foremen in mines such as the Tienfu Coal Mines, in arsenal foundries, in the Central Machine Works, and the like. While there may be some lingering effects, seen even in engineering colleges, of this old reluctance to combine manual and mental work in the same person, there can be no doubt that the isolation of the scholar is breaking down. I think that the main reason why some scientists held back from taking up war jobs was because they feared that they might never be able to return to the life of pure science, so desperate is the need of the country for applied science. If this is correct, it only shows again the necessity for strong government support for pure science. And it must be admitted that I know of a few cases where after a scientist had taken up special war work his time was almost completely wasted.

It is perhaps worth while referring to the measures which were taken in England during World War II to ensure the maximum utilisation of the scientific talent of the country in the war against Fascism. There was first a block reservation of all scientists above the age of 21 from combatant service. Then a Register of Scientists was set up, jointly under the auspices of the Royal Society and the Ministry of Labour, in order to find for everyone the job he was most fitted to do, and to know in a given case of necessity who was the person most fitted to

undertake any specific job which might need doing. I think the record of British science during the war has been a vindication of these methods. The reservation of scientists was systematically reviewed, younger ones being directed to useful work if not already doing it, or invited to accompany the armed forces as "scientific officers" without military rank carrying out "operational research", i.e. research on the potentialities and utilisation of war weapons. Meanwhile the utmost support was given to all kinds of war research, e.g. in the field of chemical defence; and, as we have recently been informed, British nuclear physicists were shifted across the Atlantic to cooperate with their American and Canadian colleagues in the two-billion dollar program of releasing intra-atomic energy. Besides all this, experienced scientists were attached to every Ministry in an advisory capacity, and special committees were set up to coordinate the scientific work of a number of different ministries and other organisations. The Cabinet itself had a Scientific Advisory Committee, and there was a special Scientific Research Advisory Office in the Prime Minister's immediate circle.

How much of all this would be applicable to China during the reconstruction period, I do not feel able to say. But I consider that these questions of the organisation of science for the national welfare are very relevant to Chinese circumstances, and deserve the most serious consideration.

International Scientific Relations

A few words must be said about China's participation in international scientific relations. China's delegation at the United Nations San Francisco Conference played an important, even a leading, part in the demand for the establishment of a United Nations Cultural and Scientific Organisation, which should perform the functions of the old League's Institute of International Intellectual Cooperation on a wider scale, and should embody an international science cooperation service continuing many of the activities engaged in during the war period by the national science cooperation offices, as well as forming a nucleus for the international scientific unions and congresses. It only remains for China to continue her pressure in this direction, and her age-old and famous respect for scholars enables her particularly readily to push forward this public work in the comity of nations, which incidentally may be a source of much prestige for herself.

One way in which China could contribute along these lines would be by inviting some forthcoming international scientific congress to meet on Chinese soil. As soon as communications improve, for example, it would be an excellent idea to induce the International Geological Congress to meet in China, for geology has long been one of China's strongest sciences. The visiting scientists could be invited to examine the loess country, the Yangtze gorges, the karst pinnacles of Kweilin, etc. etc.

Another matter worth consideration is that of appointing scientific attachés and counsellors in the diplomatic service. This is a problem now much discussed in a number of countries, and developments in the next few years should be carefully watched.

The preparation of this report has been for me a rather exacting and painful task. It has been frank, because when you asked me to speak of the shortcomings and difficulties of Chinese science I know that you wished me to be frank. But the task has been painful mainly because I should feel, were I myself Chinese, no small sense of exasperation at the amount of good advice which is tendered, often with so little foundation, by so many well-intentioned, or at any rate opinionated, foreigners. My only excuse is that for three years I have lived among Chinese scientists and technologists, have tried to learn something of their problems, and have essayed to bring to them what help was in my power.

I shall conclude with a few words on the activities of the Sino-British Science Cooperation Office, which during the war I had the honour to direct. Originally sent to China on what was primarily a goodwill mission, I speedily realised that a science and technology liaison office, analogous to what had already been set up in Washington and London, was necessary also in

Chungking. Ultimately we depended, on the British side, on the British Council (Science Division) for all matters of pure science, and on the Ministry of Production (China Affairs Office) for all matters of applied and war science. On the Chinese side we were associated, following a decision of your own, with the Council for the Promotion of Science in the National Defence. In numbers, the staff of our office comprised, from first to last, 17 scientists, of whom 5 were British and 12 Chinese; and besides these we had a clerical staff of 11, all Chinese. In the course of our travels, the British scientists personally visited some 300 Chinese scientific and technical institutions, laboratories, factories, arsenals, etc. We organised, during the period of the blockade, a supply service from India, and thus brought in, by the medium of the R.A.F., scientific research equipment, instruments, chemicals, etc. for about 250 Chinese institutions to the value of some £60,000 sterling. We also delivered, on a kind of lend-lease system, about 6000 British scientific and technical books to Chinese institutions. In addition to this we brought in microfilm and actual copies of 200 of the leading British scientific journals, and combined in a joint distribution system with the Cultural Division of the American State Department, and the Ministry of Education. Innumerable exchanges of information, and materials (such as seeds, chemical samples, and the like) were carried on; and about 150 original scientific papers by Chinese scholars were

transmitted to the West for publication. Reciprocation was also made by some splendid gifts of Chinese books for British libraries by the Ministry of Education. It is my hope that in the history of Chinese scientific life, our efforts will be worth at any rate a small footnote. They have certainly been inspired, on the part of all of us, by a disinterested affection for your great country, and we have been profoundly rewarded by the many friendships which we have made in the course of our work.

I have the honour to be,

In deep truth and respect,

Your obedient humble servant,

Fellow of the Royal Society