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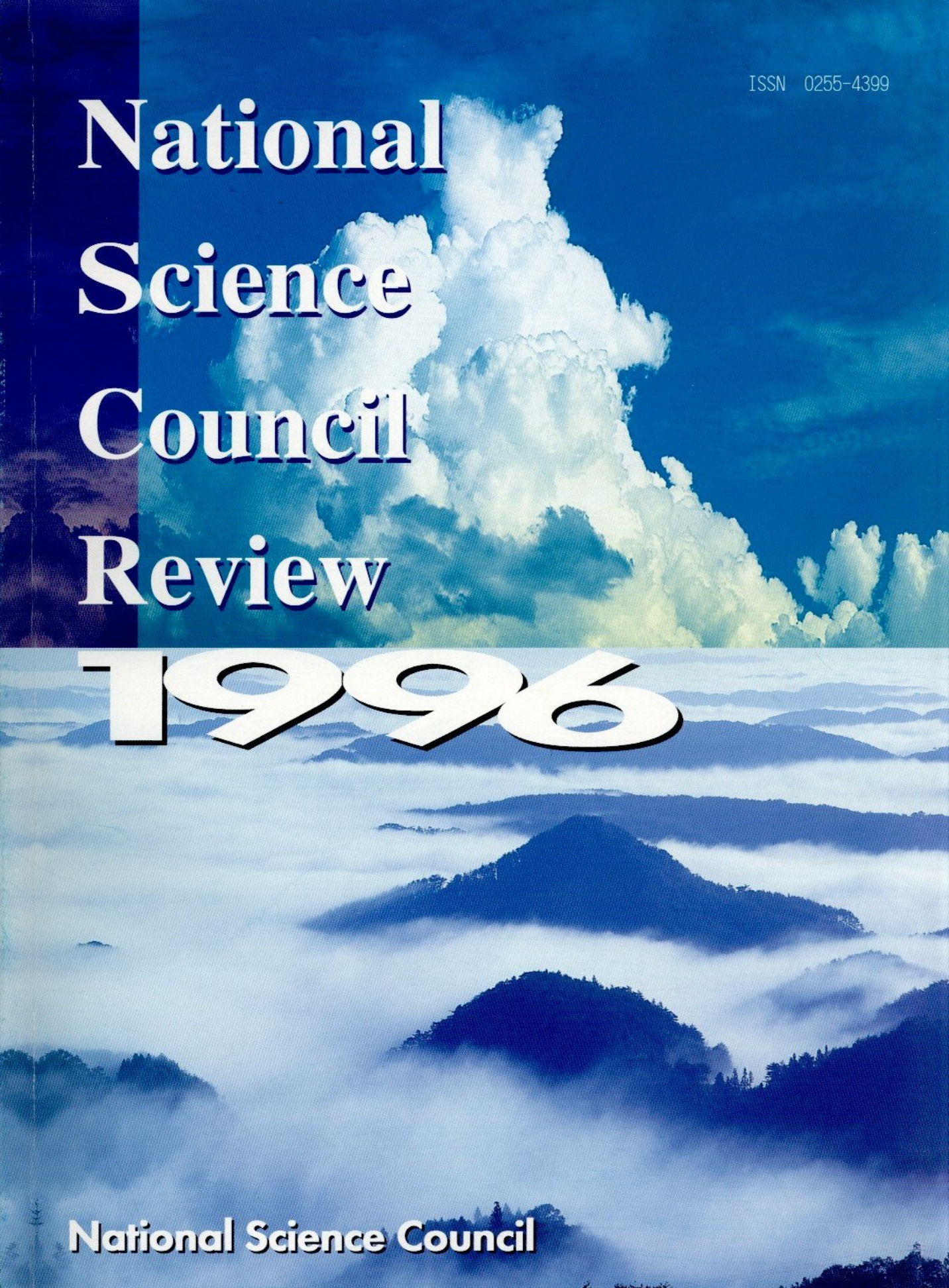
# National Science Council Review

# 1996



National Science Council

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# Chapter 1 General Overview

## I. The R.O.C.'s Scientific and Technological Development Organization

During the current stage, scientific and technological development in the R.O.C. is being carried out by means of comprehensive planning and implementation involving a division of labor. As the organization responsible for scientific and technological development, the National Science Council (NSC), Executive Yuan, has duties that include formulating policies, drafting mid- and long-term plans, coordinating and facilitating projects, and assessing the results of implementation. Besides being responsible for formulating and assessing the results of the nation's sci-tech policies, programs, and plans, the support the NSC provides to academic research projects from the Science and Technology Development Fund makes it the largest sci-tech funding organization in the R.O.C.

The NSC's organizational structure consists of a council whose eight to fourteen members include the heads of government and the minister without portfolio agencies with scientific and technological responsibilities, Executive Yuan ministers responsible for scientific and technological matters, and scholars and experts making up not more than one-third the total number of members. Council members are selected and hired by the Executive Yuan, have terms of three years without pay.

## II. International Trends in the Development of Science and Technology

Scientific and technological development ability has become a major factor in raising a nation's economic competitiveness. The emergence of a global economy in the post-Cold War era has made the development of science and technology a major focus of government at tention in many nations. It has been generally accepted that higher standards of science and technology will provide faster economic growth, more employment opportunities, and a sturdier foundation on which to build future prosperity. Since the Clinton administration took office in 1993, it has recognized that "investment in science and technology is an investment in America's future." This investment is seen in terms of economic growth, creation of jobs, the establishment of new industries, and a higher standard of living. Along the same lines, Japan's 1996 white paper on science and technology announced the ambitious goal of "making Japan the world leader in research activities." In 1996 the European Union's implementation committee published "Creating Tomorrow—European Research Serving the Public" as the guiding statement of the EU's fifth research and development plan. And in order to solve global problems including climatic change and environmental protection, international sci-tech cooperation is playing an increasingly important role in today's world.

Accompanying the publication of the 1996 science and engineering indices, the American Science Board proposed the following three goals for sci-tech policies: (1) The priority of research projects ought to be determined by national policy objectives and take into consideration limits on resources; (2) efforts should be made to improve scientific and mathematical literacy, insure an ample supply of human resources in the areas of science and engineering, and create a pool of skilled workers sufficient to meet the needs of today and the future; and (3) a strong foundation for scientific and technological development should be built by better integrating research and instruction in the university system.

Japan has attempted to prepare for the challenges of the 21st century and become a "scientific and technological innovator" by drafting the 1995 "Basic Science and Technology Law" as the legal basis for future large-scale science and technology programs. Furthermore, Japan also promulgated the "Basic Science and Technology

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Plan" in July 1996 to publicize specific sci-tech policies for the five-year period from 1996 to 2000. The content of this plan includes the establishment of a new sci-tech administrative structure, the creation of an optimal research environment, promotion of the study and public awareness of science and technology, and increases in the government's research outlays.

In the case of the European Union, the following major actions taken in 1995: Eight industry and research task forces were formed and made responsible for coordinating and guiding the formulation of research policies which will insure that research resources are best able to meet the needs of industry and society. Project supervision and evaluation methods were adopted and outside experts hired to perform an evaluation of 18 special projects. A green paper on innovation discussed problems currently impeding innovative research and proposed solutions. Research and training activities were employed to help increase the cohesiveness of the European economy and society. Of the total of 10,659 funded research projects, 2,660 were new projects begun during the year.

In order to increase national competitiveness, in 1995 the British government brought together specialists from industry, government, and educational and research institutions to jointly formulate a long-term technology plan. The plan that was devised provides for priority scientific and technological development work that will boost the competitiveness of 16 strategic industries over the next ten to twenty years. According to this plan, government and industry will respectively provide US$42 million and US$40 million in funding, and academia and industry will make project applications via joint contracts. The plan went into effect in 1996 and will continue for three years.

Science and technology are sources of new knowledge, and provide the basis for achieving economic growth and raising the standard of living. As the turn of the century approaches, all major nations are actively investing in scientific research. Therefore it is imperative that the R.O.C. also take vigorous measures to boost its technological strength and improve its ability to compete in the international arena.

## III. Scientific and Technological Research Environment and Development Strategies

The R.O.C.'s R&D funding has grown only minimally over the last few years, and in comparison with other nations, total support for R&D is at a rather low level. In spite of this situation, tight budgetary constraints have not prevented a significant improvement in the quality of research results. Now strategies are currently being devised to raise the quality of research by adjusting funding for academic research and providing adequate support for long-term cutting-edge projects conducted by truly outstanding researchers.

In order to raise the nation's scientific and technological standards, the NSC is drafting the following key measures:

### *A. Steadily Increasing Resources Available to Science and Technology*

In order to implement the prevailing recommendation that science and technology should continue to grow at a steady rate, the sci-tech budgets of government units will maintain a 15% growth rate over the next three years. In addition, public enterprises will be expected to use 10 to 15% of their R&D budget for the purpose of conducting joint academic-industrial research. In order to gradually expand the R&D capability of industry, private enterprises will be encouraged to invest more in R&D by means of tax deductions and matching funds, and will also be given opportunities to participate in joint research projects in conjunction with government units.

### *B. Strengthening Mechanisms for the Integration of Technological Resources*

In order to effectively integrate sci-tech resources dispersed throughout various government departments, the NSC is actively strengthening the functioning of the NSC Council Board. Henceforth the NSC Council Board will help integrate the nation's sci-tech resources by deliberating and reaching a consensus on such matters as the formulation of major sci-tech policies, prin-

ciples for the integration and allocation of sci-tech resources, strategies for the development of research in key areas, and large-scale research projects.

### *C. Carefully Targeting Key Areas and Striving for Breakthroughs*

In the future, the NSC's assistance for research at educational and research institutions will break with the old blanket approach and place more emphasis on support for key areas and innovative projects. In addition, there will be clear policies for support of special-topic projects: The goal of basic research shall be innovative breakthroughs and the attainment of international standards; the goal of applications research shall be meeting the needs of industrial development, public welfare, and national defense.

### *D. Providing a Legal Foundation for the Development of Science and Technology*

In order to provide legislative bodies a basis for their supervision and to insure that organizations have clear guidelines for hiring, training, compiling budgets, promoting research findings, and cooperating with other units, a "Basic Science and Technology Law" and related statutes addressing research will be deliberated and enacted with all due speed.

### *E. Stepping up Involvement in International Scientific and Technological Cooperation*

Participating in large multinational research projects and thereby acquiring access to international scientific resources has already done much to improve the R.O.C.'s scientific and technological capabilities. In the case of oceanographic and atmospheric research, participation in joint international projects has gradually made the R.O.C. a leader in these areas, and has given scientists in Taiwan access to the newest ecological data from around the world. In the field of high-energy physics, R.O.C. scientific teams have been participating in leading-edge international physics experiments at such renowned laboratories as Europe's CERN, America's Fermilab, and Japan's B Factory.

### *F. Promoting Dialog Between Science and the Humanities*

The rapid development of science and technology has led to the rise of many new issues in the humanities—such as problems involving ethics and law—and dealing with these issues now awaits the efforts of specialists in the humanities and social sciences. Therefore the NSC is establishing forums through which scientists and technologists can conduct a dialog with social scientists and humanities experts. These forums will allow the views of authorities in both areas to be collected and assist in the selection of areas where productive interdisciplinary research projects involving both the "hard" sciences and the humanities are feasible.

## IV. Administrative Concepts

In the face of rising labor costs, increasingly expensive land, and widespread concern about the environment, firms in Taiwan's export-oriented economy can only survive if they successfully upgrade, increase productivity, embrace high technology, and strive for greater added value. Thanks to the efforts of government and private industry over the last few years, science and technology have become a driving force of national development, and a broad consensus has formed behind support for sci-tech research. In order to better achieve the national goals of "using technology to stimulate modernization," "using sci-tech development to drive economic growth," and "increasing national competitiveness," and to make Taiwan an "island of high technology" in the western Pacific region, the NSC will increasingly take advantage of the NSC Council Board to serve as the scientific advisory arm of the Executive Yuan and integrate the nation's sci-tech resources—both those scattered throughout various government agencies and those in private hands—so that they can be used in as effective a manner as possible. During the current stage, the NSC will carry out sci-tech development work in accordance with the following administrative concepts:

1. Long-term, far-seeing planning of sci-tech

development should be carried out on the basis of the experiences of the world's advanced nations: According to the resolutions of the Fifth National Science and Technology Conference in September 1996, a white book on sci-tech development and mid- and long-term national science and technology development plans are to be compiled within a six-month period to serve as a basis for the administration of sci-tech research. In addition, the enactment of the "Basic Science and Technology Law" will provide a strong legal foundation for the ongoing development of science and technology.

2. The resources available for R&D should be increased: Since the national economy is still heavily dependent on medium and small-sized enterprises, vigorous efforts will be made to accelerate industrial upgrading and restructuring by means of increased budgetary support for R&D and the training of technical personnel. It is recommended that overall R&D expenditures constitute 2.5% of GDP.
3. Mechanisms for the integration and sharing of sci-tech resources should be established: Strengthening the functioning of the NSC Council Board will allow the NSC to serve as the Executive Yuan's sci-tech advisor. Mechanisms for the integration and sharing of sci-tech resources between different organizations are being established; among these is the promotion of joint R&D projects by the "Industrial Technology and Academic Cooperation Task Force" set up in conjunction with the Ministry of Economic Affairs.
4. A benignly competitive environment for sci-tech research should be created: Efforts will be made to secure the continued stable growth of the NSC-supervised National Science and Technology Development Fund. In addition, in 1998 its budget will be changed from a government unit budget to an attached unit budget so that it can function in as flexible a manner as possible. Research support strategies will be formulated in order to encourage innovative basic research and applications research meeting the needs of industry. Efforts will be made to swell the ranks of new researchers (measures already drafted include "Support for Projects of New Research Workers" and "Support for Special Projects by New Research Workers with Outstanding Records") and encourage veteran researchers to continue to pursue excellence.
5. The quality of basic research should be improved and innovative breakthroughs encouraged: An approach of support for key areas that breaks with the blanket support provided in the past will be adopted. Leading-edge research will be promoted, and emphasis placed on "quality."
6. The training and utilization of sci-tech personnel should be strengthened: The revision of the NSC's "Guidelines Governing Financial Support for the Recruiting of Sci-tech Personnel" and "Guidelines Governing Financial Support for the Hiring of Post-doctoral Researchers" has increased the number of units that can apply for funding and eased applicant qualification requirements.
7. To achieve a multiplier effect, integrated research projects should be promoted: The NSC will promote vertically- and horizontally-integrated research projects and will foster international cooperation by sending research teams to take part in large international projects and inviting prominent foreign scientists to participate in joint research at the R.O.C.'s national laboratories.
8. Research in the humanities and social sciences should be boosted: Besides increasing the budget for humanities and social sciences research, a series of "Forums for Dialog Between Science and the Humanities" will be held in an effort to find research topics of common interest and balance the development of the humanities and social sciences with that of science and technology.
9. The development of science-based industrial parks should be continued: Apart from completing the assessment of the Chunan and Tungluo sites for the fourth-stage expansion of the Hsinchu Science-Based Industrial Park, a preparatory office was established to undertake the development of a new science-based industrial park in Tainan.

# Chapter 2 The Results of the Implementation of Sci-Tech Administration

## I. The Science and Technology Development Fund

The Science and Technology Development Fund's 1996 budget of NT$8,970 million represented an increase of 6.7% over the previous year. Below is a brief report on fund utilization for various budget items:

1. NT$980.3 million was allocated for natural science and mathematics, including research in the natural sciences, mathematics and statistics, and computer science.
2. NT$1,364.3 million was allocated for engineering technology development, including engineering technology research, basic engineering research, and engineering applications research.
3. NT$1,353.1 million was allocated for bioscience, medicine, and agriculture, including research in bioscience, medicine, public health, and biotechnology.
4. NT$471.9 million was allocated for the humanities and social sciences, including research in the humanities and social sciences, and the establishment of a humanities and social sciences research center.
5. NT$289.8 million was allocated for science education development, including science education research.
6. NT$919.5 million was allocated for integrated sci-tech development, including integrated basic research and integrated applications research.
7. NT$1,700.9 million was allocated for improving the basic sci-tech research environment, including joint facilities and equipment for earthquake engineering research, submicron element R&D, and other research.
8. NT$1,458.2 million was allocated for administrative and promotional work, including recruiting researchers, etc.
9. NT$298.1 million was allocated for international programs, including strengthening the relationship between the NSC and international sci-tech organizations.
10. NT$133,4million was allocated for planning, coordination, and evaluation, including the overall planning and implementation of scientific and technological development in the R.O.C.

Significant results during 1997 include the following:

### *A. Funding Special-Topic Research Projects*

Financial support for special-topic projects from the Science and Technology Development Fund was given to institutions of higher learning, NSC-approved research organizations, and research units attached to public enterprises. A total of 67 public and private universities, 61 research organizations, and 47 junior colleges received funding during 1996.

A total of 8,517 research projects were funded during 1996. This represents an increase of 248 projects, or 3%, over the previous year. The more than NT$4,623.2 million used to fund special-topic research projects was 2.8% less than that spent the year before.

### *B. Training, Recruiting, and Rewarding Scientific and Technical Personnel*

If it is desired to raise research standards and foster the growth of sci-tech research, the training, recruiting, and rewarding of sci-tech workers is of the utmost importance. The NSC's efforts in this area are as follows:

1. Training of in-service research personnel: 188 individuals were selected for advanced study overseas and 74 were selected for advanced

study in Taiwan during 1996; the total of 262 persons was an increase of 58 over the year before.

2. Recruiting overseas sci-tech workers: During 1996 a total of 407 individuals were recruited, including foreign experts serving as special lecturers, guest research professors, guest research associate professors, and guest specialists, as well as domestic and foreign post-doctoral research assistants and overseas scholars in invitational lectureship and short-term lectureship positions. In addition, 14 persons from mainland China were recruited.
3. Monetary awards for research personnel: A total of 4,853 Class A, Class B, and ordinary awards for researchers were approved during 1996. In addition, 108 persons were selected from the list of Class A award recipients and additionally given "Outstanding" awards.
4. Commending outstanding scientists and technologists: Special commendations were awarded to five individuals in five cases during 1996.

## II. The Promotion of Comprehensive Sci-Tech Development

### *A. The Planning, Evaluation, and Review of National Sci-Tech Development*

#### 1. Convening the Fifth National Conference on Science and Technology

In order to accelerate sci-tech development and raise national competitiveness, the Fifth National Conference on Science and Technology was convened in September of this year and addressed the three topics of "the planning and effective utilization of sci-tech resources," "the establishment of a high-tech development framework," and "using science and technology to drive modernization." The wide-ranging discussions of these topics at the conference helped generate many specific and feasible proposals, among which are the following:

(1) Increasing investment in sci-tech development:

It is vital that additional resources be devoted to sci-tech research if the nation's scientific and technological development is to be accelerated. It was suggested that total R&D expenditures reach a target of 2.5% of GDP by the year 2000, and the government contribute approximately 45% of R&D funding (in other words, the government will provide R&D funding equal to 1.13% of GDP, while the private sector will provide R&D funding equal to 1.37% of GDP). Expenditures on basic research should be no less than 15% of R&D outlays, while technology development expenditures should be greater than 50%. The R&D investment of manufacturing industries should be at least 2% of turnover. In order to act on widespread recommendations that there be a steady increase in sci-tech expenditures, the government should allow the sci-tech budget to grow by 15% annually over the next few years.

In addition, with regard to the training and utilization of sci-tech personnel, it was suggested that the number of researchers with at least a bachelor's degree should rise to 52,500 by the year 2000, and that half of these should possess master's or Ph.D. degrees.

(2) Establishing six key technologies:

It was suggested that multimedia (including communications), biotechnology, aerospace, precision machinery, special materials, and environmentally-safe electric vehicles and batteries serve as the focal areas of joint technology development efforts involving various government agencies.

(3) Putting sci-tech policies on a sound legal basis:

It was suggested at the conference that a "Basic Science and Technology Law" and other laws governing R&D be drafted as soon as possible. Such laws will provide a clear basis for government agencies' hiring, training, budgeting, promotion of research findings, and cooperative mechanisms as they work to advance science and technology, and also give legislative bodies guidelines for their supervision.

(4) Publishing a "white paper" on science and technology:

The conclusions reached at National Con-

ference on Science and Technology can serve a blueprint for the nation's sci-tech development through the beginning of the next century and provide ideas for specific projects. After the conference, the NSC took the initiative in inviting other agencies to help form task forces to organize the conference's conclusions and recommendations, and in June of this year issued the results as the R.O.C.'s first "White Paper on Science and Technology" and revised mid- and long-term plans for scientific and technological development.

## 2. Strengthening Mechanisms for the Integration and Coordination of Sci-Tech Resources

(1) Strengthening the NSC Board's policy review and coordination functions:

The NSC Board is made up of experts and specialists and includes the heads of several relevant agencies, Executive Yuan ministers, and the head of the Academia Sinica. Moreover, in order to improve coordination and integration of sci-tech planning and budgeting, the head of the Directorate General of Budget, Accounting & Statistics has also been designated a board member. In order to let the NSC play the role of the government's sci-tech advisor, in the future the NSC Board will submit proposals to the Executive Yuan after discussing and achieving a consensus on such matters as the formulation of sci-tech policies, the integration and allotment of sci-tech resources, development strategies for key areas of science and technology, and the deliberation of major sci-tech projects.

(2) Establishing a mechanism for the deliberation of major sci-tech projects:

According to the "Procedural Guidelines for the Deliberation of Major Sci-tech Projects," in the future all projects whose annual budget exceeds NT$100 million or whose total budget exceeds NT$300 million may be implemented only after initial and follow-up reviews by the NSC, deliberation by the NSC Board, and submission to the Executive Yuan for final approval. This process will help avoid unnecessary or overlapping investments and will stimulate horizontal and vertical integration between different projects or different agencies.

(3) Establishing a "government sci-tech project budget control task force":

A sci-tech project budget control task force has been organized by the NSC, the Ministry of Finance, the Science and Technology Advisory Group, and Directorate General of Budget, Accounting & Statistics. This task force will more effectively control the budget of sci-tech projects, provide for a good match between projects and their budgets, and insure that the greatest possible benefits are derived from limited resources.

## 3. Integrating Sci-Tech R&D Resources

(1) Actively implementing national-level projects:

In order to bring together resources in different locations for a common purpose, the NSC is implementing national-level integrated mission-oriented projects in key areas with academic, technological, and practical significance. To date these areas have included agricultural biotechnology, gene therapy, natural disaster prevention, and the National Information Infrastructure (NII) program. The NSC will strive to tie together up-, mid-, and down-stream research resources and provide long-term, priority support in these areas in order that the results may stimulate economic growth and provide citizens with a better quality of life.

(2) Promoting inter-agency cooperative research:

The NSC's active coordination of joint inter-agency research projects has been helped along by a cooperative research task force formed in conjunction with the Ministry of Economic Affairs (industrial technology), Department of Health (medical technology), Atomic Energy Council (nuclear technology), and Environmental Protection Administration (environmental technology). This task force's job is to fine-tune the resources and research capabilities of different organizations in order to boost the R.O.C.'s overall sci-tech development capacity and increase national competitiveness.

(3) Broadening sources of sci-tech funding:

In order to broaden sources of sci-tech fund-

ing, the NSC is taking the initiative in contacting other agencies and suggesting that an appropriate proportion of money from "major public construction project funding" and "pollution control funding" be allocated to research and development. These additional sources of funding for public construction and pollution control R&D will raise the standards of research in these fields and improve citizens' quality of life. It has also been proposed that each government enterprise contribute 10-15% of its R&D budget (estimated to total NT$600-700 million) to joint industrial technology research projects. The NSC is in the midst of formulating planning, management, and training measures to assist government enterprises in raising the standards of their R&D work.

(4) Maintaining incentives for private investment in R&D:

The NSC will continue to encourage private R&D investment and participation in government research projects by providing tax deductions or matching funds.

### *B. Determining a Reasonable Growth Rate for Government Research Expenditures*

The government's goals include strengthening planning and integration of the nation's sci-tech resources, increasing total R&D expenditures to 2.5% of GDP as in the most advanced nations, and increasing government R&D expenditures to 1% of GDP and 4% of the overall government budget. In addition, a government policy objective is to become one of the world's five most competitive nations within the next four years. To achieve these goals, a resolution was passed at the 131st meeting of the NSC Board to maintain the annual growth rate of the government's sci-tech budget at a level of not less than 15% beginning in 1998. Moreover, the Fifth National Conference on Science and Technology established a consensus among industry, officialdom, academia, and the research community that 15% annual growth of the government sci-tech budget is a reasonable growth rate.

### *C. Reforming the Research Project Review System*

After deliberation at a NSC Board meeting, a decision was made to insure the effective utilization of sci-tech resources by confirming the "Review Regulations for Major Government Sci-tech Projects." It is hoped that these regulations will help deliver more tangible results from research through the use of more effective review and evaluation methods, the establishment of a system for the rational allocation of sci-tech funds, and maintenance of firm control over project timetables. Under the new regulations, projects with either an annual budget exceeding NT$100 million or a budget of NT$300 million over the life of the project will be subject to an initial review, follow-up review, and an evaluation, and will be given long-term support only after being approved by the NSC Board. These procedures will insure that major sci-tech projects meeting national needs will be guaranteed a stable source of resources.

The review of major sci-tech development projects will include the following salient points:

1. Proposals for major projects must be accompanied by a detailed feasibility analysis report and an evaluation by the responsible agency.
2. To insure that major sci-tech projects proceed smoothly, any agency may submit a completed proposal, including an evaluation and feasibility analysis, to the NSC for review at any time in light of the agency's sci-tech policy and administrative needs.
3. The NSC and the Executive Yuan Science and Technology Advisory Group will engage specialists to form a review task force. This task force will make a detailed investigation of the project, and may review the proposed schedule for the first three years of the project. The task force's recommendations will serve as input for the second review.
4. The second review committee will be composed of the assistant directors of the NSC, the Science and Technology Advisory Group, and the Directorate General of Budget, Accounting & Statistics. This committee will review the recommendations of the initial review and assign responsibility for budget

control and allocation to the Sci-tech Budget Control Task Force.

5. Projects that have passed the second review will be submitted to the NSC Board for deliberation. Projects approved by the NSC Board will be submitted to the Executive Yuan for final checking, and afterwards project expenditures will listed in the budget for the following year.
6. If a project is reviewed during the middle of the fiscal year, the NSC Board may coordinate the provision of immediate support with the responsible agency if the project is considered to have special priority or timeliness.
7. Across-the-board support for sci-tech development will be curtailed, and the feasibility and effectiveness of projects will be assessed on the basis of their economic, social, technological, and legal aspects. The following fifteen items will be taken into consideration when evaluating projects:
   (1) Need for the project
   (2) Technical feasibility (including comparisons with similar projects overseas)
   (3) Economic benefits
   (4) Effects on society and culture
   (5) Appropriateness of implementation steps and methods
   (6) Appropriateness of project schedule (including inspection dates)
   (7) Legal considerations
   (8) Manpower to carry out project
   (9) Required funding and allocation among participating agencies
   (10) Timeliness of project
   (11) Expected results
   (12) Degree of private participation
   (13) Project risk
   (14) Comparison with alternative proposals
   (15) Other aspects
8. After the project proposal has been submitted to the NSC, the initial review shall be completed within two months and, if possible, deliberation by the NSC Board shall be completed within three months.

### *D. Deliberation, Control, and Evaluation of Major Government Sci-Tech Projects*

The overall government sci-tech budget for 1998 will be NT$40.18 billion. Government agencies that have submitted major project proposals for 1998 include the Academia Sinica, Ministry of Education, Ministry of Economic Affairs (including the Industrial Technology Department, Industrial Development Bureau, National Bureau of Standards, Energy Commission, and Commerce Department), Ministry of Transportation and Communications (including the Central Weather Bureau), Ministry of the Interior, Department of Health, Environmental Protection Administration, Council of Agriculture, Atomic Energy Council, Council of Labor Affairs, Research, Development and Evaluation Commission, and the NSC. These agencies have submitted a total of 52 proposals for major projects requiring a total expenditure of NT$43.11 billion and 138 proposals for ordinary projects requiring a total expenditure of NT$5.234 billion.

After undergoing initial and second reviews, the amount of funding provided is to be as follows: NT$3.537 billion for the Academia Sinica, NT$869.5 million for the Ministry of Education, NT$19.04 billion for the Ministry of Economic Affairs (NT$14.36 billion for the Industrial Technology Department, NT$3.511 billion for the Industrial Development Bureau, NT$371.0 million for the National Bureau of Standards, NT$721.0 million for the Energy Commission, and NT$83 million for the Commerce Department), NT$395.3 for the Ministry of Transportation and Communications, NT$130 million for the Ministry of the Interior, NT$1.235 billion for the Department of Health, NT$59.04 million for the Environmental Protection Administration, NT$1.797 billion for the Council of Agriculture, NT$524.5 million for the Atomic Energy Council, NT$20 million for the Council of Labor Affairs, NT$58 million for the Research, Development and Evaluation Commission, and NT$14.54 billion for the NSC.

As for improvements to the control, audit, and evaluation system, schedule control of projects under the Executive Yuan is being strengthened and the results of project effectiveness evaluations are being made public. Government agencies' research results are being sub-

jected to public scrutiny at conferences, and specialists are being hired to perform in-depth investigations of the responsible agencies and submit comprehensive reports of their findings. The results of these efforts will serve as a major reference for decisions concerning the following year's sci-tech projects. Besides controlling 1997 projects under the Executive Yuan, during 1996 the NSC has also held results conferences in the seven fields of transportation, information, materials science, telecommunications, machinery, chemical engineering, and nuclear energy.

## III. Funding Academic Research

### *A. Supporting Special-topic Research Projects*

#### 1. Funding Principles and Methods

Because special-topic research projects have enabled universities and research institutes to continuously add to and renovate their scientific equipment and have given domestic scholars systematic, ongoing opportunities to participate in research, they must be given credit for raising the quality of domestic research to a level that now approaches international standards. Although only 2,181 special-topic research projects were funded in 1986, this number had swiftly risen to more than 8,000 in 1996.

In 1996 the NSC's project funding principles and methods included the following main aspects:

(1) "Awards" are handled separately from "funding"; applications for awards are to be made on the basis of "research findings" and applications for funding are to be made on the basis of "special-topic project plans."
(2) Applications may be made once a year.
(3) Funded special-topic research projects include the two categories of "individual projects" and "integrated projects."
(4) In order to encourage the formation of research teams and the development of "centers of excellence," extra resources and funding is to be given to integrated research projects. It is hoped that this type of project will deliver the greatest possible benefits by insuring that sci-tech resources are shared to the maximum extent and research experience and findings are exchanged widely.
(5) Funding applications are subjected to initial and second reviews. Initial review consists of an evaluation of documentary materials conducted by at least two experts in the relevant field. Second reviews are performed by a committee, whose members seek to determine a fair and appropriate level of funding through discussion and negotiation.
(6) In order to prevent participants from doubling as judges, funding applications from evaluation committee members are considered separately from the mass of other applications.
(7) On-site investigations of the original evidences of research projects are conducted.
(8) A re-application system has been established in order to correct for errors and omissions.

#### 2. Encouraging Individual Research Projects

Applicants may submit individual research project proposals that focus on their area of personal specialization or that fit into the NSC's discipline planning outline. All individual research projects must go through a two-stage review process consisting of initial and second reviews:

(1) Initial review: a peer review of documentary materials submitted by the applicant.
(2) Second review: deliberation at a meeting of several specialists in the relevant academic field.

Key aspects examined during the review process include: (1) research concept, (2) research objectives, (3) research content, (4) research methods, (5) expected results, and (6) required expenditure and manpower. Approximately 6,000 individual projects with funding of roughly NT$2.7 billion were approved from January to December of 1996.

#### 3. Increasing Support for Integrated Projects

Since 1995 outstanding researchers have

been encouraged to form research teams and carry out goal-oriented horizontally- or vertically-integrated projects. It is hoped that this type of project will foster a collegial mentality and enable the best use of limited existing resources.

Developing science and technology in the R.O.C. will inevitably require a long-term, continuous commitment to research. The NSC's support for special-topic research projects should encourage researchers to devote themselves continuously to research and development work that will help raise the nation's sci-tech standards. Efforts will be made to achieve long-term sci-tech development goals by gradually urging researchers to submit project proposals that fit into the NSC's discipline planning outline.

The following is a description of salient aspects of the submission and review of integrated project applications:

Submission of project proposals:

(1) Mission-oriented projects initiated by the NSC.
(2) Interdisciplinary or team-type projects that fit into the NSC's discipline planning outline.
(3) Team projects centered on a specific topic submitted by research teams organized by interested academics.
(4) A written research concept should be submitted to the relevant NSC department two to four months before a formal application is made. A formal application may be submitted only if the research concept has passed review.

Key areas examined during project review:

(1) The necessity of integration: this aspect includes overall objectives, overall division of labor, relationship between different subprojects, and level of integration.
(2) Coordination of manpower: this aspect includes the coordination and leadership abilities of the chief project host, the professional skills of subproject hosts, and the ability of personnel to cooperate harmoniously during the course of the project.

## 4. Promoting Cooperative research Involving Industry and Academic Institutions

(1) Industry-academia cooperative research

Lately basic research in the advanced nations has placed increasing importance on comprehensive scientific development and interdisciplinary research. In order to stimulate the growth of high-tech industries and raise national competitiveness, more emphasis is being placed on the application of research results and the linkage of scientific research with economic growth. In awareness of these trends, the NSC included appropriate strategies in the "Six-Year Mid-Term Science and Technology Development Plan." Afterwards the NSC addressed the need for cooperative research involving private industry and academic institutions by inviting representatives from industry, the government, academia, and research organizations to participate in far-reaching discussions on such aspects as cooperative projects' appropriate scope, manner of implementation, formulation of goals, evaluation procedures, personnel training, apportioning of benefits, and resulting technology transfer. In the wake of these discussions, the NSC drew up the "Implementation Guidelines for the Encouragement of Cooperative Research Involving Private Industry and the Academic Sector" and the "Application Procedures for Cooperative Research Projects Involving Private Industry and the Academic Sector." These measures will serve as a basis for the NSC's promotion of future goal-oriented academia-industry research cooperation.

(2) Features of industry-academia cooperative research

The NSC's academia-industry cooperation program was drawn up in light of the R.O.C.'s industrial and academic environment, and therefore includes the following features:

a. Projects focus on the research and development of key parts, components, and products as specified in the Six-year Mid-Term Sci-tech Development Plan. Project objectives are therefore as specific and concrete as possible. The projects should seek to advance the state

of knowledge in a particular field, and results should be in the form of patents or technology transfer.

b. Members of research teams are to be selected by the projects' primary hosts, and should be able to work together with unity of purpose in full cooperation.
c. In order to verify the necessity of the research and facilitate successful technology transfer, the private enterprise involved provide financial backing and assign personnel to participate in the research.
d. To insure that project goals and results will meet the needs of industry, industrial personnel must comprise at least one-third of the committee evaluating cooperative projects, and should comprise at least one-half of the committee evaluating research results.
e. In order to meet the requirements of industry, applications for cooperative projects need not be submitted at certain specific times. Professors in charge of projects will be given adequate encouragement and incentives.

The promotion of academic-industry cooperation has already delivered very promising results. Firstly, it has brought about a balanced mix of theoretical and practical research. Secondly, the direct participation of industry has insured that the content of cooperative research has been selected in light of the needs of the nation's industrial upgrading. After their graduation, graduate students who have participated in cooperative research should have little difficulty finding jobs in the private sector. Thanks to the commitment of the abundant experience and resources of academic institutions, private enterprises that participate in cooperative research will be able to directly share the fruits of sci-tech development in the R.O.C. Patents and other intellectual property rights emerging from cooperative projects will serve as a basis for private firms' development of new products.

Of the 91 conceptual reports for cooperative projects approved to date, 63 are now being carried out and 14 have already been completed and resulted in technology transfer.

### *B. The Training, Recruiting, and Rewarding of Sci-Tech Personnel*

#### 1. Training Sci-tech Personnel

The primary way in which the NSC carries out the training of sci-tech workers is by selecting outstanding active personnel from public and private educational institutions and public research organizations for advanced study or participation in research projects in Taiwan or overseas. This allows these individuals to absorb knowledge and helps raise academic standards in the R.O.C. following their return. A total of 4,510 persons have been approved for such sabbaticals in the 35 years since the program began in 1960 (Fig. 1). Of the 336 persons selected this year (Table 1), 234 are studying abroad and 102 are studying at domestic institutions.

#### 2. Funding the Recruiting of Sci-Tech Personnel

The recruiting of high-level scientific and technological workers is one of the NSC's most important tasks. In particular, the NSC seeks to recruit specialists who are outstanding in their field and have the experience required to carry

**Table 1. Statistical Breakdown of Persons Participating in Advanced Study and Research During 1996**

| | Natural Science | Engineeringand Applied Science | Biology,Medicine, and Agriculture | Humanities and Social Sciences | Science Education | Total |
|---|---|---|---|---|---|---|
| In Taiwan | 3 | 30 | 41 | 26 | 2 | 102 |
| Overseas | 37 | 76 | 28 | 90 | 3 | 234 |
| Total | 40 | 106 | 69 | 116 | 5 | 336 |

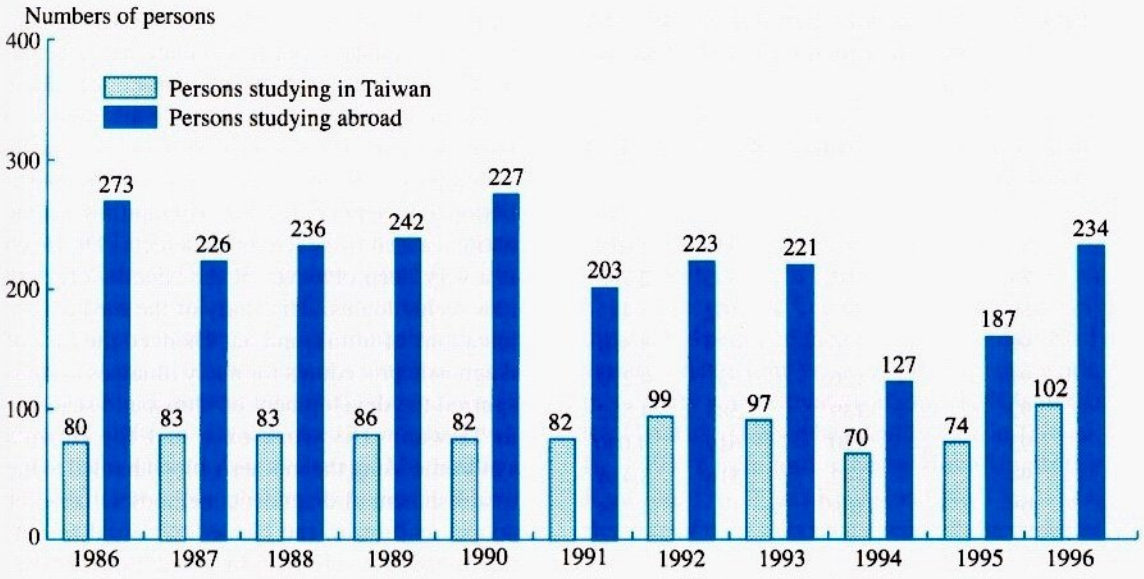


**Fig. 1. Chart of Numbers of Persons Selected for Advanced Study Since 1986.**

out research projects, teach in special fields, or assist with sci-tech development and management work. This year 510 overseas specialists were recruited to come to Taiwan to work (Table 2).

### 3. Awards for Sci-Tech Personnel

Beginning in 1996, the simplification of the awards system led to the elimination of the "Superior" award in favor of the two categories of "General Research Award" (including "Class A" and "Class B" awards) and "Outstanding Research Award." General research awards have the purpose of raising the spirit of the research community, while "outstanding" awards seek to honor workers who have generated outstanding research results or made other significant contributions.

This award system has been very successful ever since it was instituted. The ultimate goal of modifying the awards system has been to better integrate resources at institutions of higher

**Table 2. Statistical Analysis of R.O.C. and Foreign Sci-Tech Personnel Recruited in 1996**

| | Natural Science | Engineering and Applied Science | Biology, Medicine, and Agriculture | Humanities and Social Sciences | Science Education | Total |
|---|---|---|---|---|---|---|
| Guest Research Professors | 4 | 7 | 4 | 1 | 1 | 17 |
| Special Researchers | 10 | 18 | 10 | 1 | 8 | 47 |
| Special Assistant Researchers | 10 | 6 | 4 | 0 | 2 | 22 |
| Post-doctoral Researchers | 153 | 81 | 176 | 8 | 6 | 424 |
| Total | 177 | 112 | 194 | 10 | 17 | 510 |

**Table 3. A Statistical Breakdown of NSC Award Recipients Over the Last Ten Years**

| Tape of Award Academic Year | Outstanding | Superior | General |
|---|---|---|---|
| 86 | 79 | — | 2,740 |
| 87 | 86 | 333 | 3,039 |
| 88 | 95 | 362 | 2,798 |
| 89 | 97 | 402 | 3,443 |
| 90 | 126 | 479 | 3,864 |
| 91 | 136 | 537 | 4,270 |
| 92 | 139 | 583 | 4,552 |
| 93 | 150 | 619 | 4,040 |
| 94 | 142 | 516 | 3,436 |
| 95 | 108 | — | 4,745 |

learning and research organizations so that they can be used more effectively and are available for projects of national importance. Table 3 shows a detailed breakdown of the numbers of researchers awarded grants in recent years.

## 4. The Selection and Commendation of Outstanding Individuals

The selection and commendation of outstanding researchers has been carried out since 1976, and is now in its 21th year. The aim of this year's commendation activity was to stimulate even better results and make an even greater contribution to national society by expanding the training and utilization of technical manpower and encouraging sci-tech specialists to make a long-term commitment to research work. This year, the commendation of six individuals working on five separate projects was approved:

(1) Prenatal health care and diagnosis

In the midst of his busy schedule of medical work, Dr. Hsieh Feng-chou has always maintained an attitude of "learning from people's illnesses." He has made an in-depth study of fetal illnesses and the clinical uses of ultrasound. In particular, he has been active in collecting medical information pertaining to Taiwan, and every year publishes a white paper on maternal and child health care. These white papers contain collected data concerning maternal and child health care in Taiwan, discuss solutions to some of the most intractable problems in this field, and introduce and promote new prenatal diagnostic techniques. This has made a significant contribution to lessening the burden to families and the nation caused by severe birth defects. Dr. Hsieh is a very keen observer of the benefits of using new technologies. His study of the medical applications of ultrasound has changed the face of diagnostic procedures for many illnesses and has spurred the development of ultrasound scanners in Taiwan. His work on a test for Down's syndrome using the mother's blood has led to the establishment of diagnostic methods suitable for people in Taiwan, and has led to a local revolution in the prevention of this condition. Following in Taiwan's footsteps, many of the other countries in Asia are now engaging in efforts to prevent Down's syndrome. In addition, Dr. Hsieh's clinical observations of the correlation between fetal villi and missing fetal limbs have stimulated progress in the study of human birth defects. Dr. Hsieh has helped shake off the local medical community's stifling dependence on Western medical knowledge by creating guidelines that are especially suited for Taiwan; these guidelines have, in turn, had an impact on medicine in other Asian countries. His research on missing fetal limbs has not only led to world-class insights on early fetal defects, but has also helped prevent countless tragedies from the misuse of medical techniques.

(2) Development of a high-efficiency compaction technique for low-level radioactive waste

Low-level radioactive waste is one of the most troublesome problems associated with nuclear energy. The amount of radioactive waste generated directly impacts the environment and public welfare. The disposal of radioactive waste is a developing branch of technology, and old methods cannot meet today's stringent environmental protection requirements. The high-efficiency compaction technique for low-level radioactive waste developed by Mr. Huang Ching-tsun is tailored to meet the needs of nuclear waste disposal in Taiwan. Mr. Huang's new technique can

overcome the shortcomings of conventional compaction methods using cement, asphalt, or plastic. It is able to compact two barrels of stable-quality compacted radioactive waste into a volume of just 0.13 barrels. It is thus able to deliver a compaction efficiency factor of 15.4, and is 5.92 times as efficient as the method currently being used at Taiwan's No. 3 nuclear power plant. By significantly decreasing the volume of waste, this technique will greatly facilitate waste storage. Moreover, the quality of compacted waste produced via this tech is superior to that of waste compacted via conventional methods, and is even better than the quality delivered by newly-developed techniques in use overseas. Mr. Huang's high-efficiency compaction technique for low-level radioactive waste has been patented in Taiwan, the United States, and several European countries, and its innovative approach has received favorable interest abroad. It is certain to make a significant contribution to raising the R.O.C.'s nuclear waste disposal technology to international levels. The technique is now being used at domestic nuclear power plants.

(3) Innovations in the breeding of superior red bean strains and in increasing bean production

Beginning in 1968, Mr. Chen Keng-feng devoted himself to developing new red bean strains and improved techniques of bean production. The Tzai-lai strain of red beans that were grown in the past had the shortcomings of weediness, non-uniform ripening time, and persistent leaves that made harvesting laborious work. The Kaohsiung Choice No.1, Kaohsiung No.2, Kaohsiung No.3, and Kaohsiung No.5 varieties bred and popularized by Mr. Chen largely eliminated the above problems. In 1981 Mr. Hsu Chin-chuan took charge of red bean breeding and cultivation improvement work, and also made great strides in these areas. Besides raising red bean output per unit area, Mr. Hsu also successfully used new varieties in conjunction with bean harvesting machines to make harvesting less costly and labor-intensive. The varieties he developed are now widely grown throughout Taiwan (In recent years red beans have been cultivated on approximately 5,000-6,000 hectares in Taiwan). Although soybean seeds were uniformly imported from Japan in the past, the last twenty years have seen rapid progress in soybean breeding in Taiwan. Mr. Chen Keng-feng began devoting his attention to soybean breeding and cultivation technology improvement work in 1982, and successfully developed a number of new varieties together with his colleague Mr. Cheng Shih-tzao. In cooperation with the Asian Crop Improvement Center, in 1987 these two individuals developed the Kaohsiung Choice No.1 variety. After four years of promotional work, this variety was cultivated on roughly 90% of the total land used for soybean cultivation in Taiwan. In 1991 Chen and Cheng developed the Kaohsiung No.2 and Kaohsiung No.3 varieties. Because of their tolerance of cold, these varieties have made a great contribution to whole-pod soybean exports. In 1996 Chen and Cheng developed the high quality Kaohsiung No.5 variety and promoted mechanized cultivation techniques that can raise output per hectare from 5,000kg to 8,000kg. Thus these individuals have made an enormous contribution to improving the economic prospects of Taiwan's farming communities.

(4) Research on the character recognition process

Mr. Liu Ying-mao is a leading figure among the first generation of psychologists in Taiwan, and has been instrumental in bringing international recognition to psychological research in the R.O.C. Although formerly specializing in orthodox behaviorism (classical conditioning), and has won an international reputation in this field, he has lately switched his interest to cognitive psychology, and has been the R.O.C.'s foremost pioneer in this field. He has made major contributions to research on conceptual learning and human memory of word meanings. The data he has collected over the years (such as the frequency of word use) is often used by researchers in Taiwan and abroad who are studying information processing aspects of Chinese characters. Mr. Liu has recently devoted much attention to research on the cognitive psychology of the processing of the Chinese language. His work on "vocabulary naming operations" and his methods for estimating the frequency of components allow the effec-

tive estimation of components before and after vocabulary contact. This represents a very great research breakthrough. His theoretical model of the character recognition process can be broadly applied to many types of writing systems, and includes the process of perceiving meaning and pronunciation. Liu's research findings have been published in prestigious international academic journals, and have made the international academic community realize that, because of the unique structure of the Chinese writing system and its method of converting form to sound to meaning, his work may be able to resolve theoretical and practical questions that cannot be dealt with through pinyin writing systems. Thus Liu has made a great contribution to research in linguistics and linguistic information processing.

### *C. Improving the Research and Development Environment*

#### 1. Strengthening Sci-Tech Information Services

The NSC established the Science and Technology Information Center (STIC) in 1974 for the purpose of supporting the nation's sci-tech development programs through the establishment of a sound research environment. In line with the needs of industrial development and sci-tech research, STIC collects sci-tech information from the R.O.C. and abroad, analyzes and processes this information, and supplies it in a convenient and timely manner to government agencies, academic institutions, and the industrial sector.

(1) STIC's five-year operating plan encompasses five major project objectives, eight implementation strategies, and 36 subprojects. The five major project objectives are as follows:

a. Encouraging the effective utilization of sci-tech resources and supporting the execution of strategic national sci-tech projects.
b. Integrating the nation's sci-tech information resources and expanding the scope of cooperation.
c. Establishing a science and technology policy information support system.
d. Implementing a business management approach to sci-tech information services.
e. Promoting international cooperation in the area of scientific and technological information.

STIC's eight implementation strategies are as follows:

a. Establishing an open information environment and providing information services via computer networks.
b. Raising product and service quality by applying the newest information technologies.
c. Participating in strategic alliances in order to increase the effectiveness of services.
d. Obtaining access to manpower and technology information at academic and research institutions in order to offer knowledge production services.
e. Creating expanded avenues of access to information services and increasing the utility of information.
f. Establishing a scientific and technological policy information service.
g. In conjunction with national development policies, strengthening information services to high-tech industries.
h. Actively participating in information-related organizations and activities overseas and in Taiwan.

(2) Promoting higher quality among domestic academic periodicals

STIC performs judging work for the NSC's awards for exemplary domestic academic periodicals. Six periodicals won "outstanding" awards, 18 won "superior" awards, and 14 won "class A" awards in 1996.

(3) Recommending outstanding domestic periodicals to international information organizations: STIC has taken the initiative in making contact with such major international information organizations as EI, NLM, ISI, and CHI in order to recommend that they include outstanding domestic periodicals in their collections. This will provide more avenues for individuals overseas to learn about the results of research in Taiwan. STIC has

already recommended ten domestic periodicals for inclusion in the Elservier database, and 14 domestic periodicals for inclusion in the EI database.

(4) Completing establishment of the ASCA Listserv discussion group: The goals of establishing this discussion group include (1) providing the newest information to libraries and information science institutions throughout Asia, (2) promoting the free exchange of experience and views, and (3) publicizing questions in order to elicit possible solutions. Listserv subscriptions should be made as follows: Subscribe LIS-FORM (user full name).

(5) Actively participating in the construction of a scientific research hall for the Internet Expo: In preparation with the 1996 Internet World Expo, STIC helped construct the R.O.C.'s scientific research hall by supplying "An Introduction to STIC," and the four databases "Conference Papers of the R.O.C.," "Research Reports of the R.O.C.," "Directory of R&D Institutions in the R.O.C.," and "NSC Patents Available for Licensing." Interested parties in Taiwan or overseas can access these databases through the Internet at the URL http://expo96sr.edu.tw.

(6) Introducing knowledge industry services: In order to assist in the formulation of national sci-tech policies and train specialists in the areas of planning, investigation, evaluation, and trend forecasting, STIC has organized teams of representatives from industry, government, academia, and the research community to produce "intelligent" information output on the topics of "high-tech ceramics" and "technologies for comfortable living." It is hoped that this work will lead to a feasible model for the development of knowledge industries.

(7) Providing an on-line ordering service for full-text materials: STIC has put into action its goal of being user-oriented information service provider by completing an on-line full-text material ordering system. This system allows users to receive information during non-peak hours and directly browse full-text materials while on-line.

(8) Collecting scientific and technological information:

a. A total of 4,689 sci-tech publications were collected during 1996, including domestic and foreign sci-tech periodicals, research reports, conference records, books, and sci-tech reports and journals from mainland China.

b. During 1996, 22 foreign and three domestic CD-ROM databases and nine foreign databases on magnetic tape were acquired. The content of these databases included abstracts of scientific literature, abstracts of business and management literature, abstracts of education literature, degree dissertations, research reports, lists of international books and publications, abstracts of monographs, lists of firms, lists of institutions, legal information, and import/export statistics.

c. As for information on microfilm, in accordance with a cooperation plan signed with the U.S. National Technical Information Service, STIC acquired 50,808 full-text microfilmed reports of U.S. government research during 1996, resulting in a cumulative total of 362,272 microfilmed reports. In addition, STIC again acquired microfilmed copies of materials published by UNESCO during the year.

(9) Integrating sci-tech and humanities/social science information:

a. Integration of domestic research data and the creation of databases: STIC collects and processes information concerning domestic basic research, applications research, and key industries. After articles have been classified, indexed, provided with abstracts and keywords, keyed in, and proofread, STIC uses the resulting bibliographic data to compile and publish more than 30 types of publications. In addition, databases containing this data are available to users for browsing or online inquiries.

b. The acquisition of foreign research information and compilation of databases: From more than 3,000 authoritative foreign journals and reports, STIC collects information on sci-tech

research policies and budgets, strategic industrial projects, technology transfer cases, international investments and business projects, management of production systems, new and innovative technologies, manufacturing and marketing, sci-tech information activities, key developments in science and technology, and the state of R&D in major industrial technologies, etc. STIC invites specialists and scholars to write abstracts for these pieces of information, and publishes them in the form of databases and nine periodicals.

(10) Strengthening online sci-tech information services: Since it first went online in 1988, the STICNET has allowed domestic researchers to use personal computers or computer terminals to consult foreign and domestic databases created or acquired by STIC. During 1996 172 organizations began subscribing to the STICNET, resulting in a cumulative total of 964. In addition, the STICNET also had 630 individual and project host users, and had issued 10,956 passwords. At the end of the year, the STICNET provided access to 30 foreign and domestic databases containing approximately 15.7 million articles or pieces of information.

In order to broaden the use of the STICNET, STIC provides a preferential network membership program to academic and research institutions. Under this program, each school or organization need only make a single annual payment to give all personnel and students the privilege of STICNET use throughout the year; at present a total of 30 institutions are participating in this program.

(11) Enhancing STIC's online CD-ROM database services: The content of STIC's approximately 30 foreign and domestic CD-ROM databases includes sci-tech research reports, catalogs of books and journals, lists of American and European firms, laws of the European Union, and import/export statistics, etc.

(12) Promoting information sharing and cooperation:

a. Better functioning of the Sci-tech Interliberary Cooperation Association has facilitated the free flow and sharing of domestic sci-tech information and is helping libraries to cooperate in offering services.

b. STIC will continue to strengthen liaison and the sharing of materials with sci-tech information organizations throughout the world. In order to expand its sources for the acquisition of information and open new channels for the exchange of professional knowledge, STIC has become a member of such international information organizations as the American Library Association, Association of Information and Dissemion Centers, American Society of Information Science, European Association of Information Services, International Federation of Documentation, International Council for Scientific and Technical Information, and International Federation of Library Associations and Institutions. In addition, STIC has successfully taken advantage of continuing contact in the wake of the "ASCA Modern Information Technology Utilization and Management Symposium" to step up cooperation and exchange of sci-tech information with neighboring Asian countries.

c. STIC is continuing to forge stronger cooperative relationships with major foreign information service organizations (such as the U.S. National Technical Information Service, the U.S. National Medical Library, and the Japanese Science and Technology Information Center). Apart from arranging reciprocal visits of personnel, holding bilateral symposia, establishing network links, and exchanging sci-tech publications via these relationships, STIC is also promoting the use of the International MEDLARS (Medical Literature Analysis and Retrieval System) Online Center to provide more complete information services to the domestic biomedical community. In addition, STIC has also discussed with Canada the possibility of information exchanges.

(13) Enhancing information services:

a. In 1996 3,758 applications were taken for

international information system query services, queries were made on 6,542 topics, 3,538 items were printed out, a total of 153,311 items of domestic or overseas information were printed out, applications were made overseas on behalf of users for 3,538 items of original literature, photocopies of original domestic literature were provided 88,165 times, browsing services were provided 7,439 person-times, telephone inquiry services were provided 27,925 times, and CD-ROM database retrieval services were provided 13,695 times.

b. STICNET services were accessed a total of 66,868 times in 1996 and 469,785 items were printed out on- and off-line.

c. As for extension activities, during 1996 STIC conducted a total of 72 large-scale symposia, seminars, and various kinds of service promotion forums that were attended 2,131 person-times. In addition, 14 STICNET user training classes were attended by 333 students.

## 2. Strengthening Precision Instrument Research and Development

Since it was established in 1974, the NSC's Precision Instrument Development Center (PIDC) has performed precision instrument research, development, and application work in conjunction with national science and technology development plans and general trends in instrument use. Besides providing instrument maintenance, personnel training, and information services, PIDC is also working to improve the research environment, support academic research, and raise the standards of industrial technology. This year PIDC has built on its experience in the areas of electro-optics, vacuum technology, precision machinery, instrument testing, and precision measurement and control and ventured into the research and development of medical analysis and semiconductor element testing instruments. PIDC is promoting the development of precision instrument technology by providing a complete array of instrument information and maintenance services.

(1) R&D and Technology Development

a. Laser micro-processing system

A completed prototype laser micro-processing system (Fig. 2) features an illuminated point of from 2 to 30 microns and positioning precision better than 0.02 microns. This system employs a brief high energy density focusing laser to control the work piece. Its high-precision computer-controlled positioning stage can be used to create tiny images on the work piece or perform material processing. The system integrates mechanics, optics, and electronics, and has been successfully applied to microlithography, the surface processing of high-density hard disks, and the fabrication of minute bridges used in weapons ignition systems. While the system's precision exceeds that of existing commercial products, its cost will only be roughly one-third as much. Besides showing that the R.O.C. has the technology and ability to produce advanced precision instruments, this project will make a tangible contribution to academic research, high-tech industry, and national defense.

b. Laser dynamic measurement instrument

The laser dynamic measurement instrument is a laser interferometer measuring system that is capable of automatically tracking a reflected light beam. The continuous movements of the reflector attached to the object being measured can be used to measure many types of objects. This project is being carried out jointly with the American firm Excel. At present a laser dynamic measurement instrument testing laboratory has been set up and contains the first three-dimensional measurement system in Taiwan. In the future this instrument will be used to make precision measurements of the exterior of spacecraft, motor vehicles, ships, mechanical arms, and other large objects, and will thereby enable enhanced product quality and greater competitiveness.

c. Multi-target co-sputtering system

The semiconductor industry's element fabrication technology is advancing at a blistering pace, and the line width of semiconductor elements is now well into the submicron range. Because the manufacture of such tiny elements requires insulating layers with an extremely high dielectric constant, PIDC is drawing on its many years of vacuum coating and systems develop-

**Fig. 2. A laser micro-processing system developed at the Precision Instrment Development Center.**

ment experience in order to fabricate a multi-target co-sputtering system (Fig. 3). This system features three non-coplanar sputtering targets and a base seat that can hold a four-inch wafer and heat it to 800 °C. Using targets composed of different metals or metallic compounds, the system can employ a parallel direct current or radio frequency activation reaction technique to create layers with the desired composition. This is an important technology that will be used to fabricate the ultra-high dielectric layers required by the next generation of dynamic random access memory (DRAM) elements. Researching and assembling this sputtering system is just the first stage of this project, which in the future will raise the level of semiconductor fabrication technology by using the system to develop manufacturing processes and element designs.

d. Solid-state laser system

The PIDC has completed the development of an experimental 1064nm wavelength diode-pumped solid-state laser (Fig. 4) with a power output of 500mW and an excitation efficiency of 50%. This laser's technology is up to the highest international standards. Although lasers have an increasingly wide range of applications in such fields as medicine, semiconductors, and military technology, the R.O.C. has been totally dependent on imported devices. The results of this project amply verify the R.O.C.'s ability to produce advanced electro-optical components, and will provide a tangible boost to the domestic electro-optical industry. The "high-stability diode-pumped solid-state laser apparatus" developed as part of the project has already received a patent from the R.O.C. Bureau of Commodity Inspection & Quarantine.

e. Near-field optical microscope

Due to the rapid development of technology, the dimensions routinely encountered in manufacturing processes are gradually shrinking from the micron to the nanometer scale. Since conventional measurement technologies cannot meet the demands of manufacturing at the most minute scale, the PIDC has addressed this challenge by establishing a surface measurement

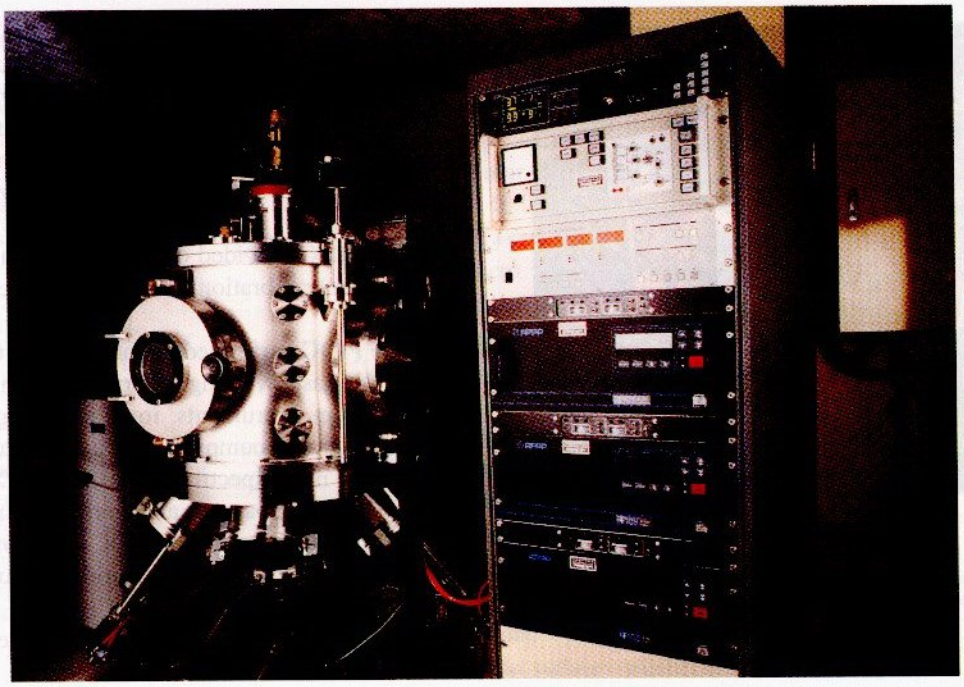

**Fig. 3. A multi-target co-sputtering system developed at the Precision Instrument Development Center.**


**Fig. 4. A solid-state laser developed at the Precision Instrument Development Center.**

laboratory and researching near-field optical microscopy. This technology can overcome the shortcomings of optical refraction and offers resolution up to ten times better than conventional optical microscopes. An electric arc-type optical filament probe tractor (Fig. 5) has already been developed. The optical filament probe has a tip diameter smaller than 0.1 micron, and is used to receive or transmit near-field optical signals. Continuing research and design of optical signal detection modules will improve the device's capabilities, which will be used in the study of electro-optical elements, light-emitting layers, and biomedical sample. In the future, this type of microscope will be a powerful measurement tool for academic and industrial researchers.

f. Eyeglass-type information processing system

In order to improve Taiwan's medical instrument technology and give a boost to the local manufacturing of medical instruments, the PIDC has teamed up with Taichung Veterans General Hospital to conduct a joint two-year project to develop an eyeglass-type information processing system. This system can be connected to a com-

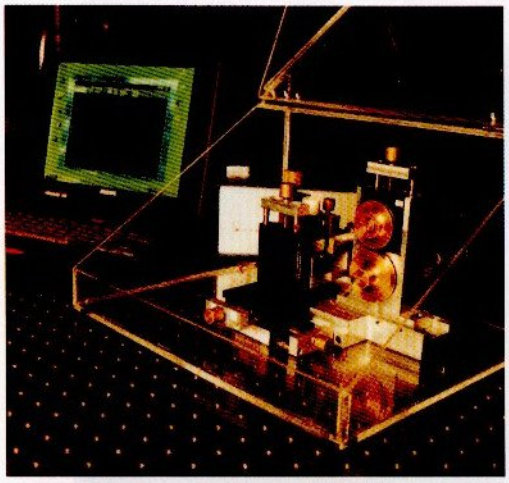

**Fig. 5. Electric arc-type filament proble tractor developed by the Precision Instrument Development Center.**

puter network and swiftly receive called-up diagnostic information from a medical database. By helping physicians to make correct diagnoses, it will raise the quality of medical treatment. Recent progress has included the development of a control interface module and the creation of a virtual medical network. The derivative "concatenated-type dual brightness difference conversion pulse-width modulation circuit assembly" developed in this project has received a patent from the R.O.C. Bureau of Commodity Inspection & Quarantine.

(2) Technological capabilities and resource sharing services

In accordance with its mission of supporting academia and high-tech industry, the PIDC has established a technological capability for many important instruments (Table 4), possesses optical and vacuum testing capabilities (Table 5, 6), and provides instrument fabrication, repair, information, and operator training services to outside users for a fee. Today the PIDC serves as a leader in the development of instrument technology throughout the R.O.C.

a. Improving technical instrument services:

(a) In 1996 PIDC provided precision machinery, optics, and glassware fabrication services on 1,539 occasions. It also provided commissioned instrument system fabrication services on nine occasions for such items as a mixing control unit and a rodent immobilization apparatus.

(b) The PIDC provided optical and vacuum instrument calibration and testing services 571 times.

(c) The PIDC performed maintenance or repair of $CO_2$ laser welding apparatus, helium leak detection instruments, ionic polishing machines, ionic pumps, ionic vacuum gauges, TEMs, mass spectrometers, E-guns, X-ray diffraction apparatus, and diamond grinding machines 19 times. The PIDC also provided maintenance services to regional instrument centers on 32 occasions.

(d) The PIDC performed SEM surface testing services for users on 270 occasions.

(e) The PIDC published six issues of the bimonthly Scientific Instrument Update in 1996.

(f) The PIDC completed the preliminary review of 170 applications by government agencies for the purchase in 1997 of instruments with a price of at least NT$3 million; performed needs assessment of 208 1997 NSC-supported special-topic research projects requesting instruments with a price of at least NT$1 million; filed basic information on 70 instruments with a price of at least NT$1 million purchased as part of 1996 special-topic research projects; and performed a survey that collected information on 932 instruments costing at least NT$1 million purchased by national institutions up to 1995. It is anticipated that these efforts will help achieve the goals of the most rational allocation and most effective use of the nation's instrument resources.

(g) In order to meet the needs of Taiwan's growing high-tech industries, the PIDC offered 21 training courses, including "Maintenance of Vacuum Sputtering Apparatus," "Fabrication and Use of Miniature Optical Elements," "Ultra-Precision Manufacturing Techniques,"

**Table 4. Chief Instrument Technology Capabilities of the Precision Instrument Development**

| Technology Category | Technical Capability |
|---|---|
| Precision positioning and measurement | Positioning accuracy: better than ± 0.02 μm |
| | Measurement resolution: 0.005 μ m |
| Vacuum system | $1 \times 10^{-10}$ torr |
| Precision mechanical processing | Ultra-precision mechanical modules: accuracy of 0.1 micro |
| | Aspherical lenses: accuracy of 0.1 micron |
| | Small apertures: diameter of 60 microns |
| | Gas-tightness of vacuum welding:<x$10^{-10}$std.cc/sec. |
| | Ultra-high vacuum systems: suitable for use in synchrotron radiation environments |
| Optical element processing | Standard planar mirror: surface precision of 0.02 μm/diam eter 100mm |
| | Standard spherical mirror: surface precision 0f 0.06 μm/di ameter 100mm |
| | Metallic mirror: surface precision of 0.06μm/diameter 100mm |
| | Parallel surfaces: parallel to 1 sec. |
| Vacuum deposition | Surface roughness of optical films: <0.6Årms |
| | Precision of film thickness: ±1Årms |
| | Sputtering and vacuum deposition of metallic, insulatot, and semiconductor films |
| Optical design | Design of various precision optical instrument systems |
| Scientific instrument maintenance | SEM, TEM, NMR, MASS, etc. |

**Table 5. Optical Testing Capabilities of the Precision Instrument**

| Tape of measurement | Instrument name and type | Scope of testing | Accuracy |
|---|---|---|---|
| Laser power | SCIENTECH | Wavelength: 0.25 ~ 10.6μm | ± 5% |
| | Laser power meter | Power range: ≤ 30W/cm$^2$ | |
| Laser power | LASER PRECISION | Wavelength: 200 ~ 1100nm | ± 5% |
| | Laser energy meter | Power range: 1–10$^3$mJ/pulse | |
| Index of refraction | PR2 Pulfrich | Material : Optical glass, liquid | ± 5% |
| | Refractometer | Index range: 1.4-1.8 | |
| Optical roughness | ZYGO 5500 | Radius of curvature:≤ 25mm | 2%(rms) |
| | Roughness instrument | Vertical range: 0.01-300nm (p-v) | |
| Optical wavefront | WYKO | Wavelength: visible ~ 1.06μm | ± λf/100 |
| Analyzer | Wavefront analyzer | Out Diameter : ± 6mm | |
| Optical lens focal length | Focal length instrument | Material: Lens, Lens system | >20mm, ± 0.3% |
| | | Length: –10 ~ 450mm | <20mm, ± 0.5% |
| Angular measurement | Angle gauge | Material: Prism, Angle Gauge, Block | ± 10 sec |
| | | Range: 0° ~ 360° | |

**Table 6. Vacuum Testing Capabilities of the Precision Instrument Development**

| Equipment name | Calibration range | System error | Object of service |
|---|---|---|---|
| Hot ion vacuum gauge | $1.33 \times 10^{-4}$~1.33 × 10-2Pa | ± 20% | Hot cation vacuum gauge |
| | | | Cold cation vacuum gauge |
| Capacitance vacuum | $1.33 \times 10^{-1}$~1.33 × 102 Pa | ± 0.267 | PaDiaphragm box vacuum gauge gauge |
| gauge | $1.33 \times 10^{2}$~1.33 × 104 Pa | ± 7.98Pa | Borden gas pressure gauge |
| | 1. 33 × $10^{4}$~1.33 × 105Pa | ± 30.59 Pa | U-type gas pressure gauge |
| | | | Mai vacuum gauge |
| | | | Piezoelectric vacuum gauge |

(1Pa=7.5x$10^{-3}$ Torr)

and "Maintenance of Semiconductor Equipment." These courses were attended by 793 persons and made a large contribution to raising the nation's technological capability and improving the effectiveness of instrument use.

(h) In order to promote international cooperation and technological diplomacy, the PIDC received 11 foreign fact-finding guests recommended by such international organizations as the International Science Foundation, the Asia-Pacific Scientific and Technological Association, and the South African National Science Foundation. These guests participated in workshops in the areas of "manufacture of glass apparatus," "maintenance of electronic systems," "evaporation deposition of films," and "applications of numerically-controlled machine tools." In addition, the PIDC also conducted the "Sixth International Scientific Instrument Training Class," the participants of which included 19 trainees from nine Latin America countries.

b. The PIDC helped promote international exchanges of instrument technology by inviting foreign specialists to attend a forum for presenting technical papers held on March 6, 1996. In-depth discussions were conducted on the topics of the application of ultra-precision grinding wheel techniques to the processing of silicon wafers, computer hard disks, and other hard and brittle materials. This event contributed to raising the standard of ultra-precision processing in the R.O.C.

c. The PIDC held the "1996 International Conference on Medical Instrument Technology" from May 28th to 30th of this year at the Taipei International Convention Center.

## 3. Establishing Regional Instrument Centers

The NSC's regional instrument centers chiefly provide services to researchers at public and private educational institutions and research organizations. Due to the rapid growth of domestic scientific and technological research in recent years, there is an ever-increasing need for instrumentation. One-third of the special-topic research projects sponsored by the NSC receive the services of the regional instrument centers, which provide their services on a total of more than 300,000 occasions annually. The regional instrument centers make a huge contribution to scientific and technological research in the R.O.C.

Instruments at the regional instrument centers are used in such fields as chemistry, physics, biology, materials science, mechanical engineering, agricultural science, semiconductor fabrication, high-frequency radar, and oceanography, to name but a few. The NSC relies on rigorous review procedures to scrutinize the centers' annual operational plans, and over successive years has expanded the scope and content of their services.

To insure that the regional instrument centers operate according to a regular set of procedures, in 1996 the NSC began requesting that the schools on whose campuses the instrument

centers are located either incorporate the centers within their organizational structure or establish a special task force and draw up management regulations. The individual schools will henceforth bear responsibility for the management of instrument center personnel. However, in the future the NSC will continue to support the instrument centers' activities via special-topic project funding.

### 4. Awards for Outstanding Domestic Academic Periodicals

The NSC has always placed importance on and encouraged the publication of academic periodicals. In order to raise the quality of domestic periodicals, help them achieve international standards, and promote international academic interchange, the fourth revision of the "Procedural Regulations Governing NSC Grants and Awards for Outstanding Domestic Academic Periodicals" was issued on October 19, 1996. Of the total of 99 periodicals that applied for NSC awards in 1996, 86 passed preliminary review, and 48 were given awards after a further evaluation by a panel of experts.

Besides promoting standard formats for journals and dissertations, the NSC's award system for outstanding domestic academic periodicals has also made editors realize the importance of international information exchange and the collection of journals by international information organizations, and has encouraged them to strive for articles that meet international standards of quality. Recently more and more R.O.C. periodicals have been collected by international information organizations, and it is anticipated that this will soon raise the international standing of academic research in Taiwan.

## *D. Establishing a National Laboratory System*

### 1. Objectives and Nature of System

To date NSC national laboratories that have been completed or are under construction include the Synchrotron Radiation Research Center, Nano Device Laboratory, Center for Research on Earthquake Engineering, Laboratory Animal Breeding and Research Center, Center for High-Performance Computing, and the National Space Program Office. The national laboratories of America and the European nations have operated successfully for many years, and have made great contributions to the integration and utilization of sci-tech resources in the nations where they are located. Because today's major research projects require the use of many items of costly and sophisticated experimental equipment and must enlist the services of specialists in many different fields, the NSC has established a national laboratory system to bear responsibility for maintaining, managing, and developing large-scale laboratory facilities available for the common use of researchers throughout the nation. In addition, the national laboratories are engaged in the production of special scientific materials that are helping to improve the nation's overall research environment, and some of the national laboratories are also responsible for implementing major research projects.

Since national laboratories are rich sources of technical manpower and research equipment, in many countries they play a leading role in the execution of large-scale integrated scientific and technological projects. Besides proposing joint projects addressing cutting -edge research areas, the national laboratories also encourage universities, research institutions, and private firms to make full use of their research facilities. Moreover, besides integrating domestic research resources, promoting the free circulation of technological information, and training technical specialists, the national laboratories are also helping raising the R.O.C.'s international academic standing by establishing cooperative relationships with their counterparts in other countries.

### 2. The Synchrotron Radiation Research Center

Synchrotron radiation provides researchers with an advanced observational tool that allows them to conduct sophisticated experiments in basic and applied science. It can also help raise the standard of domestic scientific research and

improve the technological capability of domestic industry. Because of these benefits, the NSC has established the Synchrotron Radiation Research Center (SRRC). The SRRC's major work and research results during 1996 are as follows:

(1) Upgrading accelerator performance

The SRRC's accelerator now operates five days a week, 24 hours a day; its utilization rate has been maintained at approximately 90%. The storage ring electron beam originally had a design energy of 1.3 MeV, but after SRRC personnel overcame a number of hardware and operational problems, its energy was raised to 1.5 MeV, greatly increasing beam luminance and lifespan. Thanks to the optimization of the storage ring's operational parameters and the installation of various feedback systems and stability-enhancing devices, the stability of the electron beam has seen a great improvement. The accelerator can now be operated stably under the following conditions: 1.5 MeV, 240 mA, beam lifespan of nine hours, variation in beam orbit of less than 5 microns, and long-term (24 hr.) deviation in the electron beam orbit of less than 20 microns. These numbers all exceed the design values and demonstrate that the SRRC has now joined the ranks of the world's most advanced synchrotron facilities.

(2) Development of insertion magnets

During 1996 principal research and development work involving insertion magnets included the following: The U5 undulator was purchased and accepted, and will be installed in early 1997. The U9 undulator was designed and purchased. Conceptual design work for the EPU 5.6 (elliptically polarizing undulator) was completed. The construction of the EPU 5.6 will be an extremely complex project, and is expected to be completed during 1998.

The SRRC is now studying the feasibility of installing a superconducting frequency shift magnet with an extremely powerful magnetic field. It is anticipated that these various insertion magnets will be able to produce radiation with higher energies and a wider range of frequencies. This in turn will enable a variety of sophisticated experiments to be performed.

(3) Installing new beamlines

The SRRC's 40 beamline ports can accommodate 40 radiation beams and an equal number of experiments. More beamlines will be gradually installed in the future in consideration of real needs.

During 1996 the SRRC made the following four new beamlines available to users:

a. B-03B: This one-meter Seya-Namioka monochromator beamline generates high quality 4-40eV radiation suitable for chemistry and materials science research.
b. B-06A: This six-meter low-energy spherical grating monochromator beamline generates extremely high quality 15-200eV radiation. This beamline may be used for surface, materials science, and chemistry research.
c. B-15A: This six-meter spherical grating monochromator beamline provides high energy 110-1500eV radiation suitable for experiments in materials science and surface chemistry.
d. B-11B: This double crystal monochromator beamline provides 1-9keV soft X-rays suitable for the study of materials containing Al, S, P, Si, Ni, and Cu.

The above four beamlines are currently available for the use of domestic and foreign researchers, and have been successfully used to carry out more than 100 experiments. The following beamlines are still in the construction or testing phase:

a. S-05A, B, and C: These are three X-ray beamlines generated by the W20 wiggler. In the future these beamlines will produce 1-5keV radiation suitable for research in materials science and biology.
b. B-13B: This beamline will be used exclusively for micro-machining research. It is currently being tested.
c. B-15B: This multipurpose beamline will be used for instrument development and testing. It is equipped with a double crystal monochromator and is currently being tested.
d. S-03B: This high luminosity 6-meter spherical grating monochromator beamline is gen-

erated by the U5 undulator. In the future this will be a high-flux, high-performance beamline. Due to its special design, it will have a very small focal point and will be very suited to the study of the microscopic phenomena of various materials. This beamline will be opened for use after the U5 undulator is installed and tested in early 1997.

e. B-14: This beamline will be used exclusively for X-ray lithography and is currently under construction.
f. B-08: Also referred to as the "dragon light" beamline, this beamline is generated by a six-meter spherical grating monochromator returned from America's National Synchrotron Light Source. Installation should be completed by May 1997.
g. B-02: This is a high flux beamline is produced by a six-meter columnar grating monochromator (6m-CGM).
h. B-09A: This is a wide range beamline generated by a six-meter spherical monochromator. It will generate photons with energies of 10-1500eV. It simultaneously possesses the advantages of both 6m-LSGM and a 6m-HSGM beamlines. This beamline can generate a relatively broad energy spectrum and can also resolve the current problem of insufficient beamline time.
i. S-06A: This ultra high U9 flux beamline will be extremely useful in experiments requiring a very high flux, such as research on chemical dynamics.

(4) Applications research and basic research at the SRRC

Applications and basic research are chiefly the responsibility of the SRRC's research division. The research division includes condensed state spectroscopy, molecular and atomic spectroscopy, X-ray research, magnetic spectroscopy, and industrial applications research teams. The chief results of each team during 1996 are as follows:

a. Condensed state spectroscopy

This team is oriented primarily towards basic research and secondarily towards the development of research techniques involving synchrotron radiation. The team's research scope encompasses the surfaces of semiconductor materials, high energy band gap materials, interfaces between condensed substances, and chemical reactions on surfaces. As for the development of research techniques, the team has currently completed the conceptual design of a scanning-type photoelectron energy micro-spectrometer (Fig. 6). The team is developing a number of key components for this instrument in-house. The design of the instrument was made public at an international symposium on X-ray microscopy held at Wuerzburg in 1996. It is anticipated that, after it is completed, this instrument will make a large contribution to the application of photoelectron energy spectroscopy to the study of surface chemistry.

b. Atomic and molecular spectroscopy

This team has currently acquired five systems for experimental use—a molecular beam/photodissociation mass spectroscope system, a dual ionization chamber system, a matrix isolation system, a dissociation gas flow tube/photodissociation mass spectroscope system, and a threshold photoelectron-photoion coincidence system.

Research performed in 1996 included: (1) An investigation of the dissociation energy, electron state, ionization processes, and other dynamic characteristics of dimethyl disulfide; (2) a study of the photodissociation of chlorofluorocarbons; (5) a series of spectroscopic investigations of the valence satellite electrons of krypton and xenon; (4) a study of the photodissociation of hexafluorocyclohexane (C6H6) in a solid argon matrix; and (5) a study of the autoreaction of HS in a gaseous state to form HSSH. The high-resolution spectra obtained in these projects provided a clearer theoretical understanding of the dynamics of the dissociation process and electron energy-state transitions in atoms and molecules. During 1996 this team purchased and installed a hybrid laser-synchrotron radiation experimental system that will be used to investigate aspects where the use of laser or synchrotron radiation alone would be insufficient, such

**Fig. 6. Design drawing for a scanning photoelectron energy micro-spectrometer.**

as the spectral, chemical, and physical characteristics of transient reaction intermediates.

c. X-ray research

The objective of this research team is to establish a first-rate X-ray experiment environment, and promote and engage in synchrotron X-ray research chiefly including X-ray scattering, X-ray crystallography, and X-ray spectroscopy. In the area of X-ray scattering, an ultra-high vacuum X-ray surface scattering instrument currently being constructed will be used to conduct high-resolution surface X-ray scattering experiments involving large scattering angles and wide temperature ranges. In the case of X-ray crystallography, non-ordinary chromatic dispersion methods will be tested, multiple refraction and maximum entropy number techniques will be employed to perform research on the phase of large molecules, and the effect of magnetic fields, electric fields, temperature, pressure, and acoustic waves on crystal structure will be investigated. And in the field of X-ray spectroscopy, work is underway on theoretical and experimental techniques including Extended X-ray Absorption Fine Structure (EXAFS) spectroscopy, X-ray Absorption Near Edge Spectroscopy (XANES), and fluorescence radiation spectroscopy. These techniques will be employed to perform research on catalytic reactions, materials science, and bioscience, etc.

d. Spectroscopic study of magnetism

This newly-established team will perform research on the electronic and magnetic structure of magnetic substances in the form of thin layers or massive pieces, and, in particular, will study strongly-interacting Fermi energy levels.

This team has already installed a Sienta SES-200 ultra-high resolution electron energy analyzer. This instrument uses a two-dimensional sensor to determine energy and angular distribution, and is a powerful tool for studying Fermi energy levels. Equipment currently under construction includes an instrument for resolving electron auto-spin (Fig. 7) and an experimental

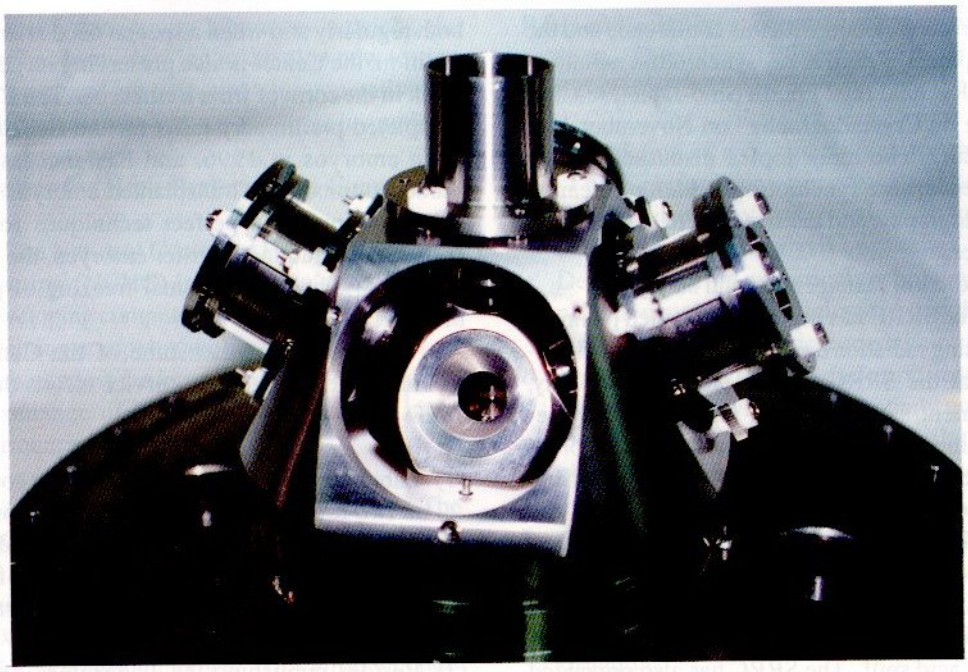

**Fig. 7. An Electron Autospin Resolution Instrument Constructed at the SRRC.**

low-temperature vacuum chamber for studying strong magnetic fields. In the future circularly polarized synchrotron radiation from the "dragon light" beamline will be used to perform high-resolution photo-absorption spectroscopy.

f. Industrial applications

This team employs synchrotron radiation to perform X-ray lithography and micro-machining research with industrial applications.

The X-ray lithography research project now underway is currently in its second phase. This project is hosted by the Nano Device Laboratory and is being assisted by the SRRC. Its goal is to develop 0.1úgm exposure techniques and perform an overall technical feasibility assessment. The techniques developed in this project will be used by the semiconductor industry to produce the next generation of integrated circuits.

Micro-machining refers to the use of lithography/electroforming/molding ("LIGA") techniques to produce mechanical elements with a high depth/width ratio. The SRRC has completed the installation and testing of a micro-machining beamline, and has also installed an exposure station scanner. Because micro-machining will be an important industrial process in the next century, the SRRC will cooperate with universities and research institutions in jointly developing applications for lithography employing synchrotron radiation. These applications will include the fabrication of micron-scale nozzles for extruding textile fibers, IC lead frames, microscopic gyroscopes, optical elements for focusing soft X-rays, microscopic pumps, and microscopic chemical reactors, etc. In addition, the SRRC is conducting regular annual conferences with the microstructure research center (FZK/IMT) at Germany's Karlsruhe National Research Institute.

(5) Promoting applications of synchrotron radiation

Foreign and domestic academic researchers used the SRRC's facilities approximately 419 person-times during 1996. To facilitate the dissemination of research results, the SRRC has held annual user conferences since 1995. The 1996 user conference was held on November 13th and

14th. In conjunction with this conference and the development of hard X-ray synchrotron radiation, the SRRC held the "Fourth Sino-Japanese Conference on Crystallography" on November 11th and 12th. The main topics discussed at this conference were synchrotron radiation research, crystallography, and the structure of surfaces and interfaces.

(6) Radiation management and safety

The SRRC has performed detailed planning addressing radiation dose control, radiation monitoring at the SRRC facility and in its vicinity, experiment safety control, and emergency response measures. Implementation of safety plans is the responsibility of the SRRC's radiation and operational safety division. In July 1996 the Industrial Safety and Health Center of the Industrial Technology Research Institute assisted the SRRC in conducting drills of emergency response measures to be taken in the case of fire, explosion, or acid spill. The SRRC has also organized a emergency response team and conducted simulated emergency response drills in order to heighten preparedness.

## 3. Laboratory Animal Breeding and Research Center

By the end of November 1996, the Laboratory Animal Breeding and Research Center had sold a total of 39,949 experimental animals including rats, mice (19 hybrid and inbred varieties), guinea pigs, hamsters, and nude mice to universities, hospitals, and research institutions, and had earned income of NT$5.52 million.

As far as animal breeding operations are concerned, the Center has established an inbred strain germ base and is using a comprehensive inbred strain breeding system to breed laboratory animals with high-quality pedigrees. The Center is also collecting and analyzing data on animal growth curves and the reproductive performance of breeding stock.

To achieve its goal of breeding high-quality laboratory animals, the Laboratory Animal Breeding and Research Center monitors the animals' environment, health (approximately 4,775 times), and heredity (approximately 7,850 times) both regularly and when a special need arises. In addition, the Center is also preserving its genetic stock in the form of frozen embryos. The Center completed preliminary tasks for the freezing of mice embryos in 1996, and has successfully produced mice from transplanted embryos. Besides continuing to perfect techniques for the collection of rat and hamster embryos, the Center has now begun the actual freezing of purebred mice embryos.

The following are some of the Center's technical and promotional service efforts during 1996:

(1) Laboratory animal technician training courses at two levels were offered. The titles of this year's courses were "Health and Hereditary Monitoring" and "Management of the Welfare and Housekeeping of Laboratory Animals."
(2) Besides publishing the *Laboratory Animal Breeding and Research Center Newsbrief* on a quarterly basis, the Center also wrote or updated a number of technical manuals. These included "Inbred Laboratory Animal Strains: Rat and Mouse," "A Pictorial Guide to Common Diseases of Mice," and "Training Handbook for Laboratory Animal Technicians (revised edition)."
(3) A guide to the Center's services has been published in an effort to increase awareness among outside users.
(4) Regional seminars on the use of laboratory animals were held 14 times during 1996 and provided a channel for communication with users at large.
(5) The Center conducted monthly seminars for domestic users and twice-yearly seminars for international users. These seminars facilitated the exchange of information concerning laboratory animals, and featured invitational lectures given by individuals from research institutions.
(6) The Center provided a number of technical services, including the testing of serum activation values, pathological tissue samples, and animal health and heredity.

In order to make a contribution to the growth

of research concerning laboratory animals, the Center has been working to develop new testing techniques and participating in cooperative research projects with various academic institutions.

## 4. Center for High-Performance Computing

The National Center for High-Performance Computing (NCHC) is the nation's top facility for developing computer and network applications and training computer applications specialists. It is also a window for international cooperation and the exchange of information concerning high-performance computing.

(1) Overview of computer equipment The NCHC has responded to the fast-paced development of computer technology by performing a careful assessment of its needs and embarking on the expansion and upgrading of its distributed parallel computer equipment. This effort will provide domestic users with the most advanced and complete high-performance computing environment possible.

A total of 1,549 users employed the NCHC's computers during 1996, chiefly for work in the fields of computational chemistry, molecular simulation, computational physics, electronics design, computational statics, computational fluid dynamics, water resources and environmental engineering, distributed computing, scientific visualization, computational mathematics, calculation of magnetic fields, and benchmarking, etc.

(2) Promotion of high-performance computing applications In an effort to broadly disseminate computer applications experience, the NCHC has hosted 56 seminars attracting 2,403 participants. Besides offering 62 courses and lectures on high-performance computing, the NCHC also helped train computer specialists by commissioning universities in different areas of the country to offer 78 training courses (roughly 2,000 trainees attended these courses).

(3) Research results The NCHC plays a very important role in integrating and disseminating the computer applications experience of industry, universities, and the research community. It is also helping various organizations overcome R&D obstacles by sponsoring joint research projects. The following is a list of some recent joint projects:

a. Completion of a discipline plan for the field of high-performance computing technology.
b. The application of fuzzy neural networks to the spectroscopic analysis of plasmas.
c. Development of numerical techniques for a plasma simulation model and a parallel system efficiency assessment model.
d. Design of a microwave dielectric resonance filter for use in wireless communications.
e. Development of numerical simulation of plasma generation and high-speed calculation methods.
f. Analysis of an artificial hip joint design.
g. Design of drugs for treating high blood pressure.
h. Application of virtual reality to bridge construction.
i. Application of a finite analysis model to a winding river channel.
j. A three-dimensional simulation of the scouring of bridge pilings.
k. A model of pollution transport in unsaturated strata.
l. A numerical simulation and analysis of a millimeter wave source.
m. An overall vibrational analysis of a motorcycle.
n. An overall dynamic analysis of a motorcycle.
o. A training course in machine part analysis.
p. A large-scale finite element structural analysis software module.
q. A submicron VHDL simulation element base.
r. An assessment of the injection of make-up groundwater.
s. A simulation of a sonic boom in a tunnel.
t. Simulation of heat flow in a fluidized bed incinerator.
u. A simulation and analysis of the continuous casting of steel ingots.
v. A simulation of the flow during the electrolytic recycling of waste liquid containing a high concentration of heavy metals.

(4) Network applications and scientific visual-

ization services

Thanks to the convenience of the Internet, the NCHC has made various types of information (including an introduction to the NCHC, computing resources and general information, R&D projects, and activities) available to users at its web site (URL: http://www.nchc.gov.tw). The NCHC is the only domestic organization producing videos showing the results of scientific visualization projects.

(5) International exchanges

In order to raise the R.O.C.'s international standing in the field of high-performance computing, the NCHC has been establishing cooperative relationships with overseas academic institutions and software companies. For example, the NCHC has signed a contract with the American firm TMA (Technology Modeling Associates) regarding a joint software development project. It is hoped that participation in joint projects with foreign firms will give the R.O.C. more experience in the development and quality control of large-scale software systems, and enable Taiwan to become a regional software R&D center in the near future.

In order to provide opportunities for interchange between domestic researchers and their overseas counterparts, the NCHC is actively arranging to hold international conferences on high-performance computing.

(6) Future outlook

Besides continuing to acquire the most advanced computing equipment, in the future the NCHC will develop optimized computational methods, and will seek to provide a mature high-performance computing environment. Apart from establishing the R.O.C.'s position in the field of computer science, the NCHC's goals including promoting the widespread use of multimedia networks and network applications.

## 5. National Center for Research on Earthquake Engineering

The field of earthquake engineering in Taiwan has already left the stage of purely theoretical research and entered the stage of mutually-reinforcing theory and practice. The purpose of the National Center for Research on Earthquake Engineering (NCREE) is to conduct integrated research projects using physical modeling at its on-site earthquake research facilities. Achievements during 1996 included the implementation of a number of research projects, the creation of an Internet site, the dissemination of the results of earthquake engineering research, the promotion of earthquake safety education, and the international exchange of research findings.

(1) Construction of a research building and earthquake simulation laboratory The structural part of the research building has been fully completed, and the laboratory's foundation slab, reinforced walls, side walls, and a high-strength floor slab 120cm in thickness have also been completed.

(2) Manpower training

Besides signing contracts with the National Taiwan Institute of Technology for the training of vibrating platform technicians and with the National Taiwan University department of civil engineering for training in relevant technologies, NCREE has also sent earthquake simulation experiment team personnel to America's National Earthquake Engineering Center in order to attend a seven-week training course.

In addition, in September 1995 and February 1996 NCREE sent personnel to the American firm MTS to perform a design review of the tri-axial vibrating platform system for earthquake simulation, inspect subsystem designs, and receive training. The goal of these visits was to review the design of the vibrating platform before it was manufactured, and confirm that its design and functions met NCREE's needs.

(3) Integrated projects

a. Research on the response of the geological foundation during earthquakes: This integrated project consists of six subprojects, and was in its second year in 1996. The project's objective is to investigate the amplification of seismic waves by geological and topographical factors, and to generate useful results that may assist in the modification of building design. Subprojects include (a) a study of the

effect of the soil in amplifying seismic waves, (b) theoretical research on topographical effects, (c) systematic identification work involving SMART-1 and SMART-2 seismographic data, (d) experimental research on the earthquake response of gravel layers and the establishment of response spectra, and (e) the development of a finite element program for analyzing the vibration response of an irregular foundation.

b. Research on the earthquake response of a new building at the National I-Lan College of Agriculture: The goal of this five-year project (from 1992 to 1997) has been to bring together all of Taiwan's specialists in earthquake engineering in order to research the earthquake response behavior of steel-reinforced concrete structures.

c. Measurement and analysis of steel-frame structures fitted with vibration isolation and energy-dissipating elements: Two five-story steel-frame structures have been constructed at the Ilan Seismic Engineering Field Experiment Station and are being used to test the actual vibration resistance of various types of vibration-isolation and energy-dissipation elements. Instruments including seismographs and a recording system have been installed and are being used to measure the earthquake response of these structures.

d. International exchanges and educational activities: One of NCREE's missions is to promote international cooperation in the field of earthquake engineering. Besides sending personnel to participate in earthquake engineering conferences in America and New Zealand, and engaging in research cooperation with America's National Earthquake Engineering Center, NCREE is also discussing with New Zealand the possibility of conducting a short- or mid-term joint project using its reaction wall and pseudo-dynamic research equipment. Moreover, in May NCREE invited seven Japanese specialists to Taiwan to discuss with local engineers and academics Japan's current and future research directions in the aftermath of the devastating Kobe earthquake of the previous year. And in October NCREE organized a group to attend the "Sino-Canadian Medium/Long Span Bridge Research Exchange Conference" in Canada. Besides conducting public awareness activities in conjunction with other government agencies, NCREE is also promoting earthquake disaster-prevention education by giving talks at schools and media organizations, publishing a bulletin and research reports, and making data files available over the Internet.

## 6. National Nano Device Laboratory

The National Nano Device Laboratory (NDL) is an important center of integrated circuit and semiconductor research in the R.O.C.

(1) Chief equipment

The NDL possesses a class 10 clean room with an area of 660 square meters and a class 10,000 clean room with an area of 1650 square meters. Up to 90 gallons per minute of ultra-pure water (particulates [$\geq 0.1\mu m$] $\leq$ 10pcs/ml; TOC $\leq$ 30ppb) and supplies of high-purity special and ordinary gasses (hydrocarbon < 10ppb; particulates [ $\geq 0.1\ \mu m$] < 10pcs/ml; $O_2$ in purified $N_2$ and purified $H_2$ < 10ppb) are provided. Other support facilities include a supply of cooling water and a waste water treatment system.

This year a gas-phase metal chemical deposition system, metal sputtering system, and a post-mechanical polishing washing device were added to the NDL's 52 major items of equipment or instrumentation. It is expected that the 193nm ArF excimer laser stepper that the NDL plans to purchase during the next year will make a great contribution to the development of circuit elements with lines of less than 0.18 micron in width.

(2) Modular technologies

The NDL's mission is mainly to research and develop modular technologies and to find ways to better integrate manufacturing processes. Work is underway on the following nine modular technologies:

a. Optical and electron beam micro-imaging module.

b. Lithography and chemical washing module.
c. High-temperature fabrication process module.
d. Gas-phase chemical deposition module.

(a) Low-pressure gas-phase chemical deposition.
(b) Plasma-assisted gas-phase chemical deposition.
(c) Metal gas-phase chemical deposition.

e. Measurement and analysis module.

(a) Electrical measurements.
(b) Physical measurements.
(c) Chemical measurements.

f. Back-end fabrication module.
g. Silicon/silicon germanide wafer module; features include:

(a) Low wafer growth temperature (< 550°C).
(b) High homogeneity.
(c) Polycrystalline wafer fabrication process suitable for mass production.
(d) Selective wafer growth capability.

h. Process and element simulation module.
i. Microwave-emitting integrated circuit research.

(3) Results of research during 1996

A total of 113 academic papers were published and 12 patents received during 1996. The following are among the notable results achieved during the year:

a. Basic research topics in preparation for the development of a 0.25 micron element fabrication module:

(a) Micro-imaging techniques.
(b) Sub-micron metal etching and pit-etching techniques.
(c) Development of polysilicon lithography techniques.
(d) Plasma damage effects.
(e) Dielectric layers.
(f) Titanium silicide production processes.
(g) Gas-phase chemical deposition of a titanium nitride diffusion barrier and the application of aluminum metal chemistry.
(h) Creation of multi-layer conducting leads.
(i) Development of chemical and mechanical polishing techniques.
(j) Gas-phase physical deposition of metallic films and analysis of the characteristics of the resulting layers.
(k) Research on the gas-phase chemical deposition of tungsten.
(l) Research on the properties of SiOF.
(m) Research on the growth of silicon germanide wafers and silicon germanide element technologies.
(n) Integration of nanometer-scale fabrication techniques.
(o) Element module.
(p) Analysis of semiconductor materials.

b. A joint project on the development of 0.25 micron element fabrication modules was undertaken in conjunction with the ITRI Electronics Research & Service Organization and completed the development of the following techniques:

(a) A gate oxidation process and quality verification techniques for 0.25 micron MOSFET elements (800°C wet oxidation, $60 \pm 3$ (thickness)).
(b) An in-line SEM technique for quickly determining the critical structural dimensions of sub-0.25 micron elements.
(c) Optimization of conditions for the lithography of 0.18 micron line width elements in polysilicon (microwave power: 300W, RF power: 35W, $Cl_2$: 20sccm, HBr: 80sccm, $O_2$: 1sccm), and a metal lithography technique for 0.65 micron Pirh.
(d) Assembly of metal PVD and CVD equipment and process assessment and verification.

c. Resource integration and manpower training:

(a) The 0.1 micron electron beam project has succeeded in using positron beam resists (such as ZEP) and electron beam resists (such as SAL) to fabricate elements with 0.1 mi-

cron line dimensions.

(b) X-ray lithography development project: Preliminary testing of tungsten and diamond film masks has gotten underway. A laser system has been developed and software written in preparation for the development of X-ray resist agents. As for graphic conversion, research on the lithographic selection ratio has been performed to confirm the effective area of the image.

To insure that its instruments and equipment are fully used, the NDL provides universities and research organizations with access to its facilities, and either supplies user training or performs fabrication tasks on a commission basis. The "Guidelines for the Use of and Training Involving the National Nano Device Laboratory's Equipment" allows researchers and graduate students to enter the NDL's clean rooms and perform research work using the NDL's most sophisticated equipment and newest technologies.

The instruments that the NDL makes available to outside users are steadily increasing in number, and included 31 items at the end of 1996. The NDL provided commissioned fabrication services on 4,670 occasions and allowed its facilities to be used 6,327 times in 1996, earning approximately NT$10 million in the process. In addition, a total of 361 persons successfully completed user training and were authorized to personally operate the NDL's equipment.

(4) Joint projects with industry

In order to assist the integrated circuit industry to maintain competitiveness by upgrading its technology, the NDL has taken the initiative in proposing joint projects to private firms. A successful example of such a project was the acquisition of chemical/mechanical polishing technologies in cooperation with the Taiwan Semiconductor Manufacturing Co. The following six joint projects are to be carried out during 1997:

a. Use of a rotating electron resonance gas-phase chemical deposition system to grow low dielectric constant layers of SiOF and $SiO_2$.
b. Research on the application of high-reliability nitride dielectric layers in non-volatile memory elements.
c. Research on ion implantation of submicron CMOS elements.
d. Research on the use of high dielectric constant materials in dynamic random access memory elements (DRAMs).
e. Research on electric migration and stress migration in ultra-large integrated circuits.
f. Research on the antenna effect of dielectric layers.

(5) Conceptual framework for cooperation with academia

In order to invite university professors to participate in research work, the NDL has recently drafted the "Guidelines for Cooperative Research at the National Nano Device Laboratory." The intent of this measure is to broaden access to the NDL's research facilities and support semiconductor-related research performed by academic and research institutions.

(6) Future outlook

The NDL is the R.O.C.'s leading facility in the area of advanced semiconductor research. The NDL will continue to take the R&D of technology modules as its primary mission, and in the future will focus on the following areas:

a. The development of submicron CMOS element fabrication techniques: Element dimensions have steadily decreased as fabrication processes have been improved. Elements with 0.25 micron line dimensions were made in 1995, the target for 1996 was 0.18 micron, and a goal of 0.1 microns has been set for 1998.
b. Development of single-crystal microwave integrated circuits: Silicon single-crystal bipolar transistors are faster than CMOS chips and are very suitable for use in high-speed elements and microwave elements. In the future SiGe heterogeneous junction transistors may rival GaAs elements in these applications.
c. Development of a 0.1 mm electron beam imaging system with increased throughput. It is anticipated that the R.O.C. will acquire the ability produce devices of this sort.
d. Research on X-ray imaging techniques: It is anticipated that X-ray imaging techniques will be used for the fabrication of 0.1 micron

elements by the year 2000. The R.O.C. is well placed to play a major role in the development of this technology. The most vital task at hand is to continue to make advances in X-ray mask fabrication, image conversion, X-ray beam design, and stepper construction.

Training of technical personnel is another of the NDL's principal missions. The NDL is making every effort to train an adequate supply of technical specialists to meet the manpower needs of the 20 domestic makers of eight-inch wafers. Many post-doctoral researchers now working at the NDL will become the future leaders of the semiconductor industry. Since the equipment used by master's degree and doctoral students receiving training at the NDL is in no way inferior to that used by industry, these individuals will be able to make a contribution as soon as they go out the door. This aspect will give Taiwan an advantage in its competition with the American and Japanese integrated circuit industries.

## 7. National Space Program Office

The following is a summary of the National Space Program Office's major efforts during 1996:

(1) Satellite bus project

The "ROCSAT-1" spacecraft project is responsible for the satellite's basic structure, and by designing and assembling the spacecraft, will lay the foundation for a domestic satellite manufacturing capability. Following the completion of the review of integrated testing procedures, this project has entered the stage of assembly and integrated testing of hardware and software components. The satellite's first payload module has been transported from America's TRW to NEC in Japan. In order to insure the success of the satellite's mission and nurture the R.O.C.'s satellite design, fabrication, assembly, and testing capability, the Space Program Office has selected 28 individuals to go overseas to facilitate technology transfer. After participating in design-stage tasks, these personnel will return to Taiwan and perform integrated testing work. Another 28 individuals will work together with and learn from the personnel who had gone overseas. The experience accumulated by the technology transfer team will be put to good use in the design and assembly of a future series of small satellites. This strategy should lend great impetus to the future growth of a indigenous aerospace industry.

(2) Payload development project

The ROCSAT-1's scientific payload will consist of an ocean color imager, an ionospheric plasma and electrodynamics instrument, and an experimental communications payload. After completion of a detailed design review of the ocean color imager in November 1996, the fabrication of the engineering assembly began. The science team has already planned completed research applications, preliminary purchasing of hardware and software has begun, and plans have been made for the transmission of scientific data to a central processing location. The ionospheric plasma and electrodynamics experiment project has completed testing of the main electronic controller's engineering assembly, performed interface testing of circuit boards in the main electronic controller and sensors, and begun constructing the sensor's flight assembly and circuit boards. As for the experimental communications payload project, the firm Tai Yang has sent personnel to NEC in Japan to take part in a technology transfer involving fabrication of a transponder engineering mockup. Detailed design review and instrument mockups were completed in April 1996. In August 1996 the engineering development assembly was accepted and fabrication of the flight assembly began. After the three payloads have successfully undergone testing, the assembled payload module will be shipped to Hsinchu and subjected to pre-launch integrated testing together with the spacecraft. Data collected by these payloads after the satellite is launched will be used for scientific purposes by research organizations in Taiwan and abroad.

(3) Domestically-produced satellite component project

The five satellite components included in this project are an on-board computer, a remote interface unit, a filter/diplexer, an antenna, and a solar array panel assembly. Engineering mockups

of these five components were completed in April 1996, and a manufacturing readiness review was performed in July. A test readiness review was completed in September, and flight assembly manufacturing was performed in November. A preliminary review of the results of manufacturing is currently underway, and involves the inspection of engineering mockup and flight assembly testing verification documents, collected data from successful tests, and documentation submitted by contractors. The inspection and acceptance of the flight assembly will be performed in January 1997 by TRW in Los Angeles and Gulton in Albuquerque. Component designs from overseas present an unprecedented challenge for Taiwanese firms, but the design process has trained a crop of new aerospace engineers who have hands-on experience working with satellite components. In the future these engineers will make great contributions to the transplantation of satellite technology in Taiwan. This project will provide confirmation that domestic firms have the ability to make spacecraft components.

(4) Integrated testing project

The chief work completed so far in the integrated testing project has been the construction of a testing building, preparation of testing equipment, and the training of personnel. A number of experienced technicians from the Space Program Office are in charge of the various planning and preparation tasks that must be completed before testing may begin. The physical structure of the integrated testing building was inspected and accepted in June 1996. The chief large pieces of testing equipment have already been delivered and are being installed in the testing building. Among this equipment, a 150kN vibration device has been installed and is being used for testing purposes. Other space environment testing apparatus, including a hot vacuum chamber, electromagnetic interference/electromagnetic compatibility (EMI/EMC) equipment, anechoic chamber, and acoustic vibration chamber, is still in the assembly phase. Principal data acquisition and recording equipment is currently being delivered and tested. The hot vacuum measurement system is now being shipped together with a heater control system. The EMI/EMC and anechoic chamber measurement system has already arrived at the Space Program Office, and the dynamic data acquisition and processing system for the acoustic vibration chamber and vibration apparatus is being tested. Because equipment in the integrated testing building will be used to test future satellites in the same class as the ROCSAT-1, the investment made in this facility can be put to good use.

(5) Ground system project

The ground system project can be divided into two parts: the ground system installation project and the mission implementation project. The former consists of the installation of the facilities needed by the ground mission, and the latter consists of actually carrying out the mission once the system has been completed and the satellite launched. Since software firms will participate in software development work, the ground system installations project will give domestic firms a chance to enjoy the benefits of software technology transfer. The second phase of control center construction has begun, and an elevated floor has been completed. Telemetry, tracking, and command equipment is being delivered, and contractors have been found for the installation of water and power utilities at the telemetry, tracking, and command station being built on the campus of National Cheng Kung University. The mission implementation project will consist of the use of the ground control system to control the satellite and keep it in a normal operating condition. The mission maintenance team will be organized from operating and maintenance personnel from domestic contractors along with specialists from the Space Program Office. All members of this team will receive training from the American firm AlliedSignal Technical Services Corp. (ATSC), prime contractor for the ground system. The second program management review (PMR) for the mission control project has been completed, and the members of the ROCSAT Maintenance and Operation Team (RMOT) have taken part in formal quality testing (FQT) work. Because the ROCSAT-1 ground system employs an open and modular software framework, it can be used in

the future to track and control other small, low-orbit satellites after undergoing suitable modifications.

The R.O.C.'s space program places equal emphasis on the success of the satellite mission and the development of a domestic space industry. Opportunities to cooperate with overseas firms in the R&D and fabrication of satellite components will give domestic firms, universities, and research organizations access to foreign technology. It is generally believed that, with the full cooperation of domestic and overseas industry, government, academia, and research communities, the space program will not only proceed smoothly, but will also stimulate the upgrading of domestic industry and help the R.O.C. play a major role in the international space market and applications industry.

### *E. Expanding International Sci-Tech Cooperation*

#### 1. Promoting Bilateral Sci-Tech Cooperation

(1) America

The NSC maintains cooperative relationships with such U.S. government agencies as the National Science Foundation (NSF), National Institute of Health (NIH), Environmental Protection Agency (EPA), National Institute of Standards and Technology (NIST), Bureau of Reclamation (Department of the Interior, BRDI), and National Technical Information Service (NTIS). A total of 16 sci-tech cooperation agreements were made between the NSC and its American counterparts during 1996; 14 of these were signed by the Taipei Economic and Cultural Representative Office in the U.S. (TECRO) and the American Institute in Taiwan (AIT). In addition, the NSC also signed agreements with the Argonne National Laboratory and Fermi National Accelerator Laboratory. All sci-tech cooperation agreements made between the NSC and the United States or other countries are based on the spirit of equality and mutual benefit. When NSC chairman Dr. Chao-shiuan Liu visited America in July 1996, his itinerary included the NSF, NIH, and NIST. In a discussion with NSF director Dr. Neal Lane, Chairman Liu indicated that the R.O.C. is eager to strengthen Sino-American cooperation in the areas of science and technology (Fig. 8).

The "Sino-American Scientific and Technological Cooperation Conference" was held in Washington D.C. in April of this year. The two sides reached a consensus during the conference that the emphasis of R.O.C.-American sci-tech cooperation should be placed on long-term ecological and earth science projects that have a regional character and can foster regional cooperation. Moreover, the two sides also agreed to step up cooperation in the areas of distance education and engineering education.

During 1996 the NSC invited many outstanding American scholars working in the fields of mathematics, physics, statistics, electronic engineering, and environmental science to Taiwan to exchange their knowledge and experience with their local counterparts.

During 1996 the NSC and the NIH jointly sponsored a project on high blood pressure and insulin resistance colonies in the Asia region. The four "Sino-American Bilateral Cooperation Symposia" included the "Symposium on Culture, the Media, and Social Workshops in Contemporary Taiwan," "Symposium on the Integration of Electrical Machinery Technology in the Pacific Region," "Symposium on the Reform of Chemistry Education in American and R.O.C. Universities," and "Symposium on the Island Arc-Continental Collision Occurring in Taiwan."

(2) Canada

Dr. J.R. Paré, director of the microwave section of the Science and Technology Center of Canada's Department of the Environment, visited the R.O.C. during February.

Dr. Claud Barrand, director of the science and technology section of Canada's National Resources Department, visited the R.O.C. during May. Senior engineer Tung Tien-pei and advisor Lao Chang-chun of the Department of the Environment's science and technology center accompanied Mr. Barrand on this visit.

Dr. David Reeve, chairman of Canada's National Energy Commission, visited the R.O.C. during October.

**Fig. 8. On July 16th 1996 NSC chairman Dr. Chao-shiuan Liu (Center on left), accompanied by NSC International Programs Department head Hsiao Kuan-hsiu (third from left) and representative to the United States Hu Chih-chiang (first on left), visited NSF director Dr. Neal Lane and Sino-American cooperative sci-tech project executive Dr. Chang Yi-pen (far right).**

Dr. Richard Turle, chief of the chemistry section of the Science and Technology Center of Canada's Department of the Environment, visited the R.O.C. during November.

The "1996 North American Chinese Academic Symposium" was held in the Canadian capital of Ottawa from June 17th to July 6th. During this event the NSC made a systematic presentation to Chinese academics and technical specialists living in North America concerning international sci-tech cooperation, plans for a new science-based industrial park in southern Taiwan, joint industrial-academic research projects, and other major policies and services.

In October the "Sino-Canadian Medium/Long Span Bridge Research Exchange Conference" was held in Ottawa and on Prince Edward Island.

(3) Germany

The NSC has signed a cooperation agreement with the Deutsche Forschungsgemeinschaft, and the two parties have maintained a close relationship. In accordance with this agreement, the two sides held the "Sino-German Engineering Technology Symposium" in Darmstatt in June and the "Sino-German Experimental Zoology Symposium" in Taipei in September. Moreover, R.O.C. and German researchers also conducted joint projects in the areas of sociology, oceanography, and nasopharyngeal cancer. During the year 69 scholars and technical specialists participated in reciprocal visits between the two nations.

In January the NSC signed a memorandum of cooperation with the German National Laboratory Federation's Karlsruhe research center. In the future the two parties will conduct joint research projects in the area of miniature electrical machinery.

Cooperation with Germany's Department of Academic Exchanges (the Deutscher Akademischer Austauschdienst, or DAAD) included reciprocal visits by ten professors. Ten R.O.C. academics visited Germany during 1996, and ten German academics came to Taiwan for

one- to three-month research visits. DAAD Secretary-General Dr. Christian Bode visited the R.O.C. in October at the head of a delegation, and in Taipei hosted a get-together for the winners of DAAD grants. Furthermore, the NSC and DAAD signed the "Cooperative Agreement for Short-term Visits to Germany by Doctoral Student Researchers for the Purpose of Research or Study." As part of this program, during 1996 the NSC sent 13 selected doctoral student researchers to Germany for the purpose of conducting short-term research of from six to eighteen months in length; in hopes of broadening the research horizons of domestic doctoral students, the NSC enabled these visits by providing full financial support.

(4) France

Under the 1996 sci-tech research cooperation framework established with the French Institute in Taipei, the two nations have conducted reciprocal visits of personnel and held the "Sino-French Plant Tissue Cultivation Symposium" in Montpellier, France.

The NSC also participated in cooperative research in marine geology and geophysics with the Institut Fran+ais de Recherche pour l'Exploitation de La Mer (IFREMER). This research chiefly consisted of projects investigating the tectonic structure of the earth's crust in the vicinity of Taiwan and the effects of the island arc-continental collision occurring in this area. Under the sponsorship of the NSC and IFREMER, the French research vessel L'Atalane visited Taiwan in May and June and made a research voyage from Keelung to Kaohsiung for the purpose of mapping the seafloor in areas where the collision of the Philippines and Eurasian plates is taking place.

The NSC has signed an administrative agreement with the Centre National de la Recherche Scientifique (CNRS) which provides for cooperation in various fields. Besides reciprocal visits of personnel and the exchange of data, this year the two sides conducted the "Sino-French Symposium on Organic and Organometallic Chemistry" in Strasbourg and carried out a joint project on biomedical cancer research.

(5) Britain

Under the NSC's sci-tech cooperation agreement with the Royal Society, the two sides continued their reciprocal visits of scientists and technical specialists. Sir Michael Atiyah, former director of the Royal Society visited Taiwan during January. At the Sino-British Economic Advisory Conference held in Taiwan during February, the two countries agreed to continue exchanges in the fields of astronomy and wireless communications.

(6) Switzerland, Belgium, and the European Community

The fact that the NSC has not signed any sci-tech agreements with Switzerland has not hindered significant cooperation between the two countries. When Dr. Heinrich Ursprung, head of the Swiss department of science and technology, visited Taiwan during October, he indicated that Switzerland would maintain an open attitude towards sci-tech cooperation, and would welcome joint projects involving Swiss and R.O.C. scientists. National Central University and the Academia Sinica have jointly sent a team to participate in a high-energy physics project at CERN. This project has continued for several years and has delivered very significant results. In the future the focus of R.O.C.-Swiss cooperation will shift to micro-electrical devices, high-energy physics, and sci-tech policy early-warning systems.

A European Union sci-tech task force made a fact-finding visit to Taiwan in October, and will work to develop sci-tech exchanges between the two parties in the future.

The R.O.C.-Belgium Plant Biotechnology Symposium was held at Ghent University in June. Dr. Jose Traest, secretary-general of Belgium's National Fund for Scientific Research, paid a visit to Taiwan in October.

(7) The Czech Republic and Slovakia

The NSC has signed a cooperation agreement with the Academy of Sciences of the Czech Republic; under this agreement 16 R.O.C. researchers visited the Czech Republic and 11 Czech specialists came to Taiwan in 1996. Dr. Rudolf Zahradnik, head of the Czech Academy of Sciences visited the R.O.C. in April.

The NSC has actively pursued contacts with

both countries since the time the Czech Republic and Slovakia became mutually independent. A bilateral sci-tech cooperation agreement was signed by the NSC and the Slovakian Academy of Sciences in March 1996. Dr. Stephan Markus, secretary-general of the Slovakian Academy of Sciences, led a delegation to the R.O.C. in June and indicated a desire to exchange research personnel.

(8) Norway

According to the cooperation agreement the NSC has signed with the Norwegian Research Council, the two sides will initially focus on the areas of geological engineering and environmental protection for their cooperative efforts. During this year the NSC sent personnel to Norway to study marine aquaculture and provided funding to professors visiting Norway to discuss joint projects in geological engineering. In October NSC vice chairman Tsai went to Norway to attend an international conference on global changes and tour the Norwegian Institute of Geological Engineering. Thus sci-tech contacts between the R.O.C. and Norway developed smoothly during 1996.

(9) Japan

The NSC continued to step up exchanges of data and mutual visits of personnel with the sci-tech community in Japan via contact between the Taipei Economic and Cultural Representative Office in Japan and Japanese Exchange Association, and between the Asia-Pacific Science and Technology Association and Japan's East Asia Science and Technology Cooperative Association. Four bilateral Sino-Japanese symposia on the topics of "submicron ultra-large integrated circuit technologies," "biotechnology and the development of the floral industry," "techniques for the use of carbon 60," and "small accelerators and their applications" were held during 1996. Twenty-nine seminars involving R.O.C. and Japanese researchers were held in Taiwan, and focused such areas as information science, electrical engineering, communications, science education, and sci-tech policies. The NSC also provided funding to 136 domestic experts who visited Japan for the purpose of attending conferences or performing fact-finding work.

(10) Philippines

The two countries agreed to the following points at the R.O.C.-Philippines Economic and Technological Cooperation Conference held in Manila in July: (1) The R.O.C. will invite a delegation from the Philippines to visit the Hsinchu Science-Based Industrial Park and will provide information and technologies pertaining to the development of science-based industrial parks. (2) The Philippines will send personnel to attend training in instrument operation and information processing at the NSC's Precision Instrument Development Center and Science and Technology Information Center.

The National Space Program Office sent personnel to the Philippines in October to promote the development of bilateral cooperation in the field of space technology. During this trip the R.O.C. delegation visited Dr. William G. Podolina, head of the Philippines Department of Science and Technology.

(11) Indonesia

Dr. Samaun Samadikun, chairman of the Indonesian Academy of Science and the Semiconductor Research and Promotion Department, came to Taiwan during May and made preliminary arrangements for the following cooperative activities: (1) participation by Indonesian personnel in post-doctoral research projects conducted by the NSC specifically for researchers from developing nations; (2) participation by Indonesian personnel in training courses held by the Precision Instrument Development Center; and (3) continued discussion between the Chung Shan Institute of Science and Technology and ITRI Electronics Research & Service Organization and their Indonesian counterparts concerning cooperation methods and topics.

(12) Vietnam

Dr. Phan Huy Tien, assistant director of the Vietnamese Institute of Science and Technology, led a delegation to the R.O.C. in April to participate in the "International Symposium on the Dynamics of the Lithosphere in Central Asia." This visit served to strengthen exchanges between the R.O.C. and Vietnam in the field of geology. In April the Vietnamese Department of Science, Technology, and the Environment sent four personnel

to Taiwan for six days of study and training. The chief objective of this trip was to give the Vietnamese an opportunity to better understand the Hsinchu Science-Based Industrial Park.

(13) Commonwealth of Independent States and South Africa

Vladimir M. Koleshko, the head of a commerce delegation from Belarus, visited the NSC during August. During November Dr. Liudmila Alexeyevna Rbitskaya, president of the University of Saint Petersburg, Dr. Yuri V. Fedotov, the university's vice president, and a professor of the Chinese language and Chinese psychology visited the NSC and conveyed their institution's interest in conducing cooperation in the humanities and social sciences.

A R.O.C.-South African symposium on composite materials systems was held at the University of Witwatersrand from March 29th to April 7th. In May a group consisting of NSC-funded specialists and personnel from the MOEA Water Resources Committee visited South Africa to study the South Africans' water resource management efforts. In addition, a ten-person South African aquaculture delegation led by Prof. Jacubos F. Prinsloo was in Taiwan from September to November. Besides inspecting the R.O.C.'s aquacultural facilities, this delegation also participated in two seminars with local specialists and exchanged views concerning aquacultural enterprises. In December a group consisting of personnel from the Council of Agriculture, Committee of International Technical Cooperation, Taiwan Fisheries Research Institute, and the NSC paid a region-by-region fact-finding visit to South Africa in order to encourage cooperative activities in the field of aquaculture.

(14) Australia and New Zealand

Prof. Grey Tegart, chairman of the international relations committee of the Australian Academy of Technological Sciences and Engineering, visited Taiwan in March upon invitation. In July the second World Fisheries Conference was held in Brisbane. Under the framework of the NSC's accord with the Australian Academy of Sciences, the Australians sent five researchers to Taiwan during 1996, where they performed cooperative research at National Tsinghua University, National Central University, Chang Gung Memorial Hospital Medical School, and Feng Chia University.

The Fourth R.O.C.-New Zealand Economic Advisory Conference was held in New Zealand on May 4th through 9th. R.O.C. and New Zealand representatives discussed areas for possible cooperation during an industrial technology symposium held concurrently with this conference.

## 2. Participation in Major International Sci-Tech Organizations

Key tasks for the NSC during 1996 were participating in the activities of the Association for Science Cooperation in Asia (ASCA) and attending the APEC science department heads' conference.

(1) Association for Science Cooperation in Asia (ASCA)

Since becoming a member of ASCA in 1994, the NSC has vigorously supported ASCA's services, sent personnel to participate in ASCA activities, and invited ASCA members to send representatives to the R.O.C. The NSC presented the R.O.C.'s experience in sci-tech information services by holding the "Seminar on Modern Utilization and Management of Scientific and Technological Information" at the STIC. In addition, 11 individuals from the ASCA member nations of Bangladesh, Vietnam, Thailand, Philippines, and Singapore attended the PIDC's international instrument technology training program.

In order to play a role in carrying out the ASCA "Asian Satellite Communications Experiment," the National Space Program Office sent personnel in November to the Philippines, Indonesia, and Singapore to perform fact-finding work concerning those nations' space technology organizations and private satellite companies. This visit also served to open channels for space research cooperation.

(2) Asia Pacific Economic Cooperation Forum

The second APEC science and technology heads' conference was held in Seoul during November. The theme of this conference was "Cre-

ativity and Mobility: Researchers Throughout APEC." NSC chairman Dr. Chao-shiuan Liu represented the R.O.C. During his speech to the assembly, Dr. Liu appealed to APEC to stress international cooperation, strengthen integration of sci-tech resources, and to designate telecommunications, environmental protection, and disaster prevention as the main topics for cooperative efforts. In addition, Dr. Liu particularly emphasized the importance of basic research in training talented sci-tech personnel and in stimulating creativity. During his discussion of the importance of regional cooperation, Dr. Liu made the following two suggestions to the assembly: Firstly, because each nation's synchrotron radiation research facility possesses its own special features and capabilities, great synergy and mutual benefit can be achieved if these facilities are opened to international use and operated on a joint basis. Secondly, the establishment of a network linking organizations responsible for promoting joint industrial-academic research could be used to foster cooperation in areas with mid-/long-term potential and no existing conflicts of interest. Dr. Liu's speech received a warm response from the assembly and his two suggestions were recorded in the conference's joint communiqu+.

During the course of the two-day conference, Dr. Liu conducted bilateral talks with representatives from Malaysia, Indonesia, New Zealand, the Philippines, Thailand, Mexico, and Korea. These talks served both to show the R.O.C.'s willingness to cooperate and to allow the R.O.C. to better understand the needs and desires of other nations as a basis for future exchanges and cooperation. The second APEC science and technology heads' conference concluded smoothly after issuing a joint communiqué and the "Seoul Declaration."

### 3. Support for Academic Exchange Activities

The NSC invited 18 prominent sci-tech figures to the R.O.C. during 1996, including Dr. Dudley R. Herschboch, a lecturing professor of Harvard University's chemistry department, and Dr. Ronald David Ekers, head of the National Australian Observatory. As for the invitation of overseas scholars to come to the R.O.C. to lecture or perform short-term research, 302 overseas sci-tech experts visited the R.O.C. throughout the year. The NSC also provided financial support on 2,113 occasions to domestic specialists wishing to attend international academic conferences, which was a 20% increase over the year before.

### 4. Strengthening Liaison with Overseas Chinese Scholars and Academic Organizations

Beginning in 1970, the NSC has set up eleven overseas offices at the R.O.C.'s representative offices located in Washington D.C., San Francisco, Los Angeles, Houston, Chicago, London, Ottawa, Tokyo, Bonn, Paris, and Brussels. Apart from collecting data and engaging in cooperative activities with local government, academic, and private organizations, these offices also serve to maintain contact with overseas Chinese scientists, engineers, and academic and professional associations.

Each office has established complete files on overseas Chinese sci-tech workers and their companies. The offices have taken the initiative in providing services, sponsoring activities, and encouraging specialists to return to the R.O.C. to teach, work, or invest.

Each of the NSC's overseas offices has worked hard to maintain contact with professional associations and other organizations of overseas Chinese academics and technologists. Besides helping organize new associations, the NSC frequently assists with association functions and actively provides services.

## *F. Planning Sci-Tech Exchanges Between Taiwan and Mainland China*

### 1. Recruiting Mainland Chinese Sci-Tech Workers to Participate in Research in Taiwan

By the end of 1996, approval had been granted to 29 individuals from mainland China wishing to come to Taiwan to engage in research;

16 of these researchers are in the natural sciences, eight in engineering, four in bioscience, and one in the humanities.

### 2. Support for Specialists Performing Short-Term Sci-Tech Research in Mainland China

By the end of 1996, approval had been granted to five individuals wishing to visit mainland China for the purpose of performing short-term research. In addition, support was also provided to 61 individuals performing research work in mainland China under the auspices of an NSC integrated research projects.

### 3. Sponsoring Cross-Straits Academic Symposia

Eight academic and technical symposia had received support by the end of 1996.

### 4. Sponsoring Sci-Tech Information Exchanges with Mainland China

The NSC's Science and Technology Information Center has made available on the Internet various material from mainland Chinese sci-tech periodicals, including the core sci-tech journal information issued by the "Chinese Scientific and Technological Information Institute." Moreover, in response to domestic researchers' need for sci-tech information from mainland China, the NSC collects more than 270 sci-tech periodicals and CD-ROM databases. Via inter-library cooperation, interested persons are now able to obtain reprints of sci-tech articles from mainland China; more than 300 applications for this service were received during 1996.

## *G. The Protection, Promotion, and Application of Research Results*

### 1. Applications for Patents and Copyrights

Of the 258 patent applications submitted during 1996, 134 were for domestic patents and 124 were for foreign patents (including patents in America, Japan, Britain, and France). Looking at the number of patent applications over the years, it can be seen that applications have climbed sharply in recent years after research workers became more conscious of the importance of protecting intellectual property rights. The total of 515 patents that had already been approved and registered up to the end of 1996 include 327 from the R.O.C., 142 from America, 34 from Japan, three each from Britain, Germany, and Korea, two from France, and one from Canada.

The R.O.C.'s copyright law emphasizes creation, and "registration" is no longer a necessary condition for recognition of a copyright. However, the NSC still provides copyright registration services in order to enhance protection for research findings. This year 14 copyrights for computer programs or linguistic works were registered.

### 2. The Promotion and Application of Research Results

Since the NSC issued procedural guidelines for the handling of technology transfer cases in 1989, the results of NSC-funded research projects have gradually been made available for the use of the private sector. After two years of vigorous promotional efforts, including many public forums on technology transfer and conferences announcing research findings, the NSC's support for technology transfer has entered a period of rapidly increasing success.

This year the NSC held 10 technology transfer forums, and in conjunction with the Engineering Technology Promotion Center, conducted four conferences announcing research findings. The 32 technology transfer cases completed during this year marked a large increase over the 17 cases completed the year before, and raised the total of NSC technology transfers to 67. (Table 7)

## *H. Stimulating Public Awareness of Science and Technology*

### 1. Reports on the Findings of Academic Research

The NSC seeks to promote international

**Table 7. NSC-Sponsored Technology Transfer Cases in Recent Years**

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | Total | Currently Underway |
|---|---|---|---|---|---|---|---|---|
| Technology Transfer | 6 | 1 | 0 | 3 | 7 | 16 | 33 | 10 |
| Authorization of Use of Computer Program | 1 | 0 | 0 | 0 | 8 | 6 | 15 | 6 |
| Authorization of Publication of Copyrighted Work | 0 | 0 | 2 | 5 | 2 | 10 | 19 | 0 |
| Total | 7 | 1 | 2 | 8 | 17 | 32 | 67 | 16 |

academic exchange and raise the R.O.C.'s standing in the academic world by widely disseminating the findings of academic research in the R.O.C. among domestic and foreign scholars. Therefore the NSC publishes a variety of academic and news periodicals which are regularly sent to domestic and foreign institutions and individuals.

The *Proceedings of the National Science Council* consists of parts A, B, C, and D featuring different academic disciplines. This publications provides the hosts of NSC-funded research projects with a forum in which to present their findings. Lately it has been acquiring an international flavor by accepting manuscripts submitted by foreign researchers.

In this periodical the NSC attempts to both protect authors' rights and promote high quality writing. Beginning in 1997, the *Proceedings of the National Science Council Part C* will be published on a quarterly basis (rather than annually) and the *Proceedings of the National Science Council Part D* will be published three times per year (rather than twice a year). In addition, in 1994 the NSC initiated the publication of the *Journal of Biomedical Science*. It is hoped that this domestically written and edited international periodical will showcase the R.O.C.'s achievements to the international academic community. Of the 125 articles included in the *Journal* during its first three years, 65.6% originated overseas, demonstrating that it has earned a significant amount of international recognition in a short period of time. It is hoped that this periodical's rigorous evaluation standards and many high-quality articles will enable it to find a place in the front ranks of international biomedical publications.

### 2. Promotion of Computer Education

Besides supporting the government's National Information Infrastructure program, broadly disseminating computer knowledge, and stimulating public interest in applications of computer technology, the Information Science & Technology Exhibition Center is working to provide efficient Internet applications and give the public "hands-on" experience using computer networks. In addition, the Center is continuing to promote a closer relationship between industry, academia, research, and the public. The Center is using a business management approach and low-cost, high-efficiency working methods to achieve its goal of implementing information technology education. Besides its general public activities, in 1996 the Center also conducted a number of special activities meeting the needs of particular groups; these included a children's information month, a senior citizens' information month, and computer activities for the handicapped.

## IV. Developing Science-Based Industrial Parks

### *A. Expanding the Hsinchu Science-Based Industrial Park*

Since it was established in 1980, the Hsinchu Science-Based Industrial Park (SIP) has attracted 197 high-tech firms, whose capital in-

**Table 8. High Technology Industries in the Hsinchu Science-based Park (December 1996)**

| Type of Industry | Number of Approved Firms | Number of already operating in SIP |
|---|---|---|
| Integrated Circuits | 82 | 71 |
| Computer and Peripherals | 44 | 43 |
| Communications | 35 | 33 |
| Electro-optics | 31 | 28 |
| Precision Machinery | 18 | 18 |
| Biotechnology | 12 | 10 |
| Total | 222 | 203 |

vestment in 1996 amounted to NT$260 billion. The turnover of park firms surpassed the NT$300 billion mark in 1996, and the number of employees exceeded 50,000. Apart from a growth rate and investment in R&D several times those of domestic manufacturers as a whole, high-tech firms in the SIP boasted a productivity rivaling that of American and Japanese industry. The success of these firms has won the park an international reputation as Taiwan's "Silicon Valley" and provided an indicator of the nation's technological progress.

Thanks to the government's whole-hearted support and the hard work of everyone at the Hsinchu SIP over the past 16 years, very positive results have been achieved in attracting high-tech firms, recruiting and training manpower, creating new products, and expanding markets. The following is a general outline of work at the SIP during 1996:

## 1. Attracting High-Tech Firms and Investments

The applications of 222 firms had been approved by the end of 1996. Of these firms, 203 had actually begun operations in the SIP (Table 8). These firms will lend fresh impetus to the development of high technology in the R.O.C.

The turnover of SIP firms during 1996 totaled NT$318.1 billion and represented growth of 6.3% over the previous year (growth of turnover in successive years is Fig. 9). High-tech products from the SIP were sold in markets spanning the globe. Besides increasing their output, SIP firms also made large investments in product R&D and had an outstanding crop of innovative new products in 1996. An example of the fine, high-performance products being made in the SIP is the eight-inch ingot of crystalline silicon produced by the Taisil Electronic Materials Corporation, the first of its kind to be made in Taiwan (Fig. 10).

## 2. Recruiting Skilled Personnel and Strengthening Training

Besides trying to attract high-tech firms, the Hsinchu SIP also wants induce more outstanding skilled personnel to settle in the area and work at SIP firms. The number of people employed at SIP companies has grown quickly over the years, and has now reached a total of 54,806 persons (Fig. 11). An analysis by educational attainment reveals that 58.61% of SIP employees have university or college diplomas, and of these 699 and 6,699 possess Ph.D. and master's degrees respectively. In order to meet future manpower needs in terms of both quantity and quality, the SIP Administration is cooperating with academic and research institutions in offering various specialized training courses. A total of 22,844 individuals have taken part in such training over the years and another 23,412 have attended in-service seminars on technical subjects (cumulative totals from 1990).

## 3. Stimulating Innovative Research and Developing High-Tech Products

Many industries in the Hsinchu SIP specialize in producing and marketing products that have

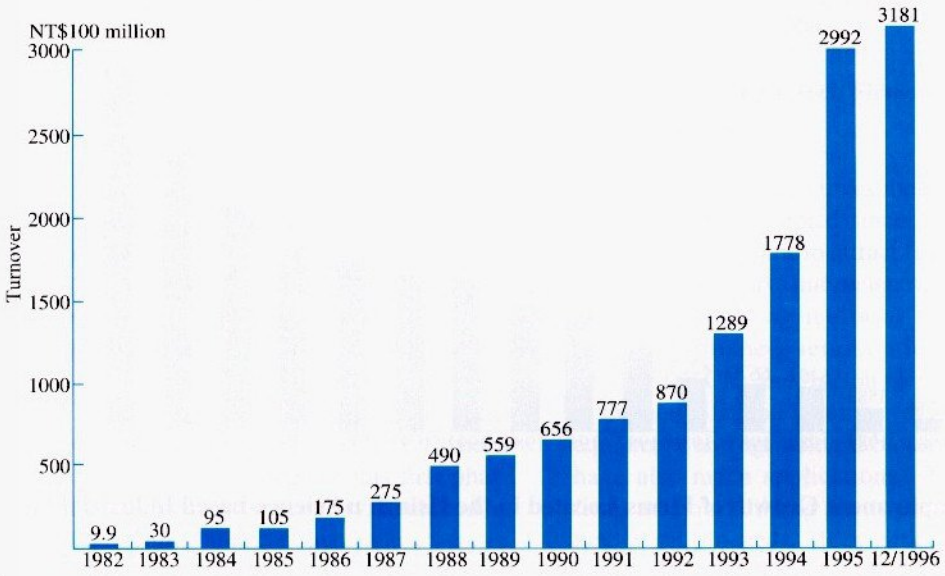


**Fig. 9. Turnover Growth of Firms Located in the Hsinchu Science-based Industrial Park.**

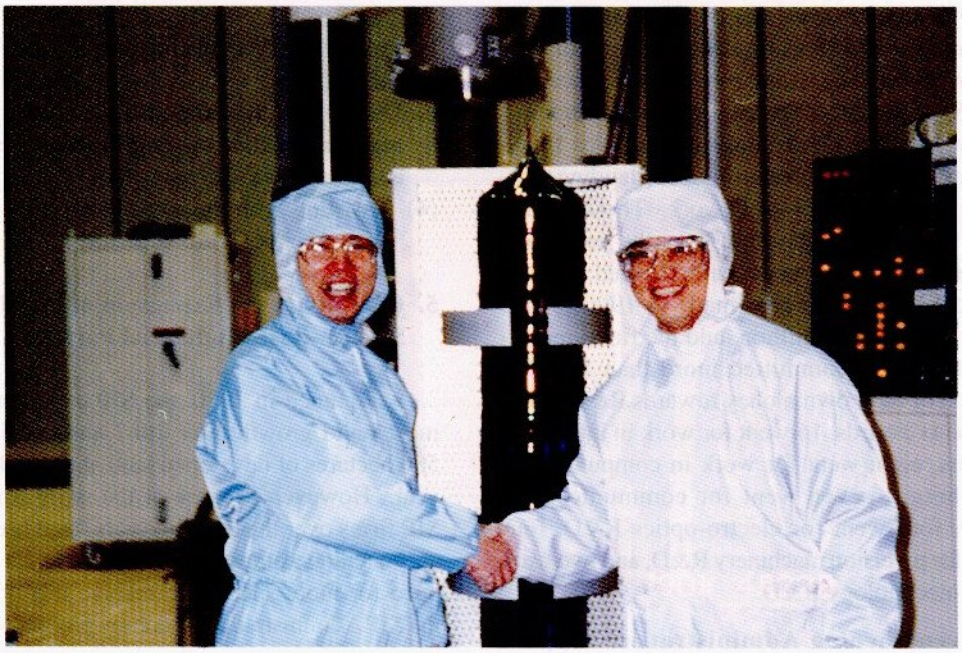

**Fig. 10. This eight-inch ingot of crystalline silicon (the raw material for the manufacture of inteigrated circuits) was produced by the Taisil Electronic Materials Corporation in April 1996 and is the first of its kind to be made in Taiwan.**

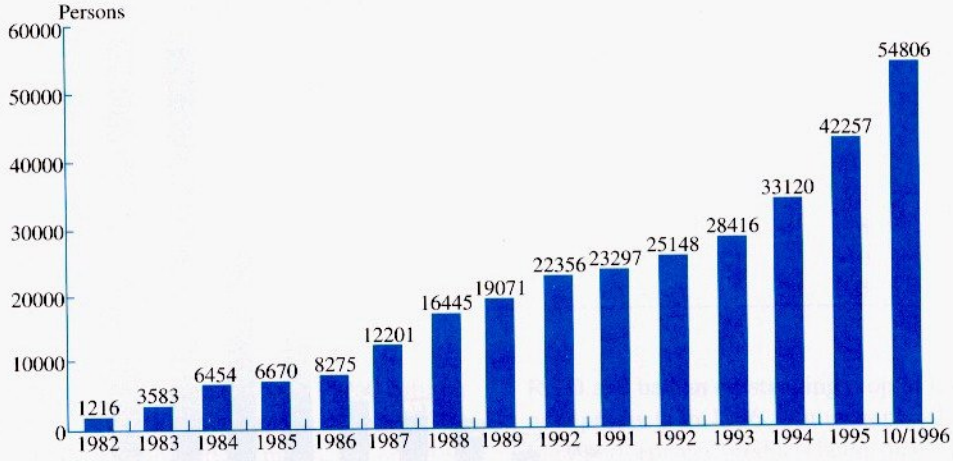


**Fig. 11. Employment Growth of Firms Located in the Hsinch u Science-based Industrial Park.**

been developed in-house. But because of the short life-cycle of high-tech products, these firms have to devote constant effort to keeping up, and thus spend a high proportion of their turnover on R&D. A 1995 survey revealed that the average R&D expenditure of SIP firms as a proportion of their turnover was 4.4%. Moreover, in accordance with the "SIP Innovative Technology R&D Program," every year the SIP Administration gives financial awards to firms performing outstanding technical innovation and R&D work. These awards have been made 395 times over the years, and the total money disbursed has exceeded NT$670 million. The 41 awards made in 1996 totaled more than NT$96 million, and the firms receiving them also committed more than NT$280 million of their own money towards R&D work. Of the 41 awards, 16 went for work in integrated circuits, eight went for work in computers and peripherals, seven went for communications R&D, four went for electro-optics R&D, four went for precision machinery R&D, and two went for biotechnology R&D.

## 4. Strengthening Administrative Support Measures

(1) The SIP Administration is continuing construction work at the Hsinchu site.
(2) Streamlining administrative procedures and revising laws and regulations.
(3) Providing strengthened information services:

a. Improving the SIP automated customs clearance system.
b. Promoting use of the Internet and the Hsinchu SIP network.
c. Developing SIP administrative and management information systems in order to enhance administrative efficiency.

(4) Assisting with the establishment of experimental schools.

## 5. Continuing the Expansion of the Hsinchu Science-Based Industrial Park

Founded in 1980, the SIP experienced its most rapid growth after 1987 and consisted of 580 hectares of developed land at the end of this year. However, because of the swift growth of SIP firms over the last few years, land use is fast approaching saturation, and there is an urgent need for more space. To resolve this problem, the SIP Administration is already proceeding with the third phase of land development. This work involves approximately 200 hectares belonging to municipal Hsinchu, and construction is to be completed by the end of 1997. Besides providing an outstanding environment for industrial

investment, the Hsinchu SIP also places great emphasis on environmental planning and development. The successful development experience gained at the SIP has made it Taiwan's showcase to the world.

### *B. Developing the Tainan Science-Based Industrial Park*

#### 1. Speeding up Land Development and Infrastructure Work

The Tainan SIP consists of 638 hectares that are to be developed in two phases. The 390 hectares that are to be developed in this first phase will consist of precision machinery, semiconductor, and agricultural biotechnology industry zones. Construction work for this phase got underway in July 1996. The second phase of development will involve the remaining 248 hectares. It is expected that all construction work will be completed by the year 2000.

#### 2. Attracting High-Tech Firms and Promoting Investment

Applications for investment in the Tainan SIP have been accepted since March 1, 1996. The SIP chiefly aims to attract firms in the areas of semiconductors, microelectronics, precision machinery, and agricultural biotechnology. Such established semiconductor firms as TSMC, Teh Chi, and Accton plan to build plants in the new SIP, and a number of semiconductor equipment and agricultural biotechnology firms have also made applications. More than ten firms are now building plants even as infrastructure work proceeds. It is anticipated that the Tainan SIP will make a great contribution to the upgrading and restructuring of industry in southern Taiwan.

# Chapter 3 NSC Promotion of Academic Research

## I. Research in Mathematics and Natural Science

### *A. Current Situation*

#### 1. Mathematics Research

Although, due to limited manpower, the scope of mathematics research in Taiwan cannot encompass all areas of this field, many important lines of investigation are being pursued (Table 9). Among the most noteworthy of these are:

(1) Research and applications of algebra and number theory
(2) Research in geometry and topology
(3) Research and applications of linear and nonlinear analysis
(4) Research on discrete and calculation methods
(5) Theory and applications of probability

There are now research teams working on each topic; these teams engage in frequent discussions and participate in annual seminars at a national or international level.

#### 2. Statistics

Statistics is still a young discipline in the R.O.C. While the number of researchers working in statistics began increasing about ten years ago, only in 1990 did the NSC consider statistics to be an independent field separate from mathematics. But thanks to support from the NSC and the efforts of the academic community, statistics research has made considerable strides over the last few years.

The number of applications for statistics research projects has grown steadily, and the 137 such applications in 1996 (including nine integrated projects) represents a sharp increase over the 88 received in 1995 (Table 10). Numerous domestic statisticians serve as associate editors for prestigious international journals. In addition, many are members of such international organizations as the Institute of Mathematical Statistics, the American Statistical Association, and the International Statistical Institute. These accomplishments show that statistics in the R.O.C. is thriving and gradually achieving an international prominence.

#### 3. Physics Research

Thanks to long-term NSC support, domestic research in basic and applied physics is being carried out on a considerable scale. The field is experiencing steady growth and improvement in terms of manpower, equipment, funding, and number of research projects. The quality of research and the significance of the results achieved have also reached very high levels (Table 11).

Research in physics is being carried out in the six major areas of condensed state physics, particle physics and field theory, nuclear phys-

**Table 9. Mathematics Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors Ph.D.-level | Lecturers | Total |
| 1992 | 141 | 4001 | 116 | 37 | 5 | | 158 |
| 1993 | 176 | 5653 | 110 | 75 | 10 | | 195 |
| 1994 | 188 | 6775 | 116 | 84 | 6 | | 206 |
| 1995 | 177 | 6574 | 86 | 96 | 25 | | 207 |
| 1996 | 228 | 7293 | 94 | 147 | 1 | | 253 |

**Table 10. Statistics Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors Ph.D.-level | Lecturers | Total |
| 1992 | 61 | 1696 | 49 | 17 | 0 | | 66 |
| 1993 | 85 | 2580 | 45 | 49 | 0 | | 94 |
| 1994 | 87 | 2690 | 52 | 40 | 0 | | 92 |
| 1995 | 88 | 2783 | 37 | 99 | 0 | | 136 |
| 1996 | 137 | 3750 | 35 | 105 | 1 | | 141 |

**Table 11. Physics Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors Ph.D.-level | Lecturers | Total |
| 1992 | 289 | 30,343 | 262 | 90 | 24 | | 376 |
| 1993 | 308 | 34,705 | 245 | 98 | 30 | | 373 |
| 1994 | 294 | 32,736 | 247 | 95 | 19 | | 361 |
| 1995 | 291 | 33,560 | 208 | 168 | 14 | | 390 |
| 1996 | 338 | 38,510 | 167 | 144 | 85 | | 396 |

ics, atomic and molecular physics, astrophysics, and statistical physics. Projects are categorized as either free research or focal research. Among the focal areas currently being promoted are high-temperature semiconductors, condensed state science, and high-energy physics. In order to insure that financial resources are allocated and utilized in the most rational and effective manner, the NSC began sponsoring integrated research projects in 1994. In 1997 the number of approved integrated projects in physics grew to 25 from 21 in 1996.

## 4. Chemistry Research

Following the completion of a revised discipline plan for chemistry in November 1995, the following six areas were selected as the focal points for research attention: (1) molecular simulation and computational chemistry, (2) ultra-micro analytical methods, (3) the synthesis and characteristics of new materials (4) biomedical chemistry research, (5) synthetic chemistry, and (6) applications of lasers and synchrotron radiation. Research task forces organized by the NSC and the Chemistry Research Center are actively devising specific integrated projects in these six areas in order to help chemistry research in the R.O.C. keep up with international trends (Table 12).

The 11 integrated projects sponsored by the NSC in 1996 addressed the following topics: (1) Edothelin receptor antagoistis—a study of hypertension-fighting compounds and their receptors; (2) applications of transition metals in organic synthesis, (3) applications of organometallic compounds in the synthesis of polymers and a study of polymer properties, (4) use of lasers to study intermolecular activity, (5) use of lasers to study major chemical constituents of the atmosphere, (6) development of analytical methods for the rapid detection of minute quantities of toxic substances in the bodies of living organisms, (7) research on "fingerprints" of trace amounts of pollutants in the environment and atmosphere, (8) the construction and application of chemical sensors, and (9) theoretical computational chemistry. In addition, inter-laboratory integrated projects on the basic medical applications of carbon complex compounds $C_{60}$ research and the medical applications of water-soluble cobalt-60 compounds were also carried out. The work on

**Table 12. Chemistry Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors | Ph.D.-level Lecturers | Total |
| 1992 | 322 | 35,011 | 274 | 69 | 14 | | 357 |
| 1993 | 344 | 36,820 | 258 | 101 | 8 | | 367 |
| 1994 | 373 | 44,665 | 288 | 98 | 10 | | 396 |
| 1995 | 309 | 41,310 | 185 | 150 | 19 | | 354 |
| 1996 | 387 | 43,918 | 192 | 200 | 12 | | 404 |

**Table 13. Earth Science Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors | Ph.D.-level Lecturers | Total |
| 1992 | 88 | 7,519 | 73 | 21 | 6 | | 100 |
| 1993 | 83 | 6,182 | 67 | 24 | 5 | | 96 |
| 1994 | 95 | 8,117 | 81 | 28 | 11 | | 120 |
| 1995 | 91 | 7,200 | 44 | 55 | 12 | | 111 |
| 1996 | 98 | 8,236 | 53 | 57 | 3 | | 113 |

the basic medical applications of carbon complex compounds was considered a very important and innovative project.

## 5. Earth Science Research

Although earth science primarily emphasizes the study of regional geological features, the results of regional geological research can be used to devise theories that are global in scope. Because Taiwan is located in an active orogenic belt, it is well situated for the study of earthquakes and mountain building activities. But due to limited research manpower, equipment, and funding, obtaining significant research results in the earth sciences requires effective planning and integration (Table 13).

When the NSC began its second discipline planning effort for the field of earth science in 1993, the following five major research topics were proposed: (1) subduction and plate collision in Taiwan and adjacent areas, (2) environmental transformations in the coastal regions of Taiwan, (3) the three-dimensional underground structure of Taiwan and adjacent areas, (4) the evolution of the lithosphere in the vicinity of southeastern China, and (5) past global changes.

Beginning in 1994, integrated research projects were organized around these five topics. The framework of these projects has not only provided for the continued implementation of bilateral joint projects with America and other countries, but has also facilitated research contacts with geologists in mainland China.

## 6. Atmospheric Science Research

The specialists making up the atmospheric science discipline planning committee have proposed the following focal topics: (1) short-term climatic fluctuations in East Asia, (2) torrential rains in the Taiwan area, (3) partial atmospheric circulation, (4) typhoons and two space science development research areas, (5) ionospheric dynamics in the vicinity of the equatorial anomaly, and (6) solar, interplanetary, and magnetospheric physics.

In order to insure that research in these areas is carried out, measures have been taken to encourage the formation of research teams and integrate various lines of study. Eight research teams are being established from August of this

**Table 14. Atmospheric Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors | Ph.D.-level Lecturers | Total |
| 1992 | 58 | 5,202 | 30 | 32 | 0 | | 62 |
| 1993 | 73 | 6,095 | 32 | 49 | 2 | | 82 |
| 1994 | 64 | 5,274 | 34 | 41 | 0 | | 75 |
| 1995 | 76 | 5,381 | 35 | 40 | 3 | | 78 |
| 1996 | 80 | 5,420 | 37 | 40 | 3 | | 80 |

year until July 1997 in order to carry out the following integrated research projects (Table 14): (1) research on the tropical ocean and atmosphere, (2) analysis and simulation of the East Asian monsoon winds, (3) experimental research on the monsoon winds of the South China Sea, (4) research on torrential rains in the Taiwan area, (5) research on partial atmospheric circulation in the Taiwan area (6) research on typhoons, (7) ionospheric dynamics in the vicinity of the equatorial anomaly, and (8) research on the magnetosphere.

With the NSC's support, not only has atmospheric science and space science research in the R.O.C. developed a local orientation, but has also actively participated in international research activities. With the ongoing sponsorship of focal research, it is hoped that group efforts will raise research standards, and a consensus on future directions will be established among workers in this field. The future revision of national plans for atmospheric science and space science will seek to achieve a consensus among atmospheric science researchers and provide for better use of data (including Central Weather Bureau data and remote sensing data obtained at natural resource satellite receiving stations), the promotion of integrated research projects, the strengthening of observational techniques, and the improvement of the quality of atmospheric science and space science research through greater teamwork.

### 7. Oceanographic Research

Oceanographic research in the R.O.C. has made great strides over the past few years, and this success must be attributed to both the rapid growth of oceanographic research units and manpower and to the use of the oceanographic vessel "Ocean Researcher-I" for exploratory work. In great contrast with past discipline plans for oceanography, the 1995 plan places strong emphasis on large-scale integrated research projects. This plan addresses on regional characteristics, seeks feedback from research workers, and calls for inter-disciplinary integrated projects and active participation in large international oceanographic efforts. Minor revisions to the discipline plan in October 1993 listed more inshore oceanographic research topics as a preparation for future projects in area.

In support of national policies for the development of ocean resources, the "South China Sea Integrated Research Project" got underway in August 1994. The initial focus of this project has been on the hydrology, currents, marine geology, and paleo-oceanography of the South China Sea. Its goal is to increase understanding of environmental conditions in this region and create oceanographic and marine resource databases that will facilitate future attempts to analyze and develop resources. In addition, geophysical research on the island arc-continental collision taking place off eastern Taiwan has had the chief goal of investigating plate structure and the evolution and dynamics of the earth's crust in this area. In conjunction with related earth science projects, this research will enable the tectonic structure of Taiwan and adjacent areas to be studied on both on land and at sea (Table 15).

## *B. Summary of Research Results*

### 1. Mathematics Research

**Table 15. Oceanographic Research Projects over the Past Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | | |
|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Associate Professors | Ph.D.-level | Lecturers | Total |
| 1992 | 65 | 8,253 | 51 | 22 | 2 | | 75 |
| 1993 | 63 | 8,102 | 43 | 18 | 1 | | 62 |
| 1994 | 59 | 8,351 | 46 | 21 | 0 | | 67 |
| 1995 | 51 | 6,740 | 31 | 24 | 0 | | 55 |
| 1996 | 61 | 7,525 | 41 | 37 | 0 | | 78 |

Chief research results in 1996 were obtained from individual-type projects in the following seven subfields: algebra and number theory, geometry and topology, analysis, infinitesimal equations, probability, numerical analysis and computational science, and discrete mathematics. In addition, another five integrated projects focused on the areas of probability, discrete mathematics, and computational science.

## 2. Statistics Research

The topics of NSC-supported research projects during 1996 chiefly included the three categories of theoretical statistics, statistics applications, and probability modeling.

## 3. Physics Research

Of the 328 physics projects supported by the NSC in 1996, 21 were integrated projects; areas studied included condensed state physics, particle physics and field theory, nuclear physics, atomic and molecular physics, statistical and non-linear physics, and astrophysics.

## 4. Chemistry Research

Of the 387 chemistry projects supported by the NSC in 1996, 48 were integrated projects; areas of focus included analytical methods, synthetic chemistry, chemistry of organometallic compounds, synthesis and characteristics of materials, biochemistry, physical chemistry, catalytic chemistry, and surface chemistry.

## 5. Earth Science Research

Earth science research can be divided into the two categories of integrated projects and individual projects. Topics of integrated projects included: subduction and plate collision in Taiwan and adjacent areas, environmental transformations in the coastal regions of Taiwan, the evolution of the lithosphere in the vicinity of southeastern China, past global changes, and the three-dimensional structure of the earth's crust below Taiwan. Topics of individual projects included: topography, mineralogy, geochemistry, structural geology, paleontology, applied geology, and geophysics.

## 6. Atmospheric Science Research

Of the 163 atmospheric science research projects supported by the NSC in 1996, 80 were integrated projects. Research results included the analysis of seasonal and annual variation in East Asia's monsoon winds; study and simulation of atmospheric dynamics; research on interactions between the sea and the atmosphere; analysis and simulation of the effect of tropical dynamics on atmospheric circulation during East Asia's early-summer rainy season; analysis of the climatic characteristics and environmental conditions of mesoscale precipitation systems; radar research and numerical modeling; analysis and modeling of the relationship between partial circulation and convective systems above land, sea, and mountains; analysis of the path, break-up, and radar data of typhoons making landfall on Taiwan; numerical modeling of the hydrological aspects of typhoons; research on ionospheric dynamics in the equatorial anomaly; research on ultra low-frequency electromagnetic waves in the mag-

netosphere; research on secondary disturbances in the magnetosphere; modeling of the interaction of discontinuities of magnetic plasmas in space; and research on the use of VHF radar to measure the thickness of the stable layer of the atmosphere. In addition, rainfall measurements and radar data from Taiwan were analyzed as part of an international project on rainfall in the tropics.

### 7. Oceanographic Research

Of the 61 NSC-funded oceanographic research projects in 1996, the topics of completed projects included the Kuroshiro current, exchange processes at the continental shelf in the East China Sea, the World Ocean Circulation Experiment (WOCE), the Past Global Changes Project (PAGES), research on the structure of marine plates and lithospheric dynamics, and the South China Sea Science Project. Other research topics included the characteristics of inshore turbulence; the interactions of the temperature structure with the spreading zone during the two-dimensional cooling of marine plates; the use of a remote-controlled submersible to study the ecology of the Fangliao undersea canyon and the adjacent seafloor; and models of the invasion of cold water along the continental shelf at Nanwan.

Besides continued implementation of the Kuroshiro Current, the South China Sea, and Past Global Changes projects, an integrated project on monsoon winds in the South China Sea, and the Global Marine Drilling and International Marine Past Global Changes projects will be launched in 1997. The topics of individual projects for 1997 will include reduced-scale testing of the reflection of sound waves from the sea floor, the characteristics of near-surface turbulence, the finite parametrization of the inverse problem of geophysics, carbonate deposition and coastal changes in the Penghu archipelago, the creation of national databases on marine currents and hydrology, and a follow-up study of the of the invasion of cold water along the continental shelf at Nanwan.

Beginning in 1997, marine geology will be centered on the Global Marine Drilling and International Marine Past Global Changes projects. Marine geologists and geophysicists from the R.O.C. will work together with their overseas counterparts in these major international projects, and will strive to raise the standards of domestic research in these areas. Moreover, oceanographers will carry out the South China Sea monsoon observation project in conjunction with atmospheric science researchers. It is hoped that simultaneous observations of atmospheric circulation and ocean currents will result in a better understanding of the chief physical processes that control the arrival, length, and fluctuations of the monsoon winds affecting Taiwan, mainland China, and the South China Sea, and will ultimately allow better forecasting of winds and short-term weather conditions throughout the East Asia region. Oceanographers' responsibilities in this project include performance of acoustic doppler current profiling (ADCP) work, collection of data from ATLAS buoys, and the measurement of the temperature and water vapor flux of the ocean boundary layer.

It must be noted that, thanks to the sustained efforts of oceanographers, this year's research results have shown significant improvements in terms of both quality and quantity. Moreover, we believe that, in conjunction with the recently-established "Earth Science Research Promotion Center" and the future "Oceanographic Research Center" whose establishment was recommended by the Fifth National Conference on Science and Technology, the field of oceanography will continue to make progress in the areas of large-scale projects, integration of resources, and the dissemination of research findings. Furthermore, the NSC will strive to establish a "National Oceanographic Laboratory" or "Oceanographic Bureau" to serve as a unified agency responsible for oceanographic matters.

## *C. Future Prospects*

The 1996 national planning, revision, and assessment report on the various fields of the natural sciences reveals that although the domestic research environment is gradually become more mature and tangible benefits are beginning to accrue from research carried out over the last

few years, "quality" still awaits further improvement and the pursuit of excellence and innovation in basic science still lags behind the world's technologically-advanced nations. This report states that the chief means of improvement is to construct a comprehensive and robust research infrastructure, place this infrastructure in the hands of well-seasoned experts, and provide an adequate supply of research manpower and logistic support. If science is given stable long-term financial support and the desire to seek quick success avoided, then major breakthroughs can ultimately be achieved.

In light of the fact that the nation's scientific resources are limited, besides maintaining consistent support for academic research, the NSC will strengthen and accelerate the following areas: (1) the establishment of a scientific research infrastructure and creation of an academic environment in which beneficial competition may flourish; (2) selection of topics for cutting-edge research and abandonment of the old blanket approach to funding; (3) continued implementation of focal research guided by discipline planning; (4) placement of equal emphasis on free research and integrated projects; (5) further improvement of the research environment; (6) concentration of funding and manpower in national-level projects that will raise the nation's overall competitiveness; and (7) support for the full functioning of the mathematics, physics, chemistry, and earth science research promotion centers. In addition, the NSC hopes to rely on a dialogue with the academic community to foster a progressive research atmosphere and a high level of interchange between researchers and society at large, thus opening a new era for scientific development in the R.O.C.

## II. Research in Engineering and Applied Science

### *A. Current Situation*

The NSC classifies engineering under the following 16 disciplines: information engineering; signal processing and communications; electrical control and medical engineering; microelectronics; electro-optics; metallic and ceramic materials; polymers; chemical and foodstuff engineering; environmental engineering; civil engineering; industrial engineering; marine engineering; solid mechanics and automation engineering; energy and heat flow; aeronautical engineering; and aerospace engineering. An outstanding senior professor has been selected to be the convener for each discipline, and made responsible for carrying out discipline planning and academic review tasks, etc., while also serving as a bridge between the NSC and the academic community.

The total budget for engineering technology research in 1996 was NT$1.991 billion (including funding for joint industrial-academic projects). Funding applications were made for 4,672 research projects, and 3,215 of these—roughly 68.8%—were approved. The average expenditure for each project was approximately NT$430,000. Professors and associate professors participated in these projects a total of 5,100 person-times, Ph.D. students totaled 2,173, and master's program students totaled 5,610. In comparison with 1995, project applications had increased by approximately 5.4%, the number of approved applications had decreased by approximately 1.9%, and the proportion of approved applications had decreased by 5.2%. In addition, the expenditure per project decreased by NT$30,000, participation by professors and associate professors increased by 3.2%, participation by Ph.D. students increased by 19% and participation by master's program students increased by 22.3%. The chief results of research carried out in 1996 included 63 research findings conferences held by the Engineering Research Center, 104 patent applications, and 96 approved patents.

While engineering research is based on individual-type projects, an effort is being made to implement the results of discipline planning and integrate existing research resources by encouraging integrated projects in focal areas of technology. It is hoped to gradually establish shared resources meeting the needs of these projects and thereby gain the greatest possible benefits from limited funding. A total of 1,219 integrated

projects in engineering were approved during 1996.

Furthermore, 40 joint projects carried out in conjunction with industry were approved and allocated NT$29.66 million in funding. Participants in these projects included 99 industrial firms, 382 professors and associate professors, and 1,051 graduate students. Results have included eight patent applications and seven technology transfers. It should be noted that most joint industrial-academic projects focused on the areas of electrical devices, information, microelectronics, electro-optics, and machinery (85% of all projects were in these areas). Thus these projects closely paralleled Taiwan's industrial ecology.

To encourage practicum-type research projects within the university system, to improve the nation's engineering R&D capability, and to promote research with both academic value and applications potential, in 1996 the NSC has established regional telecommunications research centers and continued to support four special programs with the topics of machine design practicum, silicon chip design and fabrication, computer systems research, and telecommunications research. In addition, promotional task forces in each discipline have been organized from experts from government, industry, academia, and the research community. These task forces are responsible for planning, implementing, coordinating, supervising, and reviewing up-, mid-, and downstream research projects. Task forces have already been established in the areas of industrial automation, high-precision mechanical systems, heat flow systems, computer systems, electromagnetic compatibility, very large scale integrated circuits, electronics fabrication, high-resolution displays, power electronics, civil engineering, special chemicals, wireless communications, micromechanical systems, semiconductor fabrication equipment, and medical instrumentation.

### *B. Implementing Discipline Planning*

In an effort to keep up with the pace of technological progress, in 1996 the NSC made a number of minor revisions and modifications to various engineering discipline plans in accordance with the needs and characteristics of these areas. Relevant data concerning manpower, equipment, issue of academic papers, patents, and technology transfers was also updated and made more complete. In 1996 the task forces addressing focal research areas continued to do their work in close coordination with discipline plans. Three regional telecommunications research centers were established in northern, central, and southern Taiwan in order to lend impetus to the promotion of research in this field. Furthermore, the machinery practicum program was slightly modified in a way that will make it function more effectively.

### *C. Summary of Research Results*

#### 1. Electrical Device Engineering Research

The 453 NSC-supported electrical device research projects in 1996 (including the sub-disciplines of communications, signal processing, control, power, and microwave technology) received funding of roughly NT$200.32 million. Participants in these projects included 694 professors and associate professors, 391 doctoral students, and 820 master's program students. A statistical breakdown for the various sub-disciplines is shown in Table 16.

#### 2. Information Engineering Research

Three hundred and eighty-one of the 548 information engineering projects applications in 1996 were approved (69.5% approval rate) and received funding of NT$171.47 million. Participants in these projects included 572 professors and associate professors, 408 doctoral students, and 989 master's program students. On the average, each project received NT$450,000 in funding. A statistical breakdown of the sub-fields of information engineering projects over the most recent nine years is shown in Table 17.

The seven joint industrial-academic information engineering projects in 1996 received funding of NT$78.92 million. The participants in these projects included 54 professors, 258

**Table 16. 1996 Research Projects in Electrical Device Engineering**

| Sub-discipline | Number of Projects | NSC Funding (NT$10,000) | Research Manpower | | |
|---|---|---|---|---|---|
| | | | Professors/Associate Professors | Doctoral Students | Master's Students |
| Microwave Technology/ Communications/ Signal Processing | 258 | 11,805.6 | 396 | 251 | 505 |
| Control Engineering | 86 | 2,947.1 | 122 | 58 | 137 |
| Power Engineering | 109 | 5,279.3 | 176 | 82 | 178 |
| Total | 453 | 20,032.0 | 694 | 391 | 820 |

**Table 17. Funded Information Engineering Research Projects Over the Most Recent Nine Years**

| Sub-field | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|
| Computer Systems | 8 | 15 | 10 | 21 | 30 | 39 | 53 | 75 | 29 |
| Programming Languages and Software | 10 | 6 | 13 | 12 | 22 | 28 | 20 | 23 | 37 |
| Database Systems | 11 | 12 | 13 | 22 | 22 | 29 | 23 | 35 | 36 |
| Computer Networks and Data Transmission | 1 | 5 | 9 | 13 | 12 | 22 | 34 | 28 | 62 |
| Planning Methods and Computer Theory | 16 | 7 | 19 | 27 | 35 | 35 | 15 | 16 | 17 |
| Parallel and Distributed Processing | 4 | 15 | 18 | 14 | 17 | 9 | 7 | 10 | 59 |
| Graphic Processing and Image Recognition | 2 | 5 | 11 | 25 | 32 | 51 | 38 | 71 | 59 |
| Chinese Language Processing | 5 | 9 | 9 | 11 | 8 | 15 | 10 | 10 | 21 |
| Artificial Intelligence | 14 | 13 | 11 | 13 | 17 | 37 | 45 | 39 | 35 |
| Computer Diagramming | 0 | 3 | 5 | 7 | 12 | 8 | 14 | 8 | 5 |
| System Modeling and Simulation | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 |
| Information System Management | 0 | 1 | 1 | 1 | 0 | 0 | 12 | 20 | 19 |
| Reliability and Error Tolerance | 0 | 1 | 2 | 1 | 2 | 0 | 0 | 0 | 4 |
| Miscellaneous | 0 | 1 | 2 | 1 | 2 | 0 | 0 | 0 | 0 |
| Non-academic Projects | 3 | 3 | 3 | 4 | 3 | 3 | 1 | 1 | 1 |

graduate students, and 32 technicians.

### 3. Microelectronics and Electro-optics

(1) Microelectronics engineering

Microelectronic technology is a rapidly-changing field, and advances in this area have helped Taiwan become one of the world's top eight electronics producers. Moreover, the government's Six-Year National Development Plan has selected a number of technologies that will be pivotal in making the R.O.C. one of the world's ten leading high-tech nations within the next ten years; among these technologies, the four areas of communications, information, consumer electronics, and semiconductors are included within the category of electronics. In light of this situation, in August 1995 the NSC requested academics, industry experts, and discipline committee conveners to compile an outline of the areas of microelectronics that should be developed over the next five years. The discipline planning document completed in August 1996 listed the following chief directions for future research:

a. Design of very large scale integrated circuits
b. Silicon materials and elements
c. The application of ferroelectric layers in electronic elements
d. Semiconductor materials and elements made

**Table 18. 1996 Research Projects in Microelectronics Engineering**

| | Number of approved projects | Approved funding |
|---|---|---|
| B/N family compound semiconductors | 5 | 6,167,000 |
| VLSI-CAD | 73 | 44,801,600 |
| Silicon semiconductors | 66 | 36,375,800 |
| Semiconducting compounds | 31 | 16,412,100 |
| Fabrication techniques | 26 | 11,844,400 |
| Total | 201 | 115,600,900 |

**Table 19. 1996 Research Projects in Electro-Optics Engineering**

| | Number of Approved projects | Approved funding |
|---|---|---|
| Electro-optical materials and elements | 49 | 40,677,800 |
| Optic fiber systems and their applications | 47 | 25,030,800 |
| Laser systems and their application | 5 | 4,326,500 |
| Total | 101 | 70,035,100 |

from boron and nitrogen family compounds

The 201 NSC-supported microelectronics research projects in 1996 included 116 individual-type projects and 85 integrated projects carried out by 15 teams; total funding of NT$185.6 million was allocated. Participants in these projects included 274 professors and associate professors, 214 doctoral students, and 339 master's program students. A statistical breakdown of the various sub-fields is shown in Table 18.

(2) Electro-optics engineering

The following chief directions for future research were listed in the five-year planning outline for the discipline of electro-optics:

a. Electro-optics systems and their applications
b. Fiber optic and laser systems and their applications
c. Sensors and displays

The 101 NSC-sponsored electro-optics research projects in 1996 included 76 individual-type projects and 25 integrated projects carried out by five teams; total funding of NT$70.0 million was allocated. Participants in these projects included 116 professors and associate professors, 74 doctoral students, and 139 master's program students. A statistical breakdown of the various sub-fields is shown in Table 19.

## 4. Research on Metallic and Ceramic Materials

Metallic and ceramic materials research in 1996 included 212 general-type projects receiving funding of NT$95.34 million and 10 purchases of medium-sized instruments receiving funding of NT$8.6 million. Participants in these projects included 221 professors and associate professors, 124 doctoral students, and 310 master's program students.

In addition, specialists in the field of metallic and ceramic materials were given financial support in order to attend international conferences for the purpose of issuing academic papers. In 1996 this discipline was divided into the following seven sub-disciplines: (1) ferrous materials and processing techniques; (2) molten processing; (3) light alloys, non-ferrous metals, and metal matrix composites; (4) anti-corrosion and failure engineering; (5) structural ceramic ma-

**Table 20. Research Projects in Mechanical Engineering over the Most Recent Five Years**

| | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|
| Number of approved projects | 299 | 315 | 347 | 356 | 382 |
| Approved funding (NT$10,000) | 11,604 | 11,184 | 10,290 | 10,320 | 13,575 |
| Average funding per project (NT$10,000) | 38.8 | 35.5 | 29.7 | 29.0 | 35.5 |
| Professors and associate professors (person-times) | 322 | 328 | 388 | 401 | 558 |
| Doctoral students (person-times) | 152 | 145 | 164 | 174 | 206 |
| Master's students (person-times) | 414 | 412 | 411 | 420 | 551 |

**Table 21. Statistics Concerning Energy Technology Research Projects over the Most Recent Three Years**

| | 1994 | 1995 | 1996 |
|---|---|---|---|
| Number of approved projects | 56 | 55 | 76 |
| Approved funding (NT$10,000) | 1,882 | 1,449 | 2,860 |
| Professors and associate professors (person-times) | 65 | 59 | 116 |
| Doctoral students (person-times) | 23 | 20 | 40 |
| Master's students (person-times) | 59 | 70 | 79 |

terials; (6) electronic ceramics and magnetic materials; and (7) hard coatings.

## 5. Mechanical Engineering Research

The 382 NSC-supported mechanical engineering research projects in 1996 received funding of NT$135.8 million. Researchers participating in these projects included 558 professors and associate professors, 206 doctoral students, and 551 master's program students. The scope of this research encompassed mechanisms and power transmission, structures and vibrations, power and control, lubrication and wear, fatigue and failure, stress and deformation, processing and manufacturing, and combustion and heat flow, etc. A statistical breakdown for the various disciplines is shown in Table 20. The focal areas selected by the mechanical engineering discipline task force consist of: (1) machine tools, (2) transmission systems, (3) design of mechanical systems, (4) molds, (5) electronic assembly equipment, (6) refrigeration and air conditioning, (7) ventilation systems, (8) co-generation, and (9) multipurpose engines. Interested professors have been encouraged to form research teams that will facilitate the exchange of technical knowledge through discussion and cooperation. Furthermore, in conjunction with the needs of mechanical engineering in Taiwan, resources are being integrated and research findings made public so that practical benefits can be realized.

## 6. Energy Technology Research

The 76 NSC-supported energy technology research projects in 1996 received funding of NT$28.60 million. Participants in these projects included 116 professors and associate professors, 40 doctoral students, and 79 master's program students. Statistics concerning energy technology research projects over the most recent three years are given in Table 21.

## 7. Polymer Technology Research

The 157 NSC-supported polymer technology research projects in 1996 received funding of NT$92.05 million. These projects included: (1) 97 individual projects receiving NT$ 49.16

million, (2) 59 integrated projects receiving NT$35.74 million (carried out by 14 teams), (3) one joint industrial-academic project receiving NT$3.19 million, and (4) one purchase of medium-sized instrument receiving NT$3.96 million. Project participants included 72 professors, 87 associate professors, 79 doctoral students (including five grant recipients), 238 master's program students, four lecturers, seven teaching assistants, and two technicians.

The topics of the above projects generally fall into the following categories: polymer materials, high-performance polymers, functional polymers, polymer processing, dyeing of fibers, and other polymer research. A statistical analysis of these projects is provided in Table 22 and Table 23.

## 8. Chemical Engineering Research

The 210 approved chemical engineering research projects in 1996 (297 applications; includes five team projects) received funding of NT$93.62 million. Another NT$8.37 million was allocated for the purchase of medium-sized instruments. Participants in these projects included 245 professors and associate professors, 86 doctoral students, and 335 master's program students. A statistical analysis of chemical engineering research projects over the most recent five years is given in Table 24.

## 9. Foodstuff Engineering Research

The 29 approved food engineering research projects in 1996 (48 applications) received funding of NT$13.17 million. Participants in these projects included 32 professors and associate professors, five doctoral students, and 33 master's program students. A statistical analysis of foodstuff engineering projects over the past five years is given in Table 25.

## 10. Environmental Engineering

The 136 NSC-supported environmental engineering research projects in 1996 received funding of NT$64.11 million. Participants in these projects included 147 professors and associate professors, 40 doctoral students, and 188 master's program students. Among the projects, integrated projects (carried out by seven teams) were approved and allocated NT$23.65 million.

In line with the "Environmental Engineering and Technology Development Plan," during 1996 the following directions were laid out for the discipline of environmental engineering:

(1) The origin and control of chemical byproducts of tap water sterilization.
(2) Low-cost/energy-saving/high-efficiency waste water treatment methods.
(3) Waste water treatment techniques for toxic substances that do not decompose readily.
(4) The fate of pollutants in the natural environment.
(5) Control techniques for industrial air pollutants.
(6) Environmental transport phenomena involving urban air pollutants.
(7) Incineration and monitoring of secondary pollution.
(8) Water seepage at landfills and the disposal of incinerator slag.
(9) Assessment of the degree of hazard of contaminated sites, monitoring of contaminated groundwater, and site restoration.
(10) Development of environmental engineering expert systems and optimization of the design and operation of environment engineering systems.

## 11. Civil Engineering Research

The 341 NSC-supported civil engineering research projects in 1996 received funding of NT$108.9million. Participants in these projects included 417 professors and associate professors, 105 doctoral students, and 480 master's program students. Within the above total, 94 projects were carried out by 17 research teams and received NT$36.3 million in funding.

In accordance with the "Civil Engineering and Technology Development Plan," the following focal research topics were compiled in 1996 for the discipline of civil engineering:

## Table 22. A Statistical Analysis of Polymer Technology Research Projects in 1996

| Project Topic | Individual-type Projects | | Integrated Projects | | Joint Industrial-academic Projects | | Instrument Purchase | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Projects | Funding | Number of Projects | Funding | Number of Projects | Funding | Number | Funding | Number | Funding* |
| Polymer Material | 21 | 10,753,200 | 5 (1 team ) | 2,109,400 | | | | | 26 | 12,862,600 |
| High-performance Polymers | 20 | 11,352,300 | 4 (1 team) | 2,707,900 | | | 1 | 1,500,000 | 24 | 15,560,200 |
| Functional Polymers | 32 | 15,245,700 | 18 (5 team) | 1,508,250 | | | 5 | 2,463,000 | 50 | 32,803,950 |
| Polymer processing | 9 | 5,477,500 | 13 (3 team) | 6,076,400 | 1 | 3,185,800 | 23 | 14,739,700 | | |
| Fiber and Dyeing | 11 | 4,371,500 | 19 (4 team) | 9,751,750 | | | | | 30 | 14,123,250 |
| Other Polymer Research | 4 | 1,957,000 | | | | | | | 4 | 1,957,000 |
| Total | 97 | 49,157,200 | 59 (14 team) | 35,740,700 | 1 | 3,185,800 | 6 | 3,963,000 | 157 | 92,046,700 |

*including instrument purchases

## Table 23. A Statistical Analysis of Personnel Participating in 1996 Polymer Technology Research Projects

| Project topic | Professors | Associate professors | Lecturers | Doctoral students | Master's students | Other |
|---|---|---|---|---|---|---|
| Polymer materials | 12 | 18 | 1 | 15 | 31 | 0 |
| High-performance polymers | 17 | 8 | 1 | 13 | 46 | 0 |
| Functional polymers | 28 | 25 | 0 | 37 | 80 | 3 |
| Polymer processing | 7 | 15 | 1 | 6 | 37 | 3 |
| Fibers and dyeing | 7 | 23 | 1 | 6 | 38 | 3 |
| Other polymer research | 1 | 3 | 0 | 2 | 6 | 0 |
| Total | 72 | 87 | 4 | 79 | 238 | 9 |

## Table 24. Chemical Engineering Research Projects over the Most Recent Five Years

| Year | Number of Projects | Funding | Research Manpower Professors | | | |
|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors and Associate Professors | Doctoral Students | Master's Students | Total |
| 1992 | 150 | 8,542 | 159 | 82 | 239 | 480 |
| 1993 | 153 | 7,811 | 165 | 85 | 251 | 501 |
| 1994 | 189 | 9,123 | 197 | 100 | 308 | 605 |
| 1995 | 155 | 8,725 | 165 | 68 | 261 | 494 |
| 1996 | 210 | 9,362 | 245 | 86 | 335 | 666 |

**Table 25. Foodstuff Engineering Research Projects over the Most Recent Five Years**

| Year | Number of Projects | Funding | Research Manpower Professors | | | |
|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors and Associate Professors | Doctoral Students | Master's Students | Total |
| 1992 | 27 | 1,496 | 30 | 9 | 33 | 72 |
| 1993 | 30 | 1,599 | 35 | 10 | 40 | 85 |
| 1994 | 33 | 1,413 | 35 | 13 | 42 | 90 |
| 1995 | 22 | 1,219 | 24 | 7 | 22 | 53 |
| 1996 | 29 | 1,317 | 32 | 5 | 33 | 70 |

(1) Structural engineering: bridge engineering, wind effects on tall buildings, vibration resistance of structures, dynamics of construction materials, structural dynamics.
(2) Water conservancy: water conservancy problems caused by urbanization and land development, global hydrological problems, effective use of water resources.
(3) Geological engineering: the development and utilization of reclaimed land, tunnel technology, environmental geological engineering, engineering applications of new technologies.
(4) Transportation: research on marine and air transport policies; the planning, design, construction, and management of air transport facilities; the planning, design, construction, and management of port facilities; behavioral research concerning the use of transportation systems; problems involving inter-city freight transport systems.
(5) Construction materials: high-performance concrete and concrete with lightweight reinforcement.
(6) Surveying and map-making: land surveying, photographic surveying, construction surveying, remote-sensing surveying, nautical surveying, GPS, digital image processing.
(7) Urban planning: energy-efficient and environmentally-safe structures, traditional settlements, problems involving urban residences.
(8) Construction management: characteristics of the construction industry; financial and economic analysis of the construction industry; development of environmental protection and work site health and safety management systems; development of construction management techniques for major civil engineering projects; development of integrated construction management computer systems; development of productivity and automation methods for the construction industry.

The NSC has established the "Public Construction Technology Research Promotion Task Force" in order to pool the efforts of civil engineering researchers, foster linkage between theory and practice, assist the execution of major public construction projects, and deliver benefits from technology transfer. This task force is actively planning future projects in the following key areas:

(1) Rapid transit engineering

a. Investigation of rapid transit system routes, main equipment stations, geological factors affecting station foundations, ground subsidence and remedial measures, and standards for residual subsidence.
b. Structural design, standards regulations, and restrictive conditions during the construction of rapid transit systems.
c. Study of methods of reducing rapid transit system noise and vibrations.
d. Automatic monitoring equipment and safety measures to prevent accidents and explosions.
e. Establishment of models for predicting the use load of rapid transit systems.

(2) High-speed rail system:

a. Mobilization of manpower and material resources from the academic sector in order to construct a high-speed rail system in Taiwan.
b. Training manpower and encouraging technology transfer in order to raise the standards of domestic railway engineering.
c. Raising academic standards by fostering a

**Table 26. Industrial Engineering and Management Science Research Projects over the Most Recent Five Years**

| Item | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|
| Number of Applications | 134 | 129 | 214 | 201 | 241 |
| Number of Approved Projects | 107 | 103 | 131 | 129 | 157 |
| Budgeted Funding | 1,650 | 2,282 | 2,451 | 2,451 | 2,451 |
| Approved Funding | 3,097 | 2,816 | 2,754 | 3,146 | 3,741 |
| Average Funding Per Project | 30.6 | 27.3 | 21 | 24.3 | 23.8 |

close relationship between theory and practice.

(3) Underground excavation and supporting systems:

a. Establishment of underground excavation techniques.
b. Establishment of techniques for installing supporting systems.
c. Safety measures for underground excavation and supporting systems.
d. Establishment of information resources concerning underground pipe and cable systems as references for public construction planning and management.

(4) Ground subsidence problems:

a. Public construction measures for areas with subsidence problems.
b. Establishment of national-level subsidence prevention measures.

In conjunction with the NSC's policies of promoting academic exchanges and the dissemination of research findings, the Engineering Technology Promotion Center has conducted research finding announcement conferences, research finding symposia, and academic-industrial seminars.

## 12. Industrial Engineering Research

Out of the 241 industrial engineering projects that applied for NSC funding in 1996, 157 were accepted (65.1% acceptance rate) and received funding of NT$37.41 million. Participants in these projects included 213 professors and associate professors, 53 doctoral students, and 213 master's program students.

After research and discussion by the discipline convener and the discipline planning task force, it was decided to focus attention on the five topics of information systems, task research, production systems, service systems, and human factor engineering. Besides implementing projects addressing these areas, basic and applied research in industrial engineering will attempt to meet the needs of the government's promotion of national health insurance and the Asia-Pacific Regional Operations Center plan. Table 26 shows the NSC's support for industrial engineering research projects over the last five years.

## 13. Marine Engineering Research

Of the 122 marine engineering research projects that received NSC support in 1996, 46 were individual-type projects and 76 were integrated projects (carried out by 12 teams). Total project funding was NT$44.31 million. Participating researchers included 192 professors or associate professors, 16 doctoral students, and 184 master's students. Table 27 contains a statistical analysis of marine engineering research projects in 1996.

Discipline planning for marine engineering has designated utilization of coastal land, high-performance ship technologies, and key undersea technologies as focal research areas.

## 14. Automation Engineering Research

A. General academic research projects

**Table 27. Statistical Analysis of Marine Engineering Research Projects in 1996**

Units: NT$

| | Number or Approved Projects | Approved Funding |
|---|---|---|
| Marine Engineering | 52 | 21,384,700 |
| Ship-building | 46 | 14,763,900 |
| Undersea Technology | 24 | 8,166,000 |
| Total | 122 | 44,314,600 |

**Table 28. Automation Engineering Research Projects over the Most Recent Six Years**

| Year | Number of Projects | Funding (NT$10,000) | Research Manpower | | |
|---|---|---|---|---|---|
| | | | Professors and Associate Professors | Doctoral Students | Master's Students |
| 1991 | 55 | 6,147 | 67 | 27 | 94 |
| 1992 | 92 | 6,039 | 118 | 62 | 180 |
| 1993 | 103 | 5,805 | 127 | 70 | 197 |
| 1994 | 137 | 6,468 | 178 | 83 | 261 |
| 1995 | 240 | 7,084 | 292 | 112 | 404 |
| 1996 | 185 | 6,064 | 285 | 84 | 334 |

The 185 NSC-supported automation research projects in 1996 received funding of NT$ 60.60 million. Participants in these projects included 285 professors and associate professors, 84 doctoral students, and 334 master's program students (Table 28). The projects addressed such topics as computer drawing and applications, precision manufacturing techniques, computer-assisted production scheduling, robotics, precision measurement, and semiconductor fabrication equipment.

B. Practicum-type research projects

The NSC assisted eight universities in establishing mechanical design training centers (an average of NT$3 million in funding was provided to each project) in which special machine shops will be set up. Because these machine shops will help train individuals who possess both practical skills and the ability to think creatively, they will both help prepare students for productive careers in industry and allow professors to gain experience in solving the types of practical problems faced by industry.

The NSC has also provided support for practicum-type integrated projects on such topics as optical resist covering machines, high-speed automatic wire-welding machines, automatic mold-grinding machines, and CNC lathes, etc. Moreover, in conjunction with the development of the domestic semiconductor industry, the NSC has established a semiconductor fabrication equipment promotion task force responsible for promoting focal research and the training of seed instructors.

## 15. Aeronautical Engineering Research

The NSC supported eight integrated team projects (including 41 subprojects) and 36 individual projects in aeronautical engineering, and approved funding of NT$ 30.96 million. Researchers participating in these projects included 136 professors or associate professors, 49 doctoral students, and 97 master's students (Table 29). The topics of research projects included aircraft engines, computational fluid dynamics, aviation systems, and flight navigation control.

## 16. Medical Engineering Research

**Table 29. Aeronautical Engineering Research Projects During the Most Recent Four Years**

| | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|
| Number of Approved Projects | 73 | 81 | 122 | 85 |
| Approved Funding (NT$10,000) | 4,037 | 3,420 | 3,150 | 3095.8 |
| Professors and Associate Professors (person-times) | 93 | 113 | 109 | 136 |
| Doctoral Students (person-times) | 46 | 47 | 55 | 49 |
| Master's Students (person-times) | 115 | 138 | 131 | 97 |

**Table 30. Medical Engineering Research Projects over the Most Recent Four Years**

| Year | Number of Projects | Funding (NT$10,000) | Research Manpower | | |
|---|---|---|---|---|---|
| | | | Professors and Associate Professos | Doctoral Students | Master's Students |
| 1993 | 57 | 4,176.8 | 82 | 22 | 110 |
| 1994 | 82 | 5,200.9 | 113 | 41 | 147 |
| 1995 | 97 | 5,222.6 | 141 | 53 | 170 |
| 1996 | 84 | 4,740.9 | 136 | 71 | 144 |

**Table 31. Aerospace Research Projects During the Most Recent Three Years**

| | 1994 | 1995 | 1996 |
|---|---|---|---|
| Number of Approved Projects | 33 | 40 | 48 |
| Approved Funding (NT$10,000) | 2,000 | 1,998 | 2,000 |
| Professors and Associate Professors (persons) | 41 | 49 | 67 |
| Doctoral Students (persons) | 25 | 26 | 39 |
| Master's Students (persons) | | 72 | 92 |

Eighty-four research projects in medical engineering were provided with NT$47.41 million in funding in 1996. Participating researchers included 136 professors and associate professors, 71 doctoral students, and 144 master's students (Table 30).

### 17. Aerospace Engineering Research

The NSC provided 67 aerospace engineering research projects with NT$19.98 million in funding in 1996. Researchers included 67 professors, 39 doctoral students, and 92 master's program students (Table 31). The scope of this research encompassed space science, remote sensing technology, communications and electronics, and spacecraft design and assembly.

### *D. Future Prospects*

Based on the existing foundation and recent achievements, the NSC will seek promote engineering research by making vigorous progress in the following areas:

(1) Continued promotion of research focused on key areas in order to convert knowledge into actual technological advances.
(2) Continued implementation of discipline planning in order to encourage integrated research projects and insure that limited resources are used as effectively as possible.
(3) Encouragement of practicum-type research and industrial-academic research projects. The

**Table 32. Bioscience Research Projects over the Last Six Years**

| Year | Number of Projects | Funding | Research Manpower | | | |
|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Ph. D.-holding Lectures | Doctoral Student | Total |
| 1991 | 232 | 17,268 | 228 | 5 | 32 | 265 |
| 1992 | 282 | 19,979 | 273 | 10 | 46 | 329 |
| 1993 | 314 | 27,170 | 302 | 14 | 65 | 381 |
| 1994 | 337 | 27,556 | 325 | 16 | 76 | 417 |
| 1995 | 328 | 26,988 | 319 | 7 | 60 | 379 |
| 1996 | 363 | 24,959 | 336 | 30 | 69 | 435 |

NSC hopes to enlist the support of industry and the academic community in order to upgrade industrial technology and insure that student researchers will make effective and creative employees after graduation.

(4) Strengthened assessment of research project effectiveness, and greater efforts to apply and disseminate research findings.

(5) Modification of the academic evaluation system and working bylaws in order to place equal value on basic and practical research.

(6) Encouragement of the participation of newcomers in research projects in order to inject new blood into the academic community.

## III. Bioscience Research

### *A. Current Situation*

The NSC's 1996 budget for bioscience was NT$265 million. Of the 408 applications for research project funding, 363 were approved, and of these 115, or 31.7%, were integrated-type projects. The topics of new and ongoing integrated projects included the response of plants to adverse conditions, rod-shaped viruses of insects, young leaf tobacco, coral reefs and the development of natural bioactive substances, pollen and allergic reactions, proteins and genetic engineering, bamboo mosaic virus, the response of mammalian cells to adverse conditions, mechanisms of fish disease, gene transplantation in fish, genes for pest and disease resistance in plants, control of aging in plants, structural biology, and the evolution of the terrestrial organisms of Taiwan.

Of the 365 hosts of NSC-sponsored bioscience research projects conducted in 1996, 181 persons were professors or professional researchers, 157 were associate professors or associate researchers, and 30 were teaching assistants, lecturers, or assistant researchers. This shows that professors and associate professors provide most of the manpower for bioscience research in Taiwan (91.8%). Furthermore, research projects also provided a training opportunity for 69 doctoral students (Table 32).

Bioscience research has expanded steadily over the last five years: funding has increased by 24.9%, the number of projects has grown by 28.7%, and the number of professors, associate professors, and lecturers has grown by 29.3%. Thus the growth rate of manpower has kept pace with the number of projects. The number of doctoral students has grown by more than 50% from 46 in 1992 to 69 in 1996, which shows the importance the NSC places on the training of young researchers.

### *B. Implementing Discipline Planning*

The NSC divides bioscience research into the categories of zoology, marine biology, botany, biochemistry, molecular biology, and microbiology.

The "Revised Bioscience Discipline and Resource Planning Report" issued in June 1996 generally takes into consideration the following three aspects concerning research: (1) importance in terms of basic science and practical applications; (2) degree of compatibility with existing conditions; and (3) feasibility of long-term de-

**Table 33. Research Projects in Botany During the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 130 | 10,063 |
| 1993 | 151 | 13,050 |
| 1994 | 167 | 12,717 |
| 1995 | 110 | 9,948 |
| 1996 | 146 | 10,762 |

velopment and technological integration. The chief revisions in this report consist of the inclusion of genetically-engineered proteins and the biomedical study of aging within biotechnology; the inclusion of plant aging and the brain and neuroscience within medical science; and the inclusion of the forest parts of ecological systems research within agricultural science. After inviting specialists to engage in discussions, it was decided to establish the following nine focal areas of bioscience research: gene expression and control, neurology, structural biology, developmental biology, evolution, biology resources, ecology, the response of organisms to extreme environments, and the creation of bioscience databases.

Besides strengthening integration and planning and sponsoring team projects on such topics as shrimp immunology, diagnosis of rod-shaped viruses in the blood, RFLP research, and the classification of bacteria, plants, and fish, the NSC has also tried to realize the benefits of discipline planning by promoting high-tech cellular and molecular biological research and holding a series of bioscience conferences. The topics of these conferences have included progress in immunology; new electron microscopy techniques; techniques for the transplant of plant genes and agricultural applications; the TROPICOS plant database; and new advances in neurology: ionic channels and nerve development. In order to increase knowledge in various disciplines and resolve research bottlenecks, the NSC has engaged prominent international specialists to come to the R.O.C. Local scholars have been encouraged to go overseas to participate in advanced study, gain practical training in high-tech areas, and work in joint international projects. These efforts are stimulating the exchange of knowledge, raising research standards, and accelerating progress in the field of bioscience.

### *C. Summary of Research Results*

The four main areas of bioscience are zoology (including marine zoology), botany (including the molecular biology of plants) biochemistry, and molecular biology (including microbiology). The following is a general summary of completed work in these four areas:

#### 1. Zoology Research

The 101 approved projects were provided with NT$61.78 million in funding. Project topics included: aspects of marine biology including the biology of corals, the biology of the coastal echinoderms of Taiwan, and the embryonic development of fishes; the early stages of life; the phylogenic relationships of colonial organisms; the circulatory and nervous system of rats; animal behavior; evolution in Taiwan; the mechanisms by which pathogens cause disease in fishes; and gene transplantation in fishes.

#### 2. Botany

The NSC provided funding of NT$107.6 million to 146 research projects in the field of botany (Table 33). Topics included plant classification, plant physiology, and molecular biology.

#### 3. Biochemistry Research

The NSC provided 71 research projects in the field of biochemistry with funding of NT$46.3 million (Table 34). Topics included the modification of biochemical mechanisms, the structure of biological macromolecules, the utilization of enzymes, and proteins secreted by the gonads.

#### 4. Molecular Biology Research

The NSC provided funding of NT$32.8

**Table 34. Research Projects in Biochemistry over the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 57 | 4,111 |
| 1993 | 84 | 7,110 |
| 1994 | 94 | 8,619 |
| 1995 | 66 | 5,439 |
| 1996 | 71 | 4,632 |

**Table 35. Research Projects in Molecular Biology During the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 35 | 3,673 |
| 1993 | 41 | 4,565 |
| 1994 | 44 | 4,559 |
| 1995 | 42 | 3,812 |
| 1996 | 44 | 3,278 |

million to 44 research projects in the field of molecular biology (Table 35). Topic included the control of genes, nucleic acids, white-leaf withering disease, microbes and gene transplantation, and the response of mammalian cells to adverse conditions.

### *D. Future Prospects*

Bioscience encompasses a wide range of fields and is intimately connected with other sciences. Thus, any effort to raise the domestic standard bioscience research will inevitably result in progress in other sciences. Bioscience research projects supported by the NSC in the past chiefly focused on the project hosts' areas of personal interest. At that time goal-oriented group projects were very few. However, since times have changed and closer and closer ties are emerging between different fields; solving a certain problem now often involves working in many scientific areas. For instance, gene transplantation techniques are not only able to achieve the goal of breeding certain varieties of animals, plants, and microbes, but can also shorten breeding time. Besides continuing to support outstanding individual projects, the NSC has therefore begun promoting integrated research projects based on the results of discipline planning. Through the integration of research ideas and manpower, and the sharing of facilities and equipment, scientific progress can be accelerated and research standards raised.

## IV. Agricultural Research

### *A. Current Situation*

Agricultural science encompasses the four areas of agronomy, forestry, aquaculture, and animal husbandry. In view of the recent experiences of agriculture in Taiwan, maintaining agricultural productivity will require solutions to problems involving severe water pollution, air pollution, soil pollution, deterioration of soil quality, exhaustion of water resources, ground subsidence, global climatic changes, and competitive pressure from imported agricultural products. Specialists in the field must quickly come up with effective response strategies if the crisis of agriculture in Taiwan is to be resolved. But the most urgent task at hand is to improve the agricultural environment. Although agricultural research and practice in Taiwan have begun to shift in the direction of organic farming and natural farming methods over the last few years, there are still many relevant technologies that must be developed or acquired.

As for the application of bioscience to agriculture, such new approaches as gene transplantation, protein engineering, the development of enzymes with novel functions, and the raising of agricultural product added value are gradually gaining mainstream acceptance. An RFLP genetic map of sorghum has been created. Nucleic acid probes have been used in ecological research and the classification of forms of poisoning caused by prokaryotes. Plant responses to adverse conditions at a molecular level have been investigated and the genes involved have been isolated.

**Table 36. Research Projects in Agriculture During the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 323 | 19,177 |
| 1993 | 386 | 26,425 |
| 1994 | 353 | 22,941 |
| 1995 | 378 | 25,282 |
| 1996 | 455 | 31,669 |

In the field of forestry, biotechnology involving gene transplantation has been used to protect forest resources, improve the qualities of commercial trees, and increase forest productivity. In fisheries science, biotechnology was used to breed fast-growing fish and shellfish with low mortality and good resistance to diseases. Vigorous efforts have been made in the field of animal husbandry to combine new biotechnology with conventional biological techniques in order to improve livestock and poultry breeds, manipulate animal physiology, improve animal feeding and management, and develop new animal products. In the field of veterinary medicine, the NSC has tried to encourage the use of new technologies such as molecular biology and genetic engineering to study the causes, pathology, diagnosis, prevention, control, contagion, and public health issues of the chief diseases of livestock and poultry.

In summary, agricultural researchers in the R.O.C. are fully aware of the predominant local and international trends in the field of agriculture. Since the development of agriculture and industry has not been accompanied by a counterbalancing emphasis on the recycling of resources and the maintenance of harmony between nature and human society—to the point that the ecological environment is experiencing many crises of local and global proportions—in recent years the development of sustainable agricultural systems has become a common goal of the world's developed nations. Due to Taiwan's high population density and rapid growth in agricultural, industrial, and commercial activities, the need for sustainable agriculture is especially urgent in the R.O.C.

### *B. Implementing Discipline Planning*

Agricultural research encompasses a diverse array of sub-fields. In an effort to make the most effective use of the nation's material and human resources, in October 1994 the NSC issued the "Agriculture Discipline and Resource Planning Report." However, reviews of basic and applied research over the last two or three years have made it clear that this report has some notable omissions, and therefore the "Revised Agriculture Discipline and Resource Planning Report" was completed in October 1996.

### *C. Summary of Research Results*

Agriculture research encompasses the nine disciplines of agronomy and horticulture, agricultural machinery and agricultural water conservancy, plant diseases, agricultural chemistry and food technology, forestry and water and soil conservation, fisheries technology, animal husbandry and veterinary medicine, environmental protection, and global change. NSC-supported individual and integrated research projects from August 1995 to July 1996 numbered 455 and received NT$31.67 million in funding (Table 36).

#### 1. Agronomy Research

The 23 NSC-sponsored agronomy research projects conducted in 1996 were given NT$13.05 million in support. This area of research included the topics of physiology, selective breeding, tissue culture, biological statistics, and experiment design. In addition, the large integrated project "Chromosomal Analysis of Rice Sprouts During the Developmental Phase" (receiving NT$5.63 million in funding) included seven sub-projects.

#### 2. Horticultural Research

The 15 NSC-sponsored horticultural research projects conducted in 1996 received NT$91.97 million in funding. Research included

**Table 37. Forestry Research Projects During the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 28 | 1,350 |
| 1993 | 32 | 2,616 |
| 1994 | 34 | 2,447 |
| 1995 | 38 | 1,592 |
| 1996 | 39 | 2,901 |

**Table 38. Soil and Water Conservation Research Projects During the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 10 | 612 |
| 1993 | 13 | 503 |
| 1994 | 15 | 1,032 |
| 1995 | 17 | 1,316 |
| 1996 | 8 | 490 |

the topics of selective breeding, molecular biology, tissue culture, horticultural physiology, and landscape design.

### 3. Agricultural Machinery and Agricultural Engineering Research

The 21 NSC-sponsored research projects conducted in 1996 received NT$11.33 million in funding. Work in this area included the topics of crop irrigation, design of a cereal product dryer system, design of an optimized cultivation system, and design of a precision greenhouse environment.

### 4. Plant Disease Protection Research

The 30 NSC-sponsored plant disease protection research projects received NT$20.67 million in funding. Project topics included plant disease etiology, physiology of pest and disease damage, classification of pests and diseases, and biotechnology.

### 5. Agricultural Chemistry and Environmental Protection Research

Agricultural chemistry includes the protection and improvement of the agricultural environment and the application of biochemistry to crop production and processing. Apart from three integrated projects, 21 other projects in this subfield received NSC support.

### 6. Forestry Research

The 39 NSC-supported forestry and forest products research projects received NT$29.01 million in funding (Table 37). The 21 projects in the area of forestry included such topics as indicators of biological diversity, the ecological energy balance, geographical data and remote sensing techniques, reverse osmosis in seedlings, genetic variation, nutrient dynamics, seed respiration, leaf area indicators, techniques for the analysis of nucleic acids, gene transplantation, and enzyme activity. The 18 projects in forest products included such topics as color changes in heartwood, sizing materials, non-destructive testing methods, pulp bleaching, carbohydrate variations, and design of wood strength. The integrated project "Research on Wood Material Functionality and Its Improvement" contained seven sub-projects investigating such topics as how to adjust the moisture content of wood materials, heat and sound insulation, analysis and improvement of surface characteristics, the release of formaldehyde, and the improvement of fireproofing. A research project on "the feasibility of using stress waves to assess the quality of wood and standing timber" was conducted by special arrangement.

### 7. Soil and Water Conservation Research

The eight NSC-supported soil and water conservation research projects conducted during 1996 received NT$4.9 million in funding (Table 38). Research in this area included such topics as the growth of river networks, the evolution of

**Table 39. Fisheries Science Research Projects During the Past Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 19 | 1,021 |
| 1993 | 30 | 1,839 |
| 1994 | 26 | 1,798 |
| 1995 | 27 | 2,017 |
| 1996 | 24 | 1,830 |

**Table 40. Global Changes—Long-Term Forest Ecology Research Projects During the Past Four Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1993 | 32 | 2,350 |
| 1994 | 13 | 929 |
| 1995 | 27 | 2,310 |
| 1996 | 45 | 4,000 |

water catchment areas, the stability of reservoir side slopes, the transport of marsh gas, mudstone improvement of red soil, and slope vegetation.

## 8. Fisheries Science Research

The 24 fisheries science research projects supported by the NSC in 1996 included one integrated project and 23 individual-type projects—a decrease of three over the year before. These projects received NT$18.3 million in funding—a decrease of NT$1.87 million over the previous year (Table 39). Project topics included marine biological resources and dynamic analysis; fishing gear and fishing methods; aquacultural techniques, physiology, and ecology; the aquacultural environment, prevention of fish diseases, and feed for aquatic organisms.

## 9. Animal Husbandry Research

The 36 NSC-supported research projects in animal husbandry conducted in 1996 received NT$25.58 million in funding. Research topics included heredity and breeding, physiology and nutrition, monitoring and utilization of animal product quality, and gene transplantation in livestock. Among these research projects, 35 individual-type projects received NT$19.88 million in funding and one integrated group project (including seven sub-projects) on the creation of transgenic pigs received NT$5.7 million in funding.

## 10. Research in Veterinary Medicine

The 34 NSC-supported research projects in veterinary medicine conducted in 1996 received NT$36.20 million in funding. Among these projects, 30 individual-type projects received NT$19.57 million in funding and four integrated-type group projects (including 27 sub-projects) received NT$16.63 million in funding. Research topics included clinical veterinary medicine, veterinary pathology, veterinary medicine and public health, and comparative veterinary medicine.

## 11. Global Changes—Long-Term Forest Ecology Research

The 45 projects under the "Global Changes—Long-Term Forest Ecology Research" program sponsored by the NSC during 1996 included 19 Fushan Forest Ecology projects, 12 Kuantao Creek Forest Ecology projects, and 14 Mount Nanjen Forest Ecology projects. These research projects received funding of NT$40.0 million (Table 40). Research topics included atmospheric subsidence; the hydrology and nutrient cycle of water catchment areas; and studies of forest microbes, fungus, insects, amphibians and reptiles, fish, birds, mammals, gymnosperms, and higher plants. Following the conclusion of the three-year first stage of the Fushan Forest Ecology project, the one-year second stage was begun in 1996. The Kuantao Creek Forest Ecology project is currently in the second year of the first stage. The first year of the first stage of the Mount Nanjen Forest Ecology project began in 1996. The first stage of the Tatachia High Mountain Forest Ecology Project will begin in

1997. These four forest ecology projects emphasize the collection and analysis of basic ecological data.

### *D. Future Prospects*

In the field of horticultural science, new knowledge and technologies including molecular biology, biochemistry, and cellular biology are being studied and adopted. Future efforts will include the renewal of old resources, the development of new resources, and the breeding of useful new plant varieties.

The field of agricultural water resources must confront the fact that water shortages will be a major limiting factor for Taiwan's future development. Since agricultural development is an indispensable part of the nation's growth, finding a suitable balance between agricultural production and the overall utilization of water resources is a very important issue that must be addressed in the years ahead.

Because farmers in Taiwan now depend heavily on chemical agents to control crop pests and diseases, there have been many cases of pesticide residues injuring human health. There is thus a growing need for the development of preventive methods and cultivation schemes that do not rely on the use of chemicals.

Some forestry-related issues already transcend national boundaries: the greenhouse effect, air pollution, the destruction of tropical forests due to the lumber trade, and the need for sustainable management of forest resources. To help resolve these international-scale forestry problems and achieve the goals of conservation, sustainable use of resources, and protection of the environment, in the future the NSC will organize existing research manpower to form a comprehensive research network.

Fisheries science encompasses a very wide range of research topics that include everything from theoretical research to industrial techniques. Major future issues including maintaining the balanced development of basic and applied research in fisheries science, helping industry benefit from the results of fisheries research, and insuring the continued growth of the domestic fishing industry.

Research in the field of animal husbandry has sought to employ heredity and breeding techniques to accelerate the development of improved varieties of poultry and livestock. New technologies such as gene transplantation and embryo implants have been used to launch a new era in animal breeding. The scope of veterinary medicine has expanded from an exclusive emphasis on disease prevention in meat-producing animals to meat inspection and disease prevention in household pets, aquatic organisms, and wild animals. Future topics in veterinary medicine will include the prevention of diseases that may be transmitted between animals and man, and the care of laboratory animals used in biomedical research.

Food science encompasses both fundamental science and applications research, and straddles the disciplines of biology, medicine, agriculture, and engineering. Because of this feature, food technology research is extremely diverse. Therefore, the only way to raise the level of future food technology research will be to take into consideration domestic and overseas trends and integrate existing manpower in this field.

## V. Research in Medicine and Public Health

### *A. Current Situation*

The budget for medical and public health research supported by the NSC in 1996 (January 1996-December 1996) amounted to NT$827.9 million. Of the 1,889 research project applications made, 1,330 were approved, including 318 (23.9%) integrated projects. The topics of new and ongoing individual and integrated research projects during 1996 included hypertension, traditional Chinese herbal medicines, the implantation of microcapsules in living tissue, Dengue fever, medical engineering, arterial disease and the arterial endothelium, neurology, nerve activation factors, the health effects of betal nuts, functional genes, nasopharyngial cancer, molecular medicine, hepatitis, diabetes, and Parkinson's disease.

Of the 1,551 hosts of funded research dur-

**Table 41. A Statistical Analysis of Medical and Public Health Research Projects from 1992 to 1996**

| Year | Number of Projects | Funding | Research Manpower | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | (NT$10,000) | Professors | Associate Professors | Post-doctoral Lecturers | Doctors of Medicine | Total Persons | Grants to Doctoral Students |
| 81 | 1,087 | 72,050 | 638 | 234 | 84 | 191 | 1,147 | 71 |
| 82 | 1,120 | 82,123 | 572 | 302 | 77 | 196 | 1,147 | 93 |
| 83 | 1,245 | 83,373 | 691 | 298 | 110 | 183 | 1,282 | 105 |
| 84 | 1,451 | 84,978 | 583 | 549 | 128 | 233 | 1,493 | 194 |
| 85 | 1,330 | 80,279 | 602 | 577 | 132 | 132 | 1,551 | 205 |

ing 1996, 602 were professors, 577 were associate professors, 132 were post-doctoral researchers, and 240 were doctors of medicine. In addition, 205 Ph.D. students and 620 master's students received training and experience through the projects. It can be seen that full professors comprised the majority of project hosts (42%), and a large crop of new researchers received training, providing new blood for future research in medicine and public health.

Table 41 shows that the total number of research projects has risen steadily over a five-year period, the number of full professors serving as project hosts has grown by a factor of 1.9, and the number of post-doctoral lecturers has grown even more rapidly. In addition, the number of Ph.D. students receiving training and experience in NSC-funded projects has increased by a factor of 2.9, from 71 individuals in 1991 to 205 in 1996. These figures demonstrate that the NSC has been making a successful effort to cultivate future research workers who will continue to raise the standards of domestic medical research.

### *B. Implementing Discipline Planning*

The scope of medical research supported by the NSC encompasses the three areas of basic medicine, clinical medicine, and pharmacology. Besides funding individual-type projects, the NSC is performing integration and planning work and designating focal research areas in line with the needs of hospitals, medical schools, and research institutions. Furthermore, the NSC hopes that its discipline planning work will result in a greater concentration of resources, more support for research in key areas, and a higher degree of sharing of instruments and research materials. This will lead to greater economic efficiency and more opportunities for interchange and cooperation between individual researchers.

Ten large-scale research projects and team-type projects have been carried out since the NSC's first discipline plan for the field of medicine was issued in 1987. However, the passage of time has brought great changes and increasingly high hopes for medical research. As a consequence, in April 1993 the NSC invited 21 experts in various aspects of medicine to form a planning committee responsible for coming up with a new research plan for the field of medical science. The completion of a discipline and resource planning report in September 1994 has provided domestic medical researchers with a comprehensive reference document addressing the future directions of medical research in the R.O.C. And in order to facilitate the organization of integrated projects, the report has also served to familiarized researchers with areas outside their particular specialization.

### *C. Summary of Research Results*

The NSC provided support for 1,330 medical and public health research projects during 1996. Sub-disciplines included dissection, physiology, biochemistry, microbiology and immunology, pharmacology, public health, parasitology, nutrition, nursing, internal medicine,

**Table 42. Dissection Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 18 | 1,123 |
| 1993 | 24 | 1,493 |
| 1994 | 27 | 2,196 |
| 1995 | 34 | 1,972 |
| 1996 | 3 | 1,652 |

**Table 43. Physiology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 36 | 2,213 |
| 1993 | 38 | 2,670 |
| 1994 | 41 | 3,314 |
| 1995 | 45 | 2,966 |
| 1996 | 44 | 2,645 |

surgery, dentistry, and medical technology.

Research is carried out in the form of individual-type projects and integrated or team projects. Large projects and team projects carried out in 1996 included a large project on biological energy fields, a large project on molecular medicine, a large project on hypertension, a team project on the implantation of microcapsules, a large project on Dengue fever, a large project on medical engineering, a team project on vascular disease and vascular endothelial cells, a large project on neurology, a team project on nerve activating factors, a team project on Parkinson's disease, a large project on Chinese herbal medicines, a large project on the health effects of Betal nuts, a team project on functional genes, a large project on the medical aspects of pollution, and a large project on hepatitis. The following is a summary of significant research results:

1. Dissection Research

The 31 NSC-supported dissection research projects carried out during 1996 received NT$16.52 million in funding (Table 42). The topics of major projects included:

(1) Chemistry of immune cells and cells containing nitric oxide synthase activity from the subcommissural organ of rats.
(2) Effect of anesthetics on the gene distribution of $GABA_A$ receptors of the mouse hippocampus.
(3) Node distribution phenomena shown by vascular sensory nerves in mouse forelimbs.
(4) Transplantation and sequencing of the *Trimeresurus Mucroquamatus Baprobin* gene.
(5) Use of fluorescence positioning method of nucleic acid synthesis to evaluate the chromosomal abnormalities of new rectal cancer cells.
(6) Study of nerve tissue from the rat hypoglossal ganglia.
(7) Intra-cellular fiber attachment proteins from astrocytes.

2. Physiology Research

The 44 NSC-supported physiology research projects during 1996 received NT$29.66 million in funding (Table 43). The topics of major projects included:

(1) The physiological role played by sodium/calcium exchange in bovine chromaffin cells.
(2) CRF gene expression and memory function.
(3) Mechanical receptors in arteries of normal and long-term oxygen-deprived mice.
(4) Use of brain micro-dialysis to investigate variations in dopamine activity during sexual behavior among male mice that had been exposed to prenatal stresses.
(5) The molecular mechanism of ketokonazole's effect on hydrocortisone production in swine.
(6) Exercise and the functioning of blood platelets.
(7) Effect of cocaine on the activity of dopam-

**Table 44. Biochemistry Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 41 | 3,375 |
| 1993 | 54 | 4,853 |
| 1994 | 59 | 3,314 |
| 1995 | 53 | 6,066 |
| 1996 | 60 | 4,282 |

**Table 45. Pharmacology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 35 | 2,404 |
| 1993 | 40 | 2,946 |
| 1994 | 44 | 3,932 |
| 1995 | 42 | 2,949 |
| 1996 | 42 | 2,690 |

ine-receptor nerves in the hypothalamus and the secretion of prolactin.
(8) The effect of lactin on the hypothalamus-pituitary-ovary axis.
(9) The effect of oxidized low-density lipoprotein on endothelial cells—vasopresin conversion enzyme and its mechanism of action.
(10) The effect of nitric oxide blocking on arterial blood flow in normal and hypertensive mice.
(11) The role of the renal nerve and renal medulla in hypertension caused by a chronic high level of blood insulin.
(12) The characteristics of chlorine ion channels in the cell membrane of ovarian or uterine cancer cells.

3. Biochemistry Research

The 60 NSC-supported biochemistry research projects during 1996 received NT$42.82 million in funding (Table 44). The topics of major projects included:

(1) The chemical dynamics of fat splitting, liver glucose, and fatty acid metabolism.
(2) Interactions between streptokinase peptide fragments and fibrinolytic enzymes.
(3) Alcohol and aldehyde dehydrogenase genes and alcoholism in the inhabitants of Taiwan.
(4) The mechanism of guanosine binding protein in saccular transmission.
(5) The mechanism by which DMSO stimulates the differentiation of bone marrow cancer cells.

4. Pharmacology Research

The 42 NSC-supported pharmacology research projects during 1996 received NT$26.90 million in funding (Table 45). The topics of major projects included:

(1) Anti-platelet snake venom: a collagen receptor antagonist.
(2) A study of the effect Norpavine derivatives on the heart—a comparison of the effects of (+)-2, 3-dimethoxy -norpavine and MK801.
(3) The pharmacology of indole-ketone drugs.
(4) The effects of nicotine on the heart and vascular system.
(5) Stomach damage caused by diabetes and preventive drugs.
(6) The mechanism of cellular control of sodium-activated potassium ion channels.

5. Research in Microbiology and Immunology

The 63 NSC-supported microbiology and immunology research projects during 1996 received NT$42.27 million in funding (Table 46). The topics of major projects included:

(1) An evaluation of factors affecting the cell nucleus' control of periodic cellular activities.
(2) Production of "cellular hormone—monoclonal antibody" composite proteins and application in immune therapy for B-lymphoma.

**Table 46. Microbiology and Immunology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 40 | 3,204 |
| 1993 | 43 | 4,056 |
| 1994 | 47 | 4,945 |
| 1995 | 53 | 4,491 |
| 1996 | 63 | 4,227 |

**Table 47. Parasitology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 5 | 218 |
| 1993 | 10 | 726 |
| 1994 | 12 | 1,075 |
| 1995 | 10 | 738 |
| 1996 | 13 | 850 |

**Table 48. Nutrition Research Projects over the Last Four Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1993 | 5 | 147 |
| 1994 | 11 | 690 |
| 1995 | 12 | 865 |
| 1996 | 25 | 1,426 |

(3) Planned immune cell death and the mechanism of the low immune reaction.
(4) A study of the characteristics of human papiloma virus 11 E5a protein and its linkage with the 16 kDa membrane pore protein.
(5) The expression of the tyrosine kinase gene in human stomach cancer.
(6) Point mutations of the Streptococcus mutans glucosyltransferase gene.
(7) Use of cellular factors to probe the X protein of the hepatitis B virus.

6. Parasitology Research

The 13 NSC-supported microbiology and immunology research projects during 1996 received NT$8.5 million in funding (Table 47). The topics of major projects included:

(1) The mechanism by which Trichoneme vaginalis worms stimulate monocytes to release interleukin-8.
(2) Identification of vaginal trichomonad virus proteins and identification of the mechanism of biochemical synthesis of RNA-dependent polymerase.
(3) Transplantation of mosquito phenol oxidase genes and RNA analysis.
(4) Mosquito mitochondrial genes and relationship among different species.
(5) Genetic variation in the varieties and subspecies of Oncomelania hupensis: nucleoside restriction sites and sequencing analysis.

7. Nutrition Research

Nutrition science was split from biochemistry and made an independent discipline in 1992. The 25 NSC-supported nutrition research projects during 1996 received NT$144.26 million in funding (Table 48). The topics of major projects included:

(1) The effect of lipids on the transcription-type modification of the human lipoprotein transfer protein gene in tissue cells.
(2) The effect of the long-term intake of nutrients on the aging of senescence accelerated mice (SAM).
(3) The effect of deep-fried foods on estrogen synthesis and possible role in promoting breast cancer.
(4) A preliminary study of the oxidation of the fatty components of low-density lipoproteins.

8. Public Health Research

The 34 NSC-supported microbiology and

**Table 49. Public Health Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 20 | 1,065 |
| 1993 | 26 | 1,576 |
| 1994 | 35 | 2,272 |
| 1995 | 42 | 2,797 |
| 1996 | 34 | 2,021 |

**Table 50. Nursing Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 11 | 530 |
| 1993 | 15 | 806 |
| 1994 | 19 | 1,055 |
| 1995 | 31 | 1,538 |
| 1996 | 41 | 1,918 |

**Table 51. Internal Medicine Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 111 | 5,667 |
| 1993 | 111 | 6,483 |
| 1994 | 113 | 8,439 |
| 1995 | 128 | 7,513 |
| 1996 | 178 | 10,009 |

immunology research projects during 1996 received NT$20.21 million in funding (Table 49). The topics of major projects included:

(1) Epidemiology of ovarian cancer in Taiwan.
(2) Aflatoxin-albumin adducts in blood serum.
(3) A preliminary investigation of risk factors for prostate cancer in Taiwan.
(4) A comparative study of multiple risk factors for liver cancer in Taiwan based on multi-generational and overlapping cases.
(5) The mechanism of the formation of microcellular nuclei in human lymph nodes following long-term exposure to low doses of ionizing radiation.

9. Nursing Research

The 41 NSC-supported nursing research projects during 1996 received NT$19.18 million in funding (Table 50). The topics of major projects included:

(1) Psychological and social affects on carriers of recessive X-chain hereditary disorders.
(2) The experiential structure of post-partum depression in Taiwanese women: A phenomenological study.
(3) Models of prenatal care in northern Taiwan (a survey of attitudes towards and knowledge concerning prenatal care among nurses and expectant women).
(4) A series of studies of the problem of urinary incontinence among the elderly living at home, prevalence of urinary incontinence among the elderly living at home, the level of influence of urinary incontinence, and the need for nursing care.
(5) The establishment of a elderly health care referral model and a cost-benefit analysis.
(6) The development and evaluation of a multi-media interactive videodisk learning system for the "health guidance process" in nursing education.

10. Research in Internal Medicine

The 128 NSC-supported internal medicine research projects during 1996 received NT$100.1 million in funding (Table 51). The topics of major projects included:

(1) Basic and clinical research on acute lung damage—endogenous- and exogenous-type effects of nitrous oxide in acute lung damage.
(2) The role played by interleukin-1 and interleukin-8 in acute lung damage.
(3) The clinical significance of soluble

**Table 52. Surgery Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 95 | 4,483 |
| 1993 | 96 | 5,723 |
| 1994 | 96 | 5,771 |
| 1995 | 103 | 5,607 |
| 1996 | 109 | 6,035 |

interleukin-2 receptors in patients with microcytic carcinoma of the lungs.

(4) The toxic effect of Gemcitabine on non-microcytic carcinoma stem cells alone and in conjunction with other anti-cancer drugs.

(5) A molecular study of the C protein of blood plasma.

(6) Clinically-important Candida species and a comparison of three molecular biology identification methods.

(7) The significance and application of separate and dual potential as regards classical and non-classical atrial flutter—An empirical study of the characteristics of simple electrical cauterization.

(8) Electro-physiological characteristics of abnormal ventricular tachycardia and therapy by means of high-frequency electrical cauterization.

(9) The use of single-strand polymorphic and riboside techniques to study the locations of mutations causing hypertrophic cardiac myopathy.

(10) A comprehensive project on preventing the bleeding of esophageal vasocarcinomas.

(11) Genetic markers for stomach cancer and the relationship between histopathology and prognosis.

(12) The role played by endothelin in the hypertension and insulin resistance mechanism.

(13) Insulin blocking in patients with coronary disease and hypertension.

(14) The relationship between nitric oxide synthesis in the kidney and kidney pathology in rats with STZ-induced diabetes.

(15) An animal model of liver stones and cancer of the bile duct and clinical significance.

(16) Inhibition of the growth of cells on the surface of the peritoneum with drugs that prevent fiber formation and the mechanism of extra-cellular protein gene activity.

(17) The functioning of the autonomous nervous system in Parkinson's disease induced by chronic manganese poisoning.

(18) The role played by the lateral thalamus in the pain reaction.

(19) Drug metabolism, drug concentration in the blood, and therapeutic reaction.

(20) Neurochemical abnormalities and postpartum depression.

11. Surgery Research

The 109 NSC-supported surgery medicine research projects during 1996 received NT$56.07 million in funding (Table 52). The topics of major projects included:

(1) The effects of thyroxine and progesterone on the occurrence of breast cancer.

(2) GSTM1 and GSTT1 hereditary polymorphisms as risk factors for breast cancer.

(3) The improvement of abnormal endothelial cell functioning following blood shortage and re-irrigation of the coronary arteries: the role of cardioplegic solutions.

(4) The effect of liver cell growth factor on stomach cancer receptors and cellular cycles.

(5) Analysis of dual factors for gastric gland cancer.

(6) Effect of type 16 fragment E6 of the human papiloma virus and the P53 tumor inhibition gene on colonic and rectal cancer.

12. Urology Research

The 22 NSC-supported urology research projects during 1996 received NT$141.5 million in funding (Table 53). The topics of major projects included:

(1) Analysis of variation in the p16 human urinary epithelioma gene.

**Table 53. Urology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 17 | 604 |
| 1993 | 17 | 1,017 |
| 1994 | 18 | 793 |
| 1995 | 14 | 715 |
| 1996 | 22 | 1,154 |

**Table 54. Dermatology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 9 | 369 |
| 1993 | 8 | 511 |
| 1994 | 7 | 530 |
| 1995 | 7 | 501 |
| 1996 | 9 | 555 |

**Table 55. Otolaryngology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 12 | 478 |
| 1993 | 13 | 733 |
| 1994 | 14 | 761 |
| 1995 | 12 | 710 |
| 1996 | 17 | 921 |

(2) Calcium ion concentration changes in smooth muscle cells of spongy tissue.
(3) A series of studies of the problem of urinary incontinence among the elderly living at home: prevalence of urinary incontinence among the elderly living at home, the level of influence of urinary incontinence, and the need for nursing care.

13. Dermatology Research

The 9 NSC-supported dermatology research projects during 1996 received NT$5.55 million in funding (Table 54). The topics of major projects included:

(1) The pathogenic factors and mechanisms of light-initiated skin cancer among Parathion workers.
(2) Immune reaction induced in mice by the transdermic introduction of protein antigens: (a) The relative effect of different antigen concentrations. (b) The reaction mechanism.
(3) The effect of uremic compounds on epidermis cells cultured *in vitro*.

14. Otolaryngology Research

The 17 NSC-supported otolaryngology research projects during 1996 received NT9.21 million in funding (Table 55). The topics of major projects included:

(1) The causes of Meniere's syndrome.
(2) Analysis of DNA ploidy with a mobile cell instrument to find nasopharyngeal cancer prognosis indicators.
(3) Inhibition of sympathetic nerve ganglia of the superior cervical region to relieve lack of blood in the guinea pig cochlea.
(4) Regulation of prostaglandin secretions from the nasal mucus membrane by cell element.
(5) The physiological significance of SAcat ionic channels in the inner ear's membrane.

15. Opthalmology Research

The 18 NSC-supported opthalmology research projects during 1996 received NT$9.87 million in funding (Table 56). The topics of major projects included:

(1) Use of cultured pig corneal endothelium cells to study the physiological characteristics of cellular edema caused by low-tensile liquid.
(2) The effect of Mitomycin C on the healing of scars from glaucoma filtration surgery.
(3) Effect of eye pressure on blood flow in the optic nerve disk of New Zealand white rab-

**Table 56. Opthalmology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 10 | 332 |
| 1993 | 10 | 574 |
| 1994 | 17 | 895 |
| 1995 | 15 | 839 |
| 1996 | 18 | 987 |

**Table 57. Gynecology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 20 | 743 |
| 1993 | 21 | 1,276 |
| 1994 | 24 | 1,584 |
| 1995 | 25 | 1,442 |
| 1996 | 38 | 2,328 |

**Table 58. Dental Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 39 | 1,964 |
| 1993 | 38 | 1,999 |
| 1994 | 36 | 2,357 |
| 1995 | 40 | 2,083 |
| 1996 | 34 | 1,706 |

bits—laser doppler blood flow measurements.

(4) The sodium pump of crystalline epithelial cells under conditions of high glucose concentration.

(5) The relationship between blood flow in the vascular membrane and the development of near-sighted eyeballs.

16. Gynecology Research

The 38 NSC-supported gynecology research projects during 1996 received NT$23.28 million in funding (Table 57). The topics of major projects included:

(1) The immune response of cervical cancer patients.

(2) A comparative study of endocrine secretions and effects on the uterus and ovary of pre- and post-menopause breast cancer patients who are long-term takers of Tamoxifen.

(3) Use of gene transplantation techniques to study the control mechanism of the c-kit primeval tumor gene.

(4) The correlation between the carcinogenic mechanism of cervical cancer and cell volume-sensitive chlorine ionic channels.

(5) The effect of aspirin on uterine membrane growth hormone during the implant period.

(6) Differences in cellular and embryonic growth due to variations in the expression of the IGFBP-1 gene under conditions of identical nutrition.

(7) Transmission of commonly-used drugs through the placenta and effects on the placenta.

(8) The frequency of mutations in fetal tissue genes after early-period miscarriages.

(9) Liquid-phase chromatography of IGF-binding protein in human ovarian filtrate.

(10) The role played by inhibitors and IGF-I in the growth of ovarian follicles and the functioning of the corpus luteum during induced ovulation.

(11) The mechanism of blood poisoning during pregnancy: damage to the placental blood barrier.

17. Dental Research

The 34 NSC-supported dentistry research projects during 1996 received NT$17.06 million in funding (Table 58). The topics of major projects included:

(1) Molecular pathology of oral submucosa fiberation.

(2) The health effects of the combined use of cigarettes and Betal nuts.

**Table 59. Medical Technology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 21 | 1,165 |
| 1993 | 22 | 1,646 |
| 1994 | 29 | 2,288 |
| 1995 | 35 | 2,300 |
| 1996 | 31 | 2,032 |

**Table 60. Hypertension and Stroke Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 30 | 2,311 |
| 1993 | 25 | 1,681 |
| 1994 | 25 | 1,903 |
| 1995 | 27 | 1,841 |
| 1996 | 6 | 374 |

(3) A multi-step carcinogenic mechanism involving chemicals found in Taiwanese Betal nuts.
(4) Oxidative injury caused by Hydroxychavicol in Taiwanese Betal nuts.
(5) An in vitro and vivo study of GST when polycylic aromatic hydrocarbons are used to induce squamous cell carcinoma in hamsters.
(6) The activity of neutrophils in normal and malignant periodontosis.
(7) Clinical applications of and bacterial responses to partial Tetracycline fiber therapy to treat periodontosis.
(8) Use of fish oil to treat oral cancer.
(9) Effect of clenching on chewing.
(10) Laser-induced acoustic radiation in the dental adhesion system.

18. Medical Technology Research

The 31 NSC-supported medical technology research projects during 1996 received NT$20.32 million in funding (Table 59). The topics of major projects included:

(1) The effect of TGF-$\beta$1 on PRL-secreting cells.
(2) Application of the enzymatic immunity analysis technique and high-efficiency liquid-phase chromatography.
(3) The mechanisms of respiratory cell fusion virus contagion and pneumonia diplococcus adhesion.
(4) A biochemical and molecular investigation of sporadic hematuria.
(5) The relationship between apolipoprotein E polymorphisms and Alzheimer's disease.
(6) The blood serum type of virus VP7 and VP7 protein expression.

19. Basic Research on Hypertension and Stroke

The 26 NSC-supported basic research projects on hypertension and stroke during 1996 received NT$3.74 million in funding (Table 60). The topics of major projects included:

(1) The activity and responsiveness of nerve cells in the sensory nerve activity control zone of the medulla of hypertensive mice.
(2) Basic research on hypertension and stroke—The mechanism of hypertension caused by long-term hyperinsulininenia.
(3) Basic research on hypertension and stroke—The effect of exercise on the control of blood vessel dilation by the endothelial cells of rats with spontaneous hypertension.

20. Group Research Project on Nerve Transplant Therapy for Parkinson's Disease

The 6 NSC-supported research projects concerning nerve tissue transplant therapy for Parkinson's disease during 1996 received NT$3.74 million in funding (Table 61). Major projects included an integrated team project on the use of nerve tissue transplants to treat Parkinson's disease.

21. Large-scale Research Project on Hepatitis

The 23 NSC-supported Hepatitis research

**Table 61. Team Research Projects on Parkinson's over the Last Four Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1993 | 7 | 667 |
| 1994 | 7 | 800 |
| 1995 | 7 | 476 |
| 1996 | 6 | 374 |

**Table 62. Hepatitis Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 49 | 4,783 |
| 1993 | 50 | 5,444 |
| 1994 | 46 | 5,910 |
| 1995 | 38 | 4,227 |
| 1996 | 23 | 1,879 |

**Table 63. Biotechnology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 41 | 2,913 |
| 1993 | 43 | 3,714 |
| 1994 | 46 | 3,975 |
| 1995 | 40 | 2,903 |
| 1996 | 45 | 3,417 |

projects during 1996 received NT$18.79 million in funding (Table 62). The topics of major projects included:

(1) DNA vaccines: Use of hepatitis-B surface antigens as templates.
(2) Immunological mechanism of the change of hepatitis-C viral infections from acute to chronic.
(3) Gene control in the hepatitis-C virus.
(4) The clinical and molecular biology of the hepatitis-C virus.
(5) The possible role played by mosquitoes in the transmission of hepatitis-C.
(6) T-cell response to the third non-structural sequence of the hepatitis-C virus genome.
(7) RNA replication in the hepatitis-D virus.
(8) Necessary conditions for RNA assembly in the hepatitis-D virus: The role of hepatitis-B surface antigens and RNA packaging signals.
(9) Wasting deterioration of human liver cancer cells induced by interleukin regulation.

22. Large-scale Research Project on Biotechnology

The 40 NSC-supported biotechnology research projects during 1996 received NT$29.03 million in funding (Table 63). The topics of major projects included:

(1) Factors affecting the functioning of the BiP stress response protein gene.
(2) The genetic reorganization system of Streptomyces bacteria.
(3) Establishment of a genetic engineering system for creating prolific mutant strain of pseudofilamentous growth yeast.
(4) The use of grass shrimp protein phosphatidyltyrosine dephosphatase to control the activity of protein kinase C during carcinogenesis.
(5) Production of streptokinase fusion proteins with an affinity for coagulated blood.

23. Large-scale Research Project on Medical Aspects of Pollution

The 20 NSC-supported research projects on the medical aspects of pollution during 1996 received NT$21.82 million in funding (Table 64). The topics of major projects included:

(1) The characteristics of household dust mite antigens, relationship with illnesses of the respiratory tract, and control strategies.
(2) The effect of different types of wall materials on the volatility of indoor spray pesti-

**Table 64. Research Projects on the Medical Aspects of Pollution over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 37 | 2,437 |
| 1993 | 30 | 2,241 |
| 1994 | 34 | 2,405 |
| 1995 | 26 | 2,182 |
| 1996 | 20 | 1,220 |

**Table 65. Nasopharyngeal Cancer Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 9 | 734 |
| 1993 | 9 | 920 |
| 1994 | 11 | 954 |
| 1995 | 5 | 410 |
| 1996 | 5 | 377 |

**Table 66. Research Projects on the Linkage Between Vascular Disease and Vascular Endothelial Cells over the Last Four Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1993 | 6 | 553 |
| 1994 | 7 | 270 |
| 1995 | 7 | 652 |
| 1996 | 6 | 391 |

cides.

(3) The toxicity and carcinogenic mechanisms of arsenic compounds.
(4) The effect of 1,6-DNP on DNA adducts and the mutagenicity of the HPRT gene in Chinese hamster cells.
(5) The effect of heavy metals on the physiology of mouth breeder fry.
(6) A study of the correlation of age with simultaneous exposure to Pemethrin and Fenitrothion.
(7) Long-term follow-up research project on disease caused by exposure to polychlorinated biphenyls—A study of the sexual performance and sex hormones of poisoning victims.

24. Nasopharyngeal Cancer Research

The 5 NSC-supported nasopharyngeal cancer research projects during 1996 received NT$3.77 million in funding (Table 65). The topics of major projects included:

(1) The thymine nucleoside kinase of the EB virus. (IV)
(2) Large-scale research project on nasopharyngeal cancer—Interactions between EP virus LMP and control of the trans-activity protein genes in nasopharyngeal cell lines.
(3) Radiation treatment of nasopharyngeal cancer and Histone mRNA expression.
(4) Selectivity of the EB virus latency membrane protein activator in nasopharyngeal cancer cells.
(5) The relationship of LMP-1 protein and the infection of human epithelial cells by EB virus.
(6) A comparison of the rate of detection of the EB virus in nasopharyngeal tissue of the polymerase chain reaction and EBER1 in-situ hybridization method.

25. Research on the Linkage Between Vascular Disease and Vascular Endothelial Cells

The six NSC-supported research projects on the linkage between vascular disease and vascular endothelial cells during 1996 received NT$3.91 million in funding (Table 66). Projects included an integrated team project on the lysis of thrombin in vascular endothelial cells.

26. Neurology Research

The 12 NSC-supported neurology research projects during 1996 received NT$6.44 million

**Table 67. Neurology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 11 | 594 |
| 1993 | 12 | 846 |
| 1994 | 20 | 1,580 |
| 1995 | 9 | 769 |
| 1996 | 12 | 644 |

**Table 68. Medical Engineering Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 32 | 2,010 |
| 1993 | 42 | 3,596 |
| 1994 | 54 | 4,658 |
| 1995 | 59 | 4,728 |
| 1996 | 61 | 4,856 |

in funding (Table 67). The topics of major projects included:

(1) The central nervous system pathway of the drinking response stimulated by angiotensin-III.
(2) The role played by FA kinase in nerve cell decomposition, degeneration, and regeneration.
(3) The ability of C protein kinase in gliocytes to specifically activate a sodium-hydrogen exchange mechanism.
(4) The mechanism of the promotion of neurotransmitter release by activated isoproterenol.
(5) Strengthened dopaminergic neuron functioning due to the transplant of ventral brain tissue from human embryos in mice with Parkinson's disease.
(6) Variations in the effects of protein kinase C isomerase and its receptors in different parts of the brains of mice suffering from mild chemoshock.

27. Medical Engineering Research

The 61 NSC-supported medical engineering research projects during 1996 received NT48.56 million in funding (Table 68). The topics of major projects included:

(1) The design, evaluation, and construction of a physical support device for severely handicapped children with cerebral paralysis.
(2) Integrated research project on rehabilitation engineering for cerebral vascular disease—Biodynamics and control of muscular spasms in stroke patients.
(3) Wheelchair design in view of the physiology and ergonomics of the upper body.
(4) A study of the control of standing and walking in individuals with nerve-type physical handicaps and the development and clinical evaluation of a static/dynamic standing stability control and assessment rehabilitation device with feedback of physiological signals.
(5) A preliminary study of the Phoenix-7 fully-artificial electromotive fluid pressure operated heart.
(6) Use of magnetic pulses to measure the velocity of blood flow in the body.
(7) Application of an asymmetrical membrane to a transdermal drug delivery system.

28. Research in Pharmaceutical Technology and Traditional Chinese Pharmacology

The 87 NSC-supported research projects in this area during 1996 received NT$45.36 million in funding (Table 69). The topics of major projects included:

(1) Synthesis of a Dolastatin-15 analogue that is a powerful anti-tumor agent.
(2) Design and synthesis of derivatives of the anti-cancer drug Acridone.
(3) Use of electrophoresis to analyze alkaloids from plants of the Camphor family.
(4) Synthesis and study of the characteristics of 8-iso-prostaglandin.
(5) The effect of P glycoprotein on drug absorp-

**Table 69. Pharmaceutical Technology and Traditional Chinese Pharmacology Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) |
|---|---|---|
| 1992 | 88 | 5,453 |
| 1993 | 98 | 6,755 |
| 1994 | 101 | 7,505 |
| 1995 | 90 | 4,536 |
| 1996 | 87 | 3,880 |

tion in the small intestine.
(6) A dynamic study of the pharmaceutical effects of Dicentrine.
(7) Sub-mechanisms of poor CYP2D6 metabolism in Chinese people.
(8) Screening of active components of Chinese herbal medicines.
(9) The isolation of Hepatitis-B virus-fighting compounds from the root bark of Zanthoxylum schinifolium.
(10) The isolation of compounds with anti-cancer activity from Persea obovatifolia.
(11) The isolation of physiologically-active chemical components from the rhizome of Hypericum geminiflorum.

29. Team Research Project on Diabetes

This team project on diabetes was added in 1995. The four NSC-supported research projects during 1996 received NT$2.56 million in funding. The topics of major projects included:

(1) The evolution of diabetes in areas where black-foot disease is prevalent, and the effect of arsenic on the isles of Langerhans and the metabolism of glucose—Third-year follow-up epidemiological study of individuals living where black-foot disease is prevalent and in a control group.
(2) Diabetes research—The mechanism of ET-1 regulation by insulin, IGF-1, and oxidized LDL in mouse kidney cells.
(3) The effect of insulin, heparin, and dipyridamole on freshly-isolated glomeruli endothelin-1 from diabetic mice.
(4) Renal microtubule growth factor, platelet growth factor and its receptors, and relationship with kidney growth in diabetic rats.
(5) B- and C-type natriuretic peptides and expression of their receptor genes in diabetic mice.
(6) Diabetes research—The effect of ACEI on diabetic urine and blood endothelin-1.

### *D. Future Outlook*

The NSC laid out the following reference guidelines for the planning of focal research during initial discipline planning work for the field of medical science:

(1) Research should have academic value or potential applications, or should provide social, medical, or economic benefits.
(2) Research should either address medical problems peculiar to Taiwan or should keep up with international trends in the field. In the former case, research should utilize unique advantages to develop a local orientation; in the latter case, research should maintain a far-reaching outlook and seek to make a contribution to international development.
(3) The NSC should analyze existing conditions and make use of advantageous factors. Systematic and gradual efforts should be made to eliminate current shortcomings.
(4) In order to use equipment and funding in an optimal manner, systems should be integrated and integrated research projects organized. These projects will raise the effectiveness of research by facilitating contact and interchange between researchers in different fields.

Over the years the NSC has devoted great efforts to promoting medical and public health research, and has played a pivotal role in raising the standards of medical research, improving the quality of medical treatment, and enhancing the training of medical personnel. Among many successes, local research on hepatitis and snake toxins, in particular, has won international acclaim.

In addition, up to the end of 1996, 70 domestic and international patents resulting from medical research had been applied for through the NSC and granted; many of these patents have been licensed to commercial firms for manufacture or product development. Not only has research in the area of medicine and public health raised academic standards and the quality of medical treatment, it has also helped foster the growth of a thriving biomedical industry.

Besides continuing to fund outstanding individual research projects, in the future the NSC will increase support for integrated projects in order to make progress in focal areas of medical science and achieve even more significant research results.

## VI. Research in the Humanities and Social Sciences

### *A. Current Situation*

The NSC has divided the humanities and social sciences into six categories encompassing thirteen major disciplines. The following section contains an assessment of the general situation in each discipline and provides an overview of the state of implementation of discipline plans.

#### 1. Research in Literature, History, and Philosophy

There are approximately 650 instructors in the field of Chinese literature and most researchers have received their graduate education in the R.O.C. A conservative estimate would put the number of persons performing research in this area at 300. Most researchers seek to carry out the comparative analysis of Chinese literature with an evaluative, substantive, and integrative attitude. Rather than applying for research project funding, in the past most researchers in the area of Chinese literature have applied for research grants, and 272 such applications were received in 1996. Nevertheless, the number of applications for research project funding has grown to approximately 80 from only ten five years ago.

There are currently 220 individuals working in the discipline of foreign literature. A relatively large contingent of workers is engaged in the study of American and English literature. According to the number of active researchers, the next most popular fields are French literature, German literature, Spanish literature, Japanese literature, and Russian literature. While some work is being performed in Korean and Arabic literature, vigorous efforts must be made to train specialists in other regional literatures. Of the total of approximately 500 domestic historians, roughly 240 are currently actively pursuing historical research. Research is chiefly focused on Chinese history and the history of Taiwan. Scholars working in social, academic, and cultural history are most numerous, followed by those in the history of technology, religion, and politics.

The approximately 180 domestic researchers working in the area of philosophy are more or less equally distributed between the categories of western and eastern philosophy. Besides numerous scholars studying Buddhist philosophy, there are even more specializing in Chinese philosophy—chiefly the history of Chinese philosophy. Specialists in Western philosophy are largely interested in contemporary European philosophy, British and American analytical philosophy, and spiritual philosophy. In addition, a number of workers are performing comparative studies of Western and Eastern philosophy.

Defined broadly, manpower in the discipline of linguistics (including theoretical linguistics, linguistics instruction, and instruction in various foreign languages) is at the 300-person level. However, if defined narrowly (just includin theoretical linguistics), only roughly 100 researchers are active. Research is being conducted on sociolinguistics, psycholinguistics, neurolinguistics, and the structure of various languages (Chinese dialects, Austronesian languages, Sino-Tibetan languages). All leading linguistics researchers hold Ph.D. degrees from foreign or domestic universities.

#### 2. Sociology and Anthropology

The discipline of sociology includes the three areas of sociology, broadcasting, and social

welfare/social work. Research manpower consists of approximately 460 persons. The number of Ph.D.-holding sociological researchers has increased significantly over the past ten years, and there has been a consequent rise in the quality of research. A number of research institutions and university sociology departments have succeeded in establishing a reputation in a particular subfield. However, the increase in the number of researchers has recently slowed. One trend worth encouraging is the growing attention given to European scholarship by both newcomers in the field and those who have attended graduate school overseas.

Since there are only 96 anthropology researchers at the level of professor or lecturer, this field can be considered a relatively undeveloped area of the social sciences. The quality of anthropological research is comparable to that being performed in other areas of the humanities and social sciences—passable but not up to the standards of American and British research.

### 3. Education and Psychology

There are now 695 full professors, 1,086 associate professors, 764 lecturers, and 300 teaching assistants performing research in the field of education. Sub-fields in which large numbers of researchers are working include curricula and instruction, instructional theory, educational systems, training, and guidance. Teacher training is an issue that has gained increasing attention in recent years.

Among the approximately 1,000 psychology researchers now active, about 260 are instructors at university psychology departments and graduate schools. The proportion of researchers holding a Ph.D. degree has increased and domestic research standards are gradually rising. Nevertheless, administrative restrictions on the number of personnel have resulted in a great shortage of manpower in this field. The greatest number of researchers are working in educational psychology, followed by counseling and guidance psychology, personality and social psychology, clinical psychology, and cognitive psychology. Relatively little research is being performed on business psychology and psycho-biology. Many research papers have recently been published on the topics of clinical and guidance psychology, followed by the areas of experimental cognition, personality, and social psychology. However, relatively few papers have been written on other aspects of psychology.

### 4. Law and Political Science

The 216 researchers currently working in the field of law include 150 Ph.D. holders, 45 master's degree holders, and 21 bachelor's degree holders, as well as 85 doctoral students and 740 master's students. Categorized by professional title, there are 80 full professors, 105 associate professors, and 31 lecturers active in this field. The chief focal areas of law are criminal law, civil law, and commercial law, and the largest numbers of researchers are working in these three areas.

As far as political science is concerned, there are numerous workers in the areas of experiential research, international relations, mainland China studies, and public policy. On the other hand, comparatively few workers are studying political thought. Out of the 256 researchers working in the field of political science, 191 hold Ph.D.s, 53 hold master's degrees, and 12 hold bachelor's degrees. In addition, approximately 2,000 graduate students—348 doctoral students and 1,652 master's students—participated in political science projects.

### 5. Economics

Of the 1400 researchers currently working in the field of economics, more than one-half hold Ph.D. degrees. As for area of specialization, the most popular area of finance and monetary economics is followed by international economics, quantitative and numerical methods, industrial structure and policies, and macroeconomics. Comparatively few individuals now specialize in the three areas of law and economics, economics systems, and the history of economics thought and methodology.

Scholarly papers published have gradually

grown in number over the last five years; most have addressed the areas of agricultural economics, international economics, urban and regional economics, currency and finance, and industrial structure and industrial policies. Because a paucity of researchers, relatively few papers have focused on other aspects of economics.

### 6. Management Science

The number of research projects in management science has grown rapidly over the last few years, and large numbers of young researchers are now entering this field. Not only has the number of research projects been increasing rapidly, the practical and academic value of the results obtained has also grown steadily. The scope of research in management science includes financial management and accounting, human resources and organizational behavior, marketing, business strategies, scientific and technological management, corporate management, production management, and information management. Of the 800 researchers currently working in management science, 95 are full professors, 230 are associate professors, and five are lecturers.

## *B. Implementing Discipline Planning*

### 1. Literature, History, and Philosophy

(1) According to the discipline plan for the field of Chinese literature, integrated projects will be carried out on the topics of "An Analysis of Hsuan Hsueh of the Wei and Tsin Dynasties and a Review of Major Hsuan Hsueh Works" and "A Comprehensive Study of the Lung Kan Shou Chien."

(2) In the field of foreign literature, ongoing integrated projects addressing the topics of "literary theory," "cultures of the Asia-Pacific region," and "New English Literature: Transcending Boundaries" will be continued. New integrated projects will study the topics of "Literature and Society: The Nineteenth Century British Novel" and "Focus/Out of Focus: The Evolution of Symbols of 'China' in Art and Literature."

(3) In the field of history, ongoing research on Taiwanese history will be continued and more research attention be devoted to questions concerning the family, trade and shipping, and land development. Besides socio-economic history, which has received increasing emphasis, more attention will also be given to cultural history and the history of science and technology.

(4) As for philosophy, integrated projects will be conducted on the topics of "legal and political philosophy addressing contemporary social, political, and economic questions," "environmental ethics," "social science methodology," "business ethics," "modern interpretations of Chinese philosophy," and "the philosophical foundations of cognitive science." In accordance with the discipline plan, individual research projects in philosophy will concentrate on the following areas in 1996: (a) use of western critical theory to study the political ideology of Taiwan; (b) modern interpretations of Chinese philosophy (including the philosophies of Chuang-tzu, Wang Yang-ming, Feng You-lan, and Liang Shu-ming); (c) a philosophical approach to the issue of "consciousness" in cognitive science; (d) a study of western philosophy and aspects of Buddhist thinking; and (e) an ethical study of chaotic social values in contemporary Taiwan.

(5) The main points of the discipline plan for linguistics include in-depth studies of the linguistics of the Austronesian languages, pragmatic analysis, language learning, phonetics, and the compilation of language databases. Integrated research projects will address the four topics of: (a) "the grammar of the Southern Min dialect in Taiwan," (b) "a survey of the Tibeto-Burman languages," (c) "the feasibility of the use of computers in Spanish instruction and learning," and (d) "morphology and syntax of the Sadegh language."

### 2. Sociology and Anthropology

Progress in sociology in 1996 included the

continuation of projects on the family, population, and society; urban/rural areas; ethnic relations; corporate behavior; social welfare and social work; and crime and social problems. In addition, there is a new emphasis on culturally-oriented research projects, and more attention is gradually being given to the social development of mainland China and cooperative projects with European researchers.

Future anthropological research should stress broad inter-cultural or inter-regional comparisons. More inter-disciplinary integrated projects in anthropology will be conducted.

### 3. Education and Psychology

In order to realize equal educational opportunities and promote research oriented to wards local needs, research projects on "the education of the Taiwanese aborigines" and "educational and scholastic ability indicators" have been begun.

In the field of psychology, integrated projects on "the cognitive psychology of the Chinese language" and "the interaction and integration of multiple paths in the processing of visual information" were continued and new projects on "the psychology of Taiwanese families," "the psychological development and adjustment of adolescents," and "Amphetamine Abuse: Use of Animal Models to Study Physiological and Psychological Mechanisms" were begun. Individual-type projects were mostly in the areas of cognitive processes, personality and social psychology, clinical psychology and counseling, child development, psychological testing and statistics, and educational psychology.

### 4. Law and Political Science

The 1996 discipline plan for law includes the following focal areas: (1) the assessment of administrative court decisions, (2) the interpretation of civil law, (3) the interpretation of criminal law, and (4) the interpretation of business law.

Focal areas of the 1996 discipline plan for political science include: the planning of a pioneering Taiwan study as part of the international cooperative project "A Comparative Study of Election Systems," the project "Social Justice During the Democratization of Taiwan: Three Great Controversies in Contemporary Western Political Thought and Their Influence," a comparative study of methods of electing national legislatures, theoretical issues concerning democratic politics, a comparative study of the administrative systems of Taiwan and mainland China, and the policy formulation process and structure in the PRC.

### 5. Economics

In order to better understand the state of manpower resources, current research, and the future prospects of each of the sub-fields of economics, the NSC conducted the "Discipline Planning Project for Economics" in 1996. This project resulted in recommendations concerning research topics to be given priority attention in the future. This year the NSC sponsored the following integrated research projects in eco-nomics: (1) "A Study of Economic Reform in Mainland China, China's Opening to the World, and Trade Relations Across the Taiwan Straits," "Harmonizing the Industrial Structures of Taiwan and Mainland China—A Study of the Textile/Garment, Automotive, and Electronics Industries," "Long-term Survey and Database Project—Income, Labor, Profession, and Health in Taiwan," and "Policy Selection and Agricultural Development in Taiwan." The latter three projects were continued from the previous year.

### 6. Management

The 1996 discipline plan for the field of management included research on management of the R.O.C.'s financial agencies, enterprise functions and business efficiency, how small and medium enterprise can support Taiwan's Asia-Pacific operations center plan, and automation of the distribution industry.

## *C. Summary of Research Results*

### 1. Chinese Literature

(1) Chinese studies Topics in the Chinese classics include ritual implements in the three Yi, traditional illustrations of rites pertaining to archery, the Shu Hsu Tung Kao, and textual study of Chen Chen-sun's Tzuhsueh. Topics in academic thought include the ideas of Liao Yen, Hsu Chien studies, academic thought and feminism during the early Ch'ing dynasty, and the May 4th movement.

(2) The most popular topic of projects in Chinese literature has been classical poetry. Topics in the area of *Tzu* and *Fu* included a review of methods and materials in the study of *Tzu*, typology and artistic significance of Wei-Tsin *Fu*, *Fu* studies and criticism in China and abroad during the last five years, and "The *Yishengtien Tzu*—An Automatic Concordance System." Topics in the area of novels included dreams in ro-mantic novels from the T'ang and Five Dynasties periods, Buddhist novels from the Sui and T'ang dynasties, and the language and narrative techniques of romantic novels from the Ming and Ch'ing dynasties. Topics in the area of opera included the early history of Beijing opera, operas connected with China's rites and ceremonies, and a survey of traditional opera in Taiwan and other Southern Min-speaking areas. Topics in literary history included "Post-Modern or Post-Colonial: A Reappraisal of Taiwan's Literary History" and the literary history of the Chiayi area of Taiwan.

Other literature research projects included a survey of folk literature in Taiwan; a study of Lu Tung-pin; a survey of the *kun* style of *Peikuan* music in Taiwan; a study of the exchange of children's literature between Taiwan and mainland China; and a comprehensive annotation project involving Chinese-language materials from the Tunhuang caves.

(3) The Study of Writing Apart from the "Comprehensive Study of the *Lung Kan Shou Chien*" mentioned earlier, other work included a study of the *Wang Shan Chu Chien*, research on the origin and development of writing up to the Ch'in and Han dynasties, and the collection of variant characters from Ming and Ch'ing dynasty comedies.

## 2. Foreign Literature

The scope of research in foreign literature during 1996 included the following topics: (1) feminism in literature; (2) an in-depth investigation of parallelism and the linkage of literary theory with textual and cultural aspects; (3) a discussion of particular issues involving individual authors, Chinese-American authors, and authors belonging to ethnic minorities; and (4) comparative literature.

## 3. Historical Research

NSC-supported historical research projects in 1996 addressed such topics as the history of historiography, cultural history, academic history, social history, economic history, history of science and technology, institutional history, religious history, Taiwanese history, political history, diplomatic history, military history, educational history, and art history.

## 4. Philosophical Research

NSC-supported philosophy research projects in 1996 addressed such topics as western philosophy, knowledge theory, spiritual philosophy, socio-political philosophy, applied philosophy, religion, and comparative philosophy.

## 5. Linguistic Research

The 86 NSC-supported linguistics research projects during 1996 were in the following categories: (1) general linguistics, (2) applied linguistics, (3) linguistics of the Chinese language, (4) study of Austronesian and minority languages, and (5) language instruction.

## 6. Sociological Research

The 116 NSC-supported sociology research projects during 1996 included such topics as sociological methodology; social structures and

stratification; social psychology; population, the family, and the community; social problems and controls; culture; social welfare; social work; and broadcasting.

### 7. Anthropological Research

The 12 NSC-supported anthropology research projects carried out during 1996 were in the areas of cultural anthropology, physical anthropology, and archeology.

### 8. Education Research

Educational research in 1996 included the sub-fields of education psychology, educational sociology, educational anthropology, teacher education, comparative educational systems, educational administration, adult education, special education, curriculum and instruction, physical education, library and information science, and art education.

### 9. Psychological Research

The scope of psychology research projects encompassed experimental psychology, cognitive psychology, personality, social psychology, clinical psychology, counseling, and psychological testing and measurement.

### 10. Legal Research

The 77 NSC-supported legal research projects conducted in 1996 addressed the aspects of basic legal thought, constitutional law, administrative law, financial law, criminal law, civil law, business law, and international law.

### 11. Political Science Research

The 79 NSC-supported political science research projects conducted during 1996 focused on the topics of political theory, international relations, and diplomatic affairs.

### 12. Economics Research

Most economics research projects carried out during 1996 addressed the areas of numerical and quantitative methods; microeconomics; macroeconomics and monetary economics; international economics; finance and banking; health, education, and welfare; human resources; the industrial structure and industrial policy; economic development and technological change; and agricultural and natural resource economics.

### 13. Management Research

Management research projects carried out during 1996 included the topics of financial management, accounting, human resources, organizational behavior, marketing, business strategies, technology management, corporate management, production management, operations research, and information management.

## *D. Future Prospects*

### 1. Literature, History, and Philosophy

(1) Chinese literature: Besides continuing to raise the quality of research in Chinese literature and scholarly thought, the NSC will actively prepare for increased future contact and interchange with mainland China in the areas of cultural studies, writing systems, and academic thinking.
(2) Foreign literature: In order to train research personnel, raise research standards, and maintain the ability to perform basic research in foreign literature, integrated special-topic research projects will be vigorously promoted in the field of foreign-language literature.
(3) History: Besides continued promotion of research on Taiwanese history, work in the areas of social history, cultural history, and history of science and technology will be encouraged.
(4) Philosophy: Because the standards of domestic and foreign research in this area have experienced a great improvement, a consensus has been reached that an integrated project in spiritual philosophy should be conducted. There has also been a significant improvement in the quality of scholarly papers in the

areas of political and social philosophy. Although work in practical ethics is gradually bearing fruit, further efforts must be made to raise the caliber of manpower and research results in this area. It is urgent that more effort be devoted to political philosophy. Although there have been some notable results from research on individual philosophers and on the philosophy of particular branches of science, continued encouragement and promotion is needed. In order to form research teams and raise the overall standard of the field, integrated research projects will also be promoted.

(5) Linguistics: The NSC's goal in promoting linguistics research is to quickly raise the standards of linguistics in the R.O.C. to the level found in the developed nations, and to help domestic researchers actively pursue basic research in linguistics. The achievement of these goals will depend on discipline plans that make best use of limited manpower and the promotion of research projects in key areas. In addition, vigorous efforts must be made to conduct exchanges with overseas centers of linguistic scholarship.

## 2. Sociology and Anthropology

The future development of the field of sociology will feature coordination with international trends and an emphasis on the special phenomena and problems caused by social development in Taiwan. The focus of future efforts will be on the nurturing of high-quality sociological periodicals and the holding of special-topic symposia that will be used to showcase research findings. With the cooperation of the academic community, more attention will be paid to the sociology of European and East Asian nations.

The future directions of anthropological research in Taiwan—including both cultural anthropology and archeology—can generally be summarized as the following: (1) less reliance on western theoretical frameworks and more efforts to establish theories with a local character; (2) more emphasis on the cumulative nature of research findings; (3) more promotion of interdisciplinary integrated projects; and (4) more attention to the anthropology of regions other than Taiwan, in order to better make inter-cultural comparisons.

## 3. Education and Psychology

Besides continued support for free individual research, integrated projects will be vigorously promoted. Major research efforts will include: (1) a large project on education among the Taiwanese aborigines; (2) the planning of a large project on the education of individuals with mental and physical handicaps; and (3) a large project on educational standards and indicators of academic achievement. Because each of these topics is very broad in scope, research teams will therefore be formed to pool the efforts of different units and workers.

Future psychological research will follow the directions laid out in the discipline plan for this field. Two tasks will receive particular attention: the collection of basic data in the various sub-fields of psychology and the compilation of basic psychological measurement tools.

## 4. Law and Political Science

Future law research will move in the direction of greater localization. The discipline plan for political science contains the following key points:

(1) Political thought and political theory: Future research directions will include: (a) encouragement of participation by female or feminist researchers in research on political thought; (b) promotion of research on how nationalism and racial politics may affect the acceptance of political authority; (c) encouragement of normative evaluation of democratic theory; and (d) encouragement of research on political philosophy.

(2) Regional studies and comparative political systems: Future research directions will include: (a) the origins and success of national constitutions; (b) election systems and voting behavior; (c) transformations in political

economy; (d) racial politics; and (e) research on Southeast Asia and Latin America.

(3) International relations and foreign policy: Future research directions will include: (a) diplomatic history of the R.O.C., (b) national security and military strategy; (c) regional studies of Southeast Asia and Eastern Europe; (d) the problem of human rights; and (e) questions concerning international cooperation—particularly cooperation in the Asia-Pacific region.

(4) Public policy and public administration: Future research directions will include: (a) democratization and public policy; (b) the role of public participation and question of its positioning; (c) government reform and public policy; (d) privatization policies; (e) how to strengthen implementation of the Asia-Pacific regional operations center plan; (f) policies of control and relaxation; (g) policy design; (h) evaluation of policies; (i) comparative public policies; and (j) public management.

(5) Political economics: Future research directions will include: (a) the effect of democratization on economic development: the relationship between democratization and economic liberalization, conflicts between democratization and the formulation and execution of economic policies, and the transforming effect of democratization on government-business relations; (b) economic department politics: high-tech industrial policies, environmental protection and financial departments; (c) local politics and regional political-economic frameworks; (d) the process of economic reform in mainland China; (e) political and economic interactions between Taiwan and mainland China; (f) international development models and the relationship between freedom and globalization in the domestic economic system; and (g) the process of rebuilding the international order in post-Cold War East Asia.

(6) Research on Taiwan's political experience: Future research directions will include: (a) the continuation of research on voting and political participation; (b) the structure of public opinion; (c) the political role of the National Assembly; (d) the political elite; and (e) methodology.

(7) Research on mainland China: Future research directions will include: (a) the relationship between the regions and the center; (b) the relationship between society and the nation; (c) the foreign policy of the central government; and (d) China's effect on the political and economic framework of the Asia-Pacific region.

### 5. Economics

The future will see an effort to raise the standards of research in economics through the vigorous promotion of research topics formulated through the discipline planning process and the encouragement of both integrated research and individual-type research projects.

### 6. Management Science

In the future there will be an ongoing effort to promote integrated projects in management science. Topics to receive particular attention will include the globalization of Taiwanese firms and the localization of business management. In the area of organizational theory and behavior, an attempt will be made to combine western humanism with traditional cultural concepts from China in order to develop Chinese-style organizational theories suited to Asian conditions. It is hoped that basic research in management science and the rebuilding of the management education system will raise the academic standards of the field and contribute to the prosperity of the industrial sector.

## VII. Research in Science Education

### *A. Current Situation*

During 1996 the NSC supported 464 research projects in science education that were begun during FY 1996 (July 1995-June 1996) Of these projects, 19 were in mathematics education, 24 were in science learning, 62 were in computer-

**Table 70. Science Education Research Projects over the Last Two Years**

| Year | Normal Univ. | Teachers College | Public Univ. and Colleges | Polytechnic Institute | Private Univ. and College | Other | Total |
|---|---|---|---|---|---|---|---|
| 1996 | 140 | 55 | 154 | 54 | 53 | 8 | 464 |
| 1997* | 107 | 56 | 93 | 22 | 48 | 2 | 328 |

* During first half of fiscal year ( July 1, 1996-December 31,1996 )

assisted learning, 15 were in education for gifted students, 71 were in science instructor training, six were in environmental education, eight were in information education, 16 were in industrial arts education, 59 were in technical specialization education, 34 were in technical practicum education, 26 were in general education, and 97 were in engineering education. Of the 328 projects begun during the first half of FY 1997 (June 1996-December 1996), 37 were in mathematics education, 14 were in science learning, 62 were in computer-assisted learning, 22 were in education for gifted students, 49 were in science instructor training, nine were in environmental education, seven were in information education, 14 were in industrial arts education, 42 were in technical specialization education, 24 were in general education, 27 were in engineering education, and 21 were in medical education. A relatively large number of these project were conducted at normal universities; relatively few were conducted at private universities (Table 70).

### *B. Implementing Discipline Planning*

In order to formulate integrated discipline and resources plans, in 1993 the NSC established discipline planning committees for the eight disciplines of mathematics education, physics education, chemistry education, biology education, earth science education, environmental education, information education, and natural science education. Subsequently in 1995, the NSC used existing discipline plans as a basis for revised discipline and resource plans in the fields of science education and mathematics education. Discipline plans for the fields of engineering education and technical specialty education were also drawn up at this time.

In October 1995 the NSC issued an invitation for integrated research project proposals in the areas of mathematics education, natural science education, environmental education, technical education, and university general education. After taking into consideration the needs of society and the available supply of research manpower, a number of priority research areas were drawn up. The NSC hopes that research personnel will organize themselves into teams and submit research proposals addressing these key areas.

The following are the topics of integrated research projects that were begun during the second half of 1996:

#### 1. Instructor Training

(1) A model for the training and assessment of elementary school mathematics instructors; (2) a model for the training and student teaching of elementary school natural science instructors; (3) a model for the review of middle school mathematics and natural science instructors; (4) a model for the training and evaluation of middle school biology instructors; (5) the development of instruments for the evaluation of middle school practical technology instructors; (6) a practicum and evaluation system for middle school mathematics instructors; (7) a model for the training and evaluation of vocational high school mechanical engineering instructors; (8) the evaluation of the practicum results and teaching ability of mathematics instructors; and (9) evaluation models and instruments for computer science instructors.

#### 2. Technical Education

(1) A study of the content of technical education—technology R&D methods; (2) how to improve the mechanical design ability of

five-year junior college students; (3) integrated experimental curriculum instructional strategies seeking to enhance students' practical skills and self-study ability; (4) an integrated electrical machinery teaching plan that supports precision machinery technology; (5) ways of improving machinery practicums at technical colleges in response to the needs of industry; (6) education in precision mold-making at technical colleges; and (7) improving the practical skills of technical college students majoring in electrical machinery.

### 3. Engineering Education

(1) Mechanical engineering: (a) an experimental curriculum on machinery and electrical machinery computer systems; (b) a revised curriculum on air flow dynamics in aircraft design; (c) the improvement of mechanical engineering experiments; (d) the improvement of practicum instruction in mechanical engineering; and (e) the improvement of metal processing experiment instruction.
(2) Civil engineering and marine engineering: a. the improvements of marine engineering education and b. water resource engineering education.
(3) Electrical machinery: (a) the improvements of the information education practicum curriculum; (b) the construction of a modular experiment system for electrical machinery engineering; (c) the improvement of practical control system design instruction; (d) training of semiconductor engineering personnel; (e) development of a very large integrated circuit testing and testability design curriculum; (f) the improvement of laser experiment instruction at polytechnic institutes; and (g) the improvement of electro-optics and microwave communications instruction.
(4) Other: (a) A study of the training of specialized design personnel in the R.O.C.—practical design-oriented design education; (b) integrated curriculum design; (c) the establishment of a university-level civil aircraft maintenance curriculum; and (d) the promotion of super-critical fluids in engineering education.

Besides continuing to carry out the aforementioned integrated research projects, integrated projects on the following topics were begun during the first half of FY 1997:

### 1. Mathematics Education

(1) The dynamic geometry study environment; (2) an instructional format for remote diagnosis and the establishment of a mathematics instruction knowledge base; and (3) the development of teaching materials featuring a game-style presentation of mathematics concepts.

### 2. Intelligent Computer-assisted Learning

(1) The application of distance learning systems in public elementary schools; (2) an intelligent computer-assisted diagnostic learning system (II); (3) LISA: a global social learning network; (4) an integrated study of learning strategies in a intelligent distance cooperative learning environment; (5) an integrated study of assessment and management in a intelligent distance cooperative learning environment; (6) the development of distance instruction at the R.O.C.'s open schools; and (7) and integrated project on the use of the Internet to improve earth science instruction in middle schools (1/2).

### 3. Computer-assisted Learning

(1) Factors affecting the effect of computer-assisted learning on cognition—an investigation of a natural science CAI system; (2) R&D of computerized teaching materials for core units in elementary schools; and (3) CAI as a means of inducing mildly retarded children to read from pictures.

### 4. Instructor Education

(1) STS instructor training (second year); (2) a training and evaluation format for middle school biology instructors (I); (3) a practicum and evaluation system for middle school mathemat-

ics instructors (II); (4) the science education environment in elementary and middle schools (II); and (5) the role of the history of science in science education.

**5. Education for gifted students**

(1) A comprehensive development strategy for gifted-student education in the R.O.C.; and (2) the language ability of gifted science students.

**6. Medical education**

(1) A learning environment system for the basic clinical curriculum; (2) a problem-oriented computerized curriculum and environment for dental instruction (II); (3) the application of a distributed video system to medical instruction; and (4) effectiveness and students' confidence in questions on the nursing certification test.

**7. Technical education**

(1) Integrated research on design of a curriculum framework and content for management education within the vocational education system (II)—business colleges; and (2) whether industrial engineering and management education within the vocational education system meet the needs of industrial development (II).

**8. Industrial arts education**

(1) The content and significance of industrial arts education—elementary school portion; (2) the harmonization of industrial arts education in elementary and middle schools—the harmonization of industrial arts education in public elementary schools; (3) instructional strategies in industrial arts education; and (4) the production of industrial arts examinations—the production of industrial arts examinations in public elementary schools.

**9. Information Education**

Research and development of a diversified computerized instruction format (III).

**10. General Education**

(1) Teaching materials and methods for core topics in chemistry—chemistry, medicine, and society; (2) the content of general education aiming to mold whole individuals—taking the Christian outlook and practical experience as examples; (3) teaching strategies for and curriculum content of "gender and relationships" in university general education; and (4) general education content based on traditional Chinese culture—general education concepts in the Chinese classics.

**11. Engineering Education**

(1) Super-critical fluids in engineering education (II); (2) establishment of a university-level civil aircraft maintenance curriculum (II); (3) an experimental curriculum for machinery and electrical machinery computer systems (II); (4) the improvement of mechanical engineering experiments (II); and (5) improvements in marine engineering education (II).

Approximately 320 integrated projects and 150 individual-type projects were carried out in the first half of FY 1996. In contrast with 1995, when individual-type projects outnumbered integrated projects, more individual projects had been merged to form integrated projects in 1996, demonstrating the trend towards greater integration of manpower and resources. This trend will help raise the quality and effectiveness of science education research.

### *C. Summary of Research Results*

The following is a brief summary of the topics of 1996 research projects that were completed before the end of June:

**1. Mathematics Education Research Projects**

Mathematics education research projects carried out in 1996 featured the following five topics (Table 71):

(1) Mathematics concepts and learning.
(2) Calculus instruction—computers and math-

**Table 71. Mathematics Education Research Projects over the Last Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | |
|---|---|---|---|---|---|---|
| | | (NT$1,000) | Professors | Associate Professors | Lecturers | Total |
| 1992 | 28 | 11,694 | 27 | 7 | 3 | 37 |
| 1993 | 41 | 17,480 | 30 | 23 | 2 | 55 |
| 1994 | 31 | 12,046 | 26 | 10 | 1 | 37 |
| 1995 | 32 | 11,570 | 15 | 36 | 1 | 52 |
| 1996 | 19 | 8,307 | 12 | 14 | 0 | 26 |

**Table 72. Natural Science Education Research Projects over the Last Five Years**

| Year | Number of Projects | Funding | Research Manpower | | | |
|---|---|---|---|---|---|---|
| | | (NT$1,000) | Professors | Associate Professors | Lecturers | Total |
| 1992 | 69 | 29,560 | 54 | 28 | 0 | 82 |
| 1993 | 98 | 45,464 | 63 | 53 | 2 | 118 |
| 1994 | 112 | 48,499 | 64 | 74 | 0 | 138 |
| 1995 | 172 | 75,731 | 60 | 151 | 3 | 214 |
| 1996 | 213 | 95,122 | 89 | 183 | 1 | 273 |

ematics education.
(3) Mathematics curricula.
(4) Mathematics education indicators.
(5) Education and training of mathematics instructors.

## 2. Natural Science Education Research

Natural science education research encompasses the areas of physics education, chemistry education, biology education, and earth science education, as well as the aspects of student learning, computer-assisted learning, instructor training, and education for gifted students (Table 72). The following are some topics of major research projects:

(1) Study and development of natural science concepts.
(2) Group project on intelligent computer-assisted learning.
(3) Computer-assisted learning and various sciences.
(4) Integrated project on STS instructor training.
(5) Science teachers and instruction.
(6) Integrated project on the science teaching environment in elementary and middle schools.
(7) Pre-service and in-service training for science teachers.
(8) Science instruction.
(9) Integrated project on a training and evaluation format for mathematics and science teachers in a diversified teacher training system.
(10) The spatial ability of gifted science students.
(11) A comprehensive development strategy for gifted-student education in the R.O.C.
(12) A computer-assisted medical learning system.
(13) Clinically-oriented problem-solving dental training.
(14) The application of a distributed video system to medical instruction.
(15) Social environmental education—Neighborhood environmental education for women.

**Table 73. Technical Education Research Projects over the Last Five Years**

| Year | Number of Projects | Funding (NT$10,000) | Research Manpower | | | |
|---|---|---|---|---|---|---|
| | | | Professors | Associate Professors | Lecturers | Total |
| 1992 | 6 | 1,800 | 7 | 0 | 0 | 7 |
| 1993 | 34 | 13,290 | 20 | 29 | 2 | 51 |
| 1994 | 67 | 24,640 | 37 | 53 | 1 | 91 |
| 1995 | 84 | 33,490 | 36 | 66 | 1 | 103 |
| 1996 | 75 | 27,736 | 26 | 65 | 3 | 94 |

**Table 74. Engineering Education Research Projects over the Last Three Years**

| Year | Number of Projects | Funding (NT$10,000) | Research Manpower | | | |
|---|---|---|---|---|---|---|
| | | | Professors | Associate Professors | Lecturers | Total |
| 1994 (Integrated) | 22 | 11,740 | 9 | 18 | 0 | 27 |
| (Individual) | 5 | 2,830 | 1 | 7 | 0 | 8 |
| 1995 (Integrated) | 95 | 29,440 | 31 | 62 | 10 | 103 |
| (Individual) | 26 | 8,490 | 6 | 22 | 6 | 34 |
| 1996 (Integrated ) | 84 | 28,530 | 8 | 59 | 0 | 87 |
| (Individual) | 13 | 4,800 | 6 | 13 | 2 | 21 |

(16) A format for the promotion of environmental education by private organizations.
(17) The development of junior and senior high school students' environmental knowledge and conceptual framework.
(18) The teaching of environmental education concepts in public elementary schools.

### 3. Technical Education Research

Technical education research projects carried out in 1996 included the following topics (Table 73):

(1) Industrial arts education.
(2) Technical specialty education.

### 4. Engineering Education Research

(1) Integrated projects 1996 was the second year of integrated research projects in this area; the topics of these projects included an investigation of the basic experimental and practical knowledge of technical college students and the improvement of the content of the research curriculum.
(2) Individual-type projects The scope of the 13 individual-type research projects conducted in 1996 (Table 74) included civil engineering, electrical machinery, materials science, measurement, mechanical engineering, and other areas of engineering education.

### 5. University General Education Research

A diverse array of free research and team research projects investigating the concepts, content, framework, and implementation of university-level general education were carried out during 1996. The 21 integrated projects and the five individual-type projects addressed the following topics (Table 75):

(1) General education content based on traditional Chinese culture.
(2) Teaching materials and methods for general chemistry education.
(3) Planning and design of a general university

**Table 75. University General Education Research Projects over the Last Three Years**

| Year | Number of Projects | Funding | Research Manpower | | | |
|---|---|---|---|---|---|---|
| | | (NT$1,000) | Professors | Associate Professors | Lecturers | Total |
| 1994 | 30 | 11,230 | 17 | 19 | | 36 |
| 1995 | 9 | 3,280 | 4 | 6 | | 10 |
| 1996 | 26 | 10,225 | 16 | 18 | | 34 |

social sciences curriculum.

(4) Instructional design for general engineering education.

### 6. Science Education for the General Public

(1) Since issuing the "Selection of a News Medium for the Production of a Special Sci-tech Publication" in the summer of 1995, the NSC has provided the news media with topics and materials for the production of a special publication aimed at readerships including elementary school students, junior and senior high school students, college and university students, the general public, and technical specialists. This publication seeks to present scientific and technological knowledge, news, and policies in a format that is interesting, informative, and useful. After being launched in September 1995, this publication was included in the Monday edition of the China Times for a full year, and discussed a different topic each week.

(2) In order to help young people and the general public better understand basic scientific principles, in October 1996 the NSC held a planning conference for the "Basic Science Knowledge Series." It was decided that "support" and "awards" should be employed simultaneously, and awards would be granted to outstanding sci-tech publications. It is expected that guidelines for award and support applications will be issued in June 1997.

### 7. The Development and Promotion of Science Education

(1) Project for increasing young people's basic scientific and technical knowledge and skills:

The goal of this project is to use workshops and other activities to introduce high school students, university students, graduate students, and vocational instructors to basic sci-tech knowledge and skills. It is hoped that these activities will stimulate the interest of the participants in science and provide high school science teachers with a source of relevant information. See Table 76 for activities conducted during 1996.

(2) Science education and promotion projects carried out jointly with the Ministry of Education:

This year the "Experimental Guidance Program for Outstanding High School Mathematics and Physical Science Students" was conducted in coordination with the Ministry of Education, the Taiwan Department of Education, and the Taipei and Kaohsiung bureaus of education. The goal of the project is to uncover high school students with a flair for mathematics, stimulate their interest in basic science, and provide them with training in correct scientific concepts, study methods, experimental skills, problem-solving skills, and the ability to study independently. Table 77 shows the sponsoring units, numbers of students, and number of students admitted to university without the regular entrance examination during FY 1995.

### *D. Future Prospects*

To sum up more than ten years of science education research, the target of this research has gradually expanded from primary and secondary schools to include universities and technical colleges; the research scope has expanded from fundamental science to applications science; and

**Table 76. Youth Science Skills and Knowledge Workshop Activities**

| Name | Date | Sponsoring Agency |
|---|---|---|
| Summer 1996 Youth Self-Renewal Activity—Natural Science Camp | July 8-15 | National Central University |
| Summer 1996 Youth Self-Renewal Activity—Earthquakes and Meteorology Camp | July 15-20 | National Central University |
| Summer 1996 Youth Self-Renewal Activity—Space Science Camp | July 3-9 | National Central University |
| Summer 1996 Youth Self-Renewal Activity—Acupuncture and Herbal Medicine | July 15-26 | China Medical College |

**Table 77. Number of Participating Students in the Experimental Guidance Program for Outstanding High School Mathematics and Physical Science Students and Number of Students Admitted to University without the Regular Entrance Examination**

| Host Unit | Category | Number of Students | | | Number of Students admitted to Univ. without Entrance Examination |
|---|---|---|---|---|---|
| | | First Year | Second Year | Third Year | |
| National Taiwan Univ., Department of Mathematics | Mathematics | | | 4 | 4 |
| National Tsinghua Univ., College of Science | Physics | 57 | 38 | 9 | 5 |
| | Chemistry | 48 | 21 | 7 | 6 |
| National Cheng Kung Univ., College of Science | Physics, Chemistry | 91 | 26 | 15 | 5 |
| | Mathematics | 50 | 18 | 8 | 0 |
| National Sun Yat-sen Univ., College of Science | Physics, Chemistry | 45 | 20 | 11 | 1 |
| | Mathematics | 49 | 35 | 13 | 0 |
| Academia Sinica, Institutes of Zoology and Botany | Biology | 66 | 40 | 28 | 6 |
| Total | | 406 | 198 | 95 | 27 |

a focus on pure science has gradually expanded to encompass technology and social education. Apart from transmitting scientific knowledge, educational objectives are now considered to include instilling the scientific spirit and building a healthy personality.

In hope of meeting the future needs of an increasingly diverse society and solving the particular problems confronting science education, besides continuing to implement the aforementioned research projects, the NSC is attempting to concentrate the resources in individual disciplines on focal research areas. The following are the chief focal areas of science education research for 1996 and 1997:

### 1. Basic Research in Science Education

(1) Mathematics and science education:

a. Development of instructional experiments and multi-purpose mathematics and physical science teaching materials.
b. Instruction and learning of science concepts and high-level thinking skills.
c. Distance instruction and learning systems for mathematics and physical science.
d. Gifted science students:

(a) Spatial ability of gifted science students.
(b) Language ability of gifted science students.
(c) Characteristics of the thought processes of scientists.
e. Environmental education.

(2) Applied science education:

a. Indicators of industrial arts education.
b. Activity design for industrial arts education.
c. Training in technical creativity.
d. Information education research.

**2. Engineering Creativity Education Research**

**3. Research on the Education of Outstanding Future Scientific Research Personnel**

(1) Increasing middle school students' interest in science.
(2) Training in the basic ability to carry out scientific experiments.
(3) Experimental guidance program for outstanding high school mathematics and physical science students.
(4) Participation in international competitions in physics, mathematics, chemistry, and computer science.

**4. Research on Teacher Training**

(1) Format and instruments for the evaluation of mathematics and science instructors.
(2) Practicum format for mathematics and science instructors.
(3) A distance guidance system for mathematics and science instructors.

**5. Research on University General Education**

(1) A core curriculum for university general education.
(2) Compilation of teaching materials for the university general education core curriculum.

**6. Creativity Training**

(1) Characteristics of creativity.
(2) Instilling creativity through science/technology/engineering instruction:

a. Instilling mathematical and scientific creativity in elementary school students through instruction and the learning environment.
b. A learning environment to help instill technical creativity.
c. Instilling creativity in university engineering students.
d. Instilling creativity and innovative thinking in scientific and technical personnel.
(3) Using computer network learning and training systems to instill creativity.

**7. Science Education for the Public**

(1) Science experiment/activity design.
(2) Scientific and technological reports.
(3) Scientific displays.

## VIII. Research on Development and the Environment

### *A. Current Situation*

In 1996 the NSC supported 190 projects (28 integrated projects; six individual-type projects) in the areas of disaster prevention, environmental protection, and global changes research. These projects received approximately NT$10 million in funding. All research projects promoted by the NSC's Sustainable Development Research Steering Committee in 1996 feature greater depth and the potential ability to solve practical problems. The active side of research in this area is the establishment of sustainable development, and the passive side is environmental protection and disaster prevention. For its part, global change research will increase academic knowledge and allow the collection of authoritative and reliable data. In order to realize the practical benefits of research and allow full evaluation of research results, a comprehensive research finding conference was held at NTU on November 5th and 6th. This event was designed to promote the exchange of academic and practical ideas among research personnel working in up-, mid-, and

downstream areas, facilitate the application of research findings by private enterprises or government agencies, and thereby maximize the benefits derived from research projects. To provide a basis for the allocation of resources and determine whether to continue certain projects, the results of this conference will also be used to evaluate projects. In addition, a CD-ROM collection of research papers has been produced for the convenience of interested persons. Reports of project results accompanied by English abstracts will be made available on the Internet in order to facilitate the free flow of information concerning development and the environment.

### *B. Summary of Research Results*

Natural disaster prevention research has been divided into the six categories of meteorology, flood prevention, seismology, seismic engineering, socio-economics, and the development of hillside land. The topics of completed projects have included:

#### 1. Prevention of Meteorological Disasters

(1) Integrated project on the quantitative forecasting of precipitation in the Tainan area.
(2) A model for forecasting flooding in the Pachang Creek basin.
(3) A micro-scale survey of earthquake risk in the Chia-nan region of southern Taiwan.
(4) Study and application of energy-absorbing and vibration-damping systems for bridges.
(5) Group project on debris flow.

#### 2. Environmental Protection

(1) Basic research on the sustainable development of the Taichung area.
(2) The recycling and reuse of wastes.
(3) Clean-up technologies for plant sites suffering from soil pollution.
(4) Follow-up project on the relationship between urban air pollution and respiratory diseases in schoolchildren.
(5) Various approaches to the rational utilization of water.
(6) Utilization and conservation of Taiwan's public land resources.

#### 3. Global Changes

(1) Taiwan's atmospheric environment.
(2) Land-sea exchange process in the vicinity of the mouth of Tzengwen Creek.
(3) A cost-effectiveness analysis of the reduction of greenhouse gas emissions.

### *C. Future Prospects*

Sustainable development has now become an important issue for the world's developed nations. In order to meet the challenge of this field, the NSC's Sustainable Development Research Steering Committee has sought to place balanced attention on environmental protection and economic development. Formerly called the "Environment and Development Committee," this unit was given its current name and had its operational format modified in January 1997. The committee will continue to promote research on the environment and economic development, while taking sustainable development as its basic objective, and in the future will strive to implement the recommendations of the Fifth National Conference on Science and Technology and the 17th Science and Technology Advisory Conference. It will also revise research topics on the Mid-term Plan for Sustainable Development, carefully select focal areas for future research, and promote national-level, inter-disciplinary, inter-departmental disaster prevention projects and national-level environmental risk assessment research projects. In order to utilize resources in the most effective manner, it will encourage up-, mid-, and down-stream units to increase vertical integration and will strengthen coordination and a division of labor at the NSC and other government units in order to achieve the goal of realizing horizontally-integrated, inter-disciplinary, mission-oriented projects.

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