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Nationalist China

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NATIONAL INTELLIGENCE SURVEY

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Science

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Nationalist China

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This chapter supersedes the scientific coverage in the General Survey dated August 1970.

FIGURE

Science

A. General (C)

Although the Republic of China (ROC) is trying to increase its competence in science and technology, its research and development capability is small. The country does not have a scientific tradition, and only during the last 20 years have significant efforts been made toward attaining a scientific research capability. In 1949 when the government moved from the mainland to Taiwan, the Nationalists were able to salvage only a limited number of scientific instruments and reference works, and educational institutions and research institutes on the island, formerly under Japanese control, were relatively few. With foreign assistance, mainly from the United States, the Republic of China has made good progress in promoting scientific education and in establishing research institutes and scientific societies. There are now a number of well-established universities and colleges, research institutes, and learned societies in Taiwan.

The government launched a long-range program for research and development more than a decade ago in an effort to raise the level of scientific research and to popularize science and technology among the people. Most of the emphasis was on the construction and repair of research facilities, the purchase of new equipment, and the training of research personnel. Only limited funds were made available for acquiring and maintaining the staff needed to carry out effective research. Since 1967 President Chiang Kai-shek has undertaken a major drive for modernization in Taiwan and has focused on the upgrading of science and technology essential to continued rapid economic development. Among his objectives are the coordination of science efforts with the needs of industry and agriculture, an increase in the allocation of resources for research, and the improvement of science eduction.

Although the universities and colleges have been graduating sufficient scientists and engineers for the limited needs of governmental and other research facilities, these graduates have had little training in research, and a shortage of competent research scientists exists. Nevertheless, the country possesses sufficient native talent to produce significant results during the 1970's if reasonable financial support is furnished. A small group of highly capable senior scientists, trained in Western Europe and in the United States, provides a nucleus upon which a research program eventually can be based. If appropriate research facilities are established and if the economic status of the scientists can be raised from its very low level, other Western-trained Chinese scientists living and working abroad may be induced to return to Taiwan. With foreign assistance, the central government plans to establish more research institutes and to encourage industries to construct and operate research facilities, thus providing attractive employment opportunities for scientific and technical graduates.

For many years the Government of the Republic of China has maintained strong scientific relations with the United States. Since 1964 a committee sponsored by the U.S. National Academy of Sciences and the *Academia Sinica* has devoted attention to science policy planning, advanced scientific and technical education and research, and other problems related to the strengthening of science and technology in Taiwan. The committee meets at intervals under the auspices of the Sino-American Science Cooperation Program. In September 1967 the Science Adviser to the President of the United States led a mission to Taiwan to survey its scientific and technical assets and requirements. Based on recommendations of the mission, the science budget was increased to US$30 million a year, and the U.S. Government appointed a special assistant to the U.S. Ambassador to find and implement ways of increasing the flow of science and technology from the United States to the Republic of China. In January 1969 an agreement on cooperation in the fields of science, technology, and social sciences was signed by the United States and the Republic of China, thus formalizing a condition that had existed for several years. The purpose of the agreement is to facilitate the exchange of information, ideas, and techniques through contacts between scientists and research institutes of the two countries; to utilize

special facilities available in both countries; and to examine problems of common interest. In 1971, after President Nixon's Science Adviser's visit to Taiwan, he reported that the terms of the agreement were being met, but recommended that Taiwan step-up its application of recent techological advances in oceanography, computer science, and aerial photogrammetry.

B. Organization, planning, and financing of research (S)

With the increased emphasis by the government on science and technology, some significant steps have been taken in the organization of science on a national scale (Figure 1). In March 1967 the government established the National Security Council and within it the Science Development Committee (SDC). The chairman of the SDC is the top science adviser to the President. The SDC is concerned with the overall policies for science education, research in universities and institutes, and the interrelationship between science and technology and industrial development. Five months after its formation, it effected the reorganization of the National Council on Science Development, which had been founded in 1959 as a joint undertaking of the *Academia Sinica* and the Ministry of Education. It was formed into the National Science Council (NSC), under the jurisdiction of the Executive Yuan but subject to the guidance of the National Security Council's Science Development Committee in policy matters and in the distribution of funds. The chairman and vice-chairman of the NSC are appointed by the Executive Yuan on the recommendations of the SDC. The 33 members of the NSC are also apponted by the Executive Yuan joint recommendations of NSC's chairman and vice-chairman, the *Academia Sinica*, Ministry of Education, Ministry of National Defense, Ministry of Economic Affairs, Ministry of Communications, Council for International Economic Cooperation and Development, and the Joint Commission on Rural Reconstruction. In addition to assuming all the responsibilities and functions of its predecessor, the NSC added new ones and expanded the old ones. Thus the NSC has a stronger hand than the National Council on Science Development in the task of advancing overall science education. The principal objectives of the NSC are to assist and support scientific and technical research and to promote the development of scientific education. The NSC has become responsible for strengthening research facilities at various public research institutes, universities, colleges, and high schools. It also supports rearch through grants, establishes national research professorships and sponsors national visiting professorships, plans and implements the procurement of scientific instruments, plans revisions of curriculums and teaching material for basic sciences at various educational levels, and collects and disseminates scientific data.

The *Academia Sinica*, originally founded on the mainland in 1928, was reestablished at Taipei, Taiwan, in 1949. It is composed of 10 research institutes—mathematics, physics, chemistry, botany, zoology, modern history, ethnology, economics, classical history, and philology. Although a government institution financed by the central government, *Academia Sinica* is virtually autonomous, and each member institute has been free to plan its own program. It is charged with conducting research in its own institutes and with aiding and coordinating the efforts of other research institutes and the universities in their scientific activities. The *Academia Sinica* conducts basic research and has been attempting to expand its applied research effort. The total impact of its internal research program is limited because the entire research staff of its 10 institutes numbers only a little over 200 personnel.

The Atomic Energy Council (AEC) was established in 1955 to plan and execute a program for the peaceful application of nuclear energy. It plans and promotes research and development in the field of nuclear science and technology and is concerned chiefly with nuclear education and nuclear power generation. It advises the government on nuclear energy matters and is directly responsible to the Premier. Its membership includes representation from the Ministry of Education, Ministry of National Defense, Ministry of Economic Affairs, and several universities.

A major and the best equipped facility for nuclear research is the Institute of Nuclear Energy Research (INER), formerly a part of the Chung-shan Institute of Science and Technology—CIST (also known as the Chung-shan Science Institute. Although the INER is now reported to be formally separated from the CIST, there are indications that both simply comprise separate divisions of a joint complex. The physical separation between the two is a fence; both organizations occupy the same "campus" located at Lung-t'an about 30 miles southwest of Taipei. On official government organization charts, CIST reports to the Ministry of National Defense, and INER reports to the Atomic Energy Council, which in turn reports to the Executive Yuan (Premier). There are strong indications, however, that the INER is also under

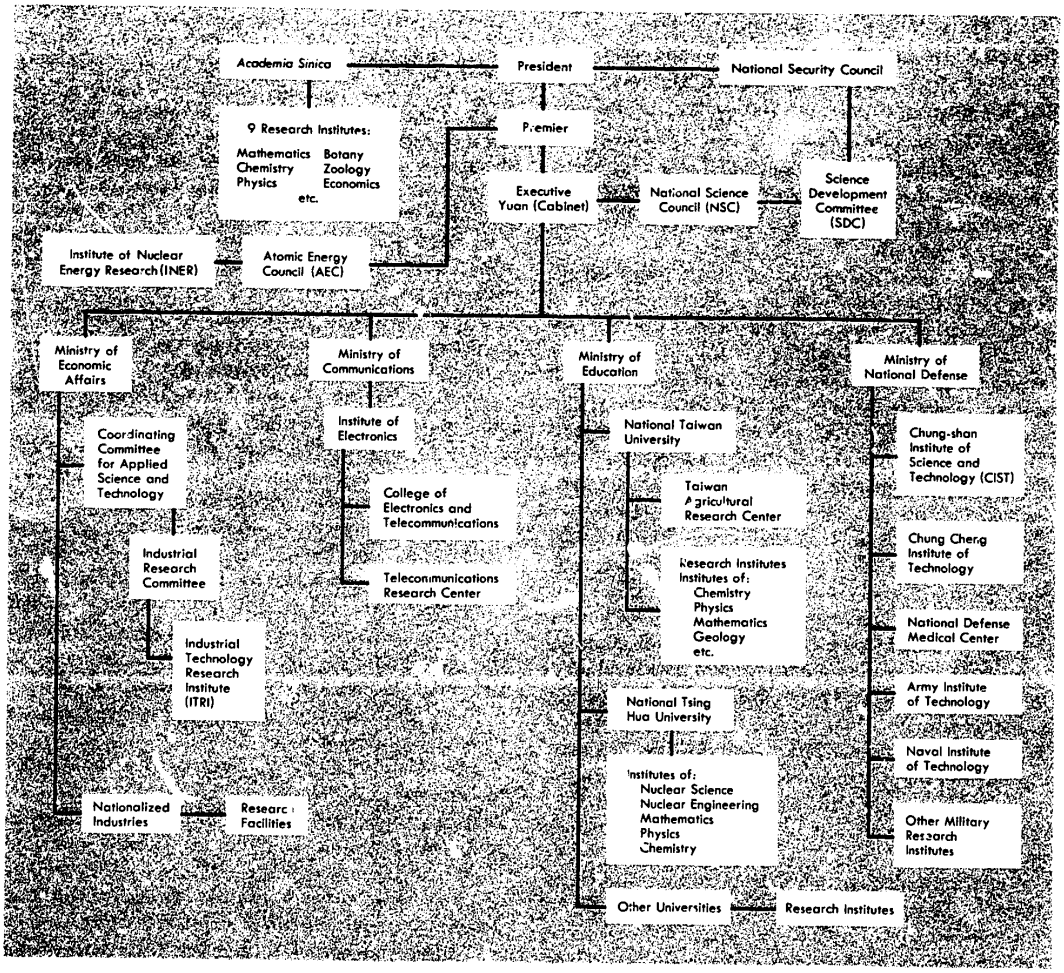

FIGURE 1. Organization of scientific and technological activities, 1973 (C)

control of the military. It is provided amply with funds. Several of its nuclear engineers, most of whom were trained in the United States, serve on committees of the AEC. However, the CIST is organized along military lines, with most divisions headed by military personnel. The tight security surrounding CIST indicates that important military research projects are probably in progress, possibly concerned with nuclear weapons.

Located close to CIST is the Chung Cheng Institute of Technology, which is operated by the Ministry of National Defense and has schools of mechanical, civil, aeronautical, and naval engineering. The institute has an enrollment of 2,000 students, all selected by the Minister of National Defense.

The Ministry of National Defense is responsible for several other facilities. The National Defense Medical Center, Taipei, which is concerned with education and research in medicine, pharmacy, and basic sciences, had a staff of 700 in 1966 and a budget of about US$420,000. The Army Institute of Technology, Taipei, trains junior technical and engineering officers and does research and development work on military problems. The Naval Institute of Technology, Tso-ying, is concerned with research and development in naval architecture, mechanical engineering, electrical engineering, and naval ordnance.

Other organizations in Taiwan conducting research principally applied, include the Ordnance Research Institute of the Ministry of National Defense, the

Radio Wave Research Laboratories of the National Taiwan University, the Ministry of Communications, the Geological Survey of Taiwan, the National Defense Medical Center, the Taiwan Weather Bureau (all in Taipei), the Taiwan provincial Veterinary Serum Institute (T'ung-hsiao), and the Telecommunications Research Center of the Ministry of Communications and Chinese Institute of Neurology (both in Chung-li).

Although some industries have small, independent research facilities, the major research for industry is government sponsored. Since 1953 the Union Industrial Research Institute (UIRI), is under the Ministry of Economic Affairs and has provided general service to industry. In July 1973, the UIRI's name was changed and two new components, the Metal Industry Research Institute, Kao-hsiung, and the Mining Research Service Organization, were added. Collectively, they are called the Industrial Technology Research Institute (ITRI). The institute conducts research for a number of industries. Most of the research is concerned with the development of domestic natural resources and the adaptation of scientific research results to the needs of the country. The research is mainly applied and of a good quality. The expenditures of ITRI are borne jointly by public enterprises, under the jurisdiction of the Ministry of Economic Affairs, which include the Chinese Petroleum Corp., Taiwan Sugar Corp., Taiwan Power Co., Taiwan Aluminum Corp., Taiwan Aikali Co., Taiwan Fertilizer Co., and the Taiwan Glass Research Institute.

The Industrial Research Council of the Ministry of Economic Affairs is a policy-framing advisory council. IRC coordinates applied research of government organizations in general and the research work of the government enterprises under the jurisdiction of MOEA in particular. Under its industrial research policy, the government lays emphasis on the promotion of industrial research capabilities and their application to attain general economic development objectives. Industrial research is thus directed toward the transfer of existing technology and the application of results of research to industries with the aim of increasing productivity, reducing cost of production, and improving the quality of products. However, the coordination of industrial research has a long way to go before it will support effectively an expanding industrial base.

Many professional scientific associations have been founded or reestablished in Taiwan since 1953. They not only act as forums for their own members but also serve as media for arousing popular interest in science. The Chinese Institute of Engineers, with about 13,000 members, has chapters in T'ai-chung, Kao-hsiung, Hua-lien, and in some foreign countries seeks to promote the professional status of engineers and improve technological knowledge and standards in Taiwan. Other groups active in promoting sciences are the Chinese Chemical Society (4,500 members), the Chinese Association for the Advancement of Science, and the Chinese Association for the Advancement of Natural Science. These organizations also sponsor public lectures and provide scholarships at universities and colleges.

Funds for scientific research are limited but are increasing. They are derived from a variety of sources including the central government; foreign aid, principally from the United States; and from foreign religious and philanthropic foundations. Taiwan's current budgetary allocations were established in a 12-year science development plan initiated in January 1969. The plan stipulated that for each of the 12 years the National Science Council is to receive US$30 million for distribution to the various scientific institutes. The council also receives additional sums from other government sources to conduct research and development and to buy equipment. Except for the small budget of the government-sponsored Industrial Technology Research Institute, private industry provides very little funds to the national research and development effort.

Through a bilateral agreement with the United States, the U.S. National Science Foundation is helping to finance a program to encourage Chinese-American professors to return to Taiwan under an exchange program to teach and conduct research at seven Taiwan research centers. Taiwan's National Science Council allocated US$250,000 to finance cooperative projects, with much of the money being designated for this exchange program. The U.S. National Science Foundation is contributing US$1,300,000 to this effort. Taiwan has other exchange programs with South Korea, South Vietnam, and Thailand.

C. Scientific education, manpower, and facilities (U/OU)

The advancement of science has become a principal objective of education in Taiwan, and efforts have been made to increase the level of science education and to popularize science among the people. All higher educational institutions are under the supervision of the Ministry of Education with the exception of the military institutes, which are under the jurisdiction of the Ministry of National Defense.

In school year 1971/72 Taiwan had a total of 96 higher educational institutions with an enrollment of 222,505, and increase of 19,032 students over the previous school year. Of the higher educational institutions, 10 are national, 18 provincial, and 68 private schools. Only a few of the national and provincial universities and several specialized institutions are important in the teaching of science and technology. The universities offering the strongest science education are the National Taiwan University, Taipei, and the National Tsing Hua University, Hsin-chu. Both of these universities have Institutes of Nuclear Science and are important in training nuclear physicists. The National Taiwan University has a College of Engineering as well as Research Institutes of Chemistry, Physics, Mathematics, Geology, and Geophysics. Colleges of science and engineering are maintained also at the Taiwan Provincial Cheng Kung University, T'ai-nan; the Taiwan Provincial Chung Hsing University, T'ai-chung; the Tunghai (Christian) University, T'ai-chung, which includes a chemical engineering curriculum; and the Taiwan Normal University, Taipei. The Taipei Institute of Technology offers a 5-year course in chemical engineering.

Graduate education is limited. The establishment of additional graduate research facilities at the Taipei Institute of Technology has provided a start toward an adequate scientific research and educational program at the graduate level. The National Taiwan University has established institutes for graduate study in bacteriology and mechanical engineering. The Institute of Nuclear Sciences at the National Tsing Hua University offers a 2-year course leading to a masters degree in nuclear science; the Institute of Physics at the university has a doctoral program. The Institute of Electronics, Hsin-chu, was established in 1958 as a graduate school of the former National Chiao-t'ung University in Shanghai. The institute has a 2-year program leading to masters and doctoral degrees and short-term training courses in telecommunication microwave electronics and electronic computers. The institute awarded the first doctorate in science to be granted in Taiwan. Additional training is available to students and graduates at annual Summer Science Seminars held under the sponsorship of the *Academia Sinica*, the National Taiwan University, and the National Tsing Hua University and funded by the National Science Council. Visiting foreign scientists act as professors during 8 weeks of lectures.

Most of the graduates who pursue higher degrees study abroad, particularly in the United States, Western Europe, and Japan. Unfortunately, the percentage of the total number studying abroad who return to Taiwan is very small. The students are deterred from returning to their homeland by inadequate salary levels in Taiwan and the belief that the environment does not provide suitable opportunities for them to progress in their careers. The government is actively seeking ways of encouraging the return of students sent abroad for higher education and has established a professorial exchange program with the United States. Through this program, the government hopes to persuade Chinese-American professors to return to Taiwan for periods of 6 months to a year to teach and carry out research in seven research centers. These centers—for chemistry, physics, mathematics, biology, engineering, oceanography, and economics—were established to further research and to promote education at the graduate level. They apparently were created in fulfillment of a directive of a 4-year plan drawn up by the National Council on Science Development and the Ministry of Education which called for the creation of graduate science centers offering both masters and doctoral degrees. The objectives of the plan were to reduce the loss of scientists to other countries by providing graduate study programs comparable to those in foreign universities; to train professors for the universities because the faculties are aging and the quality of instruction is deteriorating; and to provide the research and educational facilities required to sustain industrial and economic development.

The problem of staffing the educational institutions and research installations with qualified scientists is a serious one. Wages are low considering the educational level of scientists. To increase their income, many teachers take concurrent jobs at several schools with the resulting loss of concentration on any one course. A further problem is the seniority system within the ROC's educational system which makes advancement for younger men exceedingly slow. Thus a graduate with a doctorate who returns to Taiwan from abroad would have to wait many years before receiving either a salary or administrative and teaching responsibility commensurate with his skill. Additionally, governmental research facilities have been losing trained personnel to industry, which in turn has been losing its technicians to foreign firms in Taiwan. Critical shortages of engineers exist in such fields as nuclear power, the petrochemical industry, and geological surveys.

Although a sufficient number of scientists and engineers are being graduated from the ROC's higher educational institutions to fill most of the country's needs, there is still a shortage of competent research

scientists and engineers, because many of the graduates have had little experience and training in conducting research. It is estimated that approximately 4,500 individuals are employed in governmental and industrial and research and technological laboratories; about 1,600 are professionals and 2,900 are either technicians, laboratory assistants, or administrative and service staff personnel members. An unknown number of professionals are employed on a part-time basis. The number of researchers employed in foreign-owned industries is unknown.

Taiwan's does not have any outstanding research facilities but is making significant efforts to expand and improve facilities. As in most developing countries, the most impressive research facilities are those concerned with the nuclear science. Taiwan has adequate reactors, cyclotrons, accelerators, and cobalt-60 sources at the national university institutes for its nuclear energy program. The best equipped and most adequately financed research facility on the island is the joint complex comprising the Chung-shan Institute of Sciences and Techology and the Institute of Nuclear Energy Research. This complex conducts basic and applied research for the military and for the AEC. It is a large facility with between 20 and 30 new buildings and a total staff of about 1,900. The staff includes 50 persons with Ph.D. degrees—mostly trained in the United States—and an additional 268 with MS and BS degrees obtained in Taiwan. Good quality laboratory equipment of U.S. and Japanese manufacture is available. The complex has a Control Data Corporation 3300 computer. Its research sections include rocketry, electronics, chemical, and nuclear. It is believed that a major long-range objective of the work conducted at the complex is to develop guided missiles with nuclear warheads.

The Institute of Electronics at the National Chiao-t'ung University continues to expand its laboratory facilities and is equipped with a computer, lasers, and television, and communications and automation equipment. Some of the expensive, modern equipment at other institutes is not utilized adequately because of a shortage of well-trained personnel.

D. Major research fields

1. Air, ground, and naval weapons (S)

The Republic of China has an extremely limited military research and development capability. The country has neither the technological capability nor the industrial capability to develop or produce modern combat weapons. Some military research is accomplished at the Military Technical Research Institute of the Combined Service Force in Taipei, under the Ministry of Defense. The institute performs research for the three military services but is not capable, either technically or financially, of pursuing any large-scale research and development programs. The current effort appears to center on explosives and propellants. The joint CIST/INER complex, although primarily important for its nuclear research role, is also a research facility for its armed forces. It is suspected that its long-range objective is the development of nuclear warhead guided missiles, possibly of the 12-inch diameter, 20 kilometer range. The National Tsing Hua University is believed to be developing the inertial guidance components and equipment for the missiles. For the past 3 years it has been involved in the operation and testing of rocket propulsion systems. These test firings have used four- to six-inch diameter models with loadings of double-base and composite propellants of U.S. formulations. The ROC is not engaged in research and development of any air weapons nor is there any activity in the space field. Aeronautical efforts have been in the development of a turboprop, 2-place tandem trainer aircraft that is designated the XT-CH-1A. Design was initiated in 1970, construction was started in January 1972, and the plane was scheduled for testing in late 1973. The Chinese gained considerable technical knowledge and experience for this effort from the assembling of a U.S. modified trainer aircraft and U.S. Bell Co. helicopters. The Aero Industry Development Center is licensed to produce both of these aircraft.

Space-related activity only involves making ground-based measurements of atmospheric properties and conducting balloon-carried experiments. The capability to design and develop ground weapons is limited, and efforts are mainly devoted to the development of ammunition. Some research has been conducted on clothing and individual field equipment to improve manufacturing techniques and equipment design. No major research and development projects are underway on bridging or stream-crossing equipment. The only significant items developed thus for are a 15- to 20-man pneumatic assault boat and a short-gap, assault bridge, to be launched from an LTV (landing vehicle, tracked). A small research program is underway on automotive parts. The ROC has no known significant research and development program in the naval weapons field.

2. Biological and chemical warfare (C)

Taiwan does not have a biological warfare (BW) research and development program, although some of the biomedical and clinical research facilities give it a

limited capability to perform BW-related research. Basic biological research conducted at the Central Research Laboratory of the National Taiwan University, the Kohlberg Medical Research Laboratory, and the Taiwan Provincial Institute of Animal Health, all in Taipei, could have BW application, but presently these efforts are directed toward teaching and improving the nation's health standards.

A minor chaemical warfare (CW) research and development program is concerned with the development of locally produced CW defensive materiel. Facilities suitable for research on toxic chemical agents, munition, and detection devices are limited, but the CIST/INER complex has done some work in these areas. The National Taiwan University, Taipei, has accomplished some research on the toxic components of snake venoms and various native poisonous plants. This work appears medically oriented, but could be used in a CW program.

3. Nuclear energy (S)

The Republic of China has established a small nuclear energy program devoted to basic research and the eventual development of nuclear power generation. Progress has been achieved with the support of U.S. aid furnished under the terms of a 1955 bilateral agreement for cooperation in the peaceful use of atomic energy. Taiwan's capability in the nuclear field may, in time, enable it to develop nuclear weapons, but the country currently lacks some prerequisites in both facilities and raw materials for the development of a nuclear weapons program.

In 1955, the Atomic Energy Commission—later called the Atomic Energy Council—was established to advise the government and to plan a nuclear energy program. The Institute of Nuclear Science at the National Tsing Hua University was established in 1956 to carry out the program. The institute has the dual function of serving both as an academic training and research institution and as a national laboratory. In addition to teaching, the faculty members carry out research with assistance from the United States under a "sister laboratory" arrangement with Argonne National Laboratory in Illinois. In its function as a national laboratory, the institute provides services which include radiation monitoring and safety, instrument maintenance and calibration, supply and application of radioisotopes, and reactor irradiation of agricultural and industrial samples. To carry out its duties, the institute has a 3-megaelectronvolt (MeV) Van de Graaff accelerator and THOR (Tsing Hua Open-Pool Reactor), a pool-type research reactor acquired from the United States. THOR has been in operation since 1961 with a power level of 3 megawatts (MW).

Taiwan has plans for the eventual use of nuclear energy for the production of electric power. The program calls for the construction of eight nuclear power reactors. The government requested the use of heavy water moderated power reactors, but the Taiwan Power Co. successfully overrode the request and boiling water reactors are to be used. Construction or planning has been started for six reactors totaling 3,072 megawatts electric (MWe); two 636-MWe reactors are scheduled for operation in 1975 and 1976 and two 900-MWe reactors are scheduled for operation in 1978 and 1979. All six reactors will be located on the northern coast of Taiwan.

After the the People's Republic of China conducted its first nuclear test in October 1964, President Chiang Kai-shek reportedly ordered the establishment of a nuclear weapons research institute. The institute, originally called the Shih-men Institute of Science, was organized in April 1965 with temporary quarters in Taipei. It has since been reorganized and has become the CIST/INER complex. The nuclear portion of the complex operates a 40-MW thermal heavy water moderated, natural uranium fueled-multipurpose reactor that was purchased from Canada and transported to Taiwan under International Atomic Energy Agency safeguard controls. Preliminary arrangements were made in 1971 to also purchase from Canada a CDC Cyber 70 computer system with 65 K memory and 125 K extended core storage to handle the HAMMER nuclear computer code for simulated nuclear reactor operations. Taiwan, however, still does not have all the facilities and materials necessary for a complete nuclear weapons program. The institute has a zero power material test reactor, a low-level solid and liquid radioactive waste disposal facility, and a fuel reprocessing plant that is only a laboratory-scale model with a yearly yield of 300 grams of plutonium. The country has no known deposits of uranium; it purchased 12 tons of natural uranium metal from South Africa to operate the third core of the research reactor. Problems have also been encountered in the acquisition of facilities. An attempt was made to purchase a West German fuel reprocessing plant, but U.S. pressure prevented the acquisition because of the military implications. The probable military intent in Taiwan's efforts are indicated, but its development is uncertain in light of the foreign awareness of these efforts.

4. Electronics (C)

Electronics research and development activity is steadily improving both in the quality and quantity of the work undertaken. The most important electronics research organization is the Institute of Electronics of the National Chiao-t'ung University. It has facilities for performing research and development on electronic circuits, microwave techniques, transistors, computers, television, electron vacuum tubes, radio propagation, solid-state circuits, and lasers.

The Ordnance Research Institute, Taipei, operating under the Ministry of National Defense maintains a radio division which conducts research on infrared techniques and devices. For military reasons, the Ministry of National Defense has shown increasing interest in improving the knowledge about and the use of offensive countermeasure equipment and techniques. Taiwan has made some accomplishments in support of the military in the development of a circuit plan for field deployed computers, radar software for the guidance and control of aircraft and missiles, and rudimentary Quantum electronics. The CIST/INER complex has a CDC-3000 computer, which is used mainly for data processing for the armed forces. Some computer time is devoted to computations in the fields of mechanical, nuclear, and electronic engineering. Chinese Air Force officers, trained in the United States, operate the computer.

Taiwan has continued to upgrade and expand its domestic and international communications facilities. A major 1800-channel microwave radio-relay link was recently constructed along the western periphery of the island, linking Taipei in the north with Kao-hsinung in the south. Plans also are underway to establish a number of shorthaul microwave radio-relay links on heavily trafficked routes. Telephone switching equipment is being updated, and it is expected that subscriber toll dialing will be extended to the entire island by the end of 1976. Two tropospheric scatter links are to be constructed between Taiwan and the offshore islands of Quemoy and Matsu. Tropospheric scatter links for international telecommunications were constructed between Taiwan and Hong Kong in 1967 and the Philippines in 1969. Satellite communications were initiated in December 1969 using the Intelsat Pacific Ocean satellite. A second satellite ground station to be used with the Indian Ocean satellite was expected to be operational by late 1973.

5. Medical sciences (S)

Biomedical research is limited and remains on a relatively low level. The progress which has been achieved is the result primarily of increased financial support for medical research by the U.S. Agency for International Development (AID) and by several U.S. and Taiwanese nongovernmental groups. The GRC provides some support. Most of the best work is accomplished by individual scientists. Some laboratories have good research facilities.

The principal medical research organizations include the College of Medicine of the National Taiwan University, the National Defense Medical Center, the Kao-hsiung Medical College, the Taipei Medical College, and the *Academia Sinica*. With the increased availability of funds, the quality of medical education is improving at these facilities. Almost all the leading medical scientists in Taiwan have been trained in the United States.

Many of the most recent plans for medical research projects are keyed to the country's Ten Year Health Plan for 1966-75. One goal of the plan is to strengthen basic scientific studies and epidemiological investigations on various communicable diseases, including disease vectors. Virological and bacteriological studies conducted at the National Taiwan University include research on parasitic diseases endemic to Taiwan, including leptospirosis and filariasis; study of viral-produced tumors in tissue culture; investigation of the pathophysiology of cholera; and study of immune mechanisms in leprosy.

Other biomedical research is underway on the pharmacology and physiology of the nervous system, toxic metabolities, cancer, and hypoxia after major open heart surgery. ROC scientists are working on the pharmacology of various snake venoms and the medicinal and chemical properties of Chinese drug plants. They are doing experimental research with labeled proteins and also are studying amino acid requirements and biosynthesis of cell-wall polysaccharides. Taiwan scientists participate in the research efforts of U.S. personnel at the U.S. Naval Medical Research Unit (NAMRU) and have co-authored some of NAMRU's excellent health studies, some of which have concerned epidemiological and parasitological diseases and maternal and infant nutrition.

Armed forces medical research is of minor significance and is limited to some applied research in the National Defense Medical Center. Principal fields

of research are nutrition, preventive medicine concerning adenovirus diseases, trachoma, filariasis, schistosomiasis, and epidemiology. Research is not organized in a formal program and often reflects only the desire of an individual to do such work in addition to his regular duties at the center.

6. Other sciences (S)

a. Chemistry and metallurgy

Although most of the universities and colleges in Taiwan have departments of chemistry, very little chemical research is carried on. The staffs concentrate on teaching and have little time for research. There is little or no coordination of the minor amount of research underway. Some research is being done in the chemistry of soils and fertilizers by various agricultural research institutes and by the National Taiwan University. Studies are concerned with the uptake of fertilizer constituents and trace elements by rice, sugar, and tea, and with the effects of agricultural chemicals, such as herbicides, on plant nutrition. The universities and medical colleges do a little research in analytical chemistry and pharmaceutical analysis. The Taiwan Provincial Cheng Kung University has done some work on the polarography of uranyl complexes. A small effort is underway in biochemistry and organic chemistry, including a few studies on natural products, but synthetic organic research is very weak. Except for a little work in the kinetics of organic reactions, physical chemical research is almost nonexistent. Some studies in inorganic chemistry involving radioisotopes are done by the National Taiwan University in cooperation with *Academia Sinica*. Although the production of chemicals and related products has grown rapidly, industrial chemical research remains insignificant. Most of the technology is imported. The Industrial Technology Research Institute (ITRI) is attempting to do some research on the utilization of domestic natural resources and on process development for native industries and has the best facilities for applied chemical research; however, the effort is limited.

The ROC has little metallurgical industry and essentially no capability in metallurgical research, development, or technology. Most of the raw materials must be imported to support the very small steel and aluminum industries. The little metallurgical research evident has concerned the study of intermetallic compounds having potential use as semiconductors. This type of research usually is associated with university thesis requirements. Neither basic nor applied ferrous metallurgical or metalworking research has been conducted.

b. Physics and mathematics

Only limited research capabilities exist in nuclear, plasma, and solid-state physics. Some improvement has occurred since 1965, however, as a result of increased governmental support, improved training of personnel, and expanded research facilities. The little research underway is carried out in the Institute of Physics, Taipei, of the *Academia Sinica*, the Institutes of Nuclear Sciences at the National Taiwan University and the National Tsing Hua University, and the CIST/INER complex. Most of the emphasis is in nuclear physics and concerns reactor physics with a small but significant effort in high-energy physics. Some research is done on the reaction of light nuclei and on elastic scattering by proton and deuteron beams. Researchers at the Institute of Nuclear Sciences have been experimenting with charged-particle induced reactions. They also have done some work on gamma ray spectrum analysis, heat transfer analysis, reactor noise, and thermal stress. Some limited work is underway in low-temperature, solid-state physics, and crystallography.

The Institute of Physics of the *Academia* is engaged in solid-state studies, which include research on determining magnetic material properties, such as diamagnetism, paramagnetism, and ferromagnetism. The institute is doing some low-temperature physics research and is being equipped with cryogenic equipment and a liquid helium and air liquefier plant. Theoretical physics research concerns particle physics.

A very minor amount of mathematical research is underway in the classical field of analysis, especially function theory and series. Most of it represents simple extensions of known theory. An Institute of Mathematics was established in 1963 at the National Tsing Hua University to encourage mathematical research and to train teachers, but has achieved little. The best graduate students go abroad for their advanced training, and most of them do not return.

c. Astrogeophysical sciences

The Republic of China has a very minor capability for research in astrogeophysical sciences. Astronomical activity is limited principally to the observation of sunspots and other solar phenomena by a small observatory of the Taiwan Weather Bureau. The bureau operates a first-class operational weather system, which includes two weather radar installations (at Hua-lien and Rao-hsiung) and a rain gauge network, primarily for typhoon and flood forecasting purposes. Some academic meteorological research is accomplished at the Department of Geography and Meteorology, National Taiwan University, and the

Institute of Geophysics of the National Central Univers Although some research is being conducted in agrometeorology, most meteorological research is devoted mainly to rainfall studies for hydrological purposes.

Taiwan is active in hydrologic and hydraulic research. Most of the studies are limited to applied research and involve problems related to irrigation, flood control, soil erosion, sedimentation, and industrial and domestic water supply. Hydraulic models and field tests are used extensively in the study of sedimentation and erosion phenomena, the design of high dams and spillways, and gauging instrumentation. Although stream gauging has been in effect in Taiwan since the 1890's, much remains to be done to increase the number of rainfall, stream, flood, silt, and evaporation gauging stations. The scarcity of flood discharge records is a major deficiency affecting various model testings and the planning of complex hydraulic projects.

The country has a force of engineers with a high degree of technical training. Some lack experience, however, in the practical execution of projects of the magnitude and complexity now under consideration. The hydrologists and hydraulic engineers are active in various international scientific meetings but make only limited contributions.

Coastal engineering research has improved and appears to be increasing, especially as it pertains to harbor modernization and to the solution of silting problems. The Water Resources Planning Commission has been responsible for hydraulic and coastal engineering research since 1959. This commission operates two laboratories: The Taipei Hydraulic Laboratory at National Taiwan University and the Taiwan Hydraulic Laboratory at Taiwan Provincial Cheng Kung University. These laboratories are equipped with model test basins; wave, current, and tide simulators; and adequate data collection and measuring instruments. Research includes studies of littoral drift, wave effects on beaches, and structures, harbor improvement, sedimentation, and reclamation of land by means of dredging. Much of the research has been directed toward the improvement of the harbors of Chi-lung, Hua-lien, Kao-hsiung, and the planning of a new port for T'ai-chung.

Basic theoretical and applied geodetic research on Taiwan is limited. The area of concentration is on training in survey techniques and improvement in map production. The Mapping and Geodesy Department of the Ching Cheng Institute of Technology is the only institute that provides training in geodesy. The primary geodetic service agency is the Topographic Services, its headquarters are in Taipei and its facilities are located in T'ai-chung. The agency has a program underway to revise the existing geodetic triangulation, precise leveling, and gravity networks in Taiwan. It has cooperated with the United States in occulation observations, participated in international longitudinal determinations, and assisted in the computation and adjustment of the geodetic control network on mainland China.

The Taiwan Provincial Weather Bureau operates a network of 16 seismographs, but otherwise research in geology and terrestrial geophysics is directed mainly toward the location of petroleum and mineral resources. Routine drilling and seismic, geological, gravimetric, and geomagnetic surveys are conducted by the government-owned Chinese Petroleum Corp., supported by a partnership with U.S. Gulf Oil Co. The surveys have been conducted on Taiwan, neighboring offshore areas, and the Pescadores islands.

The oceanographic capability in Taiwan is low but is gradually increasing. The country's oceanographic activity has consisted primarily of nearshore surveys for the development of marine fisheries. However, oceanographic interest has increased as a result of participation in the International Kurshio (Japan Current) Study during 1965-66; this survey was conducted under the auspices of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization (UNESCO), with guidance from the UNESCO Science Cooperation Office for Southern Asia. The survey ship *Yang Ming* (originally the U.S. minesweeper U.S.S. *Lucid*), operated by Taiwan's Hydrographic Office, participated in this investigation. A new ship for coastal research was acquired in 1972 and cruises have been made to waters off Borneo, the Philippines, and mainland China. Taiwan has also shown increased interest in offshore mineral exploration, specifically in the exploration for oil. Foreign ships are hired to conduct these surveys, but as the country becomes more involved in oceanographic activity, there is a possibility more ships will be purchased. The Hydrographic Office produces oceanographic charts for use in conducting these surveys and antisubmarine warfare, and is doing considerable work in marine geology, particularly bathymetry. A few oceanographers are being trained in the United States.

Most of the oceanographic research is conducted at the Oceanographic Research Center of National Taiwan University Taipei, the Chinese National

Committee on Oceanic Research: the Taiwan Fisheries Research Institute, Chi-lung; and the Chinese Petroleum Corporation. The Oceanographic Research Center operates the oceanographic ship *Chiu Lien* (originally the U.S.S. *Geronimo*) in conducting nearshore research. Although cooperation among these organizations seems good, there is no overall coordinating agency. Republic of China is a member of the Intergovernmental Oceanographic Commission and the International Council of Scientific Unions. Until its expulsion from the United Nations, it was also an active member on the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas, a division of the U.N. Economic Committee for Asia and the Far East. Taiwan Served as host for the May 1971 Colloquim on Ocean Resources, a meeting which the United States and West Germany participated.

Glossary (u/ou)

ABBREVIATION	ENGLISH
AEC	Atomic Energy Council
CIST	Chung-shan Institute of Science and Technology
GRC	Government of the Republic of China
INER	Institute of Nuclear Energy Research
ITRI	Industrial Technology Research Institute
NSC	National Science Council
ROC	Republic of China (Nationalist China)
SDC	Science Development Committee