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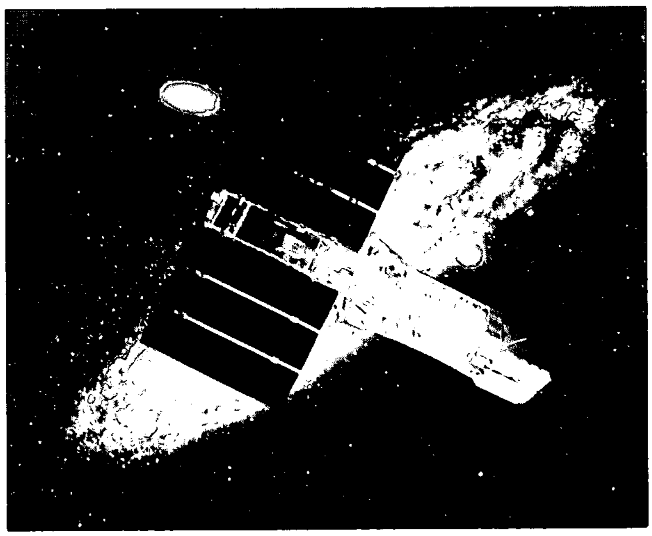
ABSTRACT

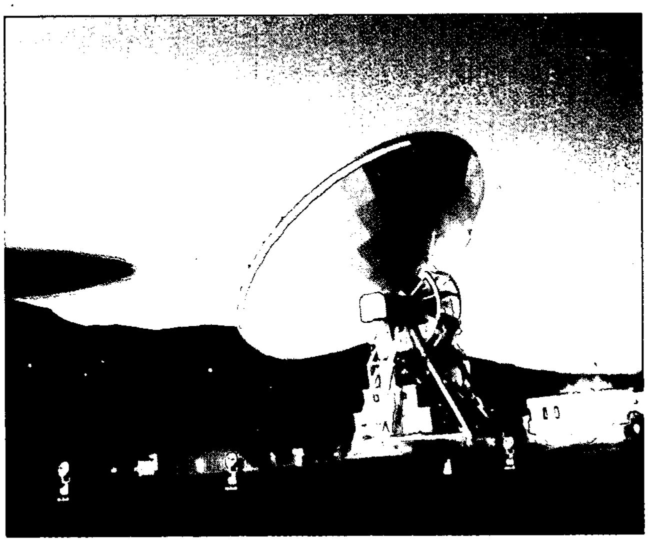
This document outlines the basic philosophy and policies of the Japanese Ministry of Education, Science, Sports and Culture (MESSC) about the promotion of scientific research for the future benefits of society. Promoting scientific research in universities and affiliated research institutions, as well as the science and technology deriving from it, is one of the Japanese government's top priorities. Chapters include: (1) Conceptual Foundations for Promoting Scientific Research; (2) Basic Policies for the Promotion of Science; (3) New Trends in the Promotion of Science; and (4) Domestic and Overseas Trends in Scientific Research. (Contains 58 tables and figures.) (WRM)

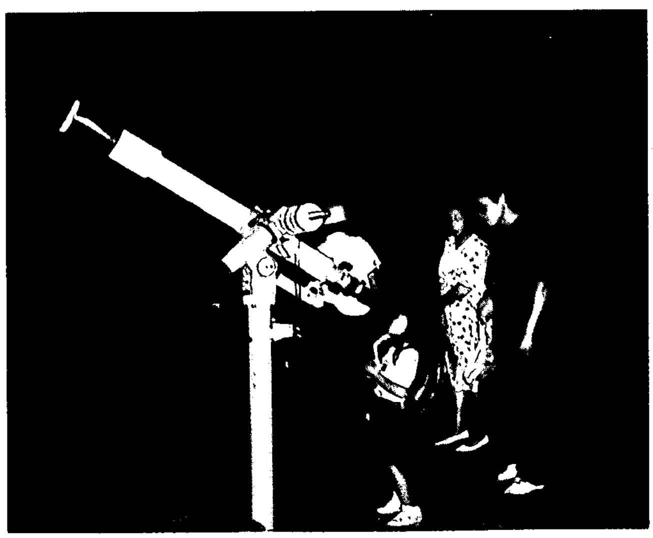
# JAPANESE GOVERNMENT POLICIES IN EDUCATION, SCIENCE, SPORTS AND CULTURE 1997



## Scientific Research: Opening the Door to the Future







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**Ministry of Education, Science, Sports and Culture**
**Japan**

# JAPANESE GOVERNMENT POLICIES IN EDUCATION, SCIENCE, SPORTS AND CULTURE 1997

## Scientific Research: Opening the Door to the Future

Ministry of Education, Science, Sports and Culture
Japan

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This is the English edition of part 1 of a report on Government policies in education, science, sports, and culture (*Wagakuni no Bunkyo Shisaku*), originally published in Japanese in 1997 by the Ministry of Education, Science, Sports and Culture.



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# Foreword

Education, science, culture, and sports play an increasingly important role in creating a society in which every individual can have dreams and goals for the future, fully demonstrate creativity and willingness to take on challenging tasks, and enjoy a fulfilling life. The Ministry of Education, Science, Sports and Culture (MESSC) is endeavoring to fulfill its mandate as the ministry responsible for educational administration by constantly reviewing its overall policies and actively implementing reforms in response to the changing times. Since fiscal 1988 an annual report on Government policies in education, science, sports, and culture has been published to inform the public of all aspects of educational policy.

Part 1 of the 1997 edition, a special feature on the role of scientific research in opening up paths to the future, reflects Japan's determination to establish a nation based on the creativity of science and technology. Promoting scientific research in universities and affiliated research institutions, as well as the science and technology deriving from it, is one of the Government's top priorities. The special feature outlines the Ministry's basic thinking and policies regarding the promotion of science and elaborates future directions and tasks.

In conjunction with the Government's program of reform in five areas, including administration, fiscal structures, and economic structures, in 1997 MESSC began implementing reforms in education, which constitutes the foundation for all other social systems. Present efforts are concentrated on reforms that reflect a basic philosophy of respect for individuality, aiming to foster children's "zest for living" [*ikiru-chikara*] in an environment that gives them "room to grow" [*yutori*]. Part 2 describes the current state of these efforts in relation to educational reform in particular. It also provides an overview of various aspects of Ministry policies in education, science, sports, and culture in light of these trends.

I hope that this report will enhance your understanding of the Government's current policies concerning education, science, sports, and culture.

Nobutaka Machimura

Minister of Education, Science, Sports and Culture
December 1997

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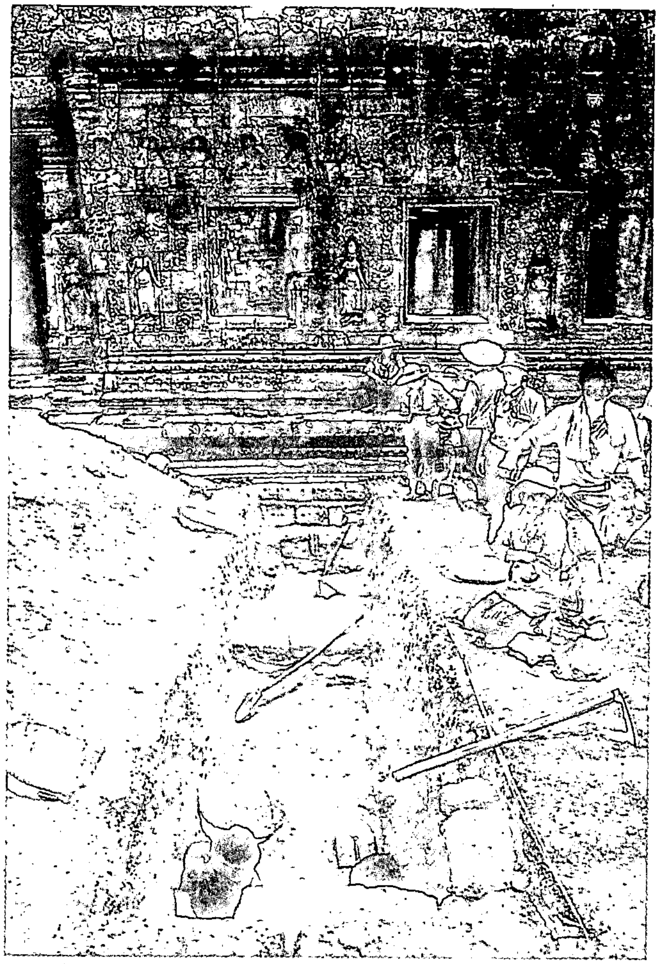


*An international team excavates archaeological remains at the World Heritage site at Angkor Wat, Banteay Kdai, Cambodia.*

## 1. Scientific Research: Why It Is Done and Who It Is For.

Scientific research refers to the creative intellectual activity in all fields of the humanities and social and natural sciences that takes place in universities and their affiliated research institutes and that has the following characteristics.

### (1) Advanced Intellectual Effort in Pursuit of Truth

Like the young Thomas Edison, children can drive their parents to distraction by continually asking "Why?" This is evidence of the innate intellectual curiosity of the species taxonomists have named "Homo sapiens," or "humans with wisdom." Our curiosity about the unknown is reflected in our desire for a structured, over-all grasp of ourselves and phenomena around us.

Scientific research is the advanced, intellectual pursuit of truth by researchers driven by the desire to attain a systematic, comprehensive understanding of humanity, society, and nature. Thus respect for researchers' autonomy and freedom of thought is absolutely vital, so scientific research is conducted mainly in universities, where this requirement can best be met.

### (2) Promoted Together with Education and Human Resource Development

In addition to advancing scientific research, universities are also mandated to apply the results in systematic education to develop future generations of human resources. Through undergraduate and other programs, universities produce people with general educational attainments and specialized abilities that enable them to contribute to society. In graduate schools, affiliated research institutes, and other facilities, universities train young researchers to further the progress of scientific research. Government reports published in the United States and many other industrially advanced nations in recent years have stressed the importance of opening universities to the community at large and have also urged universities to expand cooperation with industry with respect to research and human resource development. At the same time, these reports stress that universities must fulfill their basic role in training and educating future generations.

### (3) Lays the Foundations for the Advancement of Society and Humanity

Through university education and human resource development, the results of scientific research contribute to society's advancement. Moreover, basic and original research, which private enterprises cannot undertake, creates new knowledge that serves as a foundation for the advancement of society as a whole and the entire human race. Today global issues that could affect the survival of humankind, such as the global environment, resources and energy, food, and AIDS, are the focus of sustained international cooperation based on wide-ranging research spanning all fields from the humanities and social sciences to the natural sciences. For example, the successful excavation and restoration of ancient sites in Egypt, Cambodia, and elsewhere would not have been possible without cooperation among researchers from many countries. Their joint efforts have saved treasures that are the heritage of all humanity from being lost to the encroachment of desert or jungle.

Scientific research thus benefits the whole of society and humanity. Universities in every country receive public support and a variety of research grants, reflecting the nature of scientific research as a public commodity and an investment in the future.

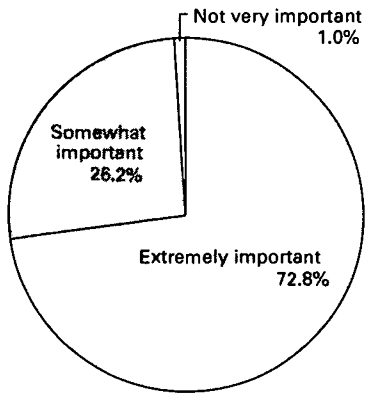
## 2. The Environment for Scientific Research

### (1) Attitudes of Researchers and the Public

In fiscal 1996 MESSC commissioned a questionnaire survey on scientific research and universities, which was sent to 500 randomly selected experts working in private companies, government laboratories and research institutes, and other non-university situations. The results are summarized below.

**(i) The importance of scientific research to humanity and society (Figure 1-1):** When asked to evaluate the importance of scientific research to humanity and society, 72.8% selected "extremely important." If "somewhat important" responses are included, almost all respondents recognized

**Figure 1-1. The Importance of Scientific Research to Humanity and Society**




Source: MESSC, "Survey on Scientific Research and Universities" (fiscal 1996).

the importance of scientific research. Although people's perceptions of scientific research may vary, most accept its importance.

**(ii) What is expected of scientific research (Figure 1-2):** Respondents were also asked to indicate what, in particular, they expected of scientific research. The most frequent response, selected by 53.5% of survey participants, was "technological innovation." In second place was "pursuit of truth" (38.6%), followed by "solution of global problems" (37.3%). The numbers opting for "technological innovation" and "solution of global problems" were relatively high, even for a survey of non-university experts. Comparison with a similar survey conducted in 1990, when 54.4% selected "pursuit of truth" and 51.3% "technological innovation" ("solution of global problems" was not an option), points to a growing tendency to expect scientific research to focus on application and development purposes, clear evidence of change in the social and economic environment surrounding scientific research.

**(iii) The roles of research in private companies and in universities (Figure 1-3):** Regarding the roles of research in private companies and universities, 88.2% felt that "university research should be encouraged in order to contribute to global progress in scientific research." The selection of this response by such a large majority indicates that non-university experts consider scientific research important and expect universities to play a significant role in it.

Other views receiving strong support included "universities should actively support research by companies through joint research" (78.5%); "universities should focus not only on basic research, but also on applied and development-style research" (69.4%); and "universities should take account of the needs of business and society in their research activities" (64.6%). These results are indicative of growing hopes that universities will expand their interaction with other research institutes and increase their research activities in areas that reflect the needs of society.

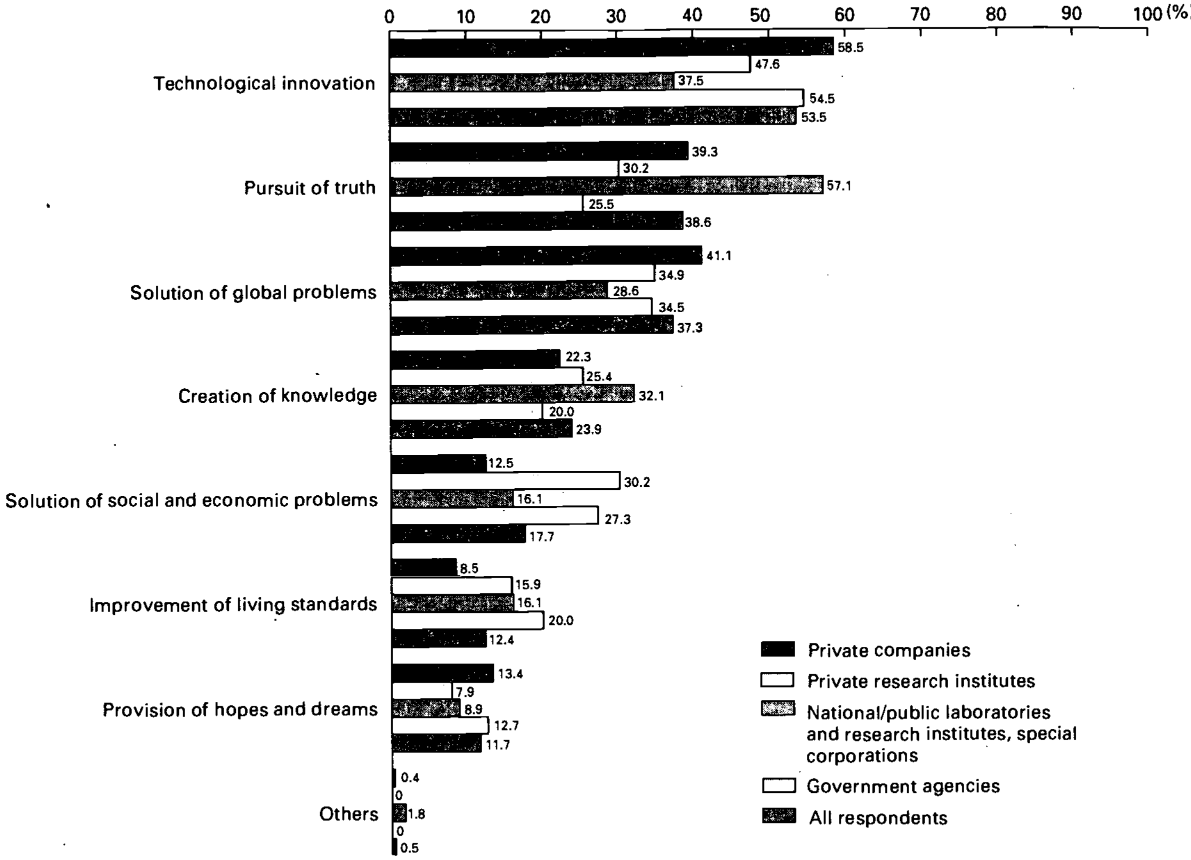
These findings make it clear that in Japan in recent years people have come to expect more from scientific research. University researchers will need to respond flexibly to society's demands. Because research achievements are intellectual assets to be shared by all humanity, researchers are enjoined to make them available to society at large by publishing and disseminating them actively.

## (2) Changes in the Environment for Science and Technology

Postwar Japan made a miraculous recovery from utter destruction. The spread and improvement of education and the qualitative and quantitative advancement of science and technology were key factors in that achievement. Needless to say, universities played an important role by making scientific research the foundation for developing highly trained human resources.

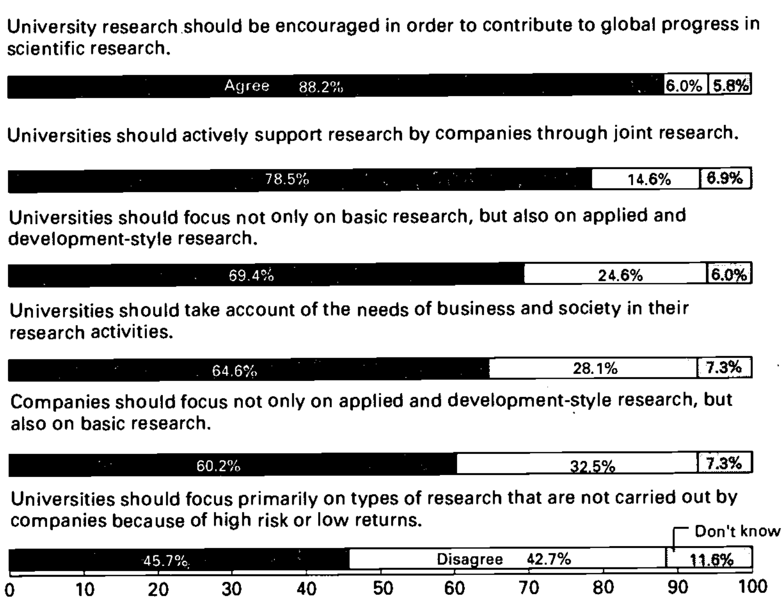
Thus far, however, Japan has generally taken a "catch-up" approach to science and technology. Technological innovation has meant applying sophisticated engineering know-how to develop ap-

**Figure 1-2. What is Expected of Scientific Research**




Note: Up to two responses.
Source: MESSC, "Survey on Scientific Research and Universities" (fiscal 1996).

**Figure 1-3. The Roles of Research in Private Companies and in Universities**




Source: MESSC, "Survey on Scientific Research and Universities" (fiscal 1996).

plications and products using basic and original technologies obtained from industrially advanced Western countries in exchange for the payment of royalties and other fees that were relatively low by today's standards.

The world is moving toward increased protection for intellectual property rights. Japan, which has pretty much finished catching up, now faces the major task of correcting its weakness in basic research and original technological development. Moreover, in addition to a trend toward fewer children, the Japanese population is aging more rapidly than that of any other industrially advanced nation, which means that despite women's entering the labor market and the implementation of various employment and job training policies, there is a danger that Japan's ability to achieve sustained growth and development will be constrained by both the quality and quantity of its work force.

The discovery, development, and stable supply of resources, energy, and food are vital priorities for Japan, which is poorly endowed with natural resources. As a member of the international community, Japan needs to make a serious response to issues that could jeopardize the survival of humanity, such as global warming, other global environmental problems, and AIDS.

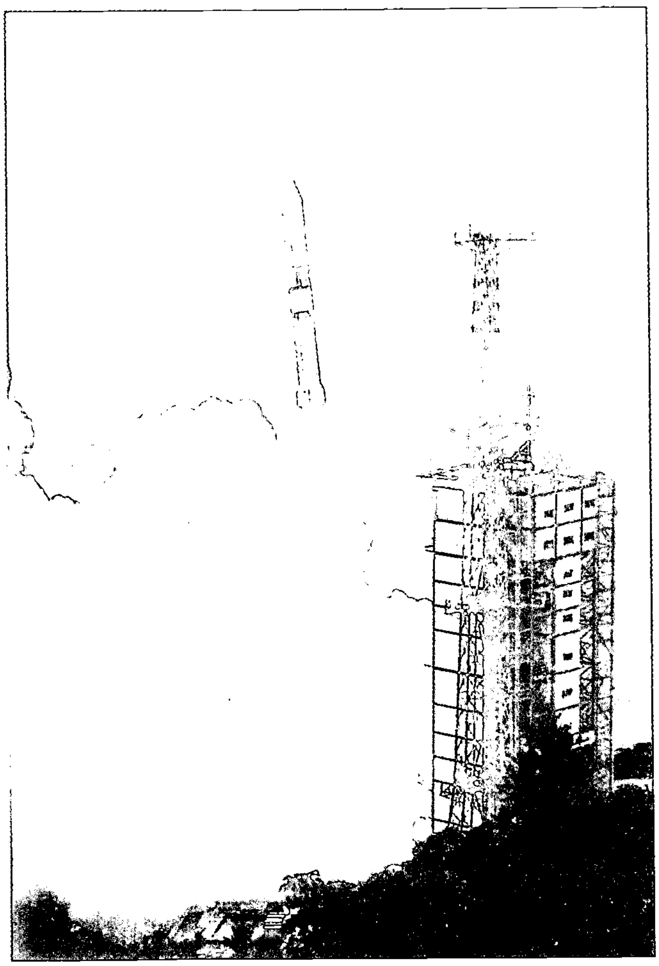
Japan exists in an environment that is changing dramatically. The key to solving our problems in a changing world is to concentrate the knowledge and wisdom of humankind on the basis of scientific research.

### (3) The Science and Technology Basic Law and the Science and Technology Basic Plan—Establishing a Nation Based on the Creativity of Science and Technology

Growing awareness of the importance of science and technology, as well as changes in the world situation, led to the Science and Technology Basic Law, which was proposed by Diet members and passed unanimously by the Diet in November 1995. As stated in the first article of the new law, its objective is "to achieve a higher standard of science and technology (hereinafter referred to as 'S&T'), to contribute to the development of the economy and society in Japan and to the improvement of the welfare of the nation, as well as to contribute to the progress of S&T in the world and the sustainable development of human society." In July 1996 the Science and Technology Basic Plan, which is based on the Science and Technology Basic Law, was adopted by cabinet decision. This plan provides a framework for comprehensive and systematic efforts to establish a nation based on the creativity of science and technology. One of the most important priorities in this program is the reinforcement of basic and creative research and development activities. Universities, as the leading centers for basic research, will have a very important role to play.

# Chapter 1

# Conceptual Foundations for Promoting Scientific Research



*Launching Japan's M-V Rocket.*

# Section 1: The Significance and Role of Scientific Research

## 1. The Basic Nature of Scientific Research

Scientific research is a universal, creative intellectual activity deriving from the fundamental human desire to seek knowledge and truth. Scientific research aims to discover new laws and principles, establish analytical and synthetic methodologies, systematize new knowledge and technology, and pioneer advanced fields of learning. It spans all disciplines from the humanities and social sciences to the natural sciences, depends on researchers' ability to develop their ideas freely and pursue research activities autonomously, and is carried out mainly in universities and their affiliated research institutions. The fruits of scientific research have inherent cultural value as intellectual assets and public commodities shared by all humanity. Transformed into applications and technology that support and enrich our lives, they also provide a basis for advancing humanity and society.

In view of these characteristics, scientific research should basically be supported by the government. This is reflected in a report produced by the Group on the Science System, an arm of the Committee for Scientific and Technological Policy established by the Organization for Economic Cooperation and Development (OECD), which identifies scientific research, which in most countries has been traditionally carried out in universities, as a public commodity that is supported by public funding (Chapter 4, Section 3.1(1)). "Realizing Our Potential," the science and technology white paper presented to the British parliament in 1993, reasons that the government should encourage scientific research because the fruits of such research belong to the society and the national economy as a whole, and not solely to those who conduct or fund it. In economics, a "public commodity" is defined as an item for which supply would not meet society's demand if left solely to market transactions (a "market failure" situation), but which could be supplied in sufficient quantities if governments provide appropriate fiscal support.

### The Role of University-Based Scientific Research in Socioeconomic Development

Analysis of economic growth according to the endogenous growth theory shows that a portion of growth cannot be explained solely by increases in the quantity of labor and capital. That portion is referred to as "total factor productivity" (TFP). It has been measured by governments and researchers in many countries, including the authors of Japan's Economic White Paper (an annual report on the state of the Japanese economy), and its strategic importance to socioeconomic development is widely recognized.

This perspective was reflected in the 1962 Education White Paper, which focused on "Japan's Growth And Education." A pioneering attempt to demonstrate, through measurement and other means, that education makes a major contribution to Japan's economic growth, this white paper concluded that "it is necessary to consider the role to be played by education on a broader basis: Education should not only aim to contribute to the economic growth of society, but also aim at the development of individual citizens who will find their proper place in the rich future society." The white paper also offered the following analysis of the role of universities and university-based scientific research.

- Economic growth today is driven by technological innovation. Rapid production increases result not so much from increases in infrastructure and in the workforce as from dramatic improvements in the level of science and technology and from the widespread application of new advances. The keys to this growth are scientific creativity, technical skills, the quality of the labor force, and people's ability to make full use of resources, all of which depend heavily on the spread and advancement of education.
- Modern industry's production capacity cannot continue to grow without people who are able to build highly productive facilities and equipment, people who can operate them, and people with the organizational and managerial skills to effectively link infrastructure with labor resources. We must therefore actively seek to advance people's skills in all of these areas. Education must play the leading role in this endeavor.

- Technological innovation derives from advanced scientific research, which means that basic research, as well as development and applied research, will become increasingly important, creating a fundamental need to train highly capable researchers. Moreover, improvements in production technology demand training of large numbers of skilled technicians and workers. Expanding science and engineering programs and improving research setups in institutions of higher education are, therefore, central priorities. Obviously, this does not mean merely the acquisition of specialized knowledge and technology in the narrow sense, but implies the training of scientists and technicians who also have acquired the broad range of basic academic skills and general education needed in an evolving industrial society.

Universities and scientific research thus play a crucial role in socioeconomic development. Japan's "catch-up" development strategy is now a thing of the past. To provide the driving force for our country's future development in an environment defined not only by limited resources and energy but also by a falling birth rate and a rapidly aging population, universities must undertake basic and original research, which the private sector cannot handle adequately, and make better use of the results in education and human resource development.

## 2. Rising Expectations of Scientific Research

The level of Japanese scientific research has improved, and at the same time, the country has come to play an increasingly important role in the international arena. Because of this, Japan is being strongly urged to step up its involvement in creative and advanced scientific research and to contribute actively to global progress in this area. Moreover, Japan's population is aging at an unprecedented rate at a time when the world is moving into an era of mega-competition in a globalized, borderless economy. There is growing concern that such changes could lead to a variety of crises for Japan, including the hollowing out of its industries, a loss of social vitality, and a decline in living standards. In addition, a number of global issues are looming on the horizon for all humanity, including the people of Japan: the global environment, food supplies, resources and energy, and infectious diseases, such as AIDS.

To deal head-on with the domestic and global problems that lie ahead, we must strive to restore our creativity and dynamism and establish a nation based on the creativity of science and technology. Japan must also play a leading role in efforts to concentrate the knowledge and wisdom of humankind as we work to build a path to the future.

If resource-poor Japan is to build a sustainably dynamic and affluent society and play a role commensurate with its status in the international community as we move into the 21st century, scientific research, which lays the foundations for scientific and technological development, must be considered as an investment in the future. We must promote highly creative scientific research at the most advanced level in the world. More is expected of scientific research than ever before.

## 3. Implementing the Science and Technology Basic Plan

Against this backdrop of heightened expectations of science and technology, the Science and Technology Basic Law was promulgated and put into effect in November 1995, and the Science and Technology Basic Plan was formulated by the Council for Science and Technology and approved by cabinet decision in July 1996.

This plan, which looks ahead over the next decade, was created as a concrete policy for science and technology in the five years between fiscal 1996 and 2000. It defines two basic directions for the promotion of research and development: (1) the vigorous promotion of research and development in response to social and economic needs; and (2) the active encouragement of basic research having aims like explaining the origins of matter and the behavior of the universe or discovering new laws and principles.

The plan also defines a number of goals. First, Japan should create systems to expand creative research and development: The Program to Support 10,000 Postdoctorals should be implemented by the year 2000; research-support staff should be recruited and trained; and the amount of research funding provided in a competitive environment should be substantially increased. Second, systems should be created to facilitate cooperation and exchange between sectors, regions, and nations. Such systems should, for example, encourage joint research with the private sector and promote industrial-academic-governmental cooperation by facilitating approval for government personnel to work in the private sector. Third, new research and development systems should be created, including setting up appropriate evaluation mechanisms and implementing impartial evaluation of work. Fourth, suitable infrastructure should be created through such measures as the prompt improvement of superannuated or cramped facilities and equipment.

The plan also calls for expanding the government research and development investment by the early 21st century to a level comparable with industrially advanced Western nations in terms of the percentage of gross domestic product. Along the same lines, the plan strongly advocates doubling science and technology expenditures within the period covered, which would mean spending a total of approximately ¥17 trillion by FY2000. At the same time, however, fiscal reconstruction is also an urgent priority for Japan. So the plan calls on the government to give proper consideration to science and technology when the budget is drafted each year, increasing expenditures as needed to implement the plan, while at the same time taking account of the fiscal situation and other factors. The June 1997 cabinet decision on the Promotion of Fiscal Restructuring identifies the years from FY1998 to FY2000 as a period of intensive reform. In view of the fiscal crisis, the government will adopt a flexible approach in implementing the plan to ensure compatibility with the restructured budget.

Promoting research and development means encouraging both basic research and research and development in key fields. Care must be taken to achieve balanced progress in the three areas of basic, applied, and development research, as well as between the natural sciences and the humanities and social sciences. Progress in research must harmonize with human lifestyles, society, and nature. In addition, researchers' autonomy must be respected, and the characteristics of research in universities must be taken into consideration.

In line with Science Council and other recommendations, MESSC has for some time been making systematic, prioritized efforts to bring Japan's research infrastructure up to international standards and to create a scientific research system that is open to the world.

MESSC is actively taking measures to advance the scientific research and related policies laid out in the Science and Technology Basic Plan. Specific steps taken in the first year, fiscal 1996, included (1) substantially increasing grants-in-aid for scientific research, (2) creating a system to provide funding to the Japan Society for the Promotion of Science (for the Research for the Future Program), (3) enhancing the research environment, including facilities and support systems, (4) forming Centers of Excellence in research (COEs), (5) promoting research under the New Program (Creative Basic Research) system, (6) recruiting and training young researchers in preparation for the Program to Support 10,000 Postdoctorals, (7) improving scientific information infrastructure, (8) promoting basic research in selected fields, such as space science, (9) setting up a program to establish high-tech research centers at private universities, (10) promoting research cooperation between universities and industry, and (11) promoting international exchange and cooperation in science. These measures are being furthered in fiscal 1997 through continued substantial budget increases that have brought funding for scientific research to ¥112.2 billion (¥10.4 billion over FY1996) and support for the Japan Society for the Promotion of Science to ¥20.6 billion (a ¥9.6 billion increase). Grants were also awarded to 5,701 researchers under the Program to Support 10,000 Postdoctorals (an increase of 1,145 over 1996), and the Private University Scientific Frontier Promotion Program was established (¥3.85 billion).

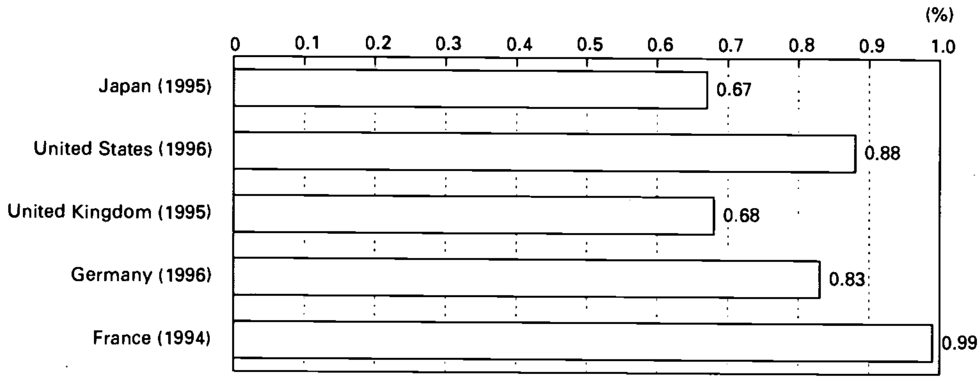
MESSC will continue making special efforts to expand the budget for expenditures that are essential to promote scientific research in universities and will make every effort to achieve the goals laid down in the Science and Technology Basic Plan.

**Underlying Idea of the Science and Technology Basic Plan Proposal to Promptly Double the Government Research and Development Investment**

The Science and Technology Basic Plan states that it is necessary to raise the total budget for science and technology to some ¥17 trillion by FY2000. This figure represents the total of the annual expenditures that would be required to double the government research and development investment and bring it up to a percentage of GDP that is comparable with major Western nations by FY2000 (Figure 1 shows the most recent data).

The inclusion of such a specific numerical target in the Science and Technology Basic Plan derives from the perception that, while Japan's investment in development and applied research, especially by private sector firms, is exceedingly high by international standards, research and development investment by the government, which is the main supporter of basic research, is very low compared with Western nations (Figure 2), and that the improvement of this situation is extremely important to the advancement of science and technology in Japan. The total government budget for science and technology in fiscal 1997 is ¥3,002.8 billion. Of this, MESSC has been given jurisdiction over ¥1,289.0 billion (42.9%), the largest allotment of any government agency (Figure 2-8).

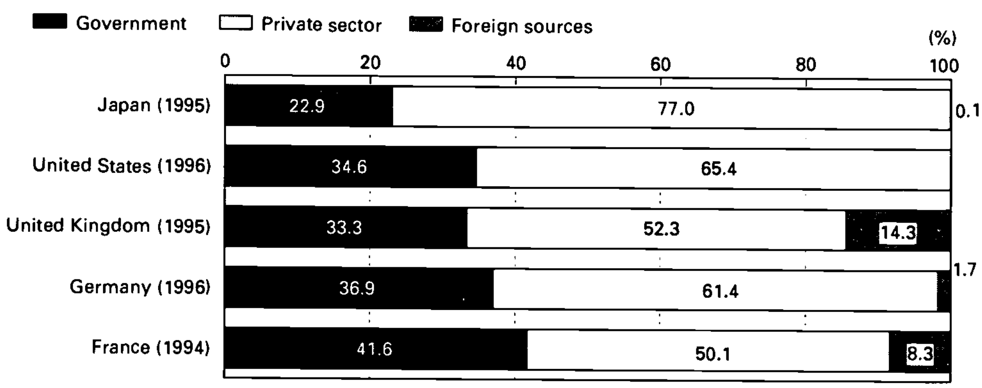
**Figure 1: Government Research Funding in Major Nations as a Percentage of GDP**




Note: The figure for the United States is provisional, while that for Germany is an estimate.

Sources: Japan: Management and Coordination Agency, "Survey of Research and Development;" Other countries: calculated from OECD, "Main Science and Technology Indicators" (1997-1).

**Figure 2: Contribution to Research Funding in Major Nations by Type of Organization**




Notes: 1. The figure for the United States is provisional, while that for Germany is an estimate. 2. Funding from sources other than the government and foreign sources has been totaled as the private sector contribution. 3. The percentages may not add up to 100% due to rounding figures.

Sources: Japan: Management and Coordination Agency, "Survey of Research and Development;" Other countries: calculated from OECD, "Main Science and Technology Indicators" (1997-1).

# Section 2: The Contribution of Scientific Research to Establishing a Nation Based on the Creativity of Science and Technology

## 1. Science and Technology

Science is a comprehensive, general concept. Its most important element is the systematization of knowledge. Scientific research is a wide-ranging, intellectual, creative activity spanning all disciplines and fields from the humanities and social sciences to the natural sciences. It aims to discover new laws and principles, establish analytical and synthetic methodologies, systematize new knowledge and technologies, and explore advanced fields of learning.

Throughout human history, scientific research—the systematization and advancement of knowledge—has developed systematically and been accompanied by education and the development of human resources in an environment of freedom. The ancient Greek philosophers gathered in the agora (public forum) to engage in free and lively debate. They formed various schools of thought, such as Stoicism, that enabled their philosophical systems to be handed down and developed. In medieval Europe, the University of Bologna in northern Italy was able to advance legal research and education after gaining its autonomy. Within and influenced by historical and cultural context, humans have eagerly advanced scientific research, primarily in universities, which have served as centers for the systematization of knowledge. This process has provided the foundation for the flowering of civilization and culture.

Thanks to this historical legacy, universities in Japan today are assured the autonomy that enables them to play a central role in scientific research and integrate research activities with education and the training of researchers. In 1996 there were approximately 243,000 researchers in Japanese universities, of whom about 165,000 were working in the natural sciences (Figure 2-1).

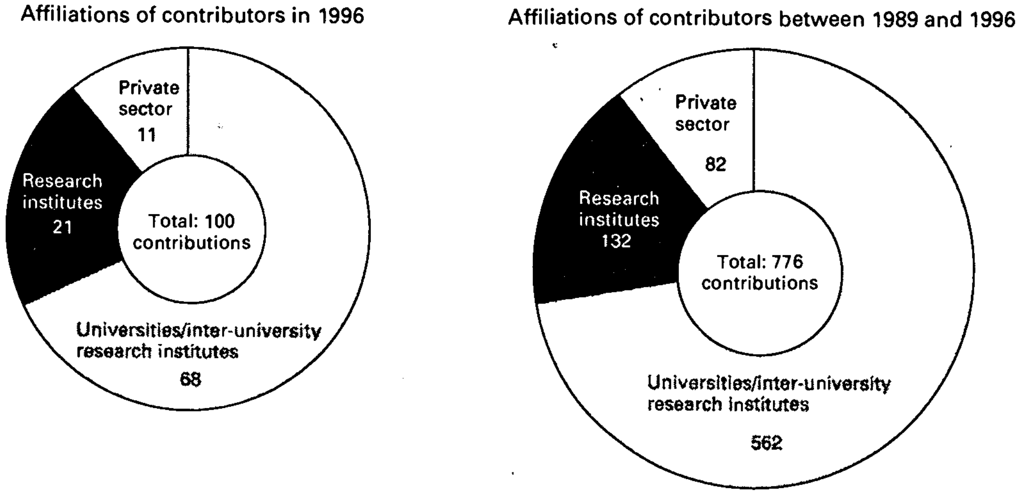
Since the industrial revolution in the 18th century, natural science, in particular, has been linked to industrial activity, which has embodied it in technology and continuously improved it. Science and technology have made mass production and mass consumption possible and become indispensable elements of civilization.

In Japan, this kind of research and development has, of course, been conducted mainly by companies in the private sector. In fiscal 1995, this sector accounted for 65.2% of total research expenditure. Of this, 71.3% targeted the development of new or improved materials, devices, systems, and processes; 22.0% was spent on applied research to discover practical uses of knowledge gained through basic research (Figure 2-7). In 1996 large business corporations (those capitalized at ¥10 million or more) and special corporations not engaged primarily in research employed approximately 384,000 researchers (of whom about 380,000 were conducting research in fields related to the natural sciences). In addition, experiment and research institutions and other facilities operated by national and local government agencies conduct research and development, primarily in fields related to the natural sciences, in line with specific policy goals like contributing to the national economy or industrial development. In 1996 approximately 46,000 researchers were employed in national and other public research institutes and institutes owned by incorporated nonprofit organizations; of these, about 42,000 were involved in work relating to the natural sciences (Figure 2-1).

This type of scientific and technological research and development is also based on scientific research in universities. And only when the results attained by practically oriented research and development have been incorporated into the intellectual systems of scientific research can humanity's intellectual assets be further developed and renovated.

The majority of contributions from Japan to the British science journal *Nature* are by researchers working in universities and inter-university research institutes (Figure 1-4), an indication that the research carried out in these institutions is highly evaluated by the international community.

**Figure 1-4. Affiliations of the Authors of Contributions from Japan to the Science Journal *Nature***




Notes: 1. Where the authors of a published paper are from more than one organization, as is the case with most papers, it is counted as one paper from each of the organizations. 2. "Research institute" refers to an experiment or research facility operated by a national or local government agency, a special corporation, or an incorporated nonprofit organization.
Source: "Nature Japan Top 10" home page (http://www.naturejpn.com).

## 2. The Importance of Basic Research

Universities provide an environment in which researchers can engage in wide-ranging research without restriction on their ideas and concepts, and in which the fruits of such work can be utilized systematically in education to develop human resources to contribute to all sectors of society.

Fundamentally, research should be viewed comprehensively, as the composite of activity spanning a wide spectrum of fields, including the humanities and social sciences. Because of the distinction between acquiring knowledge and putting it to practical use, however, research has traditionally been divided into categories like basic, applied, and development research (Chapter 2, Section 2(1)). Of expenditures for natural science research in Japanese universities in fiscal 1995, basic research accounted for 53.0%, applied research for 37.6%, and development research for 9.3%. The corresponding ratios for companies were 6.6%, 22.0%, and 71.3% respectively (Figure 2-7).

Universities thus play a central role in basic research in Japan, a role that other organizations cannot, in fact, be expected to fulfill. At the same time, universities integrate basic research with applied and development research and constantly return the results to society through education and human resource development.

The importance of basic research is described as follows in the Science and Technology Basic Plan and the German Science Council's "Theses for Research in the Universities," published in 1996.

**Science and Technology Basic Plan**

The goals of basic research are to discover new laws and principles, develop original theories, and predict and discover unknown phenomena in an effort to answer questions about the origins of matter, the behavior of the universe, and the phenomenon of life. The results of such research have intrinsic value as shared intellectual assets that contribute to the advancement of human culture. They can also instill hope and pride in a nation's people. Sometimes new research findings can have a great impact on society by leading to revolutionary changes in technological systems or by creating totally new fields of technology. Moreover, a profound understanding of nature and humanity is a major prerequisite if humanity is to achieve continuing progress while maintaining harmony with nature. In view of the importance of these contributions, we will actively promote basic research.

**The German Science Council's "Theses for Research in the Universities" (*Thesen zur Forshung in den Hochschulen*)**

Basic research is prerequisite to the development of wide-ranging knowledge. Over the long term, basic research assures scientific and technological innovation and the ability to put it to practical uses. Because basic research has this significance, its promotion must not be limited by standards derived directly from evaluation in terms of economics, industry, or technology. . . . Universities are the most important centers for basic research that researchers conduct of their own volition. . . . Research carried out in universities not only contributes to the advancement of knowledge in specific fields, but also ensures the regeneration of existing knowledge, laws, and theories in all fields. . . . The benefits of basic research cannot be achieved through short-term subsidization, and the need for a certain degree of flexibility with regard to time frames must be taken into consideration. Sustained subsidization contributes to the efficient allocation of funds in the long run. Applied research in universities is closely linked to basic research in a relationship characterized by fluid shifts. An important prerequisite to pursuing applied research is to establish effective cooperative ties with those outside the university who will utilize the results. [Translated from Japanese. Trans.]

"Science in the National Interest," a report issued by the Clinton Administration in August 1994, identifies investment in science as America's top priority for the future. The report emphasizes the vital importance of on-going investment in basic research and makes a number of recommendations, including the establishment of targets for basic research and education, and, to achieve those targets, the development of closer cooperation between the federal government and industry, universities, schools, and local governments. In "Endless Frontier, Limited Resources," a report published in April 1996 in response to a question from the President, the Council on Competitiveness calls for enhancing universities' human resource development and educational functions vis-à-vis science and technology, and for closer cooperation between universities and industry.

## 3. Goals for Science and Technology Administration

As discussed above, awareness of the importance of basic research has been growing in recent years on both the national and international levels. Other changes are also apparent.

First, there is a growing range of fields in which basic research is closely linked to applied and development research, such as bioscience, where basic research results lead to immediate practical benefits.

Second, in more and more fields, research is coming to depend on cooperation among numerous institutes and researchers. This is especially true of so-called big science, including accelerator science and research on nuclear fusion, research in the human genome (a set of chromosomes containing all the genetic information required to construct an organism), brain research, cancer and AIDS research, and strategic research, such as environmental science.

Third, a growing number of multidisciplinary fields, such as the global environment, bioscience, and information, demand joint effort encompassing the humanities and social sciences as well as natural sciences and their derivative areas of science and technology.

If progress in these areas is to be taken into consideration, it will be necessary to promote comprehensive, balanced policies that keep in view the entire range of scientific research and take account of interrelationships between natural sciences and the humanities and social sciences.

This view is reflected in the three principles underlying MESSC's approach to promoting scientific research: (1) respect for researchers' autonomy, (2) the development of a research base that encompasses all fields from the humanities and social sciences to the natural sciences, and (3) the integration of research with education and human resource development. Key aspects of policy are implemented on the basis of these principles and recommendations from the Science Council, a board set up to advise the Minister of Education, Science, Sports and Culture. Overall coordination of the policies of Japanese government organs involved with science and technology, except those that relate solely to the humanities and social sciences, is provided by the Council for Science and Technology, which advises the Prime Minister.

This board is chaired by the Prime Minister and composed of relevant ministers, including the Minister of Education, Science, Sports and Culture, together with various experts. Deliberations by the Council for Science and Technology also cover scientific research in universities, which is essential for the advancement of science and technology in Japan. Secretariat services are provided jointly by MESSC and the Science and Technology Agency.

# Chapter 2

# Basic Policies for the Promotion of Science


*The International Symposium on Disasters and Health was held in Manila in October 1996 as part of exchange activities organized under the Core University System developed by the Japan Society for the Promotion of Science. The Core Universities for the symposium, which focused on medical science, were Kobe University and the University of the Philippines.*

# Section 1: Improving the Infrastructure for Scientific Research

The factors that need to be taken into account when considering policies to promote scientific research can be broadly divided into the following four areas: (1) researchers and support personnel to assist them; (2) direct funding requirements for actual research activities; (3) facilities as venues for research activities and equipment as tools for research; (4) information for use in research, including books and data from experiments and observations, and resources like specimens and laboratory animals.

These items are essential in all fields of research. MESSC has been working to develop and improve these resources, which constitute the infrastructure for all scientific research.

This section will provide an overview of the present situation and measures currently being taken with regard to research personnel, research funding, research facilities and equipment, and scientific information and resources. It will also examine future issues.

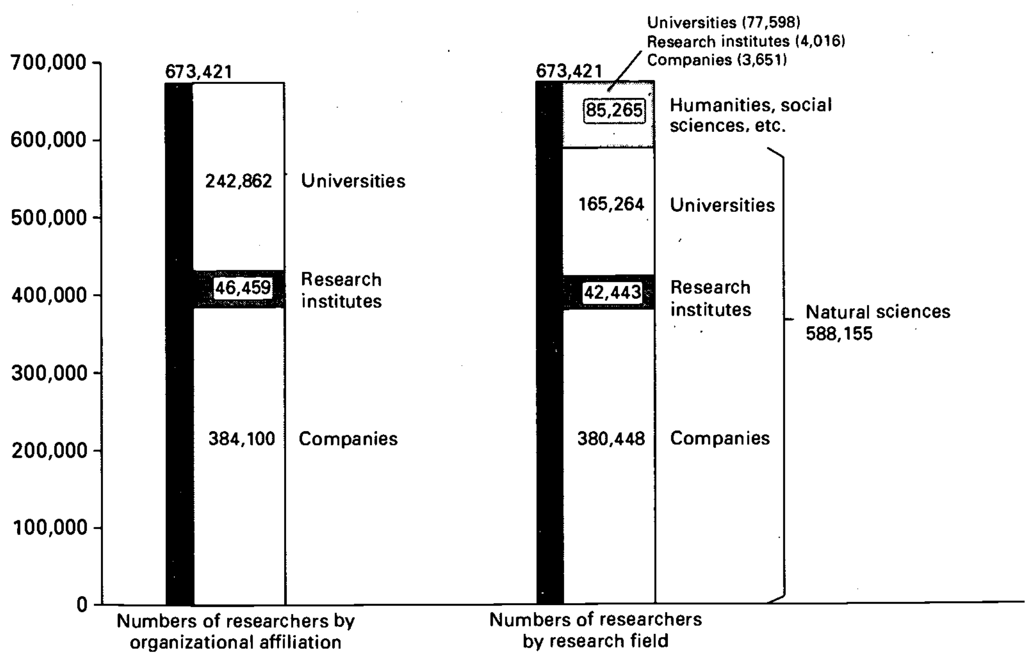
## 1. Recruitment and Training of Research Personnel

### (1) Status of Research Personnel in Japan

According to the Survey of Research and Development conducted by the Management and Coordination Agency, there were approximately 673,000 researchers in Japan as of April 1, 1996. A breakdown by affiliation shows that approximately 384,000, or over one-half, were employed by companies. Those working in universities made up the next biggest group at about 243,000, while approximately 46,000 worked in research institutes. About 588,000 (almost 90%) were involved in research in the natural sciences. This percentage rose to 99% among company researchers. Over 90% of researchers in humanities and social science fields were employed in universities. (Figure 2-1).

An analysis of annual trends in the number

**Figure 2-1: Breakdown of Researchers by Organization Type and Research Field (April 1, 1996)**




Notes: 1. "Universities" includes university departments (including graduate schools), university research institutes, inter-university research institutes, junior colleges, and colleges of technology. 2. "Research institutes" includes national, local public, and private experiment, survey, and research institutes and special corporations engaged primarily in research. 3. "Companies" refers to firms capitalized at ¥10 million or more and special corporations that do not engage primarily in research. 4. Since the figures are estimated, the totals may not agree.

Source: Management and Coordination Agency, "Survey of Research and Development" (1996).

of researchers shows that the 1996 total is approximately double the 1975 figure and 1.5 times higher than the 1985 level. The number of researchers has increased in all types of organizations, but the percentage of increase for companies has been greater than for research institutes and universities (Table 2-1).

## (2) Current Situation and Goals Relating to University Researchers

Teaching personnel in universities and inter-university research institutes play a central role in promoting scientific research (see Column). As of April 1, 1996, there were about 160,000 teaching personnel in these institutions (Table 2-2).

By educating graduate students, universities and inter-university research institutes also play a leading role in training young researchers.

Analysis of the age mix of teaching personnel, however, shows a downtrend in the number of researchers in their twenties. This is one problem faced in maintaining the vitality of university research (Figure 2-2). Training for young researchers must be improved to prevent a decline in opportunities for them to conduct research in positions of responsibility or a drop in the number of people who will be able to undertake research in the future.

**Table 2-1: Annual Trends in the Number of Researchers**

(Number of researchers)

| Year / Organization | Total | Universities | Research Institutes | Companies |
|---|---|---|---|---|
| 1975 | 310,111 | 134,458 | 29,049 | 146,604 |
| 1985 | 447,719 | 180,606 | 36,016 | 231,097 |
| | [1.44] | [1.34] | [1.24] | [1.58] |
| 1996 | 673,421 | 242,862 | 46,459 | 384,100 |
| | [2.17] | [1.81] | [1.60] | [2.62] |

Note: Figures in parentheses denote rates of increase (fiscal 1975 = 1.00).
Source: Management and Coordination Agency, "Survey of Research and Development" (1996).

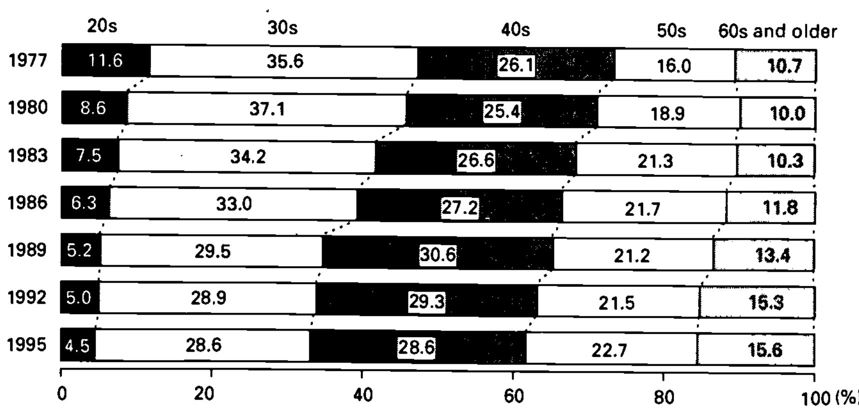
**Table 2-2: Number of Teaching Personnel in Universities and Inter-University Research Institutes**

(Number of researchers)

| National | Local Public | Private | Total |
|---|---|---|---|
| 63,031 | 11,003 | 89,291 | 163,325 |

Source: Management and Coordination Agency, "Survey of Research and Development" (1996).

**Figure 2-2: Trends in Age Mix of University Teaching Personnel**




Note: Figures may not add up to 100% due to rounding.
Source: MESSC, "Statistical Survey on School Teachers."

## Inter-University Research Institutes

### University Research Institutes
As of July 1997, there were 587 universities in Japan. In addition to their undergraduate faculties and graduate schools, these universities have also established research institutes and facilities to carry out research in specialized fields. In the national universities there are 62 affiliated research institutes (of which 20 are used jointly by researchers from universities throughout Japan) and 422 research facilities attached to faculties. These institutes and facilities conduct distinctive types of research in coordination with teaching and research in undergraduate and graduate schools.

In addition, 14 independent facilities, unaffiliated with any particular university, have been set up for joint use by university researchers.

### Inter-University Research Institutes
Institutes that undertake research in specific fields have traditionally been attached to the universities with which they have the closest ties. Progress in scientific research, however, created the need for organizations that transcended university boundaries and brought together researchers from all over Japan. The National Laboratory for High Energy Physics, established in April 1971, was the first research institute set up under the direct jurisdiction of MESSC with no specific university affiliation. (In April 1997 it was reorganized as the High Energy Accelerator Research Organization.)

Inter-university research institutes have made an important contribution to the progress of scientific research in various fields by bringing together researchers from throughout Japan and by maintaining large-scale facilities and data resources that would be beyond the capabilities of individual universities. They also cooperate in university education.

**Inter-University Research Institutes (Fiscal 1997)**

| Institute | Date of establishment | Purpose |
|---|---|---|
| High Energy Accelerator Research Organization | 1997 (reorganized) (Established in 1971 as the National Laboratory for High Energy Physics) | Direct management of research facilities (Accelerator Laboratory and Applied Research Laboratory) and integrated administration of the Institute of Particle and Nuclear Studies and the Institute of Materials Structure Science. |
| Institute of Particle and Nuclear Studies | 1997 | Research into elementary particles and nuclei using high energy particle-accelerators, and related theoretical studies. |
| Institute of Materials Structure Science | 1997 | Research into materials structure and function using synchrotron light and particle beams produced with high energy particle-accelerators, and related theoretical studies. |
| Okazaki National Research Institutes | 1981 (amalgamated) | Integrated administration of the Institute for Molecular Science, the National Institute for Basic Biology, and the National Institute for Physiological Sciences. |
| Institute for Molecular Science | 1975 | Research into the structure and functions of molecules and theoretical research pertaining thereto. |
| National Institute for Basic Biology | 1977 | Comprehensive research in basic biology. |
| National Institute for Physiological Sciences | 1977 | Comprehensive research in physiology. |
| National Institute of Polar Research | 1973 | Comprehensive polar research and observations. |
| Institute of Space and Astronautical Science | 1981 | Theoretical and applied research in space science and engineering. |
| National Institute of Genetics | 1984 | Comprehensive research in genetics. |

| | | |
|---|---|---|
| Institute of Statistical Mathematics | 1985 | Research into the mathematical principles of statistics and their application. |
| National Institute for Fusion Science | 1989 | Theoretical and applied research on nuclear fusion plasma. |
| National Astronomical Observatory | 1988 | Astronomical and related research, astronomical observations, almanac compilation, and administrative tasks related to setting and announcing Japan Standard Time and verifying clocks. |
| National Institute of Japanese Literature | 1972 | The survey, study, collection, collation, and preservation of documents and other resources relating to Japanese literature. |
| National Museum of Ethnology | 1974 | Collection and safekeeping of materials on various ethnic groups in the world as well as their exhibition before the public and research in ethnology. |
| National Museum of Japanese History | 1981 | Collection, safekeeping and public exhibition of Japanese historical, archaeological, and folk materials, and research pertaining thereto. |
| National Center for Science Information Systems | 1986 | Gathering, collating, and distributing scientific information, and carrying out comprehensive research and development relating to scientific information systems. |
| International Research Center for Japanese Studies | 1987 | International and interdisciplinary research into Japanese culture and research cooperation with Japanologists abroad. |
| National Institute of Multimedia Education | 1997 (reorganized) (Established in 1978; English name unchanged after reorganization) | Research and development of curricula and methods for education using various media, and reports on the results of research and development activities. |

14 organizations and 17 research institutes

### (3) Training Promising Young Researchers

Scientific research is basically driven by individual researchers' unfettered ideas and commitment to research, so it cannot produce fruitful results without high-quality researchers. The level of scientific research in the future depends on how researchers are recruited and trained.

Most of the young researchers who are expected to take the lead in future research are also playing a vital role in current research activities and have the potential, by virtue of their flexibility, to open up new directions in research. Securing and training outstanding young researchers is, therefore, the most important task that must be accomplished if we are to improve and advance scientific research. Doing so necessitates policies that foster the following qualities.

**(i) Creativity:** Most outstanding researchers have individuality, creativity, acute analytical skills, and lively curiosity. They also have broad perspectives and flexible intellects backed by extensive basic knowledge. Japan needs to foster young researchers who have these abilities and are constantly motivated to take on new research fields.

**(ii) An international orientation:** In view of the growing importance of international scientific cooperation and exchange and the international community's rising expectations of Japanese scientific research, it will be important for researchers to understand global research trends and participate actively in exchanges with their counterparts in other countries.

**(iii) Ability to respond aggressively to new fields:** Research is rapidly becoming more sophisticated and specialized. At the same time, developing interdisciplinary or totally new fields that go beyond traditional fields is becoming increasingly important to scientific progress. Japan needs to foster young researchers who can respond aggressively to these scientific trends.

**(iv) Abundant human qualities:** Japan needs researchers who are aware of their role and mission in society and are able to keep society and scholarship as a whole within their field of vision, rather than confining themselves to increasingly narrow fields of specialization, and who, at the same time, can harmonize science and technology with humanity, the society, and the global environment. Researchers should therefore have an abundance of the human qualities that will enable them to understand correctly their roles and responsibilities in society.

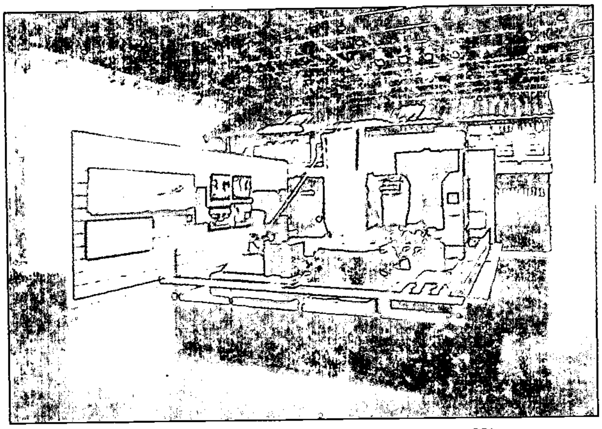
### (4) Promoting the Program to Support 10,000 Postdoctorals

In cooperation with other government organizations, MESSC is promoting a program to support 10,000 postdoctorals by FY2000. The aim of this program, which has been in progress since FY1996, is to recruit and train outstanding and creative young researchers.

The Science and Technology Basic Plan adopted in July 1996 calls for realizing the program's target by FY2000. In FY1997 MESSC, the Science and Technology Agency, the Ministry of International Trade and Industry (MITI), and the Ministry of Agriculture, Forestry and Fisheries will provide support to 7,926 postdoctoral researchers, an increase of 1,809 over the previous year. Of these, MESSC is supporting 5,701 researchers, an increase of 1,145 over the previous year. This represents over 70% of the total, evidence of the importance of MESSC's role in the program.

MESSC is promoting the following as part of the Program to Support 10,000 Postdoctoral Researchers. (Table 2-3, Figure 2-3).

**(a) JSPS Research Fellowships for Young Scientists:** To provide young researchers at the start of their careers with the opportunity to engage in full-time research and with the autonomy to freely select themes and venues for their research, this program appoints outstanding young



*A display at the National Museum of Japanese History.*

researchers who are currently enrolled in, or have completed, doctoral programs and who wish to carry out full-time research in universities or other research institutions. Those who are selected have opportunities to receive fellowships and research grants for periods of two or three years. This program was established in 1985 by the Japan Society for the Promotion of Science. It has been enhanced over the years and now forms the core of the Program to Support 10,000 Postdoctorals. This highly regarded program is an established part of the system for recruiting and training the young researchers who contribute to scientific research in Japan. (Figure 2-4)

In FY1997, a total of 3,570 doctoral course students (DCs) and postdoctoral researchers (PDs) will be supported under these fellowships (an increase of 400 over the previous year).

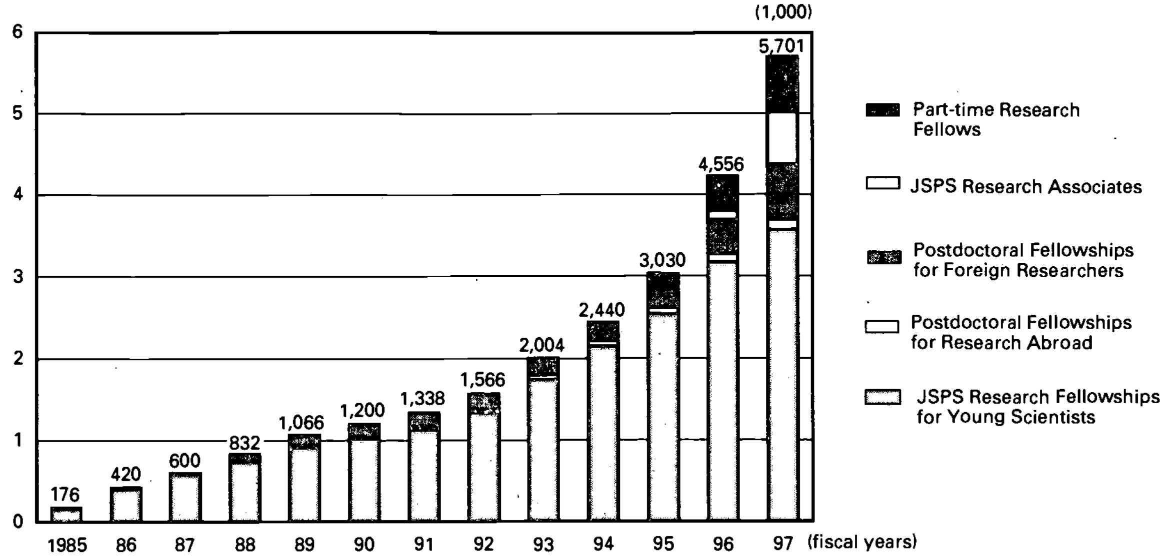
**(b) JSPS Research Fellowships for Young Scientists (Cancer, New Program, COEs):** Support is provided for young researchers who have completed doctoral courses and are participating in cancer research and research under the New Program System and the Center of Excellence (COE) Formation Program. A total of 80 will receive these fellowships in fiscal 1997, an increase of 10 over the previous year.

**(c) JSPS Postdoctoral Fellowships for Research Abroad:** This program was created to enable young Japanese researchers to devote themselves to long-term research in overseas universities and research institutes by providing living allowances, research funds, and other forms of assistance. The aim is to foster outstanding researchers who have an international perspective. In fiscal 1997, the number of researchers supported under this program will increase by 25 to 125.

**Table 2-3: MESSC Programs Related to the Program to Support 10,000 Postdoctorals**

| Category | JSPS Research Fellowships for Young Scientists | Postdoctoral Fellowships for Research Abroad | Postdoctoral Fellowships for Foreign Researchers | JSPS Research Associates | Part-Time Researchers |
|---|---|---|---|---|---|
| Implementing organization | JSPS | JSPS | JSPS | Research for the Future Program (JSPS), Universities, etc. | National universities (graduate schools, attached research institutes and facilities), inter-university research institutes |
| Qualifications | Doctoral course students (DC)<br>Postdoctoral fellows (PD) | Researchers who are employed full time in universities or other research institutes, or those who have doctorates and wish to be employed as full-time researchers in such institutions | People who have recently completed doctoral courses (within the past six years) | Persons with doctoral degrees or whom the appointment panel judges to have equivalent research abilities, and who have been recommended by research project team members or core members | Postdoctoral fellows (PD) |
| Age | Under 34 (under 36 in some cases) | Under 34 (under 36 in some cases) | | Under 40 | Under 35 |
| Period | DCs: 2 or 3 years<br>PDs: 3 years | 2 years | General: 2 years. COEs: 1 year. Special quota for American researchers<br>Short-term: 3–12 months<br>Long-term: 2 years | For the duration of the research project | As a rule, 2 years, subject to renewal each year (up to three years if necessary) |
| Types of payments | FY1997 monthly stipend<br>DCs: ¥200,000<br>PDs: ¥344,000<br>Research grant: Up to ¥1.5 million per year (Grant-in-aid for scientific research) | FY1997<br>Round-trip air fare, living expenses, research funds | FY1997<br>Round-trip air fare, living expenses, family allowance, housing allowance, etc.<br>Research grant: up to ¥1.5 million per year (Grant-in-aid for scientific research) (limited to persons appointed for at least one year) | FY1997<br>About ¥12,000–15,000 per day<br>Other allowances | FY1997<br>About ¥318,000 per month (including a commutation allowance) |
| Number of appointments | FY1997: 3,570 (including 1,390 new appointees)<br>DCs: 2,420 (including 970 new appointees)<br>PDs: 1,150 (including 420 new appointees) | FY1997: 125 | FY1997: 680<br>General: 560<br>COE: 30<br>Special quota for American researchers<br>Short-term: 45<br>Long-term: 45 | FY1997: 640 | FY1997: 686<br>Graduate schools (Venture Business Laboratory): 200<br>Attached research institutes: 161<br>Research facilities: 243<br>Inter-university research institutes: 82 |

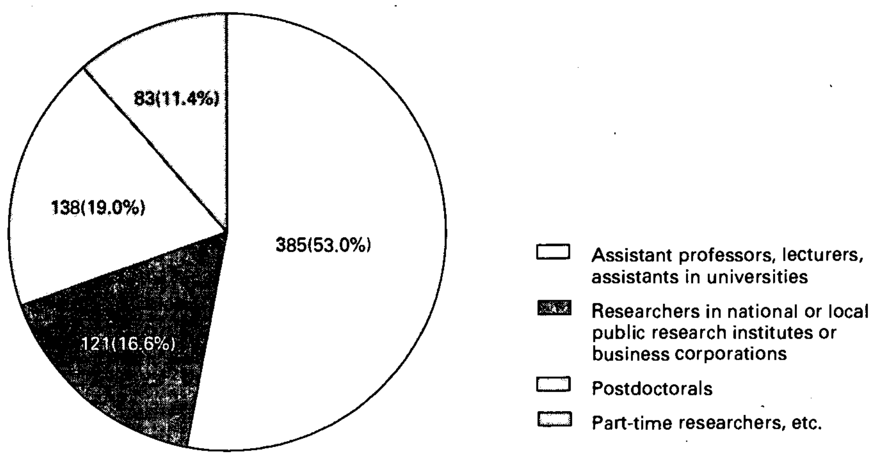
**Figure 2-3: Number of People Assisted by MESSC under the Program to Support 10,000 Postdoctorals**




| Fiscal Year | 1985 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JSPS Research Fellowships for Young Scientists | 156 | 400 | 580 | 740 | 916 | 1,020 | 1,128 | 1,336 | 1,744 | 2,150 | 2,540 | 3,170 | 3,570 |
| Postdoctoral Fellowships for Research Abroad | 20 | 20 | 20 | 20 | 20 | 25 | 35 | 45 | 55 | 65 | 75 | 100 | 125 |
| Postdoctoral Fellowships for Foreign Researchers | 0 | 0 | 0 | 72 | 130 | 155 | 175 | 185 | 205 | 225 | 255 | 420 | 680 |
| JSPS Research Associates | | | | | | | | | | | | 440 | 640 |
| Part-Time Research Fellows | | | | | | | | | | | 160 | 426 | 686 |

Source: MESSC.

**Figure 2-4: Employment Status of Recipients of JSPS Research Fellowships for Young Scientists**




Note: Based on a survey of the employment status of young researchers appointed in fiscal 1992 and 1993 one year after the completion of their appointment periods (as of April 1, 1996).
Source: JSPS.

**(d) JSPS Postdoctoral Fellowships for Foreign Researchers:** The purpose of this program is to contribute to training young researchers who have just obtained their doctorates in other countries by accepting them into Japanese universities. They receive living allowances and other assistance. The program also contributes to the training of young Japanese researchers by providing opportunities for interaction with researchers from other countries. In FY1997 support will be provided to 680 people, a rise of 260 over 1996.

*Researchers use an inverted microscope to study biological specimens collected in the Antarctic.*

**(e) JSPS Research Associates under the Research for the Future Program:** The JSPS Research for the Future Program was launched in FY1996. Young researchers who have completed doctoral courses can be employed by research institutes to participate in a research project under this program. In FY1997 the number of participants is expected to total 640, an increase of 200 over the previous year.

**(f) Part-Time Researchers:** By employing young postdoctoral researchers to work as part-time researchers, this program aims to contribute to recruiting, training, and improving the quality of young researchers and to facilitate research projects in national universities and inter-university research institutes. In fiscal 1997 assistance will be provided to 486 people, 160 more than the 1996 figure.

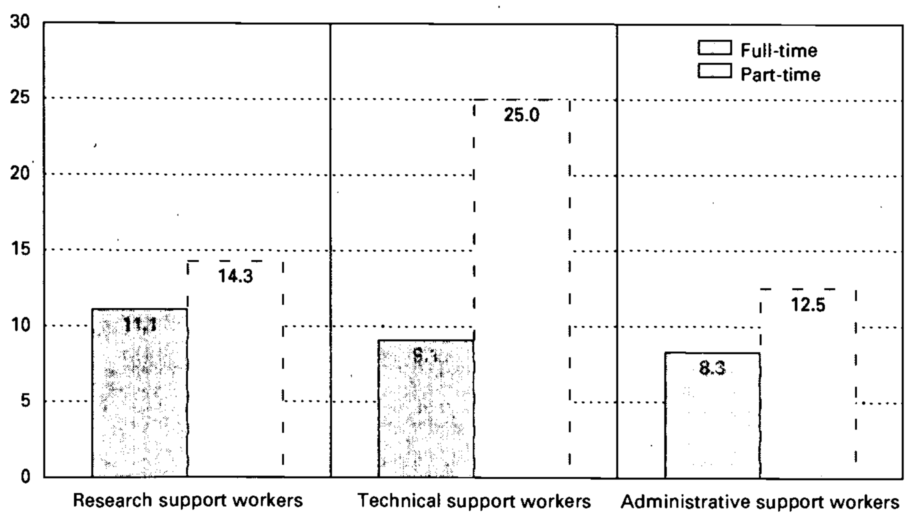
The Venture Business Laboratory (VBL) program was established to encourage creative research and development in the graduate schools of national universities as a way of sowing the seeds for new venture businesses. In fiscal 1997 the number of people receiving support under this scheme will grow by 100 to 200.

### (5) Securing Research Support Personnel

Research support personnel can be broadly divided into three categories depending on how they are involved in the activities of research organizations and projects. Research support workers assist researchers and support research work directly; technical support workers mainly perform essential technical tasks; and administrative support workers primarily handle research-related administrative and accounting tasks. These employees are indispensible human resources, the fundamental components of universities and other research organizations.

A MESSC survey of the research environment (page 42) shows that on the average, a full-time research support worker supports about eleven researchers, a technical support worker, nine, and an administrative support worker, eight. For part-time employees, the figures are approximately 14, 25, and 13, respectively (Figure 2-5). Around 70% of survey respondents thought the number of such support workers was inadequate.

**Figure 2-5: Number of Support Personnel per Researcher**




Source: MESSC, "Research Environment Survey" (fiscal 1996).

**Table 2-4: Improvements in Research Support Systems** (¥1million)

| Category | Budget for FY1996 | Budget for FY1997 | Yearly increase | Remarks Figures in parentheses represent numbers of personnel in FY1996. |
|---|---|---|---|---|
| (1) Research Assistants (RA) | 299 | 1,331 | 1,033 | Number of people enrolled in doctoral courses 2,405 (540) |
| (2) Promoting research support | 98 | 870 | 772 | Number of people with special skills 422 (50) |
| (3) Part-Time Researchers | 1,238 | 1,857 | 619 | Number of people who have completed doctoral courses 486 (326) |
| Total | 1,634 | 4,058 | 2,424 | |

Notes: 1. Research Assistants (RA): Enables outstanding doctoral students to participate as research assistants, thereby fostering their research skills while improving research systems. 2. Promoting research support: Ensures effective promotion of research projects by securing the cooperation and support of outside personnel with special skills that institutions are unable to provide for themselves. 3. Part-Time Researchers: Enables young researchers at the postdoctoral level to participate as part-time researchers, facilitating the smooth promotion of research projects while upgrading the quality of young researchers, thereby contributing to recruiting and training.
Source: MESSC.

One of the goals laid down in the Science and Technology Basic Plan is to increase the number of support staff in national universities and affiliated research institutions to about one for every two researchers as soon as possible. The eventual aim is to achieve a ratio of one support worker per researcher, as is the case in the United Kingdom, Germany, and France. MESSC therefore substantially expanded its funding for Research Assistants (RA), promoting research support, and Part-Time Researchers in fiscal 1997, an essential measure for effective promotion of research projects at national universities and inter-university research institutes (Table 2-4).

## 2. Expansion of Research Funds

### (1) Current State of Research Funds in Universities

According to the Survey of Research and Development conducted by the Management and Coordination Agency, total research funds in Japan, including the humanities and social sciences, reached ¥14,408.2 billion in fiscal 1995. Companies accounted for ¥9,395.9 billion, or 65.2%, of this total, and universities (including inter-university research institutes, junior colleges, and colleges of technology) for ¥2,982.2 billion, or 20.7%. Total research funding in Japan has increased approximately 1.6 times in the 10 years since 1986, when it was ¥9,192.9 billion. There has, however, been no significant shift in the share of the total that is spent by each type of research organization (Figure 2-6).

In fiscal 1995, public funds accounted for 22.9% of total research funds in Japan. This figure, the highest in the past 10 years, represents an increase of 1.4 percentage points compared with fiscal 1994 (Table 2-5).

Analysis of the characteristics of research funds (whether for basic and applied research or development*) in each type of organization shows that universities devote 53.0% to basic research, whereas research institutes and companies spend 54.4% and 71.3%, respectively, on development

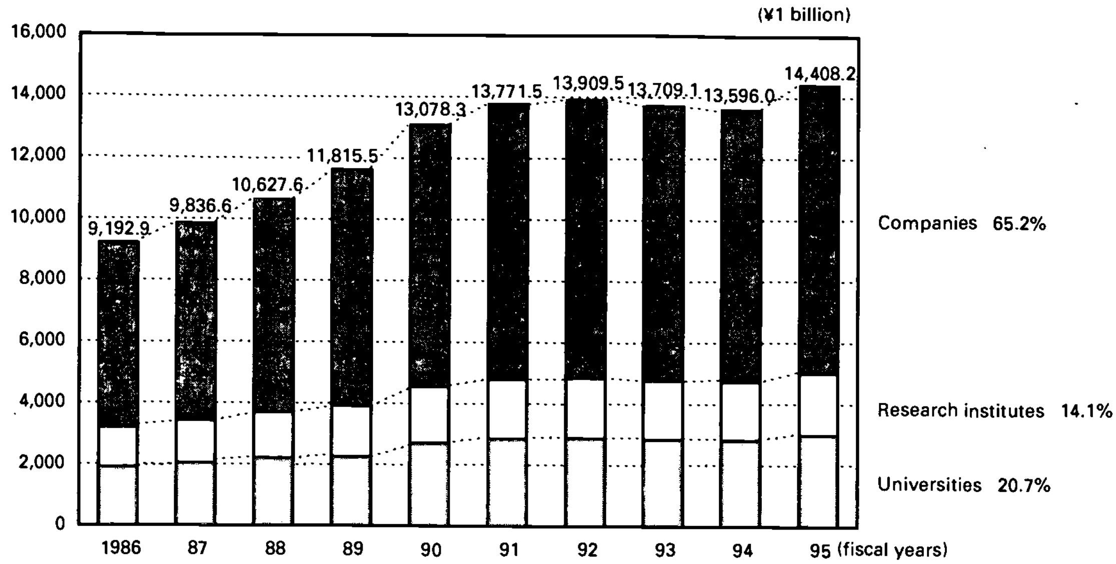
* The Management and Coordination Agency's "Survey of Research and Development" defines these terms as follows:

**Basic research:** Theoretical or experimental research undertaken for the formulation of hypotheses and theories, or for the acquisition of new knowledge, without any particular application or use in view.

**Applied research:** Research undertaken in order to determine possible uses of basic research with a specific practical aim or objective, or to explore a new form of application different from those that exist.

**Development:** The use of results gained from basic and applied research, or practical experience, that is directed to the introduction of new materials, equipment, products, systems, and processes, as well as to the improvement of those already introduced.

**Figure 2-6: Trends in Research Funding by Type of Organization**




Source: Management and Coordination Agency, "Survey of Research and Development."

**Table 2-5: Trends in Percentage of Public Research Funding** (¥1 billion)

| Fiscal year | Total research funds | Public research funds | Percentage of Public research funds |
|---|---|---|---|
| 1986 | 9,192.9 | 1,955.3 | 21.3% |
| 1987 | 9,836.6 | 2,111.8 | 21.5 |
| 1988 | 10,627.6 | 2,117.8 | 19.9 |
| 1989 | 11,815.5 | 2,202.4 | 18.6 |
| 1990 | 13,078.3 | 2,346.6 | 17.9 |
| 1991 | 13,771.5 | 2,504.5 | 18.2 |
| 1992 | 13,909.5 | 2,696.7 | 19.4 |
| 1993 | 13,709.1 | 2,965.8 | 21.6 |
| 1994 | 13,596.0 | 2,918.2 | 21.5 |
| 1995 | 14,408.2 | 3,292.4 | 22.9 |

Note: Public research funding represents the amount provided by central and local government organizations.
Source: Management and Coordination Agency, "Survey of Research and Development."

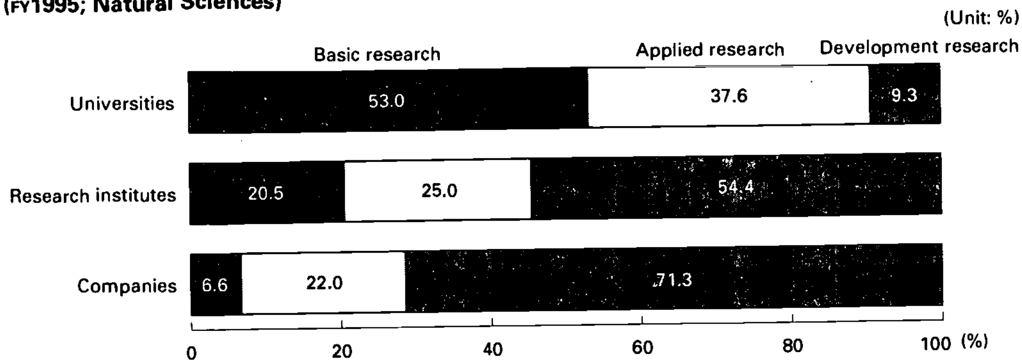
(Figure 2-7). These figures indicate that universities give priority to basic and applied research, whereas research institutes and companies focus mainly on applied and development research geared to the practical implementation of technology and the development of commercial products.

### (2) An Overview of MESSC's Research Budget

An analysis of science and technology expenditure in the overall government budget reveals that research-related expenditure in Japan will total ¥3,002.8 billion in fiscal 1997. Of this, MESSC will account for ¥1,289.0 billion, or 42.9%, the Science and Technology Agency for 24.5%, and MITI for 15.7% (Figure 2-8).

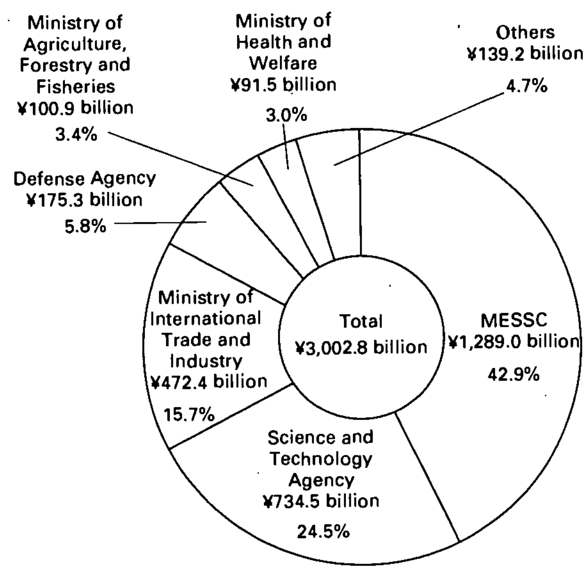
Funds for science and technology are provided by the allocation for science and technology in the general and special accounts. The MESSC general account has an appropriation of ¥324.1 billion, including ¥112.2 billion for grants-in-aid for scientific research, ¥39 billion for grants and investments by JSPS, ¥1.9 billion for local public universities, and ¥156.0 billion for private universities. The special account provides ¥964.8 billion for national universities including personnel salaries,

**Figure 2-7: Distribution of Research Expenditures by Type of Research (FY1995; Natural Sciences)**




Note: The figures may not add up to 100% because of rounding.
Source: Management and Coordination Agency, "Survey of Research and Development" (1996).

**Figure 2-8: Science and Technology Expenditure in the Fiscal 1997 Budget**




Source: Science and Technology Agency.

unit cost per professor, and facility improvement costs (Figure 2-9).

Funding for national universities is provided through the special account for national educational institutions, which is separate from the general account. This special account plays an important role not only in financing personnel salaries and the costs of day-to-day research in national universities and inter-university research institutes, but also in providing and improving all of the conditions necessary for education and research, including facilities and equipment.

Funding for local public and private universities is provided from the general account, reflecting the important function fulfilled by these institutions.

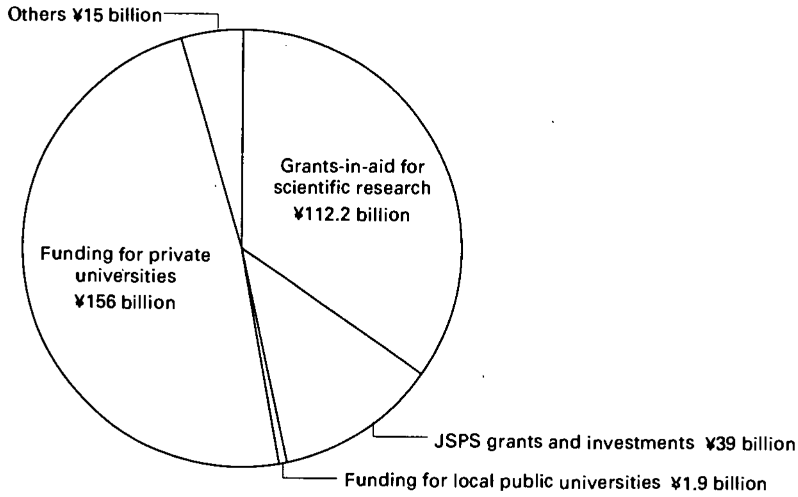
In the Science and Technology Basic Plan, research funds are divided into competitive funds, priority funds, and basic funds. The following discussion explains that portion of the MESSC research budget that bears on universities in terms of these categories.

## (3) Expansion of Competitive Funds

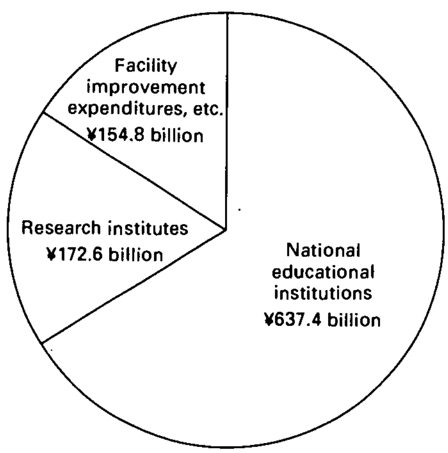
Competitive funds are allocated selectively to researchers or research groups on the basis of appropriate screening and evaluation. MESSC programs in this category include grants-in-aid for scientific research and research expenses pro-

**Figure 2-9: Breakdown of Science and Technology Expenditures by MESSC**

General account ¥324.1 billion (8.7% annual increase)




Special account for national educational institutions: ¥964.8 billion (2.3% yearly increase)




Source: MESSC.

vided under the Research for the Future Program. The Science and Technology Basic Plan calls for a substantial increase in these types of funding, and in view of their importance, MESSC has significantly increased its budget for grants-in-aid for scientific research.

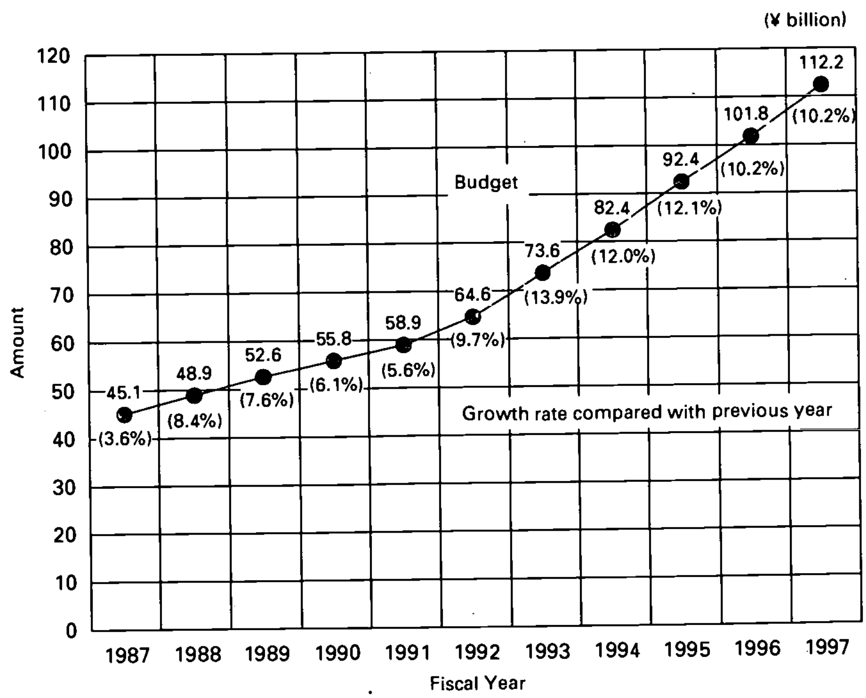
**(a) Grants-in-aid for scientific research:** Grants-in-aid for scientific research promote scientific research in Japan by stimulating appreciable progress in creative and pioneering research in all fields from the humanities and social sciences to the natural sciences. Grants are awarded to projects planned by individual researchers or research groups that involve particularly important basic research that is in keeping with current trends in scientific research (Table 2-6).

A budget of ¥112.2 billion has been allocated in fiscal 1997. As is apparent from trends in the budget (Figure 2-10), MESSC regards this as one of its most important programs for promoting scientific research. The high level of interest and anticipation with respect to these grants is apparent from Figure 2-11, which traces application and acceptance trends. In 1996 three out of five university researchers applied for grants. Grants-in-aid for scientific research are allocated on the basis of impartial screening by the Science Council. MESSC recognizes the importance of grants-in-aid for scientific research and is working to increase the amount provided as well as to promote systemic improvements and the disclosure of information (Table 2-7).

**Table 2-6: Research Categories for Grants-in-Aid for Scientific Research**

| Research Category | Description of Research Categories |
|---|---|
| Specially Promoted Research | Research that is highly regarded internationally and has the potential to yield particularly outstanding results. |
| Research on Priority Areas | Prioritized, tactical research conducted over a specific period in areas of considerable scientific and social need.<br>Examples: environmental, earth, and space sciences (the environment, earth and space, energy controls, etc.); matter and materials science (nuclear and physical science, chemical substances, new materials, etc.); information science and electronics (information and mathematics, electronic engineering, etc.); bioscience (cancer, the brain and nervous system, etc.). |
| Scientific Research | Original and pioneering research carried out by one researcher or jointly by several researchers. |
| Exploratory Research | Nascent research based on original concepts and unexpected insights. |
| Encouragement of Young Scientists (A) | Research carried out by individual researchers up to age 37. |
| Encouragement of Young Scientists (B) | Research carried out by individual teachers (in kindergartens, elementary schools, and lower and upper secondary schools) and citizens. |
| International Scientific Research | Research requiring fieldwork or research in specific regions or research institutes abroad, or necessitating joint research with researchers overseas. |
| Publication of Scientific Research Results | Grants for the publication of research results and scientific materials having great scientific value. |
| Creative Basic Research | Grants to promote research under the New Program System. |
| COE Research | Grants for the formation of Centers of Excellence. |
| JSPS Fellows | Grants for research by JSPS postdoctoral fellows (including non-Japanese fellows). |

**Figure 2-10: Trends in Budget for Grants-in-Aid for Scientific Research**

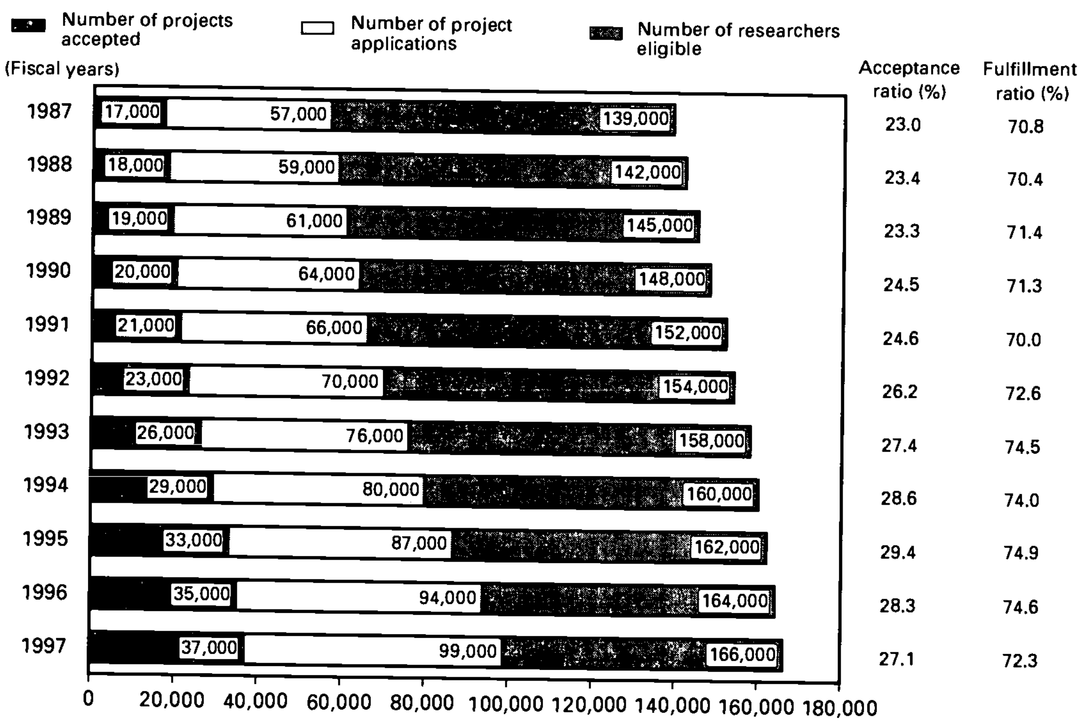



Source: MESSC.

**Table 2-7: Recent Improvements in and Disclosure of Information about the Grants-in-Aid for Scientific Research System**

| Fiscal year | Overview |
|---|---|
| 1995 | Creation of a new category to promote the establishment of Centers of Excellence. |
| 1996 | Creation of a new category to promote germinal research based on original concepts and unexpected insights. |
| | Announcement of the names of members of the document screening panels in addition to the usual announcement of the examiners responsible for deliberative selection (e.g. the names of all 2,000 examiners are disclosed) after completion of the screening process. |
| | Public announcement of selected projects through the National Center for Science Information Systems database in addition to the usual published announcement. |
| | Disclosure of reasons for not being chosen to researchers who failed to gain selection in certain categories. |
| | Elimination of the need for approval from the Minister of Education, Science, Sports and Culture for overseas travel grants, provided that certain conditions are met. |
| 1997 | Extension of research periods to give grant recipients the stability they need to focus on their research |
| | Announcement of selection results (number of projects, amount of funds) by institution of affiliation of research project leaders. |
| | Conditional approval for graduate students who are cooperating in research to travel overseas alone for such purposes as fieldwork or joint research. |
| | Clarification that researchers can be accepted by research institutes as temporary staff following the expansion of the scope of business categories for the supply of temporary workers in December 1996. |

**Figure 2-11: Grants-in-Aid for Scientific Research, Applications and Acceptances**




Notes: 1. The number of researchers eligible represents the number of full-time teaching staff in universities, junior colleges, and colleges of technology listed in the "Report on the School Basic Survey." 2. The acceptance ratio is the number of projects accepted divided by the number of project applications. 3. The fulfillment ratio is the amount allocated divided by the amount applied for by projects accepted. 4. The acceptance ratio and fulfillment ratio are based on figures for initial allocations for new projects for the fiscal year.

Source: MESSC.

**Screening and Allocation Procedures for Grants-in-Aid for Scientific Research**

Screening Mechanism

Applications are screened by the Committee on Grants-in-Aid for Scientific Research of the Science Council, which advises the Minister of Education, Science, Sports and Culture. The committee consists of approximately 2,000 examiners (formally referred to as "committee members" or "expert committee members" of the Science Council) covering all disciplines from the humanities and social sciences to the natural sciences. Projects planned independently by researchers are screened by the examiners on the basis of publicized criteria that include originality, level of scholastic contribution, and suitability of the research organization. Grants are allocated on the basis of this screening process.

Screening Method

There were nearly 100,000 applications for FY1997 grants. The majority of these were either selected or rejected on the basis of the following two-stage process.

| |
|---|
| Stage 1:<br>Documentary screening of all research projects by 3~6 (or more) examiners. |

More accurate evaluation

| |
|---|
| Stage 2:<br>All committee members split into specialized subcommittees (8~35 members) for each field to deliberate selection on the basis of results from the first stage and other information. |

In categories that involve the allocation of large research grants, decisions are based on direct interviews with applicants.

Examiners

The examiners are leading researchers representing academic societies and other organizations in Japan. In some categories, they also include researchers and other qualified persons from the private sector. Examiners are selected with the help of the Science Council of Japan. The nature of the task makes it extremely important that screening be carried out impartially. For this reason, the term of office is, in principle, strictly limited to one two-year period. Since 1996 the names of all examiners have been publicized after the completion of the screening process out of consideration for public access to information about it.

**(b) Research for the Future Program:** Japan aims to establish a nation based on the creativity of science and technology in the 21st century. An active commitment to highly creative scientific research is vital to realize goals that include solutions of global problems, socioeconomic development, and the enhancement of the quality of life. In FY1996, a new system was created to provide funds to JSPS, which is implementing the Research for the Future Program, which promotes future-oriented and highly creative research with the potential to create intellectual assets in selected fields.

Under this program, applied scientific research is conducted by the JSPS itself or is commissioned to universities or research institutions, where researchers are playing a central role in research designed to meet the needs of society. When necessary, the cooperation of industry and other sectors is sought for this university-led research. To accelerate research efforts and contribute to the training of young researchers, postdoctoral researchers are encouraged to participate in projects as JSPS research associates.

The Research for the Future Program Committee, made up of leading Japanese researchers, was established within JSPS to manage the program. The committee selects priority fields and projects on the basis of Science Council recommendations and of the results of research supported by grants-in-aid for scientific research and other types of funds. Research promotion committees, made up of top researchers, have been established for each field to plan and propose research projects and provide guidance and advice to research project teams. In addition, the Committee for Research Promotion in Specialized Areas and the University-Industry Cooperative Research Committee, which were established to promote cooperation and coordination relating to science among various sectors of society, are also providing guidance and advice about the planning and proposal of research projects.

In principle, research projects will last for five years. An interim evaluation will be carried out two years after the start of each project, however, and some may be discontinued at that stage. Final (post-project) evaluations will be made at the end of five years.

The average annual funding per project is about ¥100 million. In fiscal 1997 nine additional research fields and 87 new projects were selected, bringing the total number of new and continuing projects to 204 in 26 fields. There are 11 physical and engineering sciences, including exploratory research on novel artificial materials and substances for next-generation industries, innovation in energy generation, conversion, materials and systems for the future and computational science; nine fields from life sciences, including higher brain functions, infectious diseases and bioregulations, and genetic and environmental factors in diseases prevalent in adults and the elderly; and six fields from integrated disciplines including information life systems, causes and effects of environmental loads, and environmental conservation in the Asian region.

Seven government ministries and agencies, including the MESSC, the Science and Technology Agency, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Health and Welfare, the Ministry of International Trade and Industry (MITI), the Ministry of Transport, and the Ministry of Posts and Telecommunications, are implementing basic research promotion programs utilizing investments in special corporations. Around ¥56.9 billion was budgeted for this purpose in fiscal 1997, an increase of about ¥24.8 billion over the previous year. Universities and affiliated research institutions win most of these various types of competitive funding.

### (4) Expansion of Priority Funds

Priority funds are provided for research and development of national importance, such as big science and project research. Items in MESSC's budget that fall into this category include funds for the prioritized promotion of basic research. The Science and Technology Basic Plan calls for expanding funds of this type, which is essential to promote diversified research and development, along with increases in competitive funds.

• Promotion of basic research in selected areas: Taking into account current research trends in Japan and abroad, MESSC actively promotes fields of basic research that require an organized and international approach, that are the focus of very strong social needs, or that require relatively large expenditures for large-scale facilities and equipment. The main research fields selected by MESSC for prioritized promotion are listed in the following table.

| Research Field (Principal research institutes, etc.) | Description of Research Program |
|---|---|
| **Astronomical research: Investigating the origins of the universe** (National Astronomical Observatory) | Under a plan covering the period from FY1991 to FY1999, the National Astronomical Observatory is building a large-scale optical infrared telescope in Hawaii to study the state of the universe when our galaxy was formed. It is also using radio telescopes to observe and study the structure of the galaxy, interstellar matter, and other phenomena. Radio waves emitted from the sun's surface are being studied using a radio heliograph equipped with a large array of parabolic antennas. |
| **Accelerator science: Exploring the ultimate secrets of matter** (High Energy Accelerator Research Organization) | Under a five-year plan initiated in fiscal 1994, the High Energy Accelerator Research Organization will implement the TRISTAN II (B-Factory) project, which aims to open up a new phase in particle physics by upgrading the TRISTAN electron-positron colliding accelerator. It will also conduct experimental research using a positron accelerator and emitted light. |

| | |
|---|---|
| **Space science: World leadership in scientific satellites** (Institute of Space and Astronautical Science) | The Institute of Space and Astronautical Science conducts observations and research on phenomena in cosmic space and near the Earth, using sounding rockets and scientific satellites orbited by M-series launch vehicles developed in Japan. The institute is currently developing spacecraft for lunar and planetary exploration programs. In February 1997 it launched the world's first space-borne radio telescope using the first M-V rocket, developed under a five-year program that began in fiscal 1990. |
| **Nuclear fusion research: Developing the energy source of the future** (National Institute for Fusion Science) | In FY1990 the National Institute for Fusion Science launched an eight-year plan to construct a Large Helical Device for use in research into nuclear fusion, which is seen as the energy source for the future. It also conducts various types of research in universities. |
| **Area studies: Understanding the world's regions** (Japan Center for Area Studies at the National Museum of Ethnology) | As the core organization for networking existing research institutions, the Japan Center for Area Studies conducts inter-regional comparative research and wide ranging interdisciplinary joint research in the humanities and social and natural sciences and collects and provides research information. |
| **Biosciences: Discovering the secrets of life** | |
| **Brain research** (Niigata University Brain Research Institute, Okazaki National Research Institutes, etc.) | In addition to using grants-in-aid for scientific research and other funding, to encourage research on the brain, efforts are being made to develop and improve facilities for brain research in universities. In fiscal 1997 a program was launched to create a core research base at Niigata University's Brain Research Institute. |
| **Cancer and AIDs research** (Japanese Foundation for Cancer Research, University of Tokyo Institute of Medical Science, Kanazawa University Cancer Research Institute, Kyoto University Institute for Virus Research, Osaka University Research Institute for Microbial Diseases, Kumamoto University Center for AIDS Research, etc.) | Grants-in-aid for scientific research are being used to promote comprehensive, prioritized research on cancer. Efforts are also focused on improving and expanding research systems, training young researchers, and promoting international cooperation.<br>Grants-in-aid for scientific research are also being used to promote prioritized AIDS research. In fiscal 1997 the Center for AIDS Research was established at Kumamoto University. University facilities for AIDS research are being expanded and upgraded. |
| **Human genome research** (Human Genome Center, University of Tokyo Institute of Medical Science) | In addition to using grants-in-aid for scientiric research to promote research on the human genome, the Human Genome Center is being set up at the University of Tokyo Institute of Medical Science (see Column I). |
| **Clinical research into gene therapy** (Hospitals attached to the medical departments of Hokkaido, Okayama, and Kumamoto Universities and to the University of Tokyo Institute of Medical Science) | Under guidelines issued in June 1994 by the Science Council's Special Committee for Gene Therapy Clinical Research, plans for clinical research in genetics have been submitted by universities. These are being screened. Thus far, two programs, submitted by Hokkaido University and Kumamoto University, have been approved, and two others, submitted by the University of Tokyo Institute of Medical Science and Okayama University, are under consideration. |
| **Earthquake and volcanic eruption prediction research: Toward the prediction of earthquakes and volcanic eruptions** (University of Tokyo Earthquake Research Institute, Kyoto University Disaster Prevention Research Institute, etc.) | Earthquake prediction research includes observations of microearthquakes and crustal changes to provide basic prediction data and observations for evaluating the potential for earthquakes to occur. Research relating to the prediction of volcanic eruptions focuses on monitoring volcano-related earthquakes, geo-magnetism, and volcanic gases at active volcanoes, such as Mt. Sakurajima. (see Column II). |
| **Global environment science: Protecting our precious Earth** | In addition to international joint research and research supported by grants-in-aid for scientific research, Japanese researchers are also cooperating actively with UNESCO and other international organizations. In line with the Science Council's recommendations on the promotion of global environ- |

| | |
|---|---|
| | mental science, the establishment of a core research institute to promote comprehensive joint research aimed at finding solutions to global environmental problems is also being considered. |
| **Polar research: Studying the Earth from the North and South Poles** (National Institute of Polar Research) | As the core organization for observation programs in the Antarctic, the National Institute of Polar Research proposes and implements monitoring programs and conducts comprehensive research in the field of polar science, including aerospheric, air-water interface, geological, and biological phenomena. In fiscal 1995 a monitoring program was established to measure medium- and long-term environmental changes in the Antarctic. In fiscal 1996, Japan joined the European Incoherent Scatter Scientific Association (EISCAT) and is now participating in observations of global changes in solar and wind energy in the Arctic (See Column III). |

### Column I: Human Genome Research in Universities and Affiliated Research Institutes

1. Promotion of the Human Genome Program

"Recommendations Concerning the Promotion of the Human Genome Program in Universities" (Science Council, July 1989)

Phase I (establishment): Five years, from fiscal 1991 to fiscal 1995

"Five-Year Plan to Promote the Human Genome Program in Universities"

(Report of the Science Council Bioscience Subcommittee, July 1990)

* Recommendations concerning promotion of research in the initial five-year period: establishment of a human genome center, promotion of group research, etc.

Principal Measures

Establishment of the Human Genome Center at the University of Tokyo Institute of Medical Science

- Genome database field (fiscal 1991)
- Genome structure analysis field (fiscal 1992)
- DNA information analysis field (fiscal 1993)

Grants-in-aid for scientific research

- Research in priority areas: Research into large-scale information processing for human genome analysis (fiscal 1991~fiscal 1995, about ¥80 million~¥180 million per annum)
- Creative basic research: Human Genome Analysis Project (FY1991~FY1995, about ¥500 million per annum)

Phase II (Development): Five years, from FY1996 to FY2000

"Toward the Promotion of Human Genome Programs in Universities: Phase II (Development)" (Report of the Science Council Bioscience Subcommittee, April 1995)

Principal Measures

Improvement of the Human Genome Center at the University of Tokyo Institute of Medical Science (fiscal 1996)

- Genome sequencing analysis field
- Sequencing technology development field
- Installation of a supercomputer in fiscal 1997*

Grants-in-aid for scientific research

- Research in priority areas: Genome science: new developments in bioscience through analysis of the human genome (FY1996~FY2000, about ¥600 million per annum)

Research for the Future Program

Human Genome: In principle, a five-year research program starting in fiscal 1996

* Seven projects, including two newly initiated, under way in fiscal 1997.

2. Development of a DNA Databank

"Development of a DNA Databank" (Report of the Science Council Bioscience Subcommittee, July 1994)

* Various government organizations will jointly establish DNA Database of Japan (DDBJ) within the National Institute of Genetics to serve as a domestic base for research in this field.

### Column II: Review of Earthquake and Volcanic Eruption Prediction Programs by the Geodesy Council

At the June 1997 general meeting of the Geodesy Council, the Earthquake and Volcano Subcommittee presented the two reports summarized below.

(1) "Review of the Implementation of Earthquake Prediction Plans"

Over 30 years have passed since the Earthquake Prediction Plan was launched in 1965. In the wake of the Great Hanshin-Awaji Earthquake, which inflicted massive damage in the southern part of Hyogo Prefecture in January 1995, however, a number of changes have occurred in the situation surrounding the plan, including the establishment of the Earthquake Disaster Prevention Special Measures Act.

It was apparent from these developments that the time had come for a review of the Earthquake Prediction Plan, and activities over the 30 years since the establishment of the initial plan were therefore reassessed. The review covered aspects of earthquakes that have come to light as a result of the Earthquake Prediction Plan and the extent to which targets have been met.

The report concluded that it is generally impossible at present to predict the time, location, and intensity of earthquakes with sufficient accuracy to justify issuing warnings, but that it will be possible to predict an earthquake in the Tokai region if phenomena similar to precursors that occurred in the past are observed.

As to the future of the Earthquake Prediction Plan, the report stated that the plan should go beyond its traditional emphasis on monitoring and research targeting the discovery and investigation of individual abnormal phenomena and surveys of intervals between recurring major earthquakes. It highlighted the need for monitoring and research that focuses on identifying imbalances in strength patterns within the crust that would facilitate a constant grasp of stresses and distortions.

(2) "Review of the Implementation of the Volcanic Eruption Plan"

The disaster caused by pyroclastic flows on Mount Unzen Fugen-dake has caused changes in the information about volcanoes that is demanded by the public. Japan instituted its first Volcanic Eruption Prediction Plan in 1974 and is now into its fifth plan. At this juncture, it was decided to review overall implementation since the first plan to identify issues and prospects for the future.

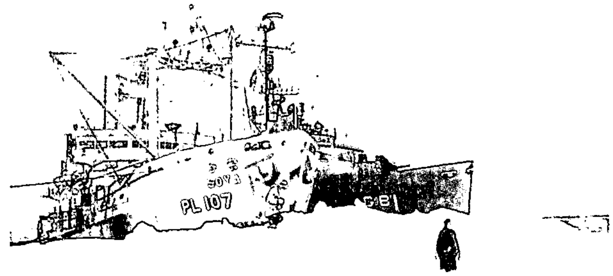
The report states that the observation process has been enhanced by the development of wide-area, high-grade, high-density, multi-faceted monitoring methods, and that it is now generally possible to detect eruption precursors on a number of active volcanoes through intensive, comprehensive monitoring.

With regard to the future of the Volcanic Eruption Prediction Plan, the report states that the development of practical prediction systems will require an understanding of the mechanism whereby eruptions and eruption precursors occur. It also stressed the importance of a four-dimensional understanding of volcanic structures, including the time axis, based on monitoring the behavior of magma, volcanic gases, and other fluids, and changes in subterranean conditions.

### Column III: A Photographic Record of 40 Years of Japanese Scientific Observations in the Antarctic

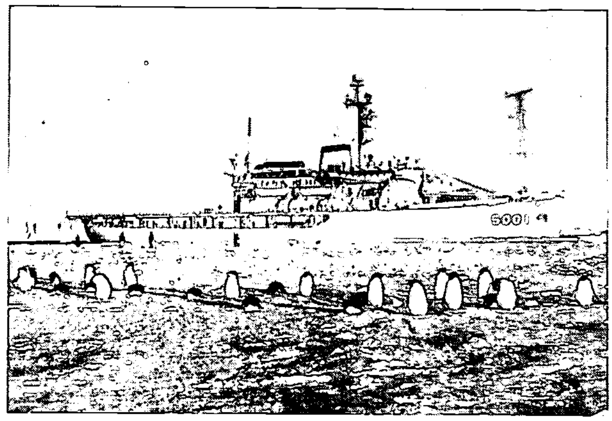
The Antarctic is an important observation site that holds the key to a scientific understanding of various global environmental problems, such as ozone holes. As a treasure-trove of meteorites, including a Martian meteorite believed to contain traces of life, the region is also crucial to space science. Japan has been conducting scientific observations in the Antarctic for 40 years. The following photographs trace the activities and achievements of expedition members from universities, the National Institute of Polar Research, and various government ministries and agencies.

*January 29, 1957: The first survey team lands on Ongul Island and names it Showa Station.*

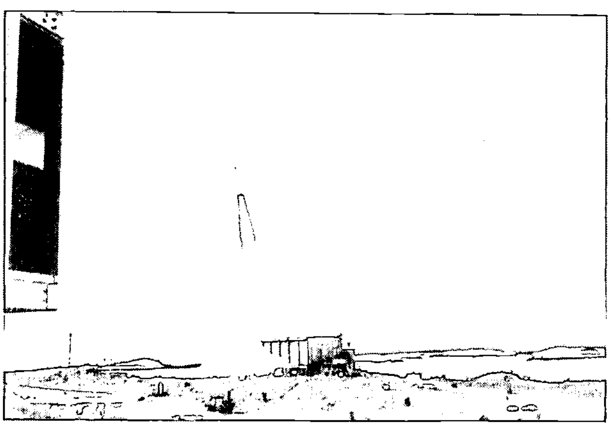



*The Japanese icebreaker* Soya *with the U.S. icebreaker* Burton Island, *which came to rescue it (second expedition, 1958).*

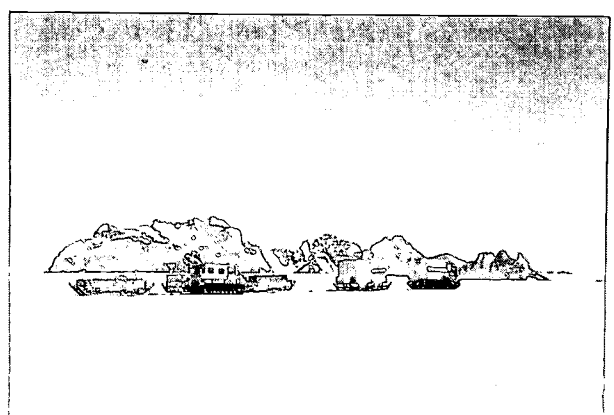
*Sakhalin dogs Taro (left) and Jiro (center), who were left to endure harsh Antarctic conditions for a year, greet the third expedition (1959).*



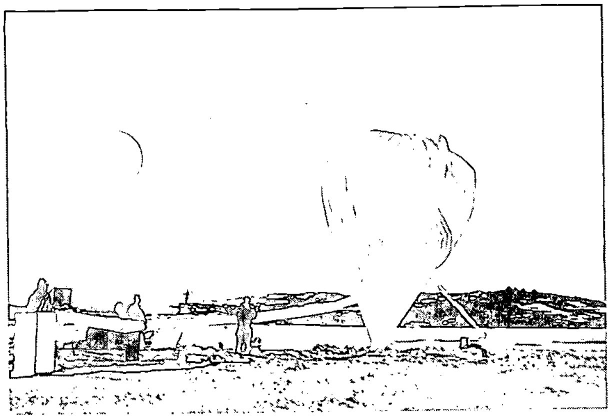

*Antarctic surveys were temporarily suspended but resumed in 1965 with the commissioning of the research vessel* Fuji *(seventh expedition).*



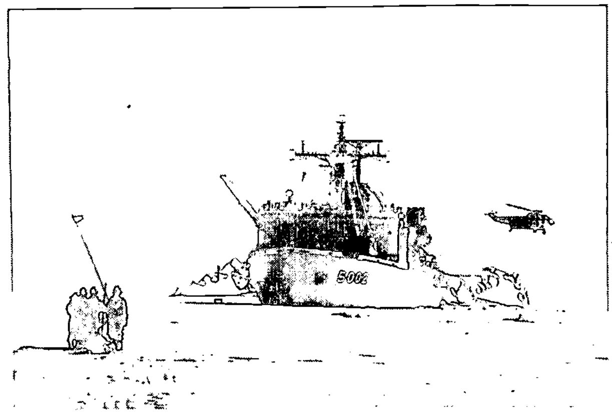
*Observation rockets were launched directly into the region of the atmosphere where the aurora forms, almost 100km above the earth (11th~19th expeditions, 1970~1978).*



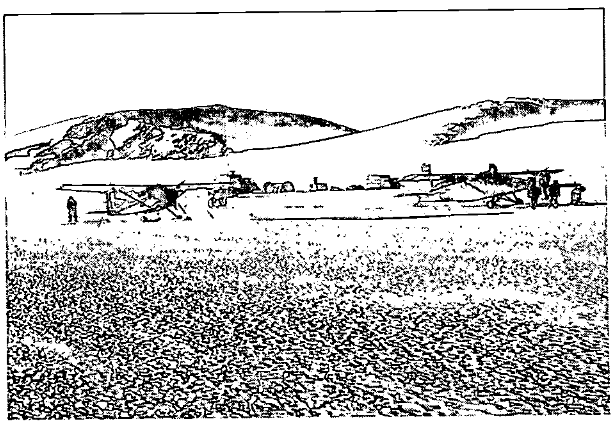
*Large quantities of meteorites were retrieved by the expedition to the Yamato Mountains (20th expedition, 1979, 1980).*



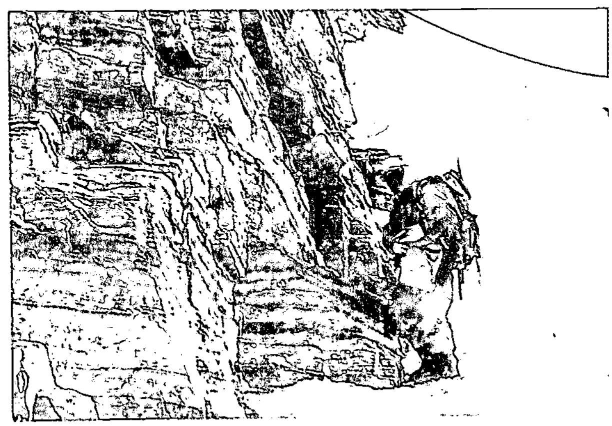
*Launching atmospheric observation balloons at Showa Station in 1982 (23rd expedition).*



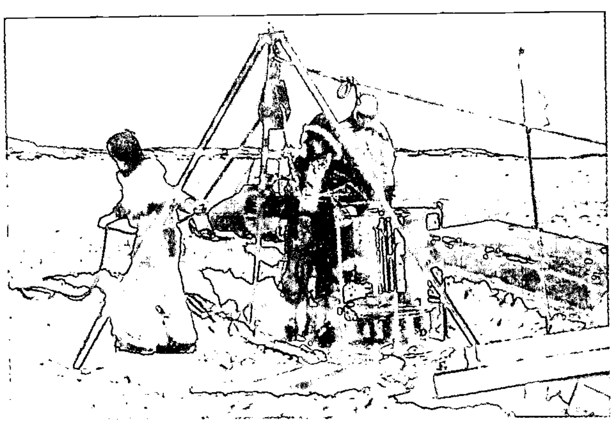
*The* Shirase *moored at the supply base for Showa Station in 1983 (25th expedition).*



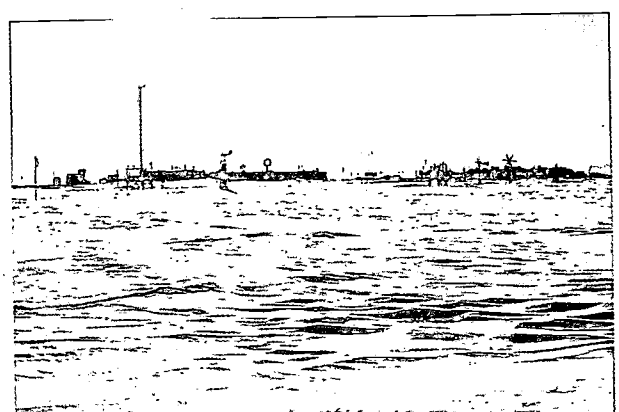
*This aerial observation base was established on bare ice on the Antarctic continent (27th expedition, 1985).*



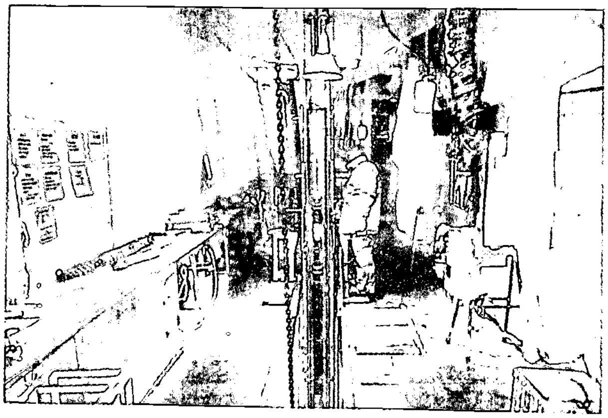
*A geological survey in the Botnnuten region of Antarctica (34th expedition, 1993).*



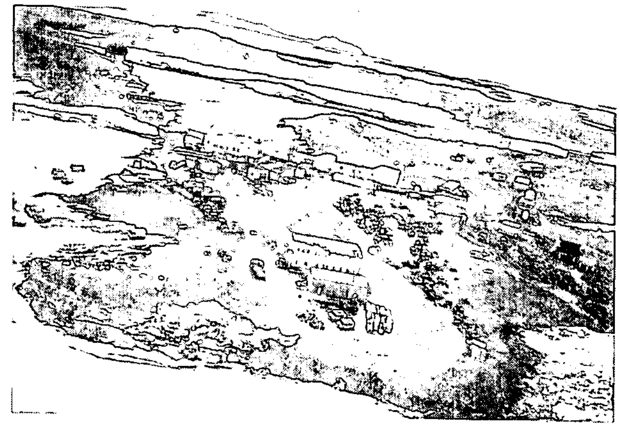
*Team members deploy a marine biological sampling system offshore from Showa Station (35th expedition, 1994).*



*Dome Fuji Station is located 1,000km inland from Showa Station at an altitude of 3,810 meters (36th expedition, 1995).*



*Scientists at Dome Fuji Station succeeded in drilling into the ice sheet to a depth of 2,500 meters (37th expedition, 1996).*



*Showa Station today.*

### (5) Increase Basic Funds

Basic funds are applied to the ordinary research funds and costs of operating research facilities and equipment that enable researchers to undertake fundamental research activities steadily and effectively. The leading example of this type of funding in the MESSC budget is the unit cost per professor in national universities. The Science and Technology Basic Plan calls for an increase in funds of this type.

• **Unit cost per professor:** Funds in this category pay for purchasing the materials and equipment needed by faculty to instruct students and conduct research, as well as the cost of utilities. Calculated on the basis of the number of faculty members, these allotments provide for the expenses essential to maintaining educational and research activities in the national universities. The amount of funding has been increasing steadily over the years and was around ¥154.1 billion in fiscal 1997.

Subsidies are also provided for regular expenditures required for education and research in private institutions of higher education. In the FY1997 budget, provision for general subsidies, which are allocated according to the number of faculty and students, is about ¥228.2 billion.

### (6) Results of the Survey of Research Costs in Universities

In FY1996 a questionnaire survey on the research environment for university researchers ("Research Environment Survey") was conducted to investigate questions relating to grants-in-aid for scientific research. The survey was sent to some 8,400 university researchers, of whom 4,994 responded, a ratio of about 60%. Results for the main items relating to research costs are outlined below.

**(a) Overview of individual research costs:** The survey asked about the sources of individual researchers' funds in fiscal 1995. This question referred to research funds used by individual researchers; overhead costs, such as facility maintenance and operating costs and utility charges, and costs relating to the education of students were excluded. The results are shown in Table 2-8.

Analysis of the sources of research funds shows that fundamental funds allocated by university authorities accounted for 34.1% of total funds, grants-in-aid for scientific research for 27.9%, private sector firms for 14.8%, government ministries and agencies (other than MESSC) and special corporations for 12.1%, and research-grant foundations and local government organizations for 11.0%.

Figures by field show that researchers in the humanities and social sciences relied heavily on funds allocated by university authorities, which accounted for 60.0% of total funding. This ratio was 29.1% for those in the natural sciences and 45.6% in multidisciplinary fields, indicating that sources of funds are comparatively diverse in these fields.

The breakdown of types of expenditure in Table 2-9 reveals significant differences between those in the humanities and social sciences and those in the natural sciences and multidisciplinary fields. In the former category, books and domestic travel accounted for a large share of expenditure (about 46% overall), while in the latter category, the percentage of funds spent on facilities, equipment, and expendable supplies was extremely high at around 80% of the total. Areas in which funding shortages were particularly acute (in order of response frequency) were: books, facilities and equipment, and domestic travel for those in the humanities and social sciences; facilities and equipment, supplies, and domestic travel for those in the natural sciences;

**Table 2-8: Individual Research Costs in Fiscal 1995 (by Field)**

(¥10,000)

| Category | Humanities & social sciences | Natural sciences | Multidisciplinary fields, etc. | All fields |
|---|---|---|---|---|
| 1. Research funds allocated by university authorities | 51 | 116 | 135 | 99 |
| 2. MESSC grants-in-aid for scientific research | 20 | 116 | 74 | 81 |
| 3. Research funds from government ministries other than MESSC, or from special corporations, etc. | 1 | 52 | 34 | 35 |
| 4. Research funds from local government organizations | 1 | 4 | 3 | 3 |
| 5. Research funds from the private sector | 4 | 68 | 26 | 43 |
| 6. Research funds from research grant foundations (excluding funds covered in item 3 above) | 3 | 18 | 14 | 13 |
| 7. Research funds from other countries | 0 | 0 | 1 | 0 |
| 8. Other funds | 5 | 24 | 9 | 16 |
| Total | 85 | 399 | 296 | 290 |

Note: Totals may not be exact due to rounding.
Source: MESSC, "Research Environment Survey" (fiscal 1996).

**Table 2-9: Breakdown of the Types of Research Expenditures Made by Individual Researchers**

(¥10,000)

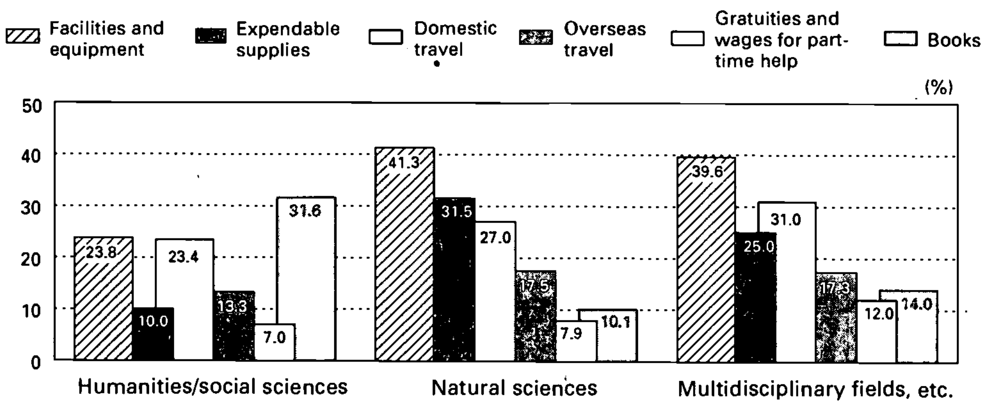
| Category | Humanities & social sciences | Natural sciences | Multidisciplinary fields, etc. | All fields |
|---|---|---|---|---|
| 1. Facilities and equipment | 18 | 151 | 118 | 107 |
| 2. Expendable supplies | 9 | 160 | 104 | 107 |
| 3. Domestic travel | 11 | 19 | 17 | 16 |
| 4. Overseas travel | 8 | 13 | 12 | 12 |
| 5. Gratuities and wages for part-time help | 6 | 16 | 18 | 13 |
| 6. Books | 29 | 9 | 13 | 15 |
| 7. Computer usage charges | 1 | 3 | 4 | 2 |
| 8. Other | 6 | 7 | 6 | 6 |
| Total | 87 | 377 | 292 | 278 |

Note: Totals may not be exact due to rounding.
Source: MESSC, "Research Environment Survey" (Fiscal 1996).

and facilities and equipment, domestic travel, and supplies for those in multidisciplinary fields. (Figure 2-12).

**(b) Effective means of improving research funding:** Survey participants were asked to consider means of improving research funding, including not only increases in government outlays, but also the diversification of funding sources and self-help efforts by universities. The most frequent response, selected by around 60% of respondents in all fields, was "promote funding from research grant foundations." The next most common choice, "promote funding from private sector companies," received an overall response ratio of 42.6%, but there was considerable variation in the percentages by field, ranging from 26.9% in the humanities and social sciences to 52.0% in the natural sciences (Table 2-10).

**Figure 2-12: Areas Particularly Affected by Funding Shortages**
(percentage of respondents who replied that funding shortages were especially acute)




Source: MESSC, "Research Environment Survey" (fiscal 1996).

**Table 2-10: Means for Diversifying Funding**

(%)

| Category | Promote funding from private sector companies | Promote funding from research grant foundations | Promote funding from local government organizations | Expand universities' internal funds | Improve and streamline university management | Other |
|---|---|---|---|---|---|---|
| All respondents | 42.6 | 60.7 | 18.6 | 18.8 | 26.8 | 6.4 |
| Humanities and social sciences | 26.9 | 61.7 | 21.0 | 25.8 | 28.7 | 7.6 |
| Natural sciences | 52.0 | 60.4 | 16.8 | 14.5 | 25.5 | 6.0 |
| Multidisciplinary fields | 38.2 | 59.7 | 21.1 | 20.7 | 27.7 | 5.2 |

Note: Up to two responses.
Source: MESSC, "Research Environment Survey" (fiscal 1996).

## 3. Improving Research Facilities and Equipment

### (1) Research Facilities

The facilities where research takes place form an important part of the research infrastructure. MESSC is taking the following steps to meet the demand for facilities that will encourage the progress of scientific research in national universities and inter-university research institutes:

(i) The "New Campus" plan is being promoted to enhance educational and research functions with a view to opening up new frontiers in scientific research;

(ii) A large helical apparatus and a large optical infrared telescope dome are being constructed as part of prioritized efforts to encourage basic research;

(iii) Open centers for pioneering research are being developed to provide flexible research facilities that can be used as venues for intensive joint research. Under this system, a research team that has won competitive research funds, such as investment funds, may install research equipment acquired with those funds in an open center, to which the team has access as long as funding continues. After the project has been completed, the center is handed over to another research team.

Other initiatives include setting up regional joint research centers and venture business laboratories.

In recent years the progressive overall deterioration and obsolescence of university facilities has brought about an annual increase in the number of buildings that need to be reconstructed or repaired. In fiscal 1997 approximately 52% of the buildings at national universities and inter-university research institutes had been standing for 20 years or more (Figure 11-4). What is more, the space available for research has become inadequate to accommodate the growth in the number of graduate and foreign students. The results of the "Research Environment Survey" show that 67.8% of researchers consider the size of laboratories and faculty offices to be the most important issue with respect to research facilities (Table 2-11). The systematic improvement of research facilities is necessary, with particular emphasis on modernizing obsolete facilities and increasing the amount of space available for research.

To ensure that research facilities are utilized effectively, it will also be necessary to develop new ideas about how they are used, such as increasing joint utilization or cooperating with outside organizations.

Efforts are also being made to improve scientific research infrastructure in private universities by enhancing research facilities. The High Technology Research Center Development Program was launched in fiscal 1996 to provide comprehensive support with respect to the research facilities, equipment, and funds required for advanced research and development projects. In fiscal 1997 the Private University Scientific Frontier Promotion Program was established to provide comprehensive support for the development of joint research-promotion centers at research hubs.

### (2) Research Equipment

Theoretical inquiry, as well as discovery and verification through experimentation, are essential to the progress of scientific research. The growing sophistication, precision, and scale of experimental research has been especially prominent in recent times, increasing the importance of experimental equipment. In addition, the use of computers, no longer limited to experimental research, has also become indispensable to theoretical research and research in the humanities and social sciences. As a result, the availability, capabilities, and precision of research equipment now have a real and significant bearing on the outcome and standard of research activities.

At the same time, qualitative deterioration and

**Table 2-11: Current Issues Relating to Research Facilities**

(%)

| Category | Accommodating information technology | Internal environment (ventilation, lighting, air conditioning, etc.) | Utilization of other research facilities | Area of laboratories and faculty offices | Aging of research facilities | Other |
|---|---|---|---|---|---|---|
| All respondents | 36.7 | 19.1 | 11.1 | 67.8 | 23.0 | 6.5 |
| Humanities/social sciences | 48.5 | 17.9 | 11.1 | 58.1 | 9.9 | 10.6 |
| Natural sciences | 30.4 | 19.7 | 10.8 | 73.8 | 30.2 | 4.4 |
| Multidisciplinary fields | 36.3 | 19.1 | 12.8 | 64.5 | 22.2 | 6.5 |

Note: Up to two responses.
Source: MESSC, "Research Environment Survey" (fiscal 1996).

quantitative shortages of university research equipment have made improvement an important goal, which MESSC is striving to achieve.

Results from the "Research Environment Survey" show that 73.9% of researchers in natural science fields and 45.4% of those in the humanities and social sciences felt that there were shortages of some items of essential equipment (Figure 2-13). Furthermore, 19.1% of researchers working in the natural sciences reported that key items of research equipment had been in use for 10 years or longer (Figure 2-14).

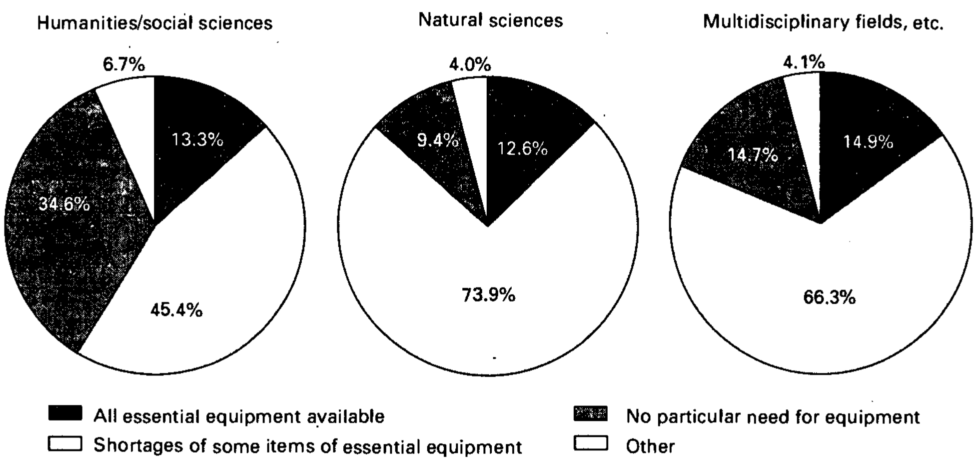
## 4. Development of Information and Resources Needed for Scientific Research

The progress of scientific research in Japan has been paralleled by rapid growth in the volume of scientific information generated by research activities. This information is an extremely valuable resource, stimulating research activities, giving greater depth to exchanges among research workers, and aiding researchers in producing the optimal results by enabling them to stay accurately informed about developments in related fields.

Researchers need access to an expanding and increasingly diverse range of scientific information, and the prompt, accurate provision of such resources is vital to the continuing advancement of Japanese scientific research in a highly information-intensive society. Also important is the wide dissemination, in Japan and overseas, of outstanding results produced by Japanese researchers.

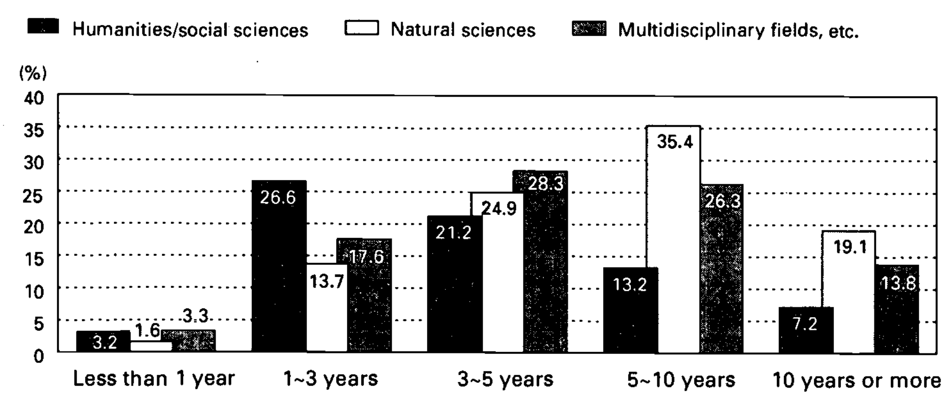
Plant and animal specimens, fossils, and other materials collected over the years in the course of

**Figure 2-13: Availability of Essential Research Equipment**




Note: Figures may not total 100% because of rounding.
Source: MESSC, "Research Environment Survey" (fiscal 1996).

**Figure 2-14: Number of Years Since Research Equipment was Purchased**




Source: MESSC, "Research Environment Survey" (fiscal 1996).

scientific research in universities also constitute a vital resource for research and education. In particular, in conjunction with the dramatic advances made in bioscience in recent years, many types of phylogenetic organisms are gaining in value because of their great importance as genetic resources for researchers working in such fields as biology, medicine, pharmacology, and agricultural sciences.

MESSC is therefore working to establish and upgrade scientific information distribution systems, such as networks and databases. It is also improving systems for the collection, storage, and distribution of scientific materials, including genetic resources.

### (1) Network Development

**(a) Science Information Network (SINET):** The growing sophistication of scientific research in recent years has been paralleled by an increase in the quantity and variety of scientific information distributed via computer networks. Setting up and enhancing networks as infrastructure for the rapid, reliable gathering and distribution of information in Japan and internationally is important to the continuing advancement of scientific research.

Japan's Science Information Network links universities and other institutions nationwide through the National Center for Science Information Systems. MESSC is speeding up the network and extending its international links. The number of institutions in the network is increasing steadily, totaling 613 as of March 1997, including 364 universities (89 national, 38 local public, and 237 private) and 249 other institutions.

Efforts to improve the network are also focusing on line speeds. Part of the main trunk line has been upgraded to 150Mbps.* Of the international links to the United States, Thailand, and the United Kingdom, traffic on the link to the United States is especially heavy, and in October 1997 the connection was upgraded from 6Mbps to 45Mbps (Figure 2-15). Future plans call for increasing network speed to the U.S. level as soon as possible and eventually achieving gigabit line speeds.

**(b) Campus Information Networks (Campus LANs):** Campus information networks link various computers within each university. They have been installed in all national universities and inter-university research institutes, with the exception of universities that are planning to relocate. ATM† exchanges are currently being installed to facilitate the distribution of multimedia information, such as audio data and motion pictures. To date, these systems have been installed in 58 national universities. MESSC plans to install ATM technology in all national universities.

MESSC is also providing private universities with subsidies for upgrading their information infrastructure, including campus LANs and information processing systems.

### (2) Database Development

The importance of electronic information has risen exponentially due to the rapid development of computer networks and advances in multimedia technology. Databases, in particular, have become extremely effective research tools by facilitating data searching, processing, analysis, and distribution. Databases that present information in structured formats that are easy to search, enabling users to retrieve what they need when they need it, have become a crucial element of the infrastructure for scientific research. The development of databases capable of making a global contribution has, therefore, become an urgent priority in Japan.

In FY1996 the National Center for Scientific Information Systems conducted a survey of scientific information databases. The results showed that the total number of databases maintained in universities had reached 2,016, of which approximately one-half (989) were open to the public.

MESSC subsidizes the creation of databases by researchers in universities and by academic societies and other organizations. The fiscal 1997

***Mbps:** Megabits per second. An Mbps is a unit of transmission speed equivalent to 1 million bits (about five newspaper pages) per second.

† **ATM:** Asynchronous Transfer Mode. This state-of-the-art, ultra-high-speed communications system supports simultaneous transfers of large volumes of multimedia information, including text, audio data, and moving pictures.

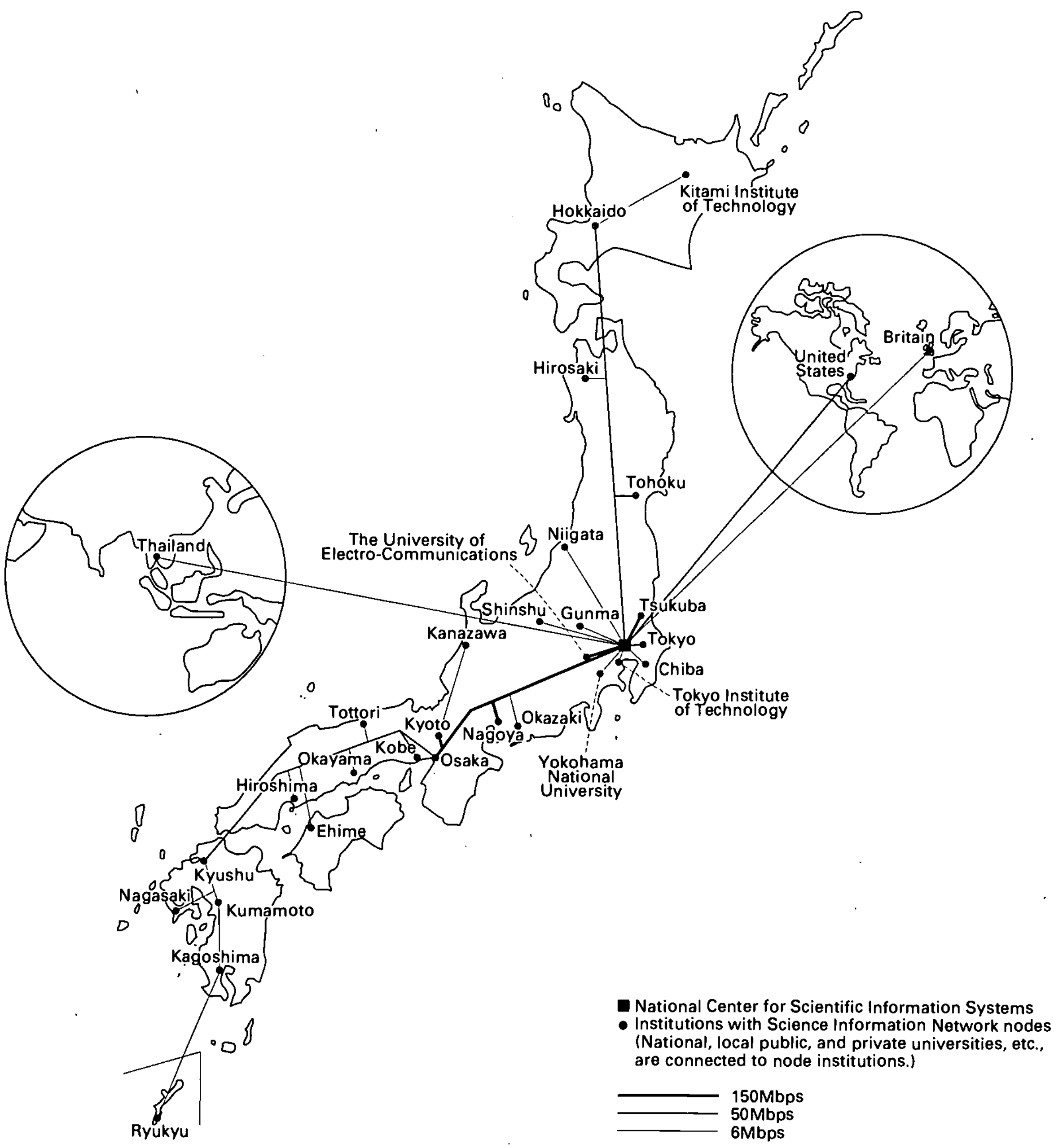
budget allocates ¥1,285 million in grants-in-aid for scientific research (Grants-in-Aid for Publication of Research Results) for this purpose, as well as ¥584 million for core institutions in fields where databases have practical potential.

In June 1997 the Science Council's Science Information Subcommittee produced an interim report on ways to develop scientific databases. On the basis of this report, MESSC will implement various measures, including the expansion of funds to promote grants-in-aid for the publication of research results. It will also consider systemic improvements.

### (3) Promoting the Use of Electronic Technology in University Libraries

University libraries play a very important role as fundamental organizations for educational and research activities. The development of multimedia

**Figure 2-15: Diagram of the Science Information Network**



technology and the spread of the Internet in recent years, however, are forcing the libraries to make major changes in the way they provide information.

In accordance with the Science and Technology Basic Plan and reports and recommendations of the Science Council, MESSC is promoting the use of electronic technology in university libraries, primarily through the measures described below.

(i) As part of its efforts to promote the improvement of electronic information collection and distribution services, in fiscal 1995 MESSC launched a six-year plan to facilitate the distribution of information through campus LANs by installing CD-ROM server systems in all national university libraries.

(ii) MESSC encourages and supports pioneering projects to develop electronic library functions in university libraries while maintaining harmony with existing functions, such as the collection, storage, and distribution of books, journals, and other resources acquired in traditional paper media. In FY1997 such projects were undertaken at the University of Tsukuba and Kyoto University. In FY1996 Nara Institute of Science and Technology launched a new initiative that differs from other university libraries: Books are stored in electronic form, and an electronic library offers searching and perusal services via the campus LAN.

(iii) Under a three-year plan that began in fiscal 1994, the National Center for Science Information Systems carried out research and development on an electronic library system whereby academic journals and other materials will be electronically input and made available over networks. In April 1997 it launched a service to input and distribute the journals of 29 academic societies, including the Information Processing Society of Japan.

Efforts to improve electronic library functions in universities have only just begun, and a wide variety of issues remain to be resolved, including technical and budgetary problems and copyright questions. The long-term goal will be the creation of an ideal system in all universities, but at present it is important for universities that have already established systems to focus on tasks that are achievable while responding to the needs of researchers and other users and fostering cooperation among related internal organizations.

### (4) Dissemination of Research Findings

The results of scientific research have traditionally been publicized through books, scientific journals, or conference presentations. With the growth of communications networks in recent years, researchers, especially those in the natural sciences, have started using the Internet to disseminate articles in Japan and abroad. This method of publicizing research findings not only contributes to their dissemination in Japan, but also plays an important role in international scientific exchange.

In view of this, MESSC is using grants-in-aid for scientific research to subsidize the publication of academic society journals, collections of papers, and scientifically important books; the translation of scientific books into other languages; and the development of databases to facilitate the rapid, widespread dissemination of research findings.

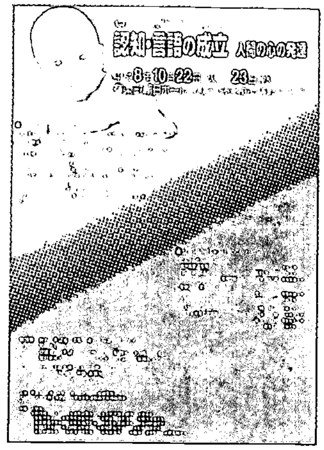
Since fiscal 1986, a series of public symposiums on "Universities and Science" have been held with MESSC support. These symposiums provide a forum for the wide dissemination of information about research trends and the results of research supported by grants-in-aid for scientific research and other funds. The symposiums focus on areas of strong public interest, providing opportunities for leading researchers to present their findings and exchange views with other participants.

### (5) Enhancement of Academic Society Activities

An academic society is an organization established through the initiative of researchers working in the same field. These associations are important forums where researchers from different universities and research organizations can come together to present and discuss research and share information. As joint research and other forms of cooperation by researchers in Japan and other countries become more common, academic societies also serve to disseminate Japanese scientific information, making them an important part of the infrastructure for scientific research.

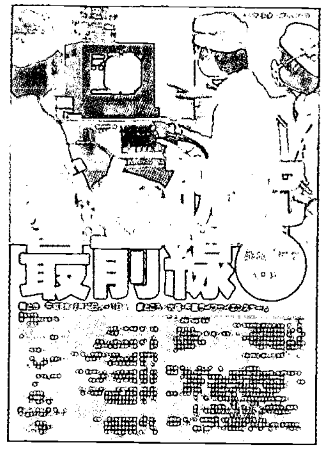
The main activities of these organizations include publishing journals and collections of

**Posters Announcing the "Universities and Science" Public Symposiums**




*The Establishment of Recognition and Language: The Development of the Human Mind*
*Tuesday, October 22~Wednesday, October 23, 1996*
*Yurakucho Asahi Hall, Tokyo*


*Jomon and Yayoi: Japan's Prehistoric Periods*
*Saturday, November 23~Sunday, November 24, 1996*
*Fukuoka Meiji Seimei Hall*

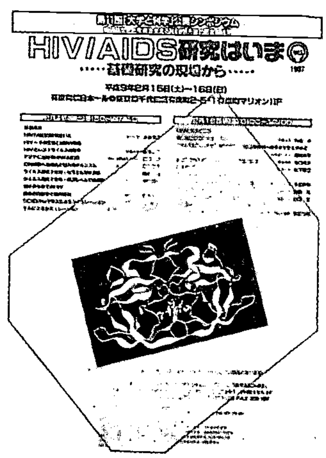


*Front-Line Cancer Research: Laboratory and Clinical Perspectives*
*Tuesday, December 10~Wednesday, December 11, 1996*
*Senri Life Science Hall, Osaka*


*Matter: Functions and Transformations*
*Monday, November 25~Tuesday, November 26, 1996*
*Yurakucho Asahi Hall, Tokyo*


*High-Temperature Super-Conductors and Fullerene Science: Progress in Understanding*
*Wednesday, December 11~Thursday, December 12, 1996*
*Nikkei Hall, Tokyo*


*Life and Information: Recent Advances in the Science of Signal Transmission within the Cell*
*Tuesday, January 21~Wednesday, January 22, 1997*
*Kobe International Conference Center*




*HIV/AIDS Research Today: News from the World of Basic Research*
*Saturday, February 15~Sunday, February 16, 1997*
*Yurakucho Asahi Hall, Tokyo*

papers discussing the latest and best research findings, and holding research symposia, scientific gatherings, seminars, and other events. In recent years, academic societies have made an important contribution to the advancement of scientific research by publishing foreign language versions of their journals and collections of papers to send overseas and hosting a growing number of international conferences, thereby publicizing and disseminating research results at home and abroad.

MESSC subsidizes various activities of these organizations, including the publication of journals and collections of papers, the creation of databases, the hosting of international conferences and scientific symposia for young people and adults, and the standardization of scientific terminology. It also assists some incorporated nonprofit organizations (incorporated academic societies) by, for example, awarding special public interest corporation* certification to non-profit organizations that engage in the activities of an academic society, providing certain conditions are met.

Contributions to special public interest corporations are tax-deductible in the case of individuals; in the case of corporations, donations can be listed as "special registration of a pecuniary loss" within the permissible limits for general donations.

### (6) Establishment and Dissemination of Scientific Terminology

It is very important to the progress of scientific research that diverse and obtuse terminology be organized and integrated and rendered in clear, simple language. Terminology is a highly significant part of the infrastructure for distributing scientific information.

Since 1947, in line with reports and recommendations from the Science Council, MESSC has been working with academic societies to establish terminology for individual fields of specialization and endeavoring to disseminate this terminology through the compilation and publication of *Japanese Scientific Terms*. To date, terminology has been established for 30 fields, including chemistry, electrical engineering, agricultural sciences, and psychology. The lists for 15 fields, including astronomy, instrument technology, and library and information science, have been revised.

### (7) Collection, Storage, and Provision of Genetic Resources

Dramatic progress in bioscience in recent years has made phylogenetic organisms important genetic resources because of their genetic interchangeability. As research resources, they provide invaluable models that can contribute to our understanding of human biological mechanisms and the causes of disease, as well as to our efforts to maintain health and solve food and environmental problems.

In June 1996 the Science Council's Science Materials Subcommittee produced recommendations "On the Utilization of Biological and Genetic Materials in Scientific Research." In FY1997 MESSC accordingly established and equipped the Biological and Genetic Resources Center, which will play a central role in systematic storage of materials for each type of organism in Japan, and the General Biological and Genetic Information Center, which will gather and distribute information about biological and genetic materials and provide overall coordination for the systematic storage of those materials. These centers will facilitate the supply of biological and genetic materials while helping to build closer cooperation among individual researchers and research organizations in Japan. Through these roles, they are expected to make an important contribution to the progress of advanced research in bioscience fields. MESSC will continue to develop resource centers for essential types of organisms, taking into account research needs and performance in research and systematic storage.

### (8) Improvement of Animal-Experimentation Facilities

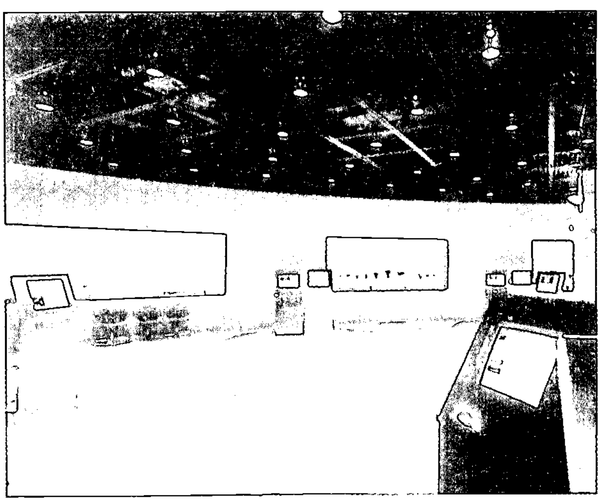
Optimal precision in experimental work is essential to research in fields like medicine and

* **Special public interest corporations:** These are corporations that are certified under the Income Tax Law Enforcement Ordinance and the Corporation Tax Enforcement Ordinance and that make a significant contribution to the promotion of the public interest, including promoting education or science, improving culture, or contributing to social welfare.

pharmacology. This requires securing laboratory animals, and improving facilities and equipment for animal experiments as well as methods of raising and managing laboratory animals. In May 1967 the Scientific Materials Committee of the Science Promotion Council issued recommendations for the improvement of animal experiments in universities. Since fiscal 1971, MESSC has been setting up modern, centrally managed animal-experimentation facilities in universities with medical schools. The purpose of these facilities is to provide an environment that ensures high degrees of accuracy and reproducibility in animal experiments, to support centralized breeding and management of high-quality laboratory animals, to develop and study laboratory animals, and to provide guidance and education for staff and students undertaking animal experiments.

Recent progress in bioscience is reflected in the increasingly diverse and sophisticated aims and content of the experiments performed by researchers who use animal-experimentation facilities. The rising standard of research in Japan and overseas makes it necessary to attain ever higher levels of precision in experiments. It is also important to conduct animal tests safely and appropriately. Developments in genetic engineering and embryological engineering have made it possible to manipulate the genes of individual animals, leading to the creation of mice with transplanted or missing genes. Animals with modified genes are now an essential research resource for bioscience, including brain research.

MESSC is currently promoting the development of centers to handle preservation, supply, development, and training tasks relating to genetically modified animals. This work is based on a July 1997 report by the Science Materials Subcommittee of the Science Council titled "The Storage, Supply and Development of Genetically Modified Animals."



*The University Museum at the University of Tokyo.*

### (9) Establishing University Museums

Scientific specimens, such as animal and plant materials and fossils, are the products of long years of scientific research in universities or systematic collection for research purposes. These materials embody a wide range of concrete information and are indispensable to scientific research. The recent development of new analytical methods, such as DNA and isotope analysis, has enhanced the importance of these materials as research and education resources that can be approached from different perspectives by different research fields.

Many universities in Europe and North America have established university museums housing extensive collections of scientific specimens. In addition to contributing to multi-faceted research on scientific specimens, these facilities are also playing an active role as centers for the distribution and reception of scientific information.

In January 1996 the Science Materials Subcommittee of the Science Council produced a report titled "The Establishment of University Museums," in which it recommended the creation of similar facilities in Japanese universities to collate, store, publicize, and display scientific specimens, provide information, and conduct systematic, original research and educational activities using the specimens. The report emphasizes the need for university museums as interfaces for "universities that are open to the community," and as facilities that can respond to a variety of learning needs.

In line with these recommendations, MESSC established the University Museum at the University of Tokyo in FY1996 and the Kyoto University Museum in FY1997. The ministry will continue to set up university museums, taking into consideration educational and research achievements utilizing scientific specimens, the state of storage and organization of such materials, and regional characteristics.

# Section 2: Enhancing Research Organizations' Ability to Promote Scientific Research

In Japan, universities and affiliated research institutions, and the various research organizations established within them, are responsible for carrying out scientific research. As each of these organizations pursues its own research objectives, it organically integrates the factors discussed above, namely personnel, funds, facilities and equipment, and scientific information and resources.

This section provides an overview of the policies that enable these organizations to function to their full potential and maintain high standards while responding to trends in scientific research and changes in society.

## 1. Formation of Centers of Excellence (COEs)

### (1) Background

The formation of COEs was first identified as a goal by the Science Council in its July 1992 report on "Strategies for Comprehensive Promotion of Scientific Research with the Prospect of the Twenty-First Century." This report referred to the great importance to the promotion of highly original, pioneering research of creating centers where the world's top researchers could come together in high-quality research environments to exchange the latest scientific information and share original ideas.

The Science Council continued to deliberate this question, and in July 1995 it produced a set of recommendations for the formation of Centers of Excellence, as summarized below.

### (2) Outline of the Science Council Proposal

**(a) Definition of COE:** The definition of COE depends on the objectives involved and other factors, making it somewhat unclear. In the present context, COE is defined as "a preeminent research base that promotes highly creative scientific research at the most advanced level in the world."

**(b) Organizational concept for COEs:** Depending on such factors as the research field and the nature of research activities, conceivable organizational units for a COE might include a chair and research section, a special course, a major field, a discipline, a research department, a research facility or center, or a network of related research organizations. These can be broadly divided into the following categories, depending on the nature of the research organization:

(i) Relatively large research organizations with clearly defined organizational structures;

(ii) Groups of loosely linked research organizations;

(iii) Groups of researchers working together under a preeminent researcher;

(iv) Joint-use groups established primarily to share facilities and equipment.

Japan already has some university and graduate school research organizations and inter-university research institutes with outstanding research environments and distinguished research records that make them worthy of being called COEs. In the future, these and other COEs in many different fields must be developed aggressively.

**(c) COE formation strategies:** The initiative for COE formation should come from research institutes, individual researchers, and research groups themselves, and must be given active support. Combining existing strategies with programs like the following will be necessary to further develop and enhance COEs.

**(i) Program to form core research bases:** This program will focus on research organizations that are established around preeminent researchers and carrying out world-class research and that have the potential to evolve into core research bases in specific fields. Such organizations would be fostered as COEs.

**(ii) Program to support the creation of advanced research environments:** This program aims to contribute to the formation of Centers of Excellence in specific fields by developing high-quality research environments capable of attracting a wide range of researchers from Japan and overseas. This will require the prioritized establishment of superior research facilities capable of supporting world-class research.

**(iii) Support program for core research institutions:** This program will promote the further advancement of field-specific research institutes that already have the distinctive features of COEs, as well as of research institutes that, because of their nature, should be developed as COEs (such as inter-university research institutes, and facilities attached to national universities for the joint use of all university researchers in Japan).

### (3) Budget for COE Formation

In line with the report and recommendations of the Science Council, MESSC has made budgetary provisions for these programs since fiscal 1995. In fiscal 1997, it allocated funds totaling ¥13,454 million (a yearly increase of ¥2,086 million) for COE formation under the above three programs. This figure includes funds for research, facilities and equipment, fellowships for young Japanese researchers and postdoctoral foreign researchers, and international symposia. In this way, MESSC is helping to support research institutes and organizations that are striving to become COEs.

## 2. Increasing Flexibility and Fluidity in Research Organizations

### (1) New Developments for Research Organizations

Scientific research derives from researchers' unfettered concepts and spans all disciplines from the humanities and social sciences to the natural sciences. As research becomes increasingly diverse and multidisciplinary, MESSC is actively promoting flexibility and mobility in research organizations at national universities to enable them to maintain their dynamism.

**(a) Introduction of a large departmental system:** As scientific research becomes more diverse and multidisciplinary, researchers in a growing number of fields are finding it appropriate to link existing research organizations (which normally consist of one professor, one assistant professor, and two assistants) into larger structures based on loose ties among related fields (the so-called large departmental system).

Since FY1978, the large departmental system has been applied when it was felt that linking two or more research departments into single large departments would make them better able to respond appropriately to research trends. In FY1997 10 research departments at the Cancer Research Institute, Kanazawa University, were joined in three large departments, while 15 research departments at the Research Institute for Applied Mechanics, Kyushu University, were grouped into three large departments. The aim of these organizational changes was to develop new approaches to scientific research, and benefits deriving from them include the following:

(i) Joint research has been facilitated by linking research groups through professors working in related fields;

(ii) It is easier to respond to new fields and borderline areas;

(iii) Skilled researchers can easily be deployed as required;

(iv) Organized international cooperation has been facilitated.

**(b) Establishing flexible research organizations:** Promoting flexible research organizations and fluidity on the part of researchers has become an important goal in recent years due to the rapidly growing tendency of scientific research to become more diverse, comprehensive, and large-scale, as well as to the growing importance of interdisciplinary research and the need to maintain the dynamism of research organizations. MESSC is therefore working to develop flexible research organizations that have a certain degree of permanence as organizations but allow research themes and researchers to be changed periodically. Examples of such organizations established over the past few years include the University of Tokyo's Research Center for Advanced Science and Technology (established in FY1987), Tsukuba University's Center for Tsukuba Advanced Research Alliance (FY1994), Tohoku University's Center for Interdisciplinary Research (FY1995), and Nagoya University's Center for Integrated Research in Science and Engineering (FY1995). These organizations are contributing to the promotion of multidisciplinary, germinal, and advanced research.

In fiscal 1997 the Center for Advanced Research Projects was established at Osaka University to provide specific research teams with a place for intensive joint research over limited periods. When a project has been completed, the research team leaves, vacating its space for use by another research team, thus providing the basis for flexible organizational management.

**(c) Establishing research departments to promote researcher mobility:** Promoting researcher mobility is important to the development of dynamic research organizations. To achieve this goal, MESSC is setting up visiting researcher departments, flexible research departments, and endowed chairs and research departments.

Visiting researcher departments are structured to accommodate interdisciplinary research, for which research organizations with fixed staff allocations are unsuitable. They also respond to the need for "open research" resulting from the fluidity of disciplinary boundaries that occurs in research involving the complex intermeshing of related fields. Instead of fixed allocations of personnel, these departments utilize researchers from other universities. At present (FY1997) there are 171 such research departments.

Flexible research departments are established by transferring researchers, and the fixed number of staff assigned to them, from existing research departments in national universities to research institutes to participate for specific periods in joint research projects involving multiple universities. At present (FY1997) there are three such departments in the Institute for Molecular Science at Okazaki National Research Institutes and two in Kyushu University's Institute for Fundamental Research of Organic Chemistry.

Endowed chairs and research departments are created at the request of donors. As of June 1997, 48 endowed chairs had been established at 26 national universities (Table 3-4).

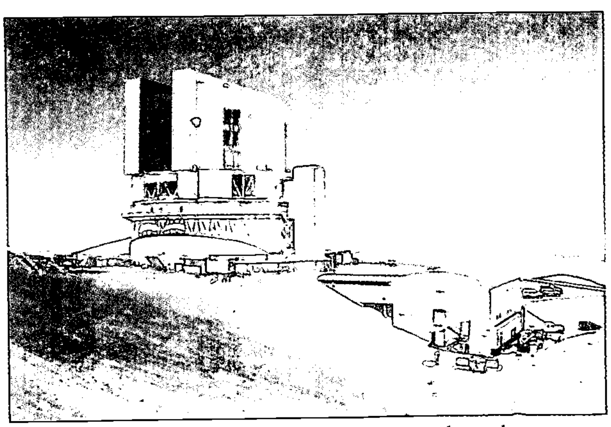
**(d) Promoting joint use:** Increasingly sophisticated research tools and methods have heightened the need for university research organizations that allow researchers from many fields to conduct joint research. The benefits of such organizations are already apparent.

MESSC has responded to trends in scientific research and the needs of society by promoting the formation of joint research systems. It has established 14 inter-university research institutes (independent institutes that are not attached to specific national universities), 20 research institutes for joint use attached to national universities, and 26 research facilities attached to national universities for joint use (institutes and facilities set up within specific national universities).

In FY1997 MESSC created the High Energy Accelerator Research Organization (an inter-university research institute), restructured the Research Institute for Applied Mechanics, Kyushu University, as research institute for joint use attached to a national university, and established the Research Center for Pathogenic Fungi and Microbial Toxicoses, a national joint-use facility in the field of pathology, at Chiba University.

**(e) Development of international research bases:** Because of the size of the facilities required, research in fields like astronomy, accelerator science, space science, and fusion is carried out mainly by inter-university research institutes. In addition to their role as national research hubs, these facilities also function as international research bases where Japanese researchers are actively engaged in projects with researchers from around the world.

The Science and Technology Basic Plan identifies the development of these international research bases as an important, government-wide policy. MESSC is actively promoting this as a priority policy with the potential to raise research standards in Japan and contribute to research worldwide.



*Subaru, the large infrared telescope currently under construction in Hawaii.*

In FY1997 MESSC created the High Energy Accelerator Research Organization to serve as an integrated research base for accelerator science, including not only particle physics, but also nuclear physics and research into the properties of mesons and muons. Also in fiscal 1997, the National Astronomical Observatory of Japan was established in Hawaii to provide a base for research relating to a large-scale infrared telescope that is currently under construction there. Efforts are also being made to bolster the research organizations at other research bases, such as the Institute of Space and Astronautical Science and the National Institute for Fusion Science, which are actively involved in basic research in many fields.

### (2) Introduction of a Selective Fixed-Term System for University Faculty Members

Researchers in Japanese universities and research institutes generally lack mobility, remaining tied to specific research venues. Because of this, research environments tend to be made up of people with homogeneous, uniform approaches that result in similar ideas and little opportunity for reciprocal criticism or competition. It is sometimes pointed out that this situation can hinder efforts to foster originality in researchers and revitalize research activities.

In 1997 the 140th session of Japan's National Diet passed the Law Concerning the Fixed-Term Appointment of Faculty Members at Universities, which provides for selective fixed-term systems to be introduced at the discretion of individual universities as a way of increasing researchers' mobility and revitalizing university research. Under any of the following circumstances, the law allows people to be appointed for fixed terms, subject to the agreement of the individuals concerned:

(i) When a person is to be recruited for a post in an educational or research organization that requires diverse human resources (flexible jobs);

(ii) When a person is to be recruited as an assistant primarily to carry out research (research assistant positions);

(iii) When a person is to be recruited for an educational or research post over a predetermined period under a specific project (project jobs).

A new employment framework has also been developed for government research workers in national experiment and research institutes with the aim of revitalizing research activities in these organizations. The same session of the Diet passed the Law Concerning the Special Measure for the Recruitment, Remuneration and Working Hours of Researchers with Fixed Terms in the Regular Service, which provides for the application of a tenure system under certain circumstances.

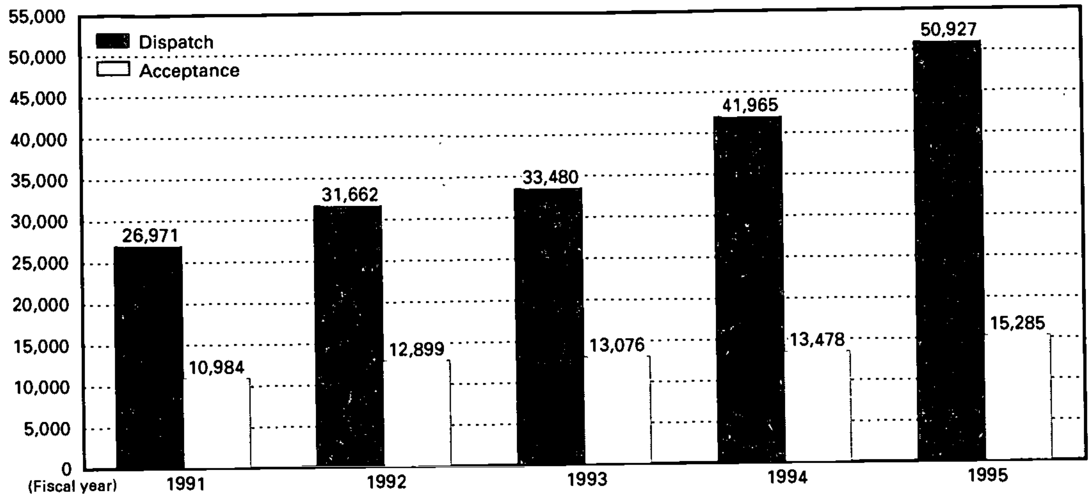
# Section 3: Promoting International Scientific Exchange and Cooperation

## 1. The Significance of International Scientific Exchange

Scientific research, which is dedicated to the pursuit of truth, should transcend national boundaries. Researchers focusing on the same goals must be able to improve the quality of their research through information exchanges, joint research, and reciprocal criticism of their results, whether in Japan or elsewhere. This type of international exchange is vital to the advancement of scientific research.

The past few years have brought a notable increase in international scientific exchange in Japanese universities and inter-university research institutes. According to surveys conducted by MESSC, the number of Japanese researchers sent overseas doubled in the four years up to FY1995, and the number of foreign researchers accepted in Japan increased approximately 1.5 times (Figure 2-16). The following factors appear to be propelling this growth, which is expected to accelerate in the years ahead.

**Figure 2-16: Exchange of Researchers in National Universities and Inter-University Research Institutes**




Source: MESSC.

### (1) The Growing Scale and Sophistication of Science

In some fields, the increasing sophistication of research is reflected in the growing size and complexity of research facilities. In the field of particle physics, for example, experiments designed to discover more elemental particles require accelerators that are more powerful and hence bigger. The increasing size and sophistication of research equipment used in various fields means that it is becoming more and more difficult, both technically and economically, for individual countries to build and operate such facilities entirely by themselves. International cooperation is therefore vital in advanced fields that require massive investments of human and material resources.

### (2) The Need for Global Approaches

More and more fields require a global approach based on international cooperation, including fields like climatology, geology, and oceanography that have implications for global environmental problems and natural disasters. Japan must participate actively in these areas.

### (3) Activating Research through the Use of Different Concepts and Methods

Exposure to different ideas and research methods helps to broaden the scope of one's own research and enrich one's ideas. Interaction with researchers from other countries is especially valuable, since it helps to raise the overall standard of research in Japan, while information provided by Japanese researchers contributes to the advancement of science globally.

### (4) The Need to Make an International Contribution through Science

In order to make an international contribution commensurate with its status in the world, Japan needs to participate actively in global joint research projects, to provide leadership in specialized fields in which Japanese researchers excel, and to accept more young researchers from Asia.

## 2. Frameworks for Diverse International Scientific Exchange

The promotion of international scientific exchange depends primarily on cooperative relationships among researchers. As outlined below, a variety of international cooperation frameworks have been created to facilitate exchange.

### (1) Cooperation with International Organizations and Scientific Groups

International cooperative research plans coordinated by international scientific organizations like the International Council of Scientific Union

(ICSU) provide unified frameworks for studies and information exchanges between participants from countries having a range of degrees of scientific advancement. Active participation in such programs is very worthwhile.

Japan is participating in a number of research programs proposed by international organizations, primarily in fields relating to the global environment that involve joint monitoring on a global scale, such as the Global Ocean Observing System (GOOS) program, the Global Energy and Water Cycle Experiment (GEWEX) Asian Monsoon Experiment Program (GAME), and the Global Change Impacts on Terrestrial Ecosystems in Monsoon Asia (TEMA) program, which is part of the International Geosphere Biosphere Program (IGBP).

Japan has long participated and cooperated actively in science programs conducted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in fields like oceanography, ecology, and hydrology. In particular, as a facet of efforts to raise scientific standards and strengthen networking and cooperation among researchers and research organizations, Japan has made financial contributions to UNESCO in the form of Funds-in-Trust to promote research and training activities in the Asia-Pacific region.

The Organization for Economic Cooperation and Development (OECD) has established the Committee for Scientific and Technological Policy (CSTP), which exchanges information on science and technology policies in member nations and makes recommendations about the solution of various domestic and international problems affecting research and development. Some working groups have been set up under the CSTP. The Megascience Forum, for example, was created in conjunction with the growth of international cooperative research in megascience fields, which are beyond the capabilities of individual nations. Members hear reports on developments in various nations and exchange views on issues like international cooperation methods and situations that are hindering international cooperation. Japan participates actively in working groups focusing on fields like nuclear physics and neutron sources. In the Group on the Science System (GSS), Japan is an enthusiastic participant in discussions revolving around evaluation of university research outcomes and universities for the twenty-first century (See Chapter 4, Section 3, 1). Japan will need to play an even more active role in efforts to solve problems relating to growing internationalization.

### (2) Bilateral Cooperation

Japan currently has government-level science and technology cooperation agreements with 32 nations. Activities include meetings of cooperative committees on the development of bilateral exchange, and reviews of joint research projects.

The Tokyo Summit in April 1996 resulted in the "Message from Prime Minister [Ryutaro] Hashimoto and President [Bill] Clinton to the Peoples of Japan and the United States: Meeting the Challenges of the 21st Century." In this message, they pledged to promote exchange between young American and Japanese researchers. In line with this initiative, MESSC has raised from eight to 50 the number of American researchers included in Research Experience Fellowships for Young Foreign Researchers. The Japan Society for the Promotion of Science (JSPS) has meanwhile established a special program for American researchers under its Postdoctoral Fellowships for Foreign Researchers. At the same summit conference, the two leaders also agreed to add the "Natural Disaster Reduction Initiative" (expanded to cover natural and man-made disaster reduction in May 1997) to the "Common Agenda: for Cooperation in Global Perspective," and to develop research cooperation between Japan and the United States with a view to reducing earthquake disasters. MESSC is planning and providing support to enable universities in Japan and the United States to conduct organized research into earthquake disasters.

## 3. Trends in International Scientific Exchange

### (1) Promotion of Researcher Exchange

Promoting exchange of researchers is one of the most important basic strategies for international scientific exchange, since such activities help to foster trust among individual researchers and lead to joint research in the future. In particular, exchange among young researchers is extremely important because of the potential to foster their creativity and international perspectives while revitalizing the research environment in Japan and overseas. MESSC is conducting the following activities through JSPS as part of its Program to Support 10,000 Postdoctoral Researchers. (See Chapter 2, Section 1, 1(4)).

**(i) Postdoctoral Fellowships for Research Abroad:** Young Japanese researchers are sent on long-term assignments to foreign universities and research institutes (100 in FY1996, 125 in FY1997).

**(ii) Postdoctoral Fellowships for Foreign Researchers:** Young researchers from other countries are accepted into Japanese universities and research institutes (420 in FY1996, 680 in FY1997).

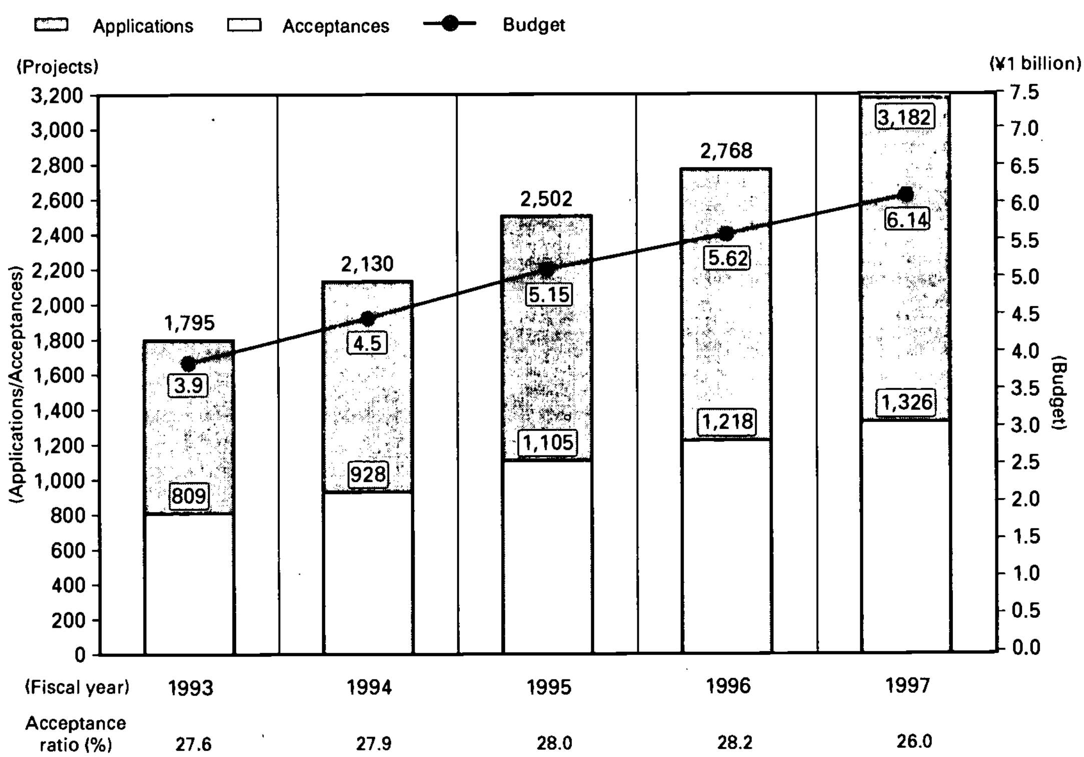
In addition, JSPS has programs to invite foreign researchers (short-term and long-term). These researcher exchange programs need to be further expanded and improved in the future.

MESSC also operates a short-term research program called Research Experience Fellowships for Young Foreign Researchers (20 researchers accepted in FY1996, 80 in FY1997). Under this program, young researchers from various countries are accepted into national universities or inter-university research institutes and given the opportunity to participate in joint research for a two-month period during the summer.

### (2) Promoting International Exchange of Scientific Information

Exchanges of scientific information help to stimulate Japanese researchers and provide excellent opportunities to disseminate Japanese scientific information. For these reasons, MESSC subsidizes various related activities, providing, for example, travel grants to researchers attending international symposia held overseas and supporting funds to national universities and inter-university research institutes for organizing symposia in Japan.

**Figure 2-17: Grants-in-Aid for Scientific Research for International Research: Applications, Acceptances and Budget**




Note: Acceptance ratios are based on initial allocations for new projects for the fiscal year.
Source: MESSC.

### (3) Promoting International Cooperative Research Projects

The increasing sophistication, scale, and diversity of scientific research are reflected in the growing importance of international cooperation and contribution and in a growing need for international cooperative research under Japanese leadership. MESSC supports cooperative research and field research by university research groups through grants-in-aid for scientific research for international research (Figure 2-17).

Related activities include joint research projects and scientific seminars conducted by JSPS under its program of international cooperation for advanced research, which targets the United States, the United Kingdom, Germany, and France, and under the Japan-Europe Research Cooperative Program, which covers European countries except the United Kingdom, Germany, and France.

For international research projects that require massive funding and participation by many countries, it is particularly important not only to work closely with other countries, but also to participate actively from the planning stage and to propose superlative research themes.

So, in addition to its financial contribution to the construction of the Large Hadron Collider (LHC) by the European Organization for Nuclear Research (CERN), for example, Japan also participates as an observer on the CERN council. In addition, within the scope of domestic scientific interest and technical capability, Japan has also accepted responsibility, from the design stage, for developing important portions of the measuring devices to be used in experiments. This illustrates how Japan can make an international contribution through participation in cooperative research while maintaining independent involvement from the development stage.

In addition, Japan is building a large-scale optical infrared telescope called Subaru on the peak of Mauna Kea in Hawaii (See Chapter 2, Section 2, 2(e)). Teaching and clerical staff were assigned to the facility in FY1997. In the future, it will be necessary to consider the role of international exchange support and other programs centering on overseas research facilities such as this.

### (4) Promoting Scientific Exchange with Asian Countries

Promoting scientific exchange with Asian countries is highly significant in that it enables Japanese scientific research to contribute not only to the improvement of scientific research infrastructure in the countries concerned, but also to the solution of shared problems in Asia. The Japan Society for the Promotion of Science is implementing the Core University Program, whereby designated "core universities" in Japan and counterpart countries are paired for joint research in specified fields that reflect the needs of the partner country. With the cooperation of other universities, these core universities carry out organized, inter-university scientific exchange, including joint research and seminars. There is also a program called "RONPAC" to assist prospective doctoral candidates. Under this program, young researchers who wish to obtain a doctoral degree through the submission of a dissertation to a Japanese university are invited to Japan and, when necessary, Japanese university teaching personnel may be sent abroad to provide research guidance.

Fostering international scientific exchange and cooperation not only with Asia and the Pacific, but also with the scientifically advanced countries of Western Europe and North America and with countries in other parts of the world, such as Eastern Europe, will require a wide range of carefully targeted activities, such as joint research, seminars, and personnel exchanges, to ensure a proper response to different countries' situations and needs with respect to scientific research systems and the training of researchers.

## 4. Improving Infrastructure for Promotion of International Scientific Exchange and Cooperation

Improving Japanese scientific research infrastructure is important to providing a solid home base for the promotion of international scientific exchange and cooperation.

### (1) Developing World-Class Research Infrastructure in Japan

MESSC is working to improve the overall level of Japan's scientific research infrastructure in order to create a research environment capable of corresponding satisfactorily with research standards in other countries at a time when international joint research is becoming increasingly sophisticated. A special priority in this context is the formation of Centers of Excellence capable of pursuing world-class scientific research in various fields.

Improving and developing programs to invite young foreign researchers to Japan necessitates raising Japanese research standards so that these people can gain international evaluation for the research they do here. Some scientific research organizations in Japan already have considerable experience in exchanging personnel with counterpart organizations overseas. These achievements must be used as the basis for further improving these organizations' ability to disseminate information.

### (2) Improving and Expanding Systems for Receiving Foreign Researchers

At present, there are international exchange departments or equivalent organizational units in 24 of Japan's 98 national universities and three of its 14 inter-university research institutes. Improving organizations responsible for the administration of international exchange and enhancing training for the personnel involved are essential both in terms of responding to research trends in other countries, and also to enable organizations to respond appropriately to the various needs and circumstances of researchers.

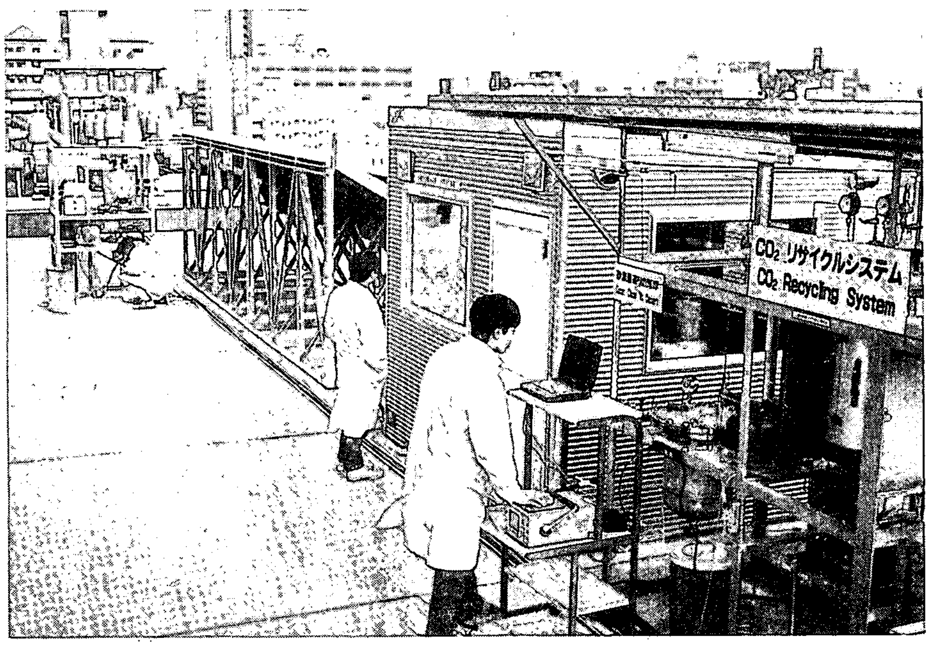
Although the number of researchers spending at least six months in Japan reached about 4,000 in FY1995, national universities and other institutions had only 1,502 housing units available for them. Systematic efforts to rectify this serious shortage of accommodation facilities must be made as soon as possible.

### (3) Improving and Expanding the Japan Society for the Promotion of Science

The Japan Society for the Promotion of Science is Japan's core organization for promoting international exchange and cooperation in scientific fields. It is currently engaged in exchange activities with 59 counterpart organizations in 38 countries and one region. It has established seven overseas liaison offices in locations throughout the world, including Washington, London, Bonn, and Bangkok, to gather scientific information from the regions concerned and distribute information about scientific trends in Japan. Compared with similar organizations in other countries, however, staffing at JSPS is still inadequate and needs to be improved and expanded.

# Chapter 3

# New Trends in the Promotion of Science




*Carbon dioxide recycling system.*

# Section 1: Toward A Prioritized Research Promotion System

## 1. Basic Thinking

The promotion of scientific research depends on continually improving the infrastructure described in Chapter 2, Section 1, including research personnel, funds, facilities and equipment, and scientific information and resources, across the entire spectrum of research fields. In promoting research on specific themes, it is also important to create and utilize systems designed to support prioritized, intensive research by appropriately combining research funds and other elements.

To give some examples, the system of unit cost per professor, which is calculated on a per teacher basis in national universities, is effective for supporting fundamental, day-to-day research activities and for maintaining the overall standard of scientific research. The promotion of research through competitive funding, such as grants-in-aid for scientific research, has been an extremely effective mechanism for encouraging the further development of specific findings that emerge in the course of fundamental research.

MESSC is working to ensure the efficient utilization of human and material resources to accommodate new research needs arising from scientific advances and socioeconomic change. It is also promoting science through the continuing development of research across the entire spectrum of fields and through the prioritized encouragement of research on specific themes.

There is an ongoing need to encourage scientific research from a long-term, comprehensive perspective through the balanced management of these two promotion systems. As discussed at the beginning of this report, MESSC places considerable importance on the continuing enhancement and utilization of prioritized research promotion systems to ensure a sensitive response to society's needs while adapting to changes in the research environment.

## 2. Prioritized Research Promotion Systems Today

The range of possible systems for prioritized research is wide and varied. The leading example is the promotion of large-scale research ("big science"), the funding of which is covered by the system for research in priority areas described in Chapter 2, Section 1, 2, (4). In the Science Council's 1992 report, large-scale research was defined as "a large-sized program to be promoted by intensive channeling of a considerably large amount of research resources including researchers, research funds, research facilities and equipments, etc. within a specified period," with accelerator science, space science, astronomy, and fusion research all listed as examples. This section focuses on prioritized promotion systems for research programs that cannot be classified as large-scale, long-term projects but still need intensive promotion on a significant scale within certain time frames. As shown in Table 3-1, the categories covered are (1) specially promoted research, (2) research on priority areas, (3) New Program Research, (4) Center of Excellence formation programs, and (5) research under the Research for the Future Program.

Items (4) and (5) have already been discussed, items (1), (2), and (3) are examined below.

### (1) Specially Promoted Research

The Specially Promoted Research category of grants-in-aid for scientific research was instituted in fiscal 1982 after a trial period that began in FY1979. It is an important research promotion system designed to encourage original, pioneering basic research in Japan. Under this system, substantial research funds are provided over periods of 3~5 years for research programs implemented by individuals or relatively small groups of researchers. The goal defined for the program when it was established was "to provide prioritized subsidization for very outstanding research that is at the leading edge of international work in the field and has the potential to yield highly valuable results." Approximately 10 programs are selected each year on the basis of rigorous screening.

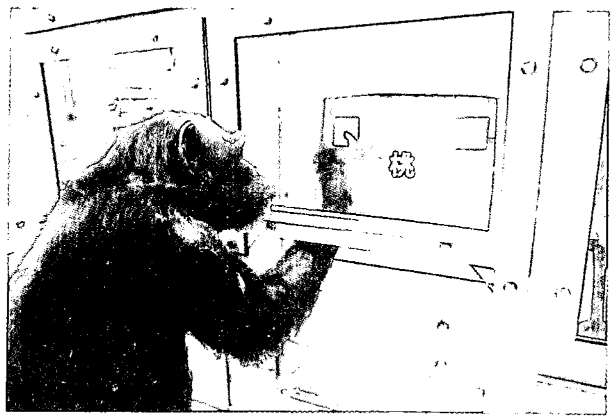
**Table 3-1: The Current State of Prioritized Research Promotion Systems**

| Item | Specially Promoted Research | Research in Priority Areas | New Program Research | Center of Excellence Formation Programs | Projects under the Research for the Future Program |
|---|---|---|---|---|---|
| Scope | Research programs organized by individual researchers or comparatively small numbers of researchers that offer the potential to produce extremely valuable results through the prioritized use of substantial research funds to promote increased effort in areas that have gained international recognition. | Subject to Science Council screening, programs that promote research in fields that have been specially selected in response to strong scientific or social needs are selected for strategic, prioritized promotion over specific periods, with the aim of achieving significant progress in the fields concerned. | (1) Research that will have a wide-ranging impact on progress in existing fields of study or will lead to the creation of revolutionary new areas of study; (2) research that will lay the foundations for the creation or development of new fields and systems of technology; and (3) research into problems that require global approaches, research that will contribute to the welfare of humanity, and research that can be conducted more efficiently through international cooperation. | High-quality, researcher-centered research organizations with the potential to evolve into core research bases capable of carrying out world-class research in specific fields. | (1) Highly creative, future-oriented research that will produce the intellectual assets and form the scientific bases for advancing economic and social development and enhancing the quality of the life of the nation in the years leading up to the 21st century; (2) university-led research (with cooperation from industrial and other sectors when necessary) aimed at meeting society's diversifying needs, with research work carried out mainly by researchers in universities and other scientific research institutions. |
| Amounts of funding | Approximately ¥50 million–¥300 million total funding per research theme | Approximately ¥50 million–¥600 million annual funding per research theme | — | — | Approximately ¥50 million–¥300 million total annual funding per research theme per year |
| Duration of research | 3–5 years | 3–6 years | 5 years | 5 years | About 5 years |
| Type of funds allocated | Grants-in-aid for scientific research | Grants-in-aid for scientific research | Grants-in-aid for scientific research<br>JSPS subsidies (fellowships for young scientists), etc. | Grants-in-aid for scientific research<br>JSPS subsidies (fellowships for young scientists, postdoctoral fellowships for foreign researchers)<br>Facility funding<br>Funding for international symposia<br>Current expenditure subsidies for private universities, etc. | Capital investment in JSPS |

Note: See Chapter 2, Section 2 for a discussion of COEs.

* All endowed chairs and research departments and centers for cooperative research have been established since fiscal 1987. The figures are for fiscal 1987.

Source: MESSC.



*Specially Promoted Research: "Acquisition and intergenerational transmission of language and recognition skills in chimpanzees" (1995~1999). Ai reads Chinese characters denoting colors.*

**Research Themes for Specially Promoted Research Programs that Start in Fiscal 1997**

**Physical and Engineering Sciences**

Formation and evaluation of quantum dot structures in high-density semiconductors
Coherent radiation of micro-bunch electronics
Exploring dark matter axions
Electronic physical control in wide-gap semiconductors and its application to energy electronics
Creation of biological motion elements using polymer gels
Formation of metal reaction fields with a view to activation of specific small molecules
Chemical research relating to plant senses and motion

**Biology**

Analysis of formation differentiation and molecular structures of coronary blood vessels
Research into motor-protein functions using protein engineering and holographic cryo-electron microscopy
Molecular-cellular biological research into abnormalities in renal membrane transportation
Comparative molecular biological research concerning peptide hormone receptors involved in adjustment of body fluids and circulation
Functions of cofilin as an actin adjustment protein

## (2) Research on Priority Areas

Research on Priority Areas is another category of grants-in-aid for scientific research. It was introduced in fiscal 1987 in response to a proposal from the Science Council in July 1985. The system is designed to encourage efficient research by combining fluid, flexible research organizations and funding in areas of scholarship in which sophisticated research tools and methods already exist. On the basis of requests from groups of researchers, funds in this category are used to provide timely support in advanced fields that have been targeted for further progress. The level of funding ranges from ¥50 million to ¥600 million per fiscal year and is provided over periods of 3~6 years, depending on the content of the research and current trends in the fields concerned. There is strong demand among researchers for Research on Priority Areas funds. In fiscal 1997 there were 178 applications, of which 23 were selected.

**Research on Priority Areas that Starts in Fiscal 1997**

The development of the mind: The mechanisms of recognition growth
Scientific research on the origins of the Japanese people and culture
Micro-region magnetism and its transmission
Formation and polar reaction of structural limitation fields

New organic chemical phenomena: New axes for the carbon shared linkage formation based on multielement cooperation effects
The chemistry of interelement fusion
Creation of a super-biosystem using sugar chain molecules with advanced recognition
Near-field nano-optics: The chemistry and engineering of isolated photons in microspaces
Analysis of microscopic mechanisms in phase transformations with a view to the control of material organization
Carbon alloys: Space control and the development of functions in carbon materials
Developments of new semiconductor structures through spin control
Research into the structural principles of software with development functions
Non CP-storage physics
Development of physical environmental processes with a view to the achievement of zero emissions
Biological functions and designer molecules
Molecular basis for the control of photosynthesis in individual plants
Molecular basis of vertebrate body plans
Cell function control through the use of molecular chaperones
Analysis of higher life phenomena from the viewpoint of transfer control mechanisms
Molecular basis of dynamic RNA functions
Diversity and uniformity in biological molecular motors
Nerve cell death and the use of molecular control to prevent it
Molecular mechanisms of arteriosclerosis

### (3) Research under the New Program System

The Research under the New Program System, which was launched in fiscal 1990, is based on a Science Council report titled "New Strategies for Promoting Scientific Research: A New Program for the Development of Science" (July 1989). The program aims to provide active encouragement for research having potential to lay the foundations for new developments in scientific research through intensive allocation of researchers, funds, and other resources. Priority areas are selected flexibly to respond appropriately to scientific research trends and needs, in consultation with the Science Council. The themes selected for promotion in fiscal 1997 are as follows.

**New Program Themes for Promotion in Fiscal 1997**

Research and development relating to an ultrahigh-speed telecommunications network to support scientific research
Molecular biological research on development and formation in the individual organism
Design and synthesis of functional biological molecules
Intracellular information transmission mechanisms
Comprehensive study on the status of the Japanese language in the international community
Gravity wave astronomy using high-sensitivity laser interferometers
Basic research for the development of sustainable biological production technology in harmony with regional environments in East Asia
Comparative historical study of population and family structures in Eurasian societies
Ocean hemisphere network: A new look at the Earth's interior
Surfaces and interfaces: Physical properties of points of contact between differing symmetries
Dynamic research about the modern Islamic world: Developing an information system and accumulating information needed to understand the world of Islam
The role of information media organizations in the formation of a human-oriented multimedia environment
Comprehensive basic research about the preservation of biodiversity and the maintenance and management of biological information in the face of global environmental disruption

## 3. Future Directions and Goals

### (1) Selection of Research Fields

The basic requirements when using prioritized research promotion systems are to monitor research trends and standards accurately, to take note of views from various sources, especially researchers, and to develop effective strategies. It is also important to select research fields and themes that deserve prioritized promotion. These are not easy tasks, and deliberation by the Science Council and other forums indicates that the following factors need to be considered:

(i) Whether progress in the research inherently creates a need for increasingly large and expensive research equipment and whether well-organized collaboration by a large number of researchers is indispensable to promoting the research;

(ii) Whether there is a high level of activity in the research field as a whole and significant progress can be expected from the investment of additional funds;

(iii) Whether it is a field for which there is strong societal need but in which it is difficult to concentrate researchers' resources due to the wide range of fields involved or the geographical scattering of research bases;

(iv) Whether the research field is growing and can be expected to develop more efficiently through timely, prioritized investment;

(v) Whether the field is significant in blazing trails or laying foundations for scientific research and can produce significant spinoff benefits for the progress of research in other fields;

(vi) Whether the field has considerable importance from the perspective of integrated progress across the entire spectrum of scientific research but requires special consideration to correct slow progress in the past;

(vii) Whether it is a scientifically or socially important field in which Japan has fallen behind by international standards;

(viii) Whether it is closely related to the solution of economic and social problems, is a facet of a national project aimed at finding such solutions, and can be expected to produce results for which there is strong societal demand.

These diverse perspectives are indicative of the need for prioritized promotion of research in fields like global environmental science, informatics, brain research, and infectious diseases. MESSC intends to give urgent attention to the promotion of research in the fields of global environmental science and informatics as discussed in sections (2) and (3) below. In these fields, too, a comprehensive approach that also encompasses the humanities and social sciences is needed, and as discussed in section (4), the promotion of scientific research in the humanities and social sciences will also be a priority in the future.

MESSC needs to ensure that research fields for prioritized promotion are selected appropriately. In this regard it will be important to monitor the current research situation, including research trends in Japan and abroad, and research funding in various fields. To ensure an appropriate response to the wishes of all concerned, especially researchers, it will also be necessary to expand and enhance the functions of the Science Council, which has traditionally been responsible for this task. A new prioritized research promotion system will need to be created on the basis of deliberations by the Science Council.

### (2) Promoting Global Environmental Science

Solving global environmental problems is an urgent task with crucial implications for human survival. We need to re-examine the way people live and to understand the natural environment on which our lives are based. This will require the integration of scientific research across fields ranging from the humanities and social sciences to the natural sciences and the creation of a new science of the global environment.

In April 1995 the Science Council produced a proposal entitled "The Promotion of Global Environmental Science." It called for considering the establishment of a core research organization for global environmental science to promote comprehensive joint research aimed at solving global environmental problems.

Numerous researchers in a wide range of fields subsequently studied this proposal. In March 1997 they produced a report on "The Role of a Core Research Organization in Relation to Global Environmental Science," summarized in items (a) through (c) below.

In accordance with this proposal and the report, MESSC will undertake further detailed studies and work toward the establishment of a core research organization. It will also promote global environmental science in cooperation with the relevant government ministries and agencies.

**(a) Current progress in research relating to global environmental problems:** Researchers in various fields, including earth science, ecology, the humanities and social sciences, engineering, and agricultural science, are taking a keen interest in the highly topical issue of global environmental problems and are accumulating research findings that will contribute to the explanation and solution of these problems.

Japan's efforts in these areas, however, do not always compare favorably with the work being done in European and North American countries. Past research has been limited to the traditional boundaries between disciplines, and exchange and cooperation among different fields have been insufficient.

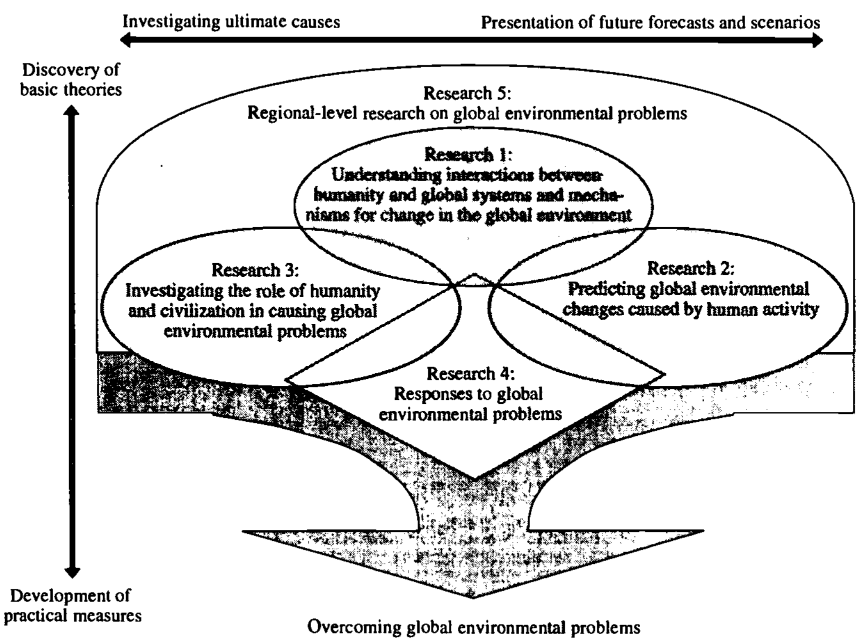
**(b) The need for global environmental science:** By explaining the mechanisms behind change in the global environment, clarifying the interaction between human activity and the global environment, and re-examining the roles of social systems and human lifestyles, scientific research focusing on global environmental problems aims to create new cultural patterns that will enable people to live in harmony with nature.

In addition to the research that is already being carried out in fields relating to the global environment, it will be necessary to apply new ideas and perspectives to efforts that center on explaining the real nature of global environmental problems and on using this knowledge to solve them. As quickly as possible, we need to integrate research in fields ranging from the humanities and social sciences to the natural sciences into the new field of global environmental science, which will be dedicated to the solution of global environmental problems, and we must establish a core institution to promote comprehensive research.

Research findings are already accruing in the various fields that relate to global environmental problems. In creating the new field of global environmental science, we will need to develop a research structure capable of operating through the core institution to maintain organic links with research in these existing fields.

In addition to their global impact, environmental problems also have regional implications. As an advanced nation in Asia and the Pacific, Japan is expected to make an active contribution, including the transfer of sophisticated technology. This

**Figure 3-1: Content and Direction of Research Relating to Global Environmental Science**




Source: "The Role of a Core Research Organization in Relation to Global Environmental Science" (March 1997).

is another factor calling for the establishment of a core research institution to propose and implement various programs, including international joint research.

**(c) Content and directions of future research:** Global environmental science should be structured as a comprehensive science dedicated to understanding the root causes of global environmental problems and to solving problems on the basis of this understanding. To achieve this goal will require research centering on the following five major themes (Figure 3-1):

Research 1: Understanding interactions between humanity and global systems and mechanisms for change in the global environment;

Research 2: Predicting global environmental changes caused by human activity;

Research 3: Investigating the role of humanity and civilization in causing global environmental problems;

Research 4: Responses to global environmental problems;

Research 5: Regional-level research on global environmental problems.

### (3) Promoting Research on Information

In January 1997 the Information Science Subcommittee of the Science Council commenced deliberations on future approaches to information research. In July 1997 it produced an interim report titled "Measures to Promote Research in Informatics," summarized in sections (a), (b), and (c) below. Meanwhile, a recommendation for the creation of a core research institute for computer science was presented by the Science Council of Japan in May 1997.

MESSC will actively promote the recommended measures, including the enhancement of graduate schools and efforts to create a core research institute.

**(a) Significance and importance:** In recent years, the range of fields affected by information research has expanded to include not only engineering fields like information science and computer science, but also bioscience, the humanities, and the social sciences. The study of information evolved from the accumulation of knowledge in existing fields. Today information research has itself yielded concepts and technologies, including computer technology, that are used in almost every field of scholarship and have contributed to the advancement of these fields and the creation of new ones (Figure 3-2). With the evolution of an information-oriented society, informatics is expected to play a major role in advancing industry, improving national living standards, and enhancing culture.

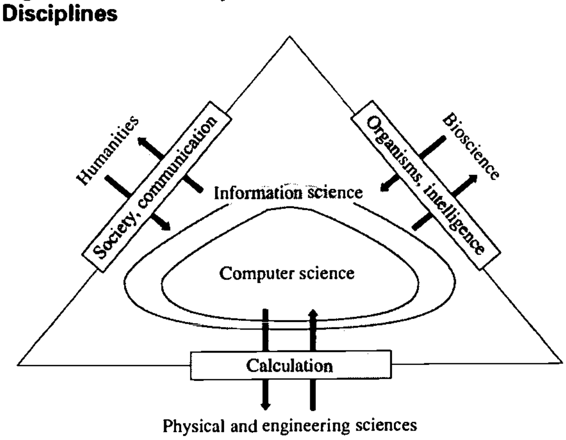
**(b) The current situation:** Japan has led the world in the hardware aspects of information research. However, it is considered to have fallen significantly behind other countries, especially the United States, in the area of software, including computer operating systems.

An examination of universities' research and teaching structures indicates that considerable progress has been made in developing research organizations, including departments, major subjects, and, in recent years, graduate school departments. In many cases, however, there are imbalances in educational and research content and in faculty composition, and there are still too few researchers and students.

Compared with Europe and North America, and especially with the United States, Japan falls short in both its researcher population and also the number of trained people supplied to society. Major increases are needed in these areas.

What is more, not only Western countries but also some Asian nations are making systematic efforts to promote active research and development efforts in information-related fields.

**Figure 3-2: The Composition of Information-Related Disciplines**




Source: Science Council, Information Science Subcommittee, "Measures to Promote Informatics Research" (Interim Report; July 1997).

**(c) Future promotion policies:** To catch up with the West and contribute to the promotion of science at the world level, Japan will need to:

(i) Establish a core research institution in the information field. It will be extremely important to encourage integrated, comprehensive information research in cooperation with university faculties and graduate school departments, national research institutions, businesses, and other organizations, as well as research institutes in other countries.

(ii) Develop human resources. This is an urgent priority and will require further improvement and expansion of university faculties and graduate schools.

(iii) Promote the research necessary to systemize information-related disciplines, including the humanities and social sciences. Such work should take into account the significance and value of information.

(iv) Place heavy priority on allocating research funds to information-related fields.

### (4) Promotion of Research in the Humanities and Social Sciences

The Science Council produced basic reports on the promotion of science in 1973, 1984, and 1992. Each of these reports contained ideas and strategies for promoting scientific research in general. In relation to the humanities and social sciences, in particular, they emphasize the need for promotion that takes account of the characteristics of each field.

In the July 1992 report, for example, the Science Council refers to trends in research in the humanities and social sciences: "To promote the humanities and social sciences, it will be necessary to accelerate efforts to expand and enhance the overall research infrastructure in these fields. It is also important to promote research on a prioritized basis, especially in fields that are the focus of pressing needs. It is appropriate in this context to give consideration to areas of the humanities and social sciences that are expected to make a particularly positive contribution, such as the global environment, bioethics, area studies, and policy science." The Discussion Group on the Promotion of Research in the Humanities and Social Sciences, which was established within the Science Council's Special Committee on Scientific Research Systems, subsequently carried out a study focusing on the need to promote scientific research in the humanities and social sciences and on promotion strategies. In March 1995 it produced a report titled "The Promotion of Scientific Research in the Humanities and Social Sciences."

The aim of the Science and Technology Basic Plan is to promote comprehensive, systematic policies for research and development in the natural sciences. It also recognizes, however, that interaction between the natural sciences and the humanities is important to the progress of science and technology and it calls for taking care to ensure harmony between the two areas.

It will therefore be necessary to give priority to promoting research in the humanities and social sciences using the systems described above and taking into account the characteristics of these fields.

Germany's Federal Ministry for Education, Science, Research and Technology (Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie) made the following comments about the importance of the humanities and social sciences in its 1996 Federal Report on Research (*Bundesbericht Forschung).*

**German Federal Government Report on Research (*Bundesbericht Forschung*)**

"Science is an integral part of our culture and the sciences shape and mould the cultural development in Germany with a lasting effect. Science and research are among the sources that nourish our intellectual life. Cultural wealth and the intellectual climate are not least reflections of scientific development.

"The Federal Government's research policy is guided by this role of science and research which is of central importance for the creative abilities of our polity. It highlights the significance of the humanities and social sciences and supports their dialogue with the natural sciences to further a better understanding of the complexity of human action and its underlying motivation.

"Many of the central questions raised by modern social development cannot be answered by science and technology; on the contrary—it is the pace and depth of scientific and technological development that bring up the question of the value-based coordinate system of society and its directive influence on personal action. Science that faces the question about its ethical basis and limits makes an important contribution to laying normative foundations.

"The dialogue between science and society is indispensable. Science must 'meddle', it must raise its voice in public. The Federal Ministry of Education, Science, Research, and Technology (BMBF) will intensify its support of this dialogue by organising events and issuing publications focusing on questions about our future, thus contributing to a better acceptance of new technologies and developments in our society."

# Section 2: New Approaches to University-Industry Cooperation and Collaboration

## 1. Growing Expectations of University-Industry Cooperation and Collaboration

All sectors of our society have grown more aware of the need to discover new knowledge, create new technology, and use these advances to build new industries if Japan is to achieve an affluent, prosperous social environment in the twenty-first century. More than ever before, scientific research has become the focus of society's hopes and expectations, including a desire for increased cooperation and collaboration between universities and industry. Over the past few years, in particular, people have looked to university research for new advances that can lead to commercial activities, such as venture businesses, that will contribute to industrial restructuring and the revitalization of local communities and economies.

It is incumbent on universities to respond to these expectations on the part of society, including industry, and contribute to their fulfillment. Through expanded interaction with the wider community, universities receive fresh external stimuli that can revitalize their research activities and lead to the discovery and development of new areas of scientific research, which is valuable both to universities and to society in general because of the potential to contribute to the accumulation of humanity's intellectual assets and the advancement of the national economy.

The promotion of cooperation and interaction between industrial, academic, and governmental circles is identified as a pillar of the Science and Technology Basic Plan, which indicates a variety of promotion strategies. The "Action Plan for Economic Structure Reform," which was adopted by the Cabinet in May 1997, and the "Program for Educational Reform" (revised edition), a report submitted to the Prime Minister by the Minister of Education, Science, Sports and Culture in August 1997, also call for increased efforts to promote research based on university-industry cooperation and collaboration (Table 3-2).

## 2. Current Situation and Achievements

### (1) MESSC Efforts to Improve Various Systems

The ensuing discussion focuses primarily on arrangements for research cooperation between national universities and industry. MESSC has, however, also adopted a variety of measures for private universities, including subsidies for the creation of joint research promotion centers under the Private University Scientific Frontier Promotion Program and tax concessions for donations to school corporations that establish private universities. It is hoped that these measures will promote research cooperation between universities and industry in ways that reflect the different characteristics of national, local public, and private universities.

Research cooperation between national universities and industry is being actively encouraged

**Table 3-2: Cabinet Decisions, etc., Concerning University-Industry Cooperation and Collaboration**

**Science and Technology Basic Plan (Cabinet Decision, July 1996)**

- The range of cases in which researchers from national universities can engage in joint research at private sector research facilities will be expanded.
- Means of handling the calculation of retirement allowances pertaining to periods of leave taken for the purpose of participation in joint research between the private sector and the government will be considered as soon as possible.
- Efforts will be made to facilitate the administration of secondary employment permits to enable government researchers to do research, provide advice, or undertake similar activities in the private sector outside their normal working hours.

**Action Plan for Economic Structure Reform (Cabinet Decision, May 1997)**

- Provision will be made as soon as possible to enable nongovernment parties to set up facilities at national experiment and research institutes and national universities for use in joint research projects.
- The government will consider measures to acquire intellectual property rights for, and promote the distribution of, research findings from national universities. The necessary steps will be taken by fiscal 1998.
- The government will study and implement specific measures to promote university-industry cooperation on a comprehensive basis. Measures will include the establishment of forums for liaison and consultation across agency and ministry lines, and systems to facilitate the acquisition of intellectual property rights for, and the distribution of, research results from national universities.

**Program for Educational Reform (Report to the Prime Minister, August 1997)**

- The Act for Partial Amendment of the Special Law for Education Officials was promulgated to prevent unfavorable deductions from the retirement allowances of national university faculty members who take leaves of absence to participate in joint research projects. To implement the Act, relevant government ordinances will be enacted in the autumn of 1997.
- To smoothly transfer research results from national institutes to industry, measures for securing patents on research results and promoting their publication will be discussed, and necessary action will be taken in fiscal 1998.
- We will take necessary measures to allow private parties to establish research facilities for joint research development on the premises of national institutes.
- Joint research will be conducted through the cooperation of local enterprises and national institutes, and research results will be returned to local communities. For this purpose, we will consider measures for national institutes to use facilities owned by local public organizations.
- In light of actual social recognition, we will consider the issue of national institute researchers' participation in business management, such as becoming venture business partners, while exchanging opinions with related ministries and agencies.
- The Ministries Conference for the Promotion of Institutes and Industry Cooperation will reach conclusions in the discussion of practical measures to comprehensively promote cooperation, and we will take necessary action to implement the measures after full discussion with other ministries and agencies.

through the introduction of public funding under the systems described below. To further enrich and enhance scientific research, research resources need to be diversified. Private sector and other outside funding now ranks alongside government grants-in-aid for scientific research as a valuable source of support for national universities, which are the main centers for scientific research (Table 3-3).

**(a) Joint research with the private sector:** This type of research focuses on themes of common interest to researchers in national universities and private enterprises. It is carried out in a wide range of fields, bringing together the research capabilities of the national universities and the technological strength of the private sector. Joint research with the private sector is expected to produce outstanding results. The number of projects has increased steadily over the years and is expected to grow even more in the future, partially due to the systemic improvements discussed below (Figure 3-3).

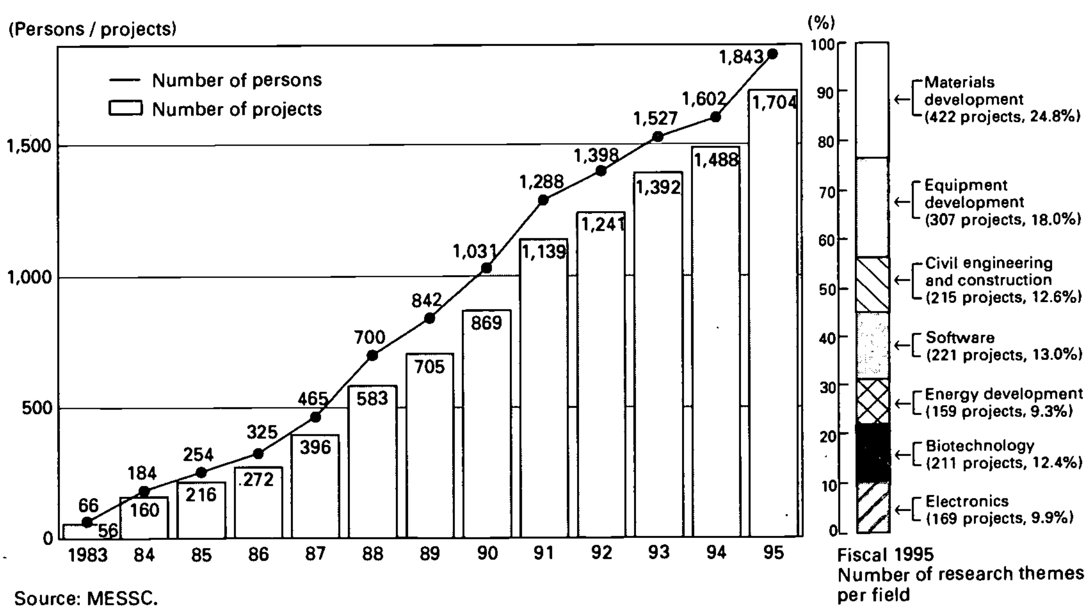
**(b) Commissioned research:** In the course of research and development activities, private companies and government agencies and institutions sometimes commission basic research to national universities. This system enhances the effectiveness of research and development by utilizing the basic research resources that have accrued in national universities. National university researchers who accept commissions undertake research at the expense of the companies or agencies commissioning it and cooperate in those organizations' research and development efforts by providing reports on the results of their work. The number of research commissions accepted has quadrupled in the decade since FY1985 (Figure 3-4).

**Table 3-3: Research Cooperation between National Universities and Industry (Growth over the Past 10 Years)**

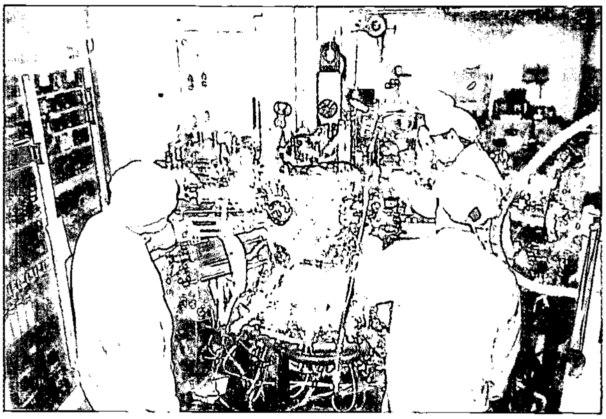
| Category | Fiscal 1985 | Fiscal 1996 | Rate of increase |
|---|---|---|---|
| Joint research with the private sector, etc. | Research projects: 216<br>Researchers accepted: 254 | Research projects: 1,704<br>Researchers accepted: 1,843 | About 7.8 times<br>About 7.2 times |
| Commissioned research | ¥3,490 million | ¥14,110 million | About 4.0 times |
| Commissioned researchers | Researchers accepted: 842 | Researchers accepted: 867 | About 1.0 times |
| Grants and endowments | ¥22,400 million | ¥48,700 million | About 2.1 times |
| Endowed chairs and funded research departments | * 2 universities<br>1 endowed chair<br>4 funded research departments | 24 universities<br>43 endowed chairs<br>11 funded research departments | 12.0 times<br>43.0 times<br>About 2.7 times |
| Centers for cooperative research | * 3 centers | 49 centers | About 16.3 times |

* All endowed chairs and funded research departments and centers for cooperative research have been established since fiscal 1987. The figures are for fiscal 1987.

**Figure 3-3: Joint Research with the Private Sector**




Source: MESSC.



*Joint research with private enterprise (semiconductor electronic elements).*

In FY1995 the government introduced a new basic research promotion system involving the use of subscriptions paid to special corporations. National universities accepted 152 commissioned research projects worth approximately ¥7 billion under this system.

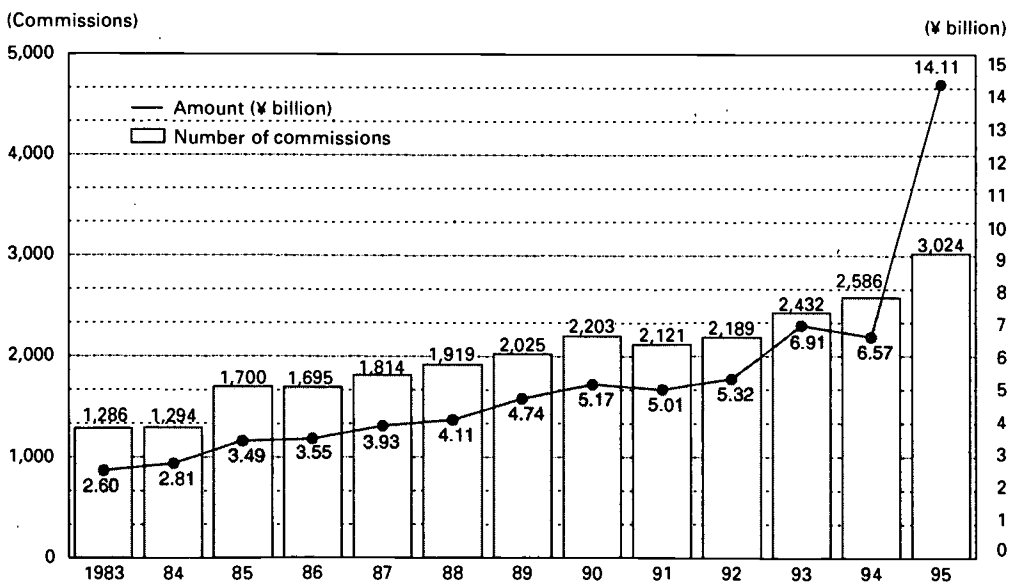
**(c) Commissioned researchers:** This system enables engineers and researchers employed in the private sector to receive graduate-level guidance in the latest research at national universities and inter-university research institutes. Participating researchers and engineers improve their talents and skills, gaining knowledge that they subsequently utilize in research at their home organizations.

**(d) Grants and endowments:** National universities accept donations to encourage scientific research from private firms, individuals, and other sources under the scholarship endowment accounting system. These donations make up the bulk of funding that national universities receive from the private sector. The national universities are able to use these funds flexibly and effectively to provide scholarships for students and to finance research, international exchange, and other activities. Donations to national universities are treated as donations to the government, making them eligible for tax benefits.

**(e) Endowed chairs and funded research departments:** Scholarship donations to national universities and inter-university research institutes can be used to establish endowed chairs or funded research departments in accordance with the wishes of donors. Endowed chairs have been created in a wide range of fields, including economics, engineering, science, and medicine. Their presence has helped to enrich and enliven university education and research (Table 3-4).

**(f) Establishment of joint research centers:** MESSC has set up centers for cooperative research at 49 national universities in 42 prefectures. As venues for joint research, commissioned research, and other activities involving the private sector, these centers act as interfaces between industry and the academic world. They also help to stimulate cooperation and collaboration with local industries by providing engineering staff in pri-

**Figure 3-4: Acceptance of Commissioned Research**




Note: The figures exclude commissioned experiments, pathological tissue analyses and testing of therapeutic drugs.
Source: MESSC.

**Table 3-4: Establishment of Endowed Chairs and Funded Research Departments (as of June 1, 1997)**

| Name of Institution | | Endowed Chair/Funded Research Department | Donor |
|---|---|---|---|
| Hokkaido University | Faculty of Economics | Chair of corporate financing | Japan Bond Research Institute |
| | Faculty of Engineering | Chair of snow and ice engineering | East Japan Railway Co.<br>Hokkaido Railway Co. |
| | Graduate School of Engineering | Chair of urban metabolism systems (Ebara) | Ebara Corporation |
| | | International chair of aquatic environmental engineering (Nishihara) | Nishihara Engineering Co.<br>Nishihara Environmental Sanitation Research Corp. |
| Asahikawa Medical College | School of Medicine | Chair of clinical pharmacology (Tsumura) | Tsumura & Co. |
| Tohoku University | Graduate School of Engineering | Endowed chair of large-scale system stage engineering (East Japan Railway) | East Japan Railway Co. |
| | | Endowed chair of advanced electrical engineering (Tohoku Electric Power) | Tohoku Electric Power Co., Inc. |
| | Institute for Materials Research | Endowed research department for materials design virtual laboratory (IBM and Hitachi) | IBM Japan, Ltd.; Hitachi, Ltd. |
| Yamagata University | School of Medicine | Endowed chair of cellular information analysis (Yamanouchi Pharmaceutical) | Yamanouchi Pharmaceutical Co., Ltd.<br>Yamagata Technopolis Foundation |
| University of Tsukuba | Master's Program in Health and Physical Education | Endowed chair of professional sports coaching (JFA and J.League) | Football Association of Japan (JFA)<br>Japan Professional Football League (J.League) |
| Gunma University | Faculty of Medicine | Chair of neurological and psychiatric pharmacology (Tsumura) | Tsumura & Co. |
| The University of Tokyo | Faculty of Medicine | Endowed chair of vascular physiology (Tsumura) | Tsumura & Co. |
| | | Endowed chair of pharmacological epidemiology | 15 companies, including Takeda Chemical Industries, Ltd. |
| | | Endowed chair of hepatitis virology (SKBB) | Smith Kline Beecham Biologicals |
| | | Endowed chair of biological defense functions (Tsumura) | Tsumura & Co. |
| | Faculty of Pharmaceutical Science | Chair of functional pathology | Takeda Chemical Industries, Ltd. |
| | Faculty of Engineering | Endowed chair of steel-making system synthesis (BF-5) | Nippon Steel Corp.; Kawasaki Steel Corp.; NKK Corp.; Kobe Steel, Ltd.; Sumitomo Metal Industries, Ltd. |
| | Graduate School of Engineering | Endowed chair of transport system engineering (Central Japan Railway) | Central Japan Railway Co. |
| | | Endowed chair of global environment engineering (Shin-Etsu Chemical) | Shin-Etsu Chemical Co., Ltd. |
| | | Endowed chair of maintenance engineering (East Japan Railway) | East Japan Railway Co. |
| | | Endowed chair of reliability engineering for materials used in extreme environments (Tokyo Electric Power) | Tokyo Electric Power Co., Inc. |
| | Graduate School of Law and Politics<br>International Center for Comparative Law and Politics | Endowed research department for international capital market law | Nomura Foundation for Social Science |
| | Institute of Medical Science | Endowed research department for genetic engineering | Eisai Co., Ltd. |
| | | Endowed research department for signal molecule control of stem cells (Amgen) | Amgen Limited |
| | | Endowed research department for cellular processing (Asahi Chemical Industry) | Asahi Chemical Industry Co., Ltd. |
| | | Endowed research department for the investigation of hematogenic factors (Chugai Pharmaceutical) | Chugai Pharmaceutical Co., Ltd. |
| | Center for Climate System Research | Endowed research department for global climate change (Itochu Group) | 13 Itochu Group companies, including Itochu Corp. |
| Tokyo Medical and Dental University | Medical Research Institute | Research department for victim behavior (Secom) | Secom Science and Technology Foundation |
| Tokyo Institute of Technology | Faculty of Engineering | Endowed chair of cooperation engineering (East Japan Railway) | East Japan Railway Co. |
| | Faculty of Bioscience and Biotechnology | Endowed chair of molecular bioscience (Schering-Plough) | Schering-Plough K.K. |

**Table 3-4: Establishment of Endowed Chairs and Funded Research Departments (as of June 1, 1997) [continued]**

| Name of Institution | | Endowed Chair/Funded Research Department | Donor |
|---|---|---|---|
| Tokyo Institute of Technology [cont.] | Faculty of Bioscience and Biotechnology [cont.] | Endowed chair of sugar chain bioscience (Mitsubishi Chemical, Seikagaku) | Mitsubishi Chemical Corp.; Seikagaku Corp. |
| | Research Center for Quantum Effect Electronics | Endowed chair of quantum device systems (Hitachi) | Hitachi, Ltd. |
| Tokyo University of Fisheries | Faculty of Fisheries | Endowed chair for international fisheries and food industry studies (Toyo Suisan Kaisha, Ltd., Shoichiro Tanahashi Memorial) | Toyo Suisan Kaisha, Ltd.; Mori Kazuo; Towa Shokuhin Kenkyu Shinkokai |
| Hitotsubashi University | Faculty of Commerce | Endowed chair for futures market theory | Commodities Futures Association of Japan<br>Tokyo Commodity Exchange<br>Tokyo Grain Exchange |
| Yokohama National University | Faculty of Engineering | Chair of sensor engineering | New Cosmos Electric Co. |
| Fukui Medical University | High-Energy Medicine Research Center | Endowed research department for radiological pharmacology | Nihon Medi-Physics Co., Ltd. |
| Hamamatsu University School of Medicine | Faculty of Medicine | Clinical pharmacology (Japan Pharmaceutical Manufacturers Association) | Japan Pharmaceutical Manufacturers Association |
| | Photon Medical Research Center | Research department for light technology (Photonics) | Hamamatsu Photonics K.K. |
| Nagoya University | School of Engineering | Endowed chair of human life support biomechanics (Toyota) | Toyota Motor Corp. |
| | Center for Integrated Research in Science and Engineering | Endowed research department for energy systems (Chubu Electric Power) | Chubu Electric Power Co., Inc. |
| Nagoya Institute of Technology | Research Center for Micro-Structure Devices | Endowed research department for chemical-mechanical precision processing (Fujimi) | Fujimi Inc. |
| Kyoto University | Graduate School of Human and Environmental Studies | Chair of international preventive nutritional medicine | Otsuka Pharmaceutical Co., Ltd. |
| | Graduate School of Medicine | Chair of molecular immunology and allergy | Bayer Yakuhin, Ltd. |
| | Graduate School of Engineering | Chair of integrated planning of water resource quality | Kubota Corp. |
| Kyoto Institute of Technology | Faculty of Textile Science | Chair of advanced fiber technology | Japan Chemical Fibers Association |
| Osaka University | Faculty of Economics | Endowed chair of the economics of risk and information (Tokio Fire & Marine) | Tokio Marine & Fire Insurance Co., Ltd. |
| | Faculty of Medicine | Endowed chair of molecular neurobiology (Tanabe) | Tanabe Seiyaku Co., Ltd. |
| | | Endowed chair of cognitive neuroscience (Ono Pharmaceutical) | Ono Pharmaceutical Co., Ltd. |
| | Faculty of Pharmaceutical Science | Endowed chair of clinical pharmacological efficiency evaluation (Taisho) | Taisho Pharmaceutical Co., Ltd. |
| | Graduate School of Engineering | Endowed chair of applied laser energy engineering (Photonics) | Hamamatsu Photonics K.K. |
| | Osaka School of International Public Policy | Endowed chair of the asset management industry | Nomura Asset Management Co., Ltd. |
| The University of Tokushima | School of Medicine | Chair of clinical molecular nutrition science (Otsuka Pharmaceutical) | Otsuka Pharmaceutical Factory, Inc. |
| Kagawa Medical University | Faculty of Medicine | Chair of chemical and biological information (Teikoku Seiyaku) | Teikoku Seiyaku Co., Ltd. |
| Kyushu University | Faculty of Economics | Chair of insurance studies | Yasuda Fire & Marine Insurance Co., Ltd. |
| | Graduate School of Information Science and Electrical Engineering | Chair of applied superconductivity | Kyushu Electric Power Co., Inc. |
| | Interdisciplinary Graduate School of Engineering Sciences | Chair of electrical energy systems | Kyushu Electric Power Co., Inc. |
| Kyushu Institute of Technology | Faculty of Engineering | Chair of electrical system control engineering | Kyushu Electric Power Co., Inc. |
| Kumamoto University | Faculty of Pharmaceutical Science | Endowed chair of pathological pharmacological analysis | Aso Pharmaceutical Company, Limited |
| | Faculty of Engineering | Endowed chair of advanced electrical energy technology | Kyushu Electric Power Co., Inc. |
| Japan Advanced Institute of Science and Technology, Hokuriku | School of Information Science | Endowed chair of advanced ultra-parallel computing systems (Kokusai Electric) | Kokusai Electric Co., Ltd. |
| Nara Institute of Science and Technology | Graduate School of Bioscience | Taisho Pharmaceutical chair in genome function analysis | Taisho Pharmaceutical Co., Ltd. |

(48 endowed chairs and 13 endowed funded research departments in 26 universities)

vate companies with advanced technical training, technical advice, and other assistance relating to research and development (Table 3-5).

In addition, national universities are progressively establishing research cooperation departments and sections to serve as interfaces for cooperation and collaboration with the wider community.

**Table 3-5: Establishment of Centers for Cooperative Research**

| Year | University | Center |
|---|---|---|
| Fiscal 1987 | Toyama University<br>Kobe University<br>Kumamoto University | Center for Cooperative Research<br>Center for Cooperative Research and Development<br>Cooperative Research Center |
| Fiscal 1988 | Muroran Institute of Technology<br>Gunma University<br>Tokyo University of Agriculture and Technology<br>Gifu University<br>Nagoya University | Center for Cooperative Research and Development<br>Center for Cooperative Research<br>Cooperative Research Center<br>Center for Cooperative Research<br>Center for Cooperative Research in Advanced Science and Technology |
| Fiscal 1989 | Ibaraki University<br>Utsunomiya University<br>Nagoya Institute of Technology<br>Kyushu Institute of Technology<br>Saga University | Center for Cooperative Research and Development<br>Cooperative Research Center<br>Center for Cooperative Research<br>Center for Cooperative Research<br>Joint Research and Development Center |
| Fiscal 1990 | Yamanashi University<br>Mie University<br>Kyoto Institute of Technology<br>Okayama University<br>Nagasaki University | Cooperative Research and Development Center<br>Cooperative Research Center<br>Cooperative Research Center<br>Cooperative Research Center<br>Joint Research Center |
| Fiscal 1991 | Yokohama National University<br>Niigata University<br>Shizuoka University<br>Yamaguchi University<br>The University of Tokushima | Cooperative Research and Development Center<br>Center for Cooperative Research<br>Center for Joint Research<br>Center for Collaborative Research<br>Center for Cooperative Research |
| Fiscal 1992 | Kitami Institute of Technology<br>Yamagata University<br>The University of Electro-Communications<br>Fukui University<br>Kagoshima University | Cooperative Research Center<br>Cooperative Research Center<br>Cooperative Research Center<br>Center for Cooperative Research in Science and Technology<br>Research and Development Center |
| Fiscal 1993 | Iwate University<br>Akita University<br>Shinshu University<br>Tottori University<br>Oita University | Cooperative Research Center<br>Cooperative Research Center<br>Cooperative Research Center<br>Center for Joint Research and Development<br>Research and Development Center |
| Fiscal 1994 | Saitama University<br>Chiba University<br>Ehime University<br>Kyushu University<br>Miyazaki University | Cooperative Research Center<br>Center for Cooperative Research<br>Center for Cooperative Research and Development<br>Advanced Science and Technology Center for Cooperative Research<br>Cooperative Research Center |
| Fiscal 1995 | Kanazawa University<br>Osaka University<br>Hiroshima University<br>Kochi University<br>The University of the Ryukyus | Center for Cooperative Research<br>Cooperative Research Center for Advanced Science and Technology<br>Center for Technology Research and Development<br>Center for Joint Research and Development<br>Center for Cooperative Research |
| Fiscal 1996 | Hokkaido University<br>Obihiro University of Agriculture and Veterinary Medicine<br>The University of Tokyo<br>Shimane University | Center for Advanced Science and Technology<br>Cooperative Research Center<br>Center for Collaborative Research<br>Cooperative Research Center |
| Fiscal 1997 | Hirosaki University<br>Kyushu Institute of Design | Cooperative Research Center<br>Design Research Center |

### (2) Research Cooperation between Universities and Industry through External Organizations

**(a) University-industry cooperation programs of the Japan Society for the Promotion of Science:** The Japan Society for the Promotion of Science has established the Advisory Committee to University-Industry Research Committees, the Committee for Research Promotion in Specialized Areas, and University-Industry Cooperative Research Committees made up of leading researchers from academia and industry. These groups provide forums for developing new fields for research cooperation between universities and industry. These committees discuss research and share information on selected fields, goals, and important issues relating to technology development. Some of the topics examined by the Advisory Committee to University-Industry Research Committees and other groups are already being researched under the Research for the Future Program.

The Japan Society for the Promotion of Science also provides assistance for international symposiums. This aspect of the Society's activities is handled mainly by the University-Industry Cooperative Research Committees.

**(b) Activities of research grant foundations:** Many incorporated nonprofit organizations have been established for the primary purpose of providing grants for scientific research. Such organizations, which are supported by donations from industry and other sectors of society, provide researchers with research grants and awards. They make an important contribution to promoting science. As of May 1997, 132 foundations and 32 trust funds were providing subsidies for scientific research.

## 3. Consultative Committee Deliberations

MESSC is endeavoring to promote research cooperation between universities and industry. In February 1996 it established the Consultative Committee for Research and Surveys Regarding University-Industry Cooperation and Collaboration to discuss approaches to this task. In December 1996 the committee produced an interim report, and in March 1997 it submitted a report titled "Building New Mechanisms for University-Industry Cooperation" to MESSC.

The basic thinking behind the report was that: First, there is growing pressure for university research organizations to cooperate and collaborate with industry, and such cooperation, when undertaken in awareness of the social roles and responsibilities of both sides, will benefit both industry and universities, as well as society as a whole; second, university-industry cooperation and collaboration should be promoted by creating systems to facilitate participation by interested researchers, rather than attempting to involve all teaching personnel; and third, cooperation will need to be administered under highly transparent systems that include the establishment of clear standards and the disclosure of information.

The report also highlights a number of basic directions for reform and goals for university-industry cooperation and collaboration. First, efforts should be made to reform attitudes on both sides and to promote dialogue between industry and universities. Second, systemic improvements must be made to facilitate cooperative research in private sector companies. Third, local bases for interaction should be established. Fourth, efforts should be made to promote the transfer of technology in various formats from universities to industry.

MESSC has been implementing the suggested systemic changes since December 1996.

## 4. Progress toward Systemic Improvements

MESSC has made the following improvements in its systems on the basis of the Program for Educational Reform and the deliberations of the consultative committee.

### (1) Increasing Situations in Which Joint Research Can Be Undertaken with Private Corporations

In the past, joint research involving national universities and private sector organizations normally had to be conducted within the national universities. Research could be carried out in facilities owned by the company participating in the project only under exceptional circumstances that necessitated the use of specific facilities owned by the company that could not easily be brought into the university. In March 1997 the relevant notification was amended to allow researchers to go to the facilities of partner companies to conduct research.

### (2) Removal of Disadvantages Respecting Retirement Allowances

In the past, when a national university faculty member took leave to participate in joint research with a company, only one half of the person's leave period was considered valid for calculating the retirement allowance, causing a reduction in the amount payable to the person on retirement. The government moved to eliminate this financial disadvantage by amending the Act for Partial Amendment of the Special Law for Educational Officials for cases in which participation in joint research makes a special contribution to its efficient implementation. The bill, which was put before the 140th ordinary session of the National Diet, was passed in April and has now been promulgated. The fixed-term appointment of faculty members at universities was passed by the same session of the Diet and went into effect in June. The selective fixed-term system provided in this law (Chapter 2, Section 2, 2(2)) will also help to promote researcher exchange between industry and universities.

### (3) Expansion of Scope for Secondary Employment

In December 1996 the government amended the notification relating to secondary employment for teachers in national universities who are employed outside of their normal working hours to carry out research and development or other activities for profit-making enterprises. Among the changes introduced is a provision making such arrangements subject to approval in principle. Effective as of fiscal 1997, this amendment also eliminates the previous regulation that limited the number of secondary jobs to seven and the number of hours to eight per week.

### (4) Extension of Preferential Patent Implementation Period for Partner Companies

In the past, companies engaging in joint research with national universities enjoyed preferential rights to patents resulting from such research for a maximum of seven years. The relevant notification was amended in March 1997 to increase this period to 10 years from the date of the patent application, with provision for further extension if necessary. This change took effect in fiscal 1997.

### (5) Procedural Improvements

In March 1997 related ordinances and notifications were amended to speed up and simplify administrative procedures for the acceptance of commissioned research and scholarship donations. The requirement to obtain the approval of the Minister of Education, Science, Sports and Culture when receiving payments from international agencies and foreign organizations was removed, effective from fiscal 1997.

MESSC has been able to implement these improvements with respect to national universities, and it is hoped that similar improvements will be made with respect to local public and private universities.

### (6) Taxation Measures to Promote University-Industry Cooperation and Collaboration

Tax reforms implemented in fiscal 1997 include measures to encourage joint research between universities and private sector companies. The joint experiment and research tax system was extended to the end of March 1999 and expanded to cover expenditures for specific joint research projects carried out in-house by private companies.

## 5. Future Strategies

MESSC expects these systemic improvements to provide additional impetus for the promotion of university-industry cooperation and collaboration. In March 1997 a report was compiled on the proceedings of the Consultative Committee for Research and Surveys Regarding University-Industry Cooperation and Collaboration. A variety of issues and measures concerning the promotion of university-industry cooperation and collaboration are identified in the "Action Plan for Economic Structure Reform," which was adopted by the Cabinet in May 1997, and in the August 1997 amendment to the "Program for Educational Reform." In addition to systemic improvements to encourage personnel exchanges, it will also be necessary to consider the following issues from the standpoint of ensuring the effective and efficient transfer of university research results to society:

(i) Incentives and support for patent acquisition by university teachers;

(ii) Return of investment income from intellectual property rights;

(iii) Improvement of liaison functions to mediate patents for private sector companies; and

(iv) Training research coordinators.

MESSC is working actively to expand university-industry cooperation and collaboration. In June 1997, it began to hold meetings of both the Consultative Committee for Research and Surveys Regarding University-Industry Cooperation and Collaboration and the Interministerial Conference on University-Industry Cooperation and Collaboration. The former committee brings together scientific experts and others to discuss the promotion of university-industry cooperation and collaboration from the specialist's perspective. The latter brings together representatives of government ministries and agencies involved in the promotion of university-industry cooperation to discuss comprehensive, strategic approaches to this task.

# Section 3: Improving Evaluation Systems for Scientific Research

## 1. Significance and Importance of Research Evaluation

In recent years there has been growing interest in the evaluation of the scientific research conducted in universities and national research institutions. Improving evaluation systems has become more important than ever before because:

(i) Despite Japan's tight fiscal situation, the budget for scientific research has been increasing steadily and expenditures on individual research projects have also risen dramatically, making evaluation important from the standpoint both of the efficient, prioritized allocation and effective utilization of research funds and also of the government's accountability to the taxpayers, who foot the bill;

(ii) The research community has been criticized for being closed and insulated from competition, making it necessary for researchers themselves to do some introspection and to ensure that their activities are transparent so as to avoid misconceptions and to gain public understanding and support for their research activities.

The evaluation of scientific research should not be discussed solely in terms of social factors, however, since it also has important aspects deriving from the characteristics inherent in scientific research itself. First, because scientific research is driven by the free ideas of researchers, it is characterized by extreme variety in objectives, nature, scale, and methods. Second, in many cases, research results can lead to unexpected progress many years in the future. Because of this, the evaluation of scientific research must not be approached from a uniform, short-term perspective based on expectations of immediate gains, but rather from the standpoint of providing stimulation, advice, and encouragement for research activities.

## 2. Current Trends in Research Evaluation

In universities, peer review has functioned effectively as a method for evaluating scientific research, subjecting it to strict evaluation from various perspectives.

### (1) Evaluation of Research Topics

In Japan, grants-in-aid for scientific research are awarded selectively to support outstanding

**Figure 3-5: An Example of the Evaluation System for Grants-in-Aid for Scientific Research (Research in Priority Areas)**

| Prior Evaluation (Screening) | Interim Evaluation | Postcompletion Assessments (announcement of results) |
|---|---|---|
| Solicitation of proposals for fields ⇓ Processing of applications ⇓ Selection of themes for hearings ⇓ Hearings ⇓ (Screening panels) Selection of fields ⇓ Solicitation of research theme applications ⇓ Processing of applications ⇓ Screening panels for individual fields ⇓ (Screening panels) Selection of themes<br>* Examiners' names publicized after completion of screening process.<br>* Reasons for nonacceptance of fields disclosed to applicants. | Annual<br>Research progress reports submitted<br>1st, 3rd, and 5th years<br>Research progress reports submitted (read by screening panel members; hearings held if necessary)<br>2nd and 4th years<br>Hearings | Year after completion<br>Hearing<br>Research report (in booklet form) and outline (English and Japanese) submitted<br>(Stored in National Center for Science Information Systems database, available for access by researchers throughout Japan)<br>Public symposiums<br>Voluntary publication of research results at academic society meetings, etc. |

projects based on researchers' free ideas. The Science Council solicits applications, which are then subjected to impartial evaluation. The Science Council's Committee on Grants-in-Aid for Scientific Research engages some 2,000 experts to evaluate research proposals, using methods that vary according to the funding category.

The evaluation system, which includes interim and postcompletion assessments for large grants, is administered impartially and is constantly being improved (Figure 3-5). Positive steps have been taken to improve the transparency of the system, such as publicizing the names of all examiners after the allocation assessment process is completed and disclosing the reasons for not accepting projects in some cases.

According to "A Survey on Scientific Research and Evaluation," which itself received a grant-in-aid for scientific research in 1994, over 80% of the researchers involved in the evaluation of projects for grants-in-aid for scientific research in fiscal 1994 were confident of their evaluations, while over 60% of the researchers who underwent such evaluations were satisfied with the results (Figure 3-6). This indicates that, while there is still room for improvement, the system for evaluating grants-in-aid for scientific research is already of a very high standard and ensures appropriate and impartial evaluation.

**Figure 3-6: Attitudes toward Evaluations of Projects for Grants-in-Aid for Scientific Research**

| | | |
|---|---|---|
| Evaluators | | |
| | Confident of own evaluation | 86% |
| | Not sure | 10% |
| | Not confident of own evaluation | 4% |
| Those evaluated | | |
| | Satisfied with evaluation results | 64% |
| | Not sure | 20% |
| | Dissatisfied with evaluation results | 16% |

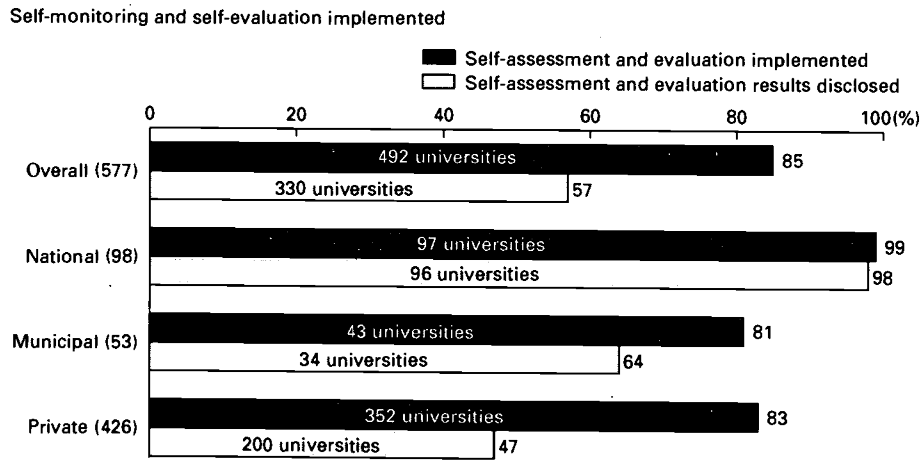
Source: "Survey on Scientific Research and Evaluation," a report on research funded by grants-in-aid for scientific research in fiscal 1993 and 1994 (September 1994).

**(2) Evaluation of Research Institutions**

Since the 1991 amendment of the Standards for the Establishment of Universities, most universities have introduced self-monitoring and self-evaluation systems for their educational and research activities and have also begun to disclose the results of such evaluations (Figures 3-7 and 3-8). Over the past few years, a rapidly growing number of universities have also introduced systems for external evaluation (Figure 3-9).

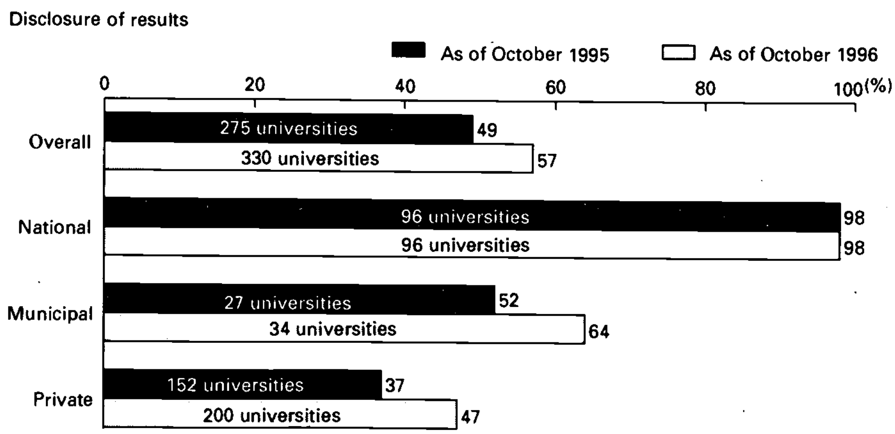
To ensure that inter-university research institutes and joint-use research institutes attached to national universities are managed and run properly, research and educational activities in these institutions are subject to evaluation by boards of trustees made up of outside researchers and experts (inter-university research institutes), by management councils that include researchers working in the same field (inter-university research institutes), or by joint-use facility management committees (joint-use research institutes attached to national universities). In addition, over 90% of research institutes have already established their own outside evaluation organizations, and the majority now disclose the results of evaluations (Figure 3-10). Almost 70% of research organizations have established internal rules for the evaluation of their activities, including management (Figure 3-11).

**Figure 3-7 Self-Monitoring and Self-Evaluation in Universities (as of October 1996)**



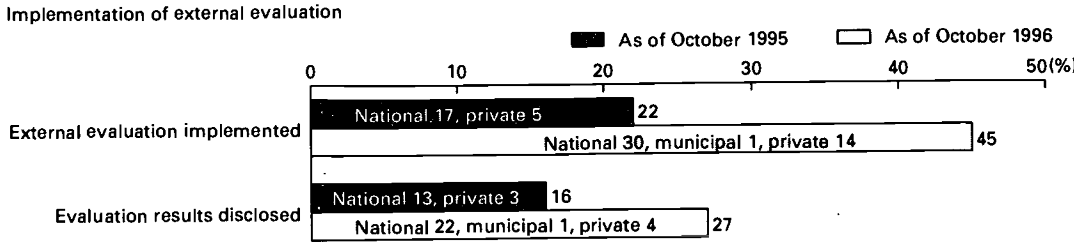

Source: MESSC.

**Figure 3-8 Disclosure of Self-Monitoring and Self-Evaluation Results by Universities**



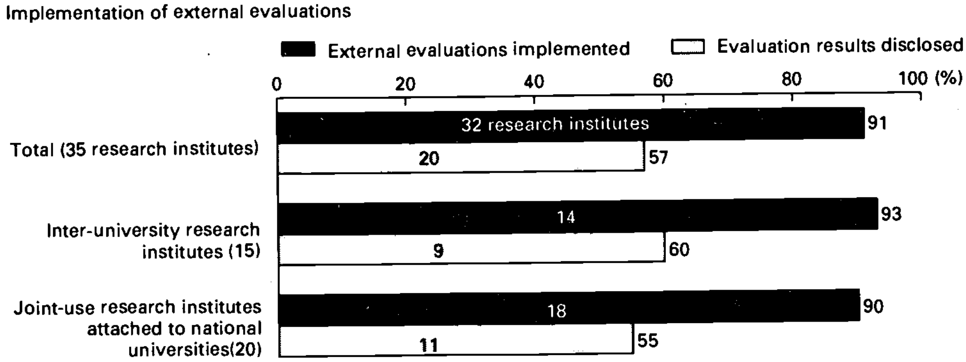

Source: MESSC.

**Figure 3-9: Introduction of Outside Evaluation into Self-Monitoring and Self-Evaluation in Universities**



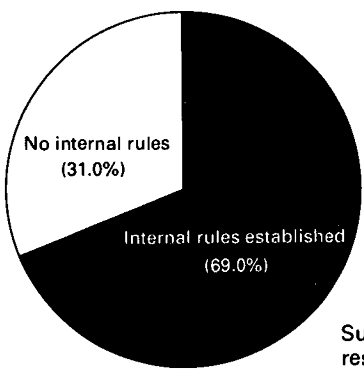

Source: MESSC.

**Figure 3-10: Self-Monitoring and Self-Evaluation in Inter-University Research Institutes**




Source: MESSC.

**Figure 3-11: Establishment of Internal Rules for Research Evaluation in Inter-University Research Institutes**




Types of internal rules (multiple responses)

| | |
|---|---|
| Organizational and personnel management | 91.2% |
| Selection of research and development fields and themes | 88.2% |
| Development of facilities, information infrastructure, and research support systems | 82.4% |
| External exchange, including joint research | 100.0% |
| Others | 26.5% |

Survey coverage: 15 inter-university research institutes, 19 joint-use research institutes attached to national universities, 16 research facilities

Source: MESSC.

## 3. Development of Research Evaluation Systems

Because of the diversity and broad scope of scientific research, the assessment of research themes must employ systems that reflect the characteristics of research projects, including objectives, nature, methods, scale, duration, and field. Similarly, systems developed for evaluating research institutions must reflect the aims for which those institutions were established, the fields in which they operate, and other characteristics.

### (1) Examiners

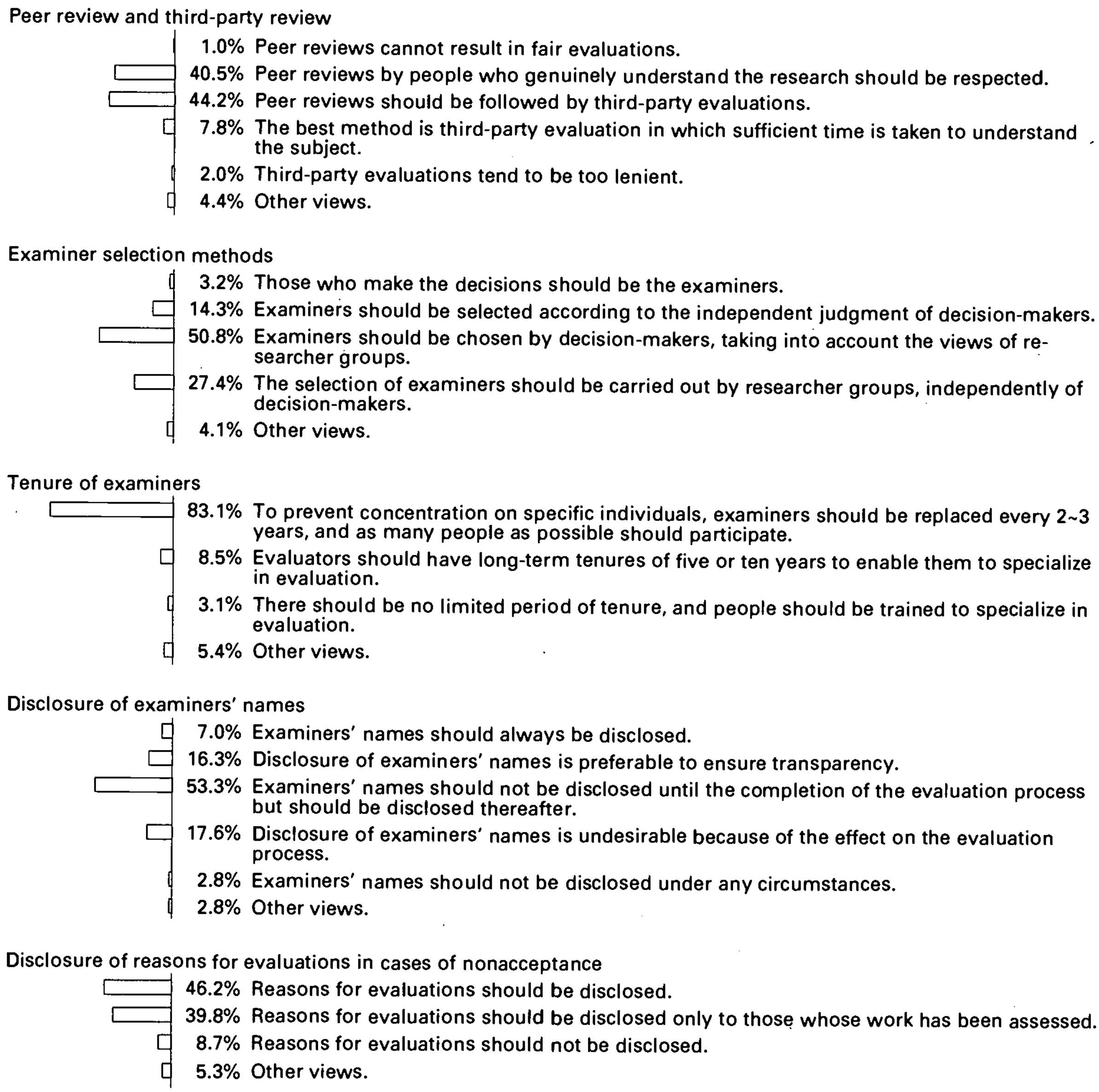
Examiners are the most important element in evaluation systems, and high-quality personnel must be recruited to ensure appropriate evaluation.

Participants in the Survey on Scientific Research and Evaluation were asked to state their views on the methods used to select examiners. The majority felt that the views of research groups should be taken into account when choosing decision-makers (persons who plan evaluations and make some kind of decision on the basis of evaluation results) (Figure 3-12).

Survey respondents were also asked to state their views on the tenure of examiners. Over 80% felt that, to prevent concentration on specific individuals, examiners should be replaced every 2~3 years, and as many people as possible should participate. With regard to the disclosure of examiners' names, approximately one-half of researchers thought that examiners' names should not be disclosed until the completion of the evaluation process but should be disclosed thereafter. The names of examiners for grants-in-aid for scientific research are always disclosed after the comple-

**Figure 3-12: Researchers' Attitudes Regarding Examiners**

Questionnaire responses: about examiners



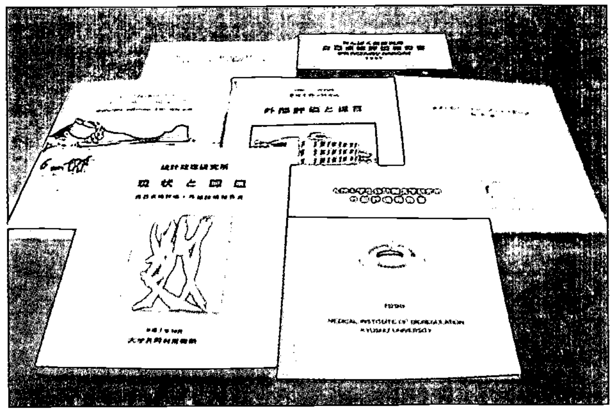

Source: "Survey on Scientific Research and Evaluation."

tion of the evaluation process, if not before.

The majority of researchers thought that the reasons for evaluations should be disclosed either generally or just to the those whose work was assessed. Disclosure of reasons for nonacceptance has already been introduced for some types of grants-in-aid for scientific research. MESSC is considering extending the use of this approach, since disclosure not only provides guidance to those who undergo evaluation, but also contributes to assessing the evaluation process itself.

### (2) Timing of Evaluations

The evaluation of research themes can be carried out in three stages: before the work starts, midway through a project, and after completion. Evaluations must be scheduled in ways suited to the content, nature, and other characteristics of research projects. Thus, for example, interim evaluations may be omitted in the case of short-term research, but several interim evaluations may be carried out at regular intervals during medium- and long-term projects. What is more, the various types of evaluations are closely related: Postcompletion evaluations are also further evaluations of the results of preproject and interim evaluations and provide useful information for selecting new research themes.



*Examples of evaluation reports from inter-university research institutes and joint-use research institutes attached to national universities.*

### (3) Evaluation Criteria

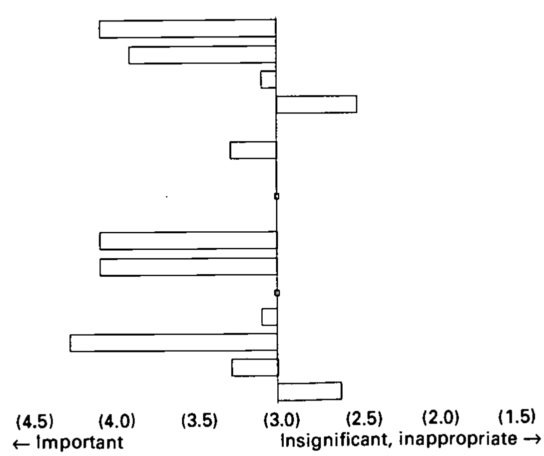
Objective data that can be used in research evaluations include the number of papers published, the number of citations from papers, the number of patents obtained, the number of invitations to speak at international conferences, and awards won. According to the Survey on Scientific Research and Evaluation, papers published and citations from papers are ranked among the most important evaluation criteria, and recognition by research groups also scored high (Figure 3-13). Respondents felt that objective data are important to getting evaluation results accepted by research-

**Figure 3-13: Researchers' Views on Evaluation Criteria**

Questionnaire responses: 5-stage assessment of research evaluation criteria

Question: Indicate the importance of the following criteria in relation to the evaluation of research in your field along a scale of 5-4-3-2-1, where 5 means "most appropriate and important" and 1 means "insignificant or inappropriate."

| Evaluation Criterion | 5-stage evaluation Average score |
|---|---|
| Publication of papers | 4.1 |
| Citations from papers | 3.9 |
| Number of other works | 3.1 |
| Number of items produced to support research | 2.5 |
| Number of successful applications for grants-in-aid for scientific research, etc. | 3.3 |
| Number of successful applications for joint research, etc. | 3.0 |
| Number of invitations to speak at international conferences | 3.6 |
| Awards, etc. | 3.6 |
| Inventions, discoveries, patents, etc. | 3.0 |
| Human resource development, personnel exchanges | 3.1 |
| Recognition by research groups | 3.8 |
| Recognition by young researchers | 3.3 |
| News value | 2.4 |




Source: "Survey on Scientific Research and Evaluation."

ers and society at large and such data should be used effectively as reference information for evaluations. The survey results also reflect the view that ultimately evaluations should be based on a synthesis of quantitative and qualitative aspects, but that at present, numerical criteria are not necessarily adequate, and their limitations need to be taken into account when such information is used.

### (4) Evaluation Support Systems

To support the appropriate implementation of evaluations, and also to ensure that the process does not seriously disrupt the core activities of the researchers who either implement or undergo evaluations, support systems must be developed and improved. In particular, improvements are needed in the management of related organizations, such as examination committees, and in the collection, collation, and analysis of objective data (numbers of papers, citations from papers, information about books, etc.) that can be used as evaluation criteria, of information about international research trends, and of evaluation results. Systems for developing and maintaining databases must also be set up.

### (5) Handling of Evaluation Results

The full value of evaluations cannot be realized unless the results are properly utilized. Evaluation findings must be reflected appropriately in areas like: research planning; the allocation of funds, personnel, and other research and development resources; improving the management of research institutes; and improving the research systems that embrace individual research themes.

As mentioned earlier, it is necessary not only to disclose evaluation results and reasons to those who undergo evaluation, but also to take active steps to use various forums and means to disseminate evaluation findings to the wider community so as to assure fairness and suitability and to gain the understanding and support of society. Each year MESSC publicizes general information about grants-in-aid for scientific research, including details of the projects selected, screening policies and timetables, evaluation criteria, and the membership of examination panels. The majority of universities and other institutions that undertake self-monitoring and self-evaluation procedures also publicize the results.

## 4. Improving Research Evaluation

### (1) Creating an Overall Evaluation Policy

The Science and Technology Basic Plan, decided on by the Cabinet in July 1996, stipulates that impartial evaluation must be a facet of efforts to create a new research and development system. It also states that the evaluation process should be facilitated through the formulation of basic guidelines to be used for all government research and development, with due respect for public opinion. The Subcommittee on Evaluation Guidelines was established under the Committee on Policy Matters of the Council for Science and Technology and commenced deliberations to formulate a draft policy. In July 1997 the Council for Science and Technology submitted an opinion to the Prime Minister. This was followed by the formulation of "Views Concerning National General Guidelines on the Method of Evaluations for Government Research and Development," which was adopted by the Prime Minister and is now serving as guidelines for evaluations.

The guidelines cover the entire range of government-funded research and development carried out by organizations within government ministries or agencies or by research and development institutions, including national experiment and research institutes, national universities, and special corporations. The guidelines do not cover research in the humanities and social sciences, however, and they also stipulate that evaluations should take into account the characteristics of scientific research.

### (2) Science Council Deliberations

Because evaluation is indispensable to making scientific research more lively and creative, the Science Council has long been considering approaches to evaluation across the entire spectrum of scientific research.

In a July 1992 report titled "Strategies for Comprehensive Promotion of Scientific Research with the Prospect of the Twenty-first Century," the Science Council emphasized the importance of regular self-monitoring and self-evaluation and continuous improvement efforts by research organizations as a way of maintaining an environment in which researchers can function dynamically and the organizations can sustain their vitality. The report also states that, while cases in other countries may serve as references, Japan needs to develop its own evaluation system to ensure the prioritized allocation of research funds.

Since this report was issued, the Science Council's Special Committee on Scientific Research Systems has continued its deliberations. In July 1997 it produced an interim report titled "Evaluation in Scientific Research," which also took account of progress in the Science Council deliberations described above. Subsequently the committee has been soliciting opinions from various quarters and conducting deliberations with a view to formulating a recommendation.

### Overview of "Evaluation in Scientific Research (Interim Report)"

I. Basic Thinking on Evaluation

- Evaluations should focus primarily on academic significance, but, depending on the field and research objectives, should also take into account contributions to society and the economy.
- Criteria for academic significance should include the level and originality of the research, the potential for future progress, and contributions to other fields. Criteria for contributions to society and the economy should include the creation of new technology, the formation of intellectual property (patents, etc.), the development of new industrial infrastructure, the improvement of the infrastructure for daily living, policy formation, and the advancement of humanity and culture. Contributions to education and human resource development must also be given consideration.
- The humanities and social sciences are closely related to culture and tradition, so evaluation in these areas must reflect a diversity of values. Because these areas are not amenable to simple, uniform criteria, full consideration must be given to the limitations this places on the effectiveness of numerical indicators and on the general applicability of evaluations.
- A nationwide system is needed to support the collection, collation, analysis, and distribution of information about objective data that can be used as evaluation indicators, international research trends, evaluation findings, and the distribution of research resources, as well as other information from throughout Japan. The quality and quantity of data in the databases of the National Center for Science Information Systems, and systems for utilizing that information, must be improved.
- Active steps to inform the public of evaluation results is important.

II. Evaluation of Research Projects

(i) Evaluation of research projects receiving ordinary research funds
- Peer review systems for specialist researchers will need to be further refined, and approaches to self-imposed evaluation developed.
- Evaluation could also be made a facet of self-monitoring and self-examination undertaken by the university on institution of affiliation.

(ii) Evaluation of research projects receiving general research grants
- Disclosure of reasons for nonacceptance should be expanded, and consideration should also be given to the creation of systems to inform society at large of outstanding research achievements.
- Consideration must also be given to allocation screening suited to the objectives and characteristics of each research category, as well as to improving interim and postcompletion evaluations.

(iii) Evaluation of research projects promoted from the viewpoint of science and technology policy

- For creative basic research (under the New Program System), further efforts are needed in such areas as disseminating evaluation results to the wider community and evaluating the project selection process itself.
- In the case of the Research for the Future Program of the Japan Society for the Promotion of Science, the methods used in interim and postcompletion evaluations must be considered thoroughly and a suitable system arranged.

(Evaluation of large-scale research projects)

- Further efforts are needed to enhance evaluation methods (by, for example, seeking the opinions of foreign researchers and outside experts) and to make evaluation results known to the public.
- In the case of international joint research, it will be necessary to carry out evaluations effectively and efficiently in cooperation with governments or other organizations in the countries concerned.

III. Evaluation of the Research Functions of Universities and Affiliated Research Institutions

(i) Self-monitoring and self-evaluation

- Greater efforts must be made to set up implementation arrangements that suit individual universities' circumstances, to encourage the participation of outside researchers and experts in evaluations, to improve and enhance evaluation criteria and methods, and to establish the practice of carrying out self-monitoring and self-evaluation at regular intervals. It will also be necessary to support such efforts on the part of universities.
- Steps should be taken to make the results of self-monitoring and self-evaluation available to the public in more comprehensible forms.

(ii) Evaluation of inter-university research institutes

- It will be necessary to create an organization covering all inter-university institutes to carry out organized, systematic self-monitoring and self-evaluation in which users and other outside researchers participate.
- Increased use should be made of the evaluation functions of boards of trustees and management councils, and positive steps should be taken to make the results known to the wider community.
- It will be necessary to improve support systems for external evaluations carried out independently by inter-university research institutes and joint-use research institutes attached to national universities. Measures are needed to provide active support for the dissemination of information about research activities, accomplishments, and evaluation results in Japan and overseas.

# Section 4: Fostering Public Understanding of Scientific Research and Expanding Learning Opportunities

## 1. The Growing Sophistication of Scientific Research and Researchers' Responsibilities

Science and technology are expected to provide answers to global problems and other issues having implications for the future of the human race. Yet the increasing sophistication and precision of science and technology and the growing specialization of scholarship have given rise to social issues in which advanced scientific research and the development of technology conflict with bioethics and human values. One such issue arose in February 1997, when scientists in the United Kingdom cloned a sheep with a genetic makeup identical to that of the parent cells from which it was created. In such cases, it is necessary to proceed on the basis of a social consensus created by providing the public with information about the safety issues involved and the utility of the research.

To a greater or lesser degree, scientific research is carried out in the context of a reciprocal relationship with society. Researchers must take account of the social significance and impact of their activities and findings and must also work to inform the public about the content and results of their research.

Science and technology are becoming increasingly sophisticated and precise, and scholarship is growing more and more specialized. Individual researchers and research groups must ensure that their work is backed by ethics and a sense of responsibility. Only then will society come to understand and accept research activity and science be able to advance in ways that maintain harmony with humanity, society, the global environment, and nature.

## 2. The Benefits of and Need to Pass on Humanity's Intellectual Assets

The results of scientific research are intellectual assets for the human race and must be used to benefit as many people as possible. They must also be handed down for successive generations to use and develop. A variety of opportunities should therefore be provided for people to learn about science and technology. In the schools, science and technology education must be improved to stimulate children's interest and motivate them to learn. An understanding of science and technology must also be fostered through social education.

Article 19 of the Science and Technology Basic Law stipulates that the government shall "implement necessary policy measures to promote the learning of science and technology in school and social education, to enlighten the people in science and technology and to disseminate knowledge on science and technology, so that all Japanese people including the young can deepen their understanding of and interest in science and technology with every opportunity."

A key component of the Program for Educational Reform, which was presented to the Prime Minister by the Minister of Education, Science, Sports and Culture in January 1997, was the "promotion of science and technology education to heighten the interest of juveniles in science and technology." MESSC is working to inform the public, especially young people, about the content and results of research and to improve support for learning based on the use of actual materials in museums and other facilities. Specific measures include increasing opportunities to open facilities at national universities and elsewhere to the public and enhancing the content of such programs.

As science and technology have advanced, adults, too, have shown growing interest in a broad range of cultural activities. At the same time, they face demands to acquire new knowledge to keep pace with technological innovation. For the people and society, these needs are closely interrelated and must be met in an integrated fashion. For this reason, it is important to achieve balanced progress in science and technology in all fields from the humanities and social sciences to the natural sciences.

## 3. Efforts by MESSC

### (1) Enhancing Science and Technology Education in Schools

To a large extent, Japan's social and economic development has been supported by science and technology. Science and technology education in the schools has played an extremely important role in this and efforts must be made to enhance it further.

Improvements have been made in the content of science education from the standpoint of fostering scientific attitudes and interests, including the use of observation and experimentation to look at and think about nature. The present courses of study have been revised at all levels to emphasize observation and experimentation and to expand learning activities based on independent exploration and problem-solving. As part of its efforts to achieve the aims set out in the courses of study, MESSC holds seminars and publishes guidance materials. It is also revising equipment standards for science education and systematically installing and upgrading experimental equipment.

In the area of technology education, too, MESSC is working to expand practical and experience-based learning. In addition, it is revising the standards for industrial education facilities and equipment in preparation for upgrading experimental and learning facilities in upper secondary schools to reflect changes in educational content resulting from advances in industrial education. In addition, MESSC is establishing joint-use industrial education facilities with state-of-the-art information equipment and advanced technical apparatus and systematically improving facilities and equipment for industrial education.

In fiscal 1996 MESSC began designating model districts for practical research on ways to foster interest in science through hands-on experience of advanced science and technology. Science education equipment that meets the new standards is also being installed in education centers, which are core facilities for teacher training at the regional level. The ministry is also setting up science education centers to promote experience-based scientific learning for schoolchildren. In addition, MESSC is expanding opportunities for schoolchildren to come into contact with researchers and technicians by assigning special part-time teachers, who are not required to have teaching certificates, to public elementary and lower secondary schools.

**(2) Providing Diverse Opportunities to Gain Familiarity with Science**

Because of the rapid progress and increasing sophistication of science and technology, people must constantly acquire new knowledge and skills, so learning opportunities must be expanded.

In cooperation with museums, schools, and other relevant institutions, MESSC is undertaking a wide variety of pilot projects to extend the functions of science museums and promote their effective utilization. In fiscal 1997 it launched a project to spread these programs throughout Japan. To improve the quality of curators and other museum staff, MESSC is also providing specialized training for natural science museum personnel. The ministry is also promoting research and development relating to special science education programs for young people that take advantage of the locations and specialized services of various facilities, such as museums, National Youth Houses, and Children's Nature Centers. In addition, MESSC is working to achieve national coverage for the University of the Air, which employs television and radio to provide courses relating to science and technology.

The National Science Museum undertakes a variety of educational and information activities designed to foster understanding of science and technology. These include science courses and field trips for young people and families.

Universities and colleges of technology are also helping to make science and engineering more attractive by actively disseminating information about these fields and offering trial enrollment programs to provide young people and the general public with opportunities for hands-on experience. In response to requests from organizers of science exhibitions and similar projects, MESSC is compiling and distributing a register of "science volunteers" who can present lectures, experiments, and other activities for young people.

It is also necessary to return the benefits of scientific research in universities to the community and to familiarize the public with that research. Measures to achieve these goals include the Universities and Science public symposiums, at which the results of a wide variety of research supported by grants-in-aid for scientific research and other forms of funding are presented to the general public. In addition, MESSC subsidizes the cost of scientific lecture programs and other activities put on by academic societies and private sector research organizations for young people and the general public (See Chapter 2, Section 1, 4(4) and (5)).

University research institutes and inter-university research institutes are increasingly opening their research facilities to the general public and providing information or lecture programs about their research activities. For example, the National Astronomical Observatory holds an Astronomy Symposium for the general public, including young people, twice a month. In the first week of August each year, it also holds "Star Week" in cooperation with supporting organizations and institutions throughout Japan. In the field of space science research, the Institute of Space and Astronautical Science organizes "Space Schools" three times a year, primarily as a way to foster dialogue between the public and researchers. Universities and research institutions are striving to become more accessible to the public through such open-house days, exhibitions, and other events. In January 1997 the National Science Museum held "The Antarctic Exhibition—A Continent of Wonder" to mark the 40th anniversary of polar observations. This exhibition provided an opportunity for the general public to view the results of research spanning many years.

**(3) The Science Council's Response**

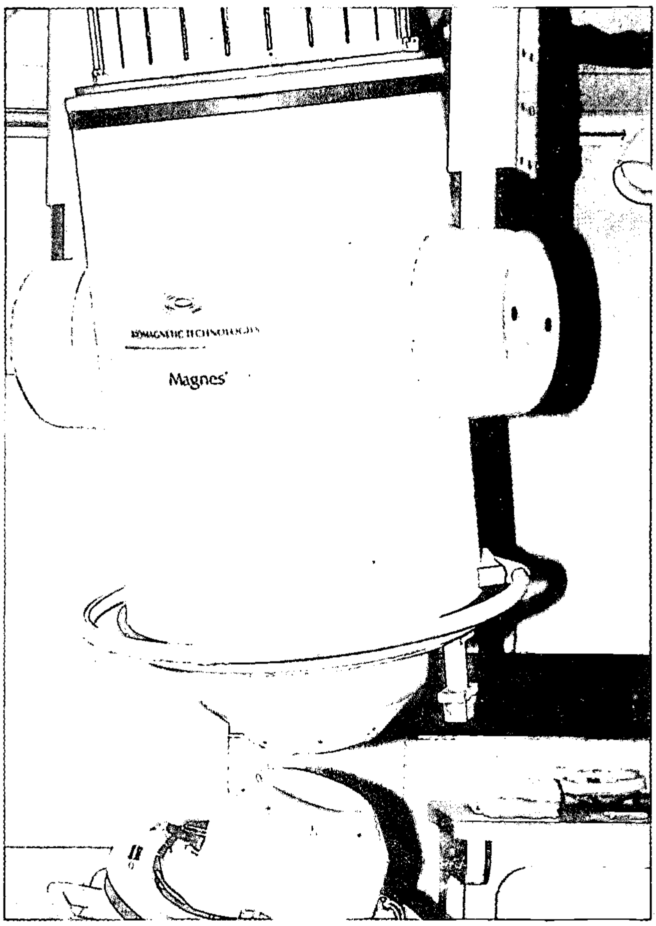
Under a new system introduced in March 1997, all proceedings of the Science Council will, in principle, be disclosed. The purpose of this measure is to ensure transparency in the management of the Science Council, which studies and deliberates important matters pertaining to science.

In view of the reaction in Japan and overseas to the aforementioned cloning of a sheep, a working group has been established within the Science Council to study, from the scientific and specialist's perspective, new ethical issues relating to cloning research in universities and other institutions. This group has been studying related issues since June 1997. A July 1997 report by the Council for Science and Technology on Basic Plans for Research and Development on Life Science includes a recommendation that there should be no cloning of humans. In line with a statement made by the Prime Minister after receiving this report, it has been decided to set up a Panel on Life Ethics within the Council for Science and Technology.

*Poster for the National Astronomical Observatory's "Star Week."*

# Chapter 4

# Domestic and Overseas Trends in Scientific Research




*A magnetoencephalograph (MEG).*

# Section 1: The Level of Research in Japan

Overall research activity in individual countries or regions can be evaluated quantitatively by calculating national totals of papers published in scientific journals and citations from those papers (the number of times published papers are quoted by other researchers). Total numbers of scientific papers indicate the scale of research in each country and allow international comparisons. In Section 1 below, "Research Levels in Terms of Numbers of Scientific Papers," this method is used to measure the quantitative level of research in Japan.

The value of scientific papers is assessed in terms of the number of citations in other papers. Of course, individual citations do not necessarily affirm the value of a paper, since some may be critical or willfully designed merely to boost the number achieved. In general, however, research standards in individual countries can be compared by reckoning numbers of citations from scientific papers. In Section 2, "Research Levels in Terms of Citations from Scientific Papers," numbers of citations are used as an indicator of research quality.

In addition to these objective indicators, subjective evaluations by researchers themselves can also be used to indicate the level of research. In Section 3, "Researchers' Perceptions of the Level of Research," the situation in Japan is analyzed on the basis of results from a questionnaire survey of researchers.

## 1. Research Levels in Terms of Numbers of Scientific Papers

In 1996 the National Center for Science Information Systems published the results of an international comparative study that analyzed yearly and national totals of papers published in science, engineering, and medicine, as recorded in large, internationally respected databases in Europe and North America. The databases used were: (1) INSPEC (compiled by the British Institution of Electrical Engineers), which covers physics, electrical and electronic engineering, computers, and other scientific and engineering fields; (2) Chemical Abstracts (compiled by Chemical Abstracts Services under the auspices of the American Chemical Society), which covers the field of chemistry; (3) COMPENDEX (compiled by Engineering Information of the United States), which covers engineering fields; and (4) EMBASE (maintained by Elsevier Science Publishers of the Netherlands), which covers medical fields. Trends in the numbers of papers in 28 subcategories were analyzed for seven countries by country and by year. Using data obtained from this survey, the number of papers from each country that was registered in each of the databases was calculated at three-year intervals from 1978 to 1993. Table 4-1 lists the results in order of national rankings.

These findings show that Japan's share of the scientific and engineering papers registered in INSPEC increased from 7% to 10% and that the country's global ranking rose from fourth to second. For Japanese papers in chemistry, figures from the Chemical Abstracts database show an increase from 10% to 13% of the total. Analysis of the COMPENDEX database revealed that the ratio of Japanese engineering papers grew from 6% to 9%. In both fields, Japan's international ranking advanced from third to second place. According to an analysis of the EMBASE, Japan's share of papers in the field of medicine expanded from 6% to 9%, while its international ranking rose from fourth to second or third, about the same level as the United Kingdom.

The overall number of papers registered in these databases is gradually increasing. The growth rate of the number of papers produced in Japan has exceeded the overall growth rates of the individual databases and is the highest among the seven countries surveyed (Japan, the United Kingdom, the United States, Germany, France, Russia/Soviet Union, and Canada).

## 2. Research Levels in Terms of Citations from Scientific Papers

"National Science Indicators on Diskette (1981-1996)," which is produced by the American company Institute for Scientific Information using its

**Table 4-1: National Rankings of Numbers of Research Papers by Year and Field (INSPEC, CA, COMPENDEX, EMBASE)**

| Year/Field | First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|
| 1978 | | | | | |
| Physical and Engineering Sciences | U.S.A. (28) | Russia/U.S.S.R. (7) | U.K. (7) | Japan (7) | Germany (6) |
| Chemistry | U.S.A. (24) | Russia/U.S.S.R. (20) | Japan (10) | Germany (8) | U.K. (6) |
| Engineering | U.S.A. (36) | U.K. (7) | Japan (6) | Germany (6) | Russia/U.S.S.R. (6) |
| Medicine | U.S.A. (34) | Germany (9) | U.K. (8) | France (6) | Japan (6) |
| 1981 | | | | | |
| Physical and Engineering Sciences | U.S.A. (29) | Japan (7) | Germany (6) | U.K. (6) | Russia/U.S.S.R. (6) |
| Chemistry | U.S.A. (26) | Russia/U.S.S.R. (17) | Japan (11) | Germany (7) | U.K. (6) |
| Engineering | U.S.A. (35) | Japan (8) | U.K. (7) | Germany (5) | Russia/U.S.S.R. (4) |
| Medicine | U.S.A. (35) | Germany (9) | U.K. (8) | Japan (7) | France (6) |
| 1984 | | | | | |
| Physical and Engineering Sciences | U.S.A. (27) | Japan (7) | Russia/U.S.S.R. (7) | Germany (6) | U.K. (6) |
| Chemistry | U.S.A. (26) | Russia/U.S.S.R. (15) | Japan (11) | Germany (7) | U.K. (6) |
| Engineering | U.S.A. (32) | Japan (9) | U.K. (7) | Germany (6) | Russia/U.S.S.R. (6) |
| Medicine | U.S.A. (38) | Japan (8) | U.K. (8) | Germany (8) | France (6) |
| 1987 | | | | | |
| Physical and Engineering Sciences | U.S.A. (29) | Japan (8) | Germany (6) | U.K. (6) | Russia/U.S.S.R. (6) |
| Chemistry | U.S.A. (26) | Russia/U.S.S.R. (13) | Japan (12) | Germany (7) | U.K. (6) |
| Engineering | U.S.A. (28) | Japan (10) | U.K. (6) | Germany (5) | Russia/U.S.S.R. (4) |
| Medicine | U.S.A. (38) | U.K. (9) | Japan (8) | Germany (7) | France (5) |
| 1990 | | | | | |
| Physical and Engineering Sciences | U.S.A. (30) | Japan (9) | Russia/U.S.S.R. (7) | Germany (6) | U.K. (6) |
| Chemistry | U.S.A. (27) | Russia/U.S.S.R. (13) | Japan (13) | Germany (8) | U.K. (5) |
| Engineering | U.S.A. (27) | Japan (9) | U.K. (5) | Germany (5) | Russia/U.S.S.R. (4) |
| Medicine | U.S.A. (34) | U.K. (9) | Japan (8) | Germany (7) | France (6) |
| 1993 | | | | | |
| Physical and Engineering Sciences | U.S.A. (30) | Japan (10) | Germany (6) | U.K. (6) | France (5) |
| Chemistry | U.S.A. (27) | Japan (13) | Germany (7) | U.K. (6) | Russia/U.S.S.R. (5) |
| Engineering | U.S.A. (32) | Japan (9) | U.K. (5) | Germany (4) | Russia/U.S.S.R. (4) |
| Medicine | U.S.A. (34) | U.K. (9) | Japan (9) | Germany (7) | France (6) |

Notes: 1. The figures for physical and engineering sciences, chemistry, engineering, and medicine represent numbers of papers registered in the databases of INSPEC, Chemical Abstracts, COMPENDEX, and EMBASE, respectively. 2. Figures in parentheses represent percentages of total numbers of papers.

Source: National Center for Science Information Systems, "International Comparative Survey of Numbers of Scientific Papers."

Science Citation Index, can be employed as a basis for international comparisons of numbers of citations. A comparative analysis of numbers of papers and citations was carried out using statistics published over the period from 1981 to 1996 in 19 categories (agricultural sciences, astrophysics, biology & biochemistry, chemistry, clinical medicine, computer science, engineering, ecology & environment, geosciences, immunology, molecular biology & genetics, materials sciences, mathematics, neuroscience, physics, plant & animal sciences, pharmacology, microbiology, and multidisciplinary fields).

In all categories, the United States ranked first in terms of the total number of citations. In recent years, however, Japan has ranked second or third in many categories. Table 4-2 shows national percentages and rankings based on numbers of citations at three-year intervals (totals for the preceding five years) since 1981. These figures reveal a gradual rise in the number of citations from Japanese papers and in Japan's share of world totals. At the start of the 1981~85 period, Japan ranked second in three categories (agricultural sciences, chemistry, and materials sciences) and third in two (biology & biochemistry and engineering). Since then there has been a gradual rise in its overall shares and rankings in all categories. While it still ranked second in the same categories in the 1990~94 period, it had achieved third place in four categories (biology & biochemistry, clinical medicine, physics, and pharmacology) and was fifth or higher in 13 of the 19 categories.

The graph in Figure 4-1 shows how national shares of world totals of papers in each field have changed over the years. Although the United States' share has gradually declined, it still accounts for about one-third of the international total. The rate of increase in the number

**Table 4-2: Japan's Ranking and Shares of World Totals for Citations from Research Papers by Year and Field**

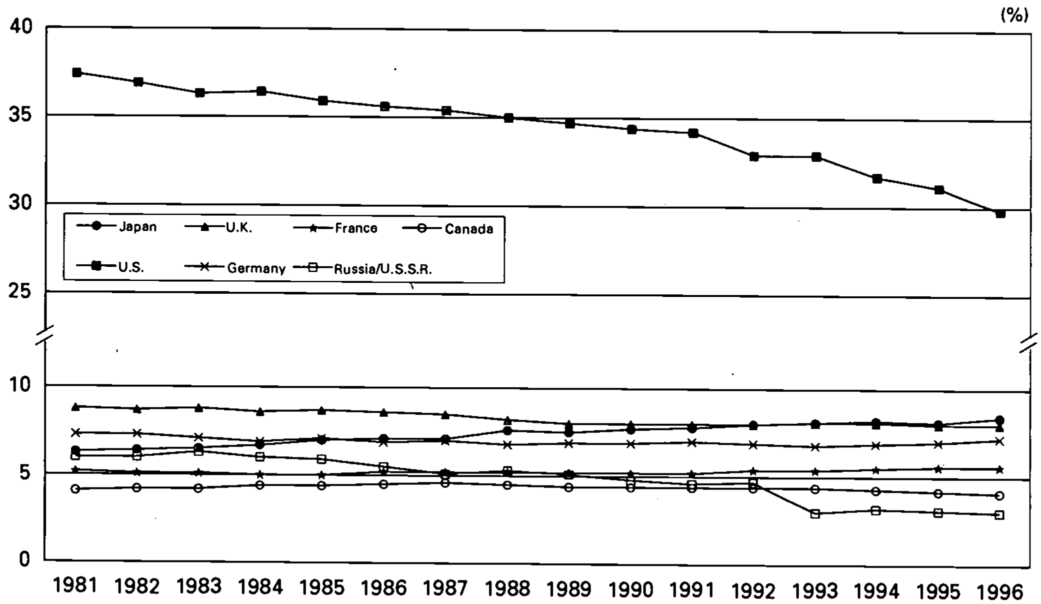
| | 1981–1985 | | 1984–1988 | | 1987–1991 | | 1990–1994 | |
|---|---|---|---|---|---|---|---|---|
| | Share | Ranking | Share | Ranking | Share | Ranking | Share | Ranking |
| Agricultural Sciences | 11.3% | 2 | 11.6% | 2 | 12.0% | 2 | 11.5% | 2 |
| Astrophysics | 1.7% | 10 | 2.8% | 9 | 3.4% | 6 | 3.2% | 7 |
| Biology & biochemistry | 6.7% | 3 | 7.4% | 3 | 7.6% | 3 | 7.8% | 3 |
| Chemistry | 10.2% | 2 | 10.5% | 2 | 10.5% | 2 | 10.3% | 2 |
| Clinical medicine | 2.4% | 7 | 3.0% | 6 | 3.7% | 5 | 4.4% | 3 |
| Computer science | 3.3% | 5 | 3.8% | 5 | 3.1% | 6 | 3.2% | 6 |
| Engineering | 7.9% | 3 | 7.6% | 3 | 7.7% | 3 | 7.2% | 4 |
| Ecology & environment | 1.8% | 8 | 2.1% | 8 | 2.2% | 8 | 1.9% | 9 |
| Geosciences | 2.0% | 8 | 2.3% | 7 | 2.5% | 7 | 2.4% | 7 |
| Immunology | 3.35 | 6 | 4.0% | 4 | 3.9% | 5 | 4.5% | 5 |
| Molecular biology & genetics | 3.9% | 5 | 3.5% | 5 | 3.9% | 5 | 4.2% | 5 |
| Materials sciences | 9.1% | 2 | 11.6% | 2 | 12.5% | 2 | 12.1% | 2 |
| Mathematics | 3.6% | 6 | 3.8% | 6 | 3.8% | 6 | 3.5% | 6 |
| Neuroscience | 3.3% | 7 | 3.7% | 6 | 4.3% | 6 | 5.2% | 5 |
| Physics | 7.0% | 4 | 7.9% | 3 | 9.4% | 2 | 8.9% | 3 |
| Plant & animal sciences | 4.6% | 5 | 5.0% | 6 | 5.1% | 5 | 5.1% | 5 |
| Pharmacology | 6.0% | 4 | 7.2% | 4 | 7.7% | 3 | 7.5% | 3 |
| Microbiology | 5.3% | 4 | 5.4% | 4 | 5.6% | 4 | 6.1% | 4 |
| Multidisciplinary fields | 2.3% | 7 | 2.7% | 7 | 3.4% | 7 | 4.3% | 6 |
| Total | 5.3% | 4 | 5.7% | 4 | 6.1% | 4 | 6.3% | 4 |

Source: Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1996."

of papers produced in Japan is higher than the rates for the United Kingdom, Germany, and France. Japan's total has increased about 2.4 times over the past 16 years, and its share of the world total has also risen from 6.3% to 8.4%. In 1993 it moved into second place, putting it ahead of the United Kingdom.

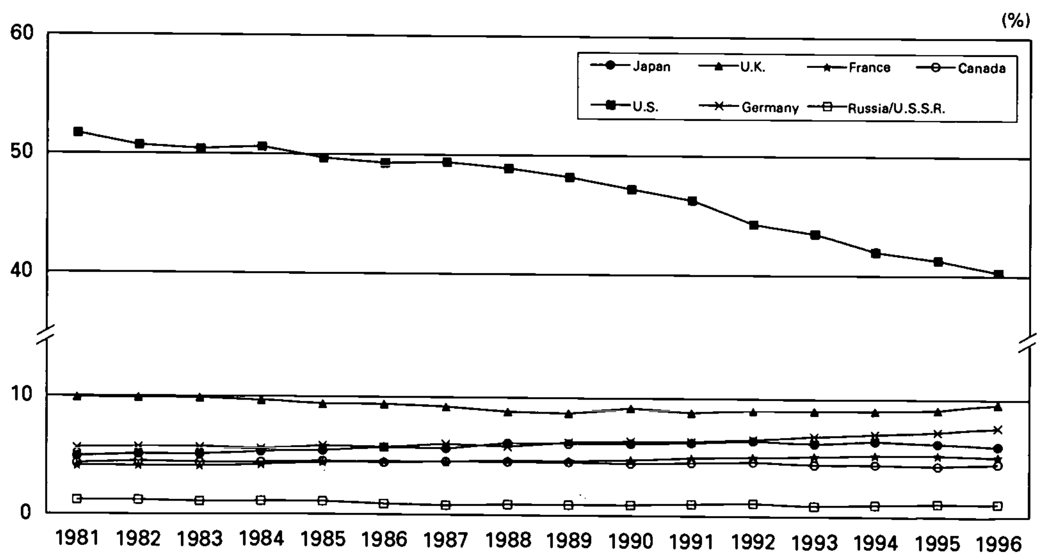
Figure 4-2 shows annual shifts in national shares of citations from papers. In all categories, the United States accounts for about one-half of citations, but its share has gradually declined. While the figures for the United Kingdom, Canada, and Russia (the Soviet Union) have tended to stagnate, Japan, Germany, and France have registered gradual uptrends. Japan has boosted its share of all citations from papers by around 30% over the past 15 years and now compares favorably with European countries.

**Figure 4-1: Trends in National Shares of World Totals of Scientific Papers**




Source: Institute for Scientific Information, "National Science Indicators on Diskette, 1981–1996."

**Figure 4-2: Trends in National Shares of World Totals of Citations from Scientific Papers**




Source: Institute for Scientific Information, "National Science Indicators on Diskette, 1981–1996."

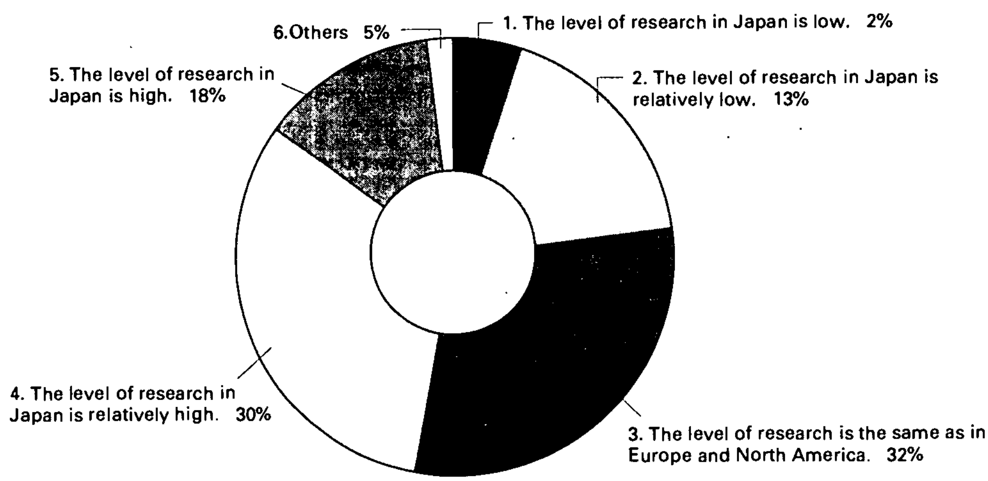
## 3. Researchers' Perceptions of Research Levels

The Survey of Trends in Scientific Research in Japan, which was funded by a grant-in-aid for scientific research in fiscal 1997, took the form of a questionnaire survey of researchers working at the forefront of scientific research as research team leaders or members of screening panels for grants-in-aid for scientific research. The survey focused on the level of research in Japan.

Five hundred Japanese researchers were asked to compare the level of research in Japan with standards in European and North American countries using a five-point evaluation scale. As shown in Figure 4-3, a high percentage of respondents considered the level of research in Japan to be "the same as in Europe and North America" (32%) or "fairly high"(30%), while 18% thought the level was "high." Overall, the results indicate that more people have come to feel that research in Japanese universities and other institutions has reached a high level by international standards.

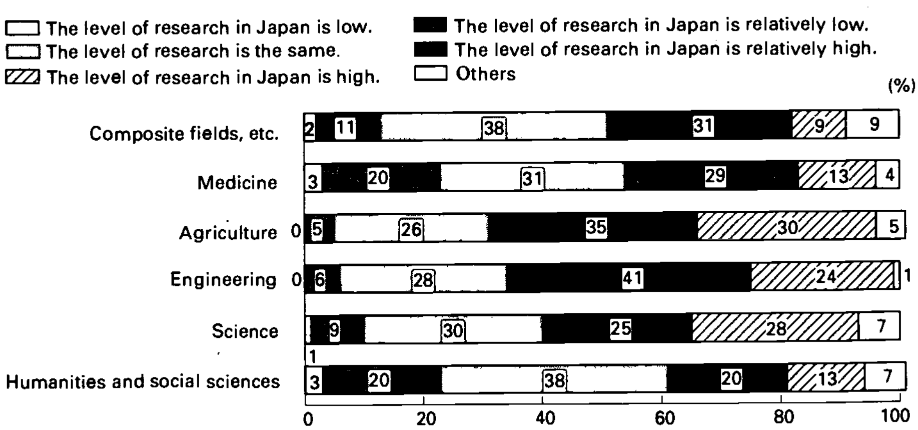
The same results are analyzed by research field in Figure 4-4. A high percentage of researchers (those who chose responses 3~5) believe that in the natural sciences, levels of research in Japan are now equal to or higher than in the West, especially in science, engineering, and agriculture. The fields in which a high percentage of respondents thought that the standard of research in Japan was

**Figure 4-3: Perceptions of Research Levels**




Note: "Others" includes no response.
Source: MESSC, "Survey of Trends in Scientific Research in Japan."

**Figure 4-4: Perceptions of Research Levels in Individual Fields**




Notes: 1. "Others" includes no response. 2. Figures may not add up to 100% due to rounding.
Source: MESSC, "Survey of Trends in Scientific Research in Japan."

relatively low were the humanities and social sciences, and medicine.

### 4. Level of Research in Japan Improving Steadily

As is apparent from the above discussion, many leading researchers feel that, on the whole, Japanese scientific research, especially in the natural sciences, has achieved international standards. The researchers' subjective assessments are basically borne out by objective comparisons of numbers of scientific papers. Overall, Japan ranks either second, following the United States, or a close third, behind the United Kingdom. It has reached the same level as the European countries in all categories and has surpassed them in many fields. And in all categories, Japan's rate of increase is far ahead of Europe and North America.

The expansion of the range of scientific journals included in the four databases studied could work in Japan's favor. From an overall perspective, considering that in some fields it is still the custom in Japan to submit papers to domestic journals (most of which are not included in the aforementioned databases, even though some of these journals are published in English as well as in Japanese) it is clear that, in terms of numbers of scientific papers, research activity is more intense in Japan than in Europe or North America.

The Science Citation Index is made up of papers published in authoritative scientific journals. It currently covers approximately 4,000 journals. An increase in a country's share of the total number of papers recorded here indicates an improvement in the quality of research in that country. Japan's share has risen in most fields, confirming that the overall quality of research has improved.

In terms of numbers of citations from scientific papers in the 1990~94 period, Japan ranks fourth behind the United States, the United Kingdom, and Germany. The qualitative standard of Japanese research is especially high in those fields in which Japan occupies one of the top rankings.

Using database analysis to evaluate research standards means relying primarily on scientific journals published in the United States, and few papers written in Japanese are (or can be) included in European or North American databases. For this and other reasons, papers written in Japan are inevitably at a disadvantage. In addition, the inadequacy of information distribution in Japan means that there are few citations in foreign papers; moreover, Japanese scholars tend to cite papers written in other countries. The number of citations from Japanese papers is, therefore, inevitably low compared with totals for other countries.

When these factors are taken into account, it becomes clear that, while Japan cannot match the United States in terms of research levels, it is producing results that compare favorably with work carried out in Europe. Despite a research environment that is not ideal, researchers' efforts have brought a steady improvement in the standard of Japanese research, which is expected to rise still further as the infrastructure for scientific research is upgraded.

## Section 2: Trends in Individual Research Fields

Accurately monitoring trends in individual research fields is necessary to planning and proposing science policy. The Survey of Trends in Scientific Research in Japan, a research project funded by grants-in-aid for scientific research in fiscal 1996 and 1997, administered a questionnaire to researchers in various fields, and the results were studied and analyzed by leading research workers. This section provides a brief overview of the latest survey results, with particular emphasis on future directions, but it deals only with characteristic trends and does not cover all important fields of research.

## 1. The Humanities and Social Sciences

The humanities and social sciences relate to the entire spectrum of human culture, encompassing mental and spiritual activities, social phenomena, and human culture and civilization as broadly defined. Identifying trends common to this entire category is therefore impossible, and the following discussion focuses on a number of particularly important trends.

In reaction to the growing fragmentation and specialization of scholarship and research themes, there is now a notable tendency toward more comprehensive and interdisciplinary approaches, especially in areas like history and political science. A new field known as "policy studies" or "policy science," which focuses on practical policy formulation and problem-solving, has been created, and fusion is also occurring between economics and other social sciences, and between social sciences and natural sciences, such as information science. In some situations, society is also demanding dialogue between the natural sciences and the humanities and social sciences in fields of research that involve issues relating to ethics and norms, such as cloning (the creation of cells and organisms with identical genetic structures).

Economics, more than any other social science, has adopted many of the methods of natural science and is moving in broadly similar directions, employing the mathematical theory of nonlinear dynamics, large-scale computer simulations, and other techniques to integrate economics with complex systems theory, which elucidates dynamic interrelationships.

The spread of computers and advances in information technology have provided researchers in the humanities and social sciences, including economics, sociology, psychology, geography, and cultural anthropology, with increasingly sophisticated measurement methods that are enhancing their ability to discover and explain reality. Research in fields like linguistics, literature, religion, archaeology, and philology can now be carried out efficiently and systematically thanks to the development of databases of source documents and other materials and the use of CD-ROMs (compact disk read-only memory) to support image and audio processing.

Society's increasing reliance on information technology may lead to the synthesis of the humanities and social sciences into the comprehensive multidisciplinary field of informatics, which will depend on computer science and information science for its infrastructure.

Japan's ability to contribute to the international flow of information in the areas of literature and linguistics is obviously limited due to the importance of language in these fields. In general, however, researchers are increasingly shifting from a focus on introducing or importing foreign information toward disseminating or exporting information of Japanese origin through international comparative studies and other means.

In many areas of the humanities and social sciences, researchers are reacting sensitively to changes in the contemporary situation, including the end of the Cold War, the evolution of an advanced information society, and developments relating to resources, energy, food, environmental problems, and other global issues. These changes are driving a shift toward international, multidisciplinary, comprehensive approaches. In the field of law, this pattern is manifested in the recent formation of academic societies for international economic law, international human rights law, and European Union (EU) law.

The trend toward a comprehensive approach is typified in the field of area studies, where there is a growing tendency toward a multidisciplinary fusion of fields to create more organized or networked structures. Empirical research has also increased, and one characteristic trend in recent times has been research that strives for a more comprehensive approach from the Asian point of view.

Changing trends in Japan and abroad are expected to lead to the development of new fields in the humanities and social sciences, and some observers point to the need for support measures, including the development of infrastructure and centers, to promote trends toward comprehensive and international approaches.

## 2. Mathematical and Physical Science

Mathematics has evolved while maintaining close links with classical physics. Modern mathematics, too, is fusing with quantum statistical mechanics to form mathematical physics, becoming an increasingly sophisticated and diverse field. At the same time, it has also become a basic analytical tool in all fields of scholarship. The mathematical theories of John Von Neumann made possible the development, evolution, and spread of the computer, which has become the symbol of modern civilization. The various theories that have supported the development of information science and information theory, including probability theory, statistics, cryptography, and chaos theory, are also applications of mathematics.

Knot theory, which is derived from geometry, is used not only in quantum statistical mechanics and other aspects of theoretical physics, but also in biochemistry to classify deoxyribonucleic acid (DNA) nodes. Other elements of mathematics, such as analysis, algebra, probability theory, and statistics, have made possible the development of the mathematical and metrical analytic tools used in economics and other social sciences. In recent years, progress has also been made in applications for game theory and linear planning. In addition, there has been reciprocal stimulation and fusion among different fields of mathematics, leading to the formation of fields like algebraic geometry, complex analysis, and differential geometry.

In the field of particle physics, researchers are moving toward an understanding of particles, which are the ultimate forms of matter, and the four forces (gravitational, electromagnetic, strong nuclear, and weak nuclear) that operate between them. Standard models have been proposed to explain three of the four forces (except gravity). In 1994 the top quark was discovered through an experiment involving proton-proton collisions at the Fermi National Accelerator Laboratory in the United States. The crucial task remaining for this model is the investigation of the Higgs boson, which will enable us to understand the origins of mass.

Researchers have proposed Grand Unified Theory (GUT) to account for the three forces other than gravity, and the supersymmetry GUT appears to have particular potential. Future research will need to focus on the verification of GUT's prediction that protons decay into positrons and other particles, and the discovery of supersymmetry particles, the existence of which the supersymmetry GUT hypothesizes.

Another focus of future research will be the breakdown of the basic symmetry of particles (violation of CP symmetry). It will also be necessary to explain neutrino oscillation in order to verify the mass of neutrinos, which is assumed to be zero in the standard model.

Researchers in Japan are also working to solve these riddles. Projects include the B-Factory Plan, which involves the use of an electron-positron collider maintained by the High Energy Accelerator Research Organization. Another focus of research is Super-Kamiokande, which is a large-scale water Cherenkov cosmic particle detection system established by the University of Tokyo's Institute for Cosmic Ray Research to monitor cosmic particles. Other projects involving the use of large-scale accelerators are currently in progress at facilities in the United States, such as the Stanford Linear Accelerator Center (SLAC), and in Europe, including the European Organization for Nuclear Research (CERN).

Nuclear physics takes a more macroscopic view of the atomic nucleus than particle physics. Future research themes will include the creation of high-density nuclear matter, especially a high-temperature quark-gluon plasma, by using heavy ion collisions to establish conditions similar to those that existed at the beginning of the universe.

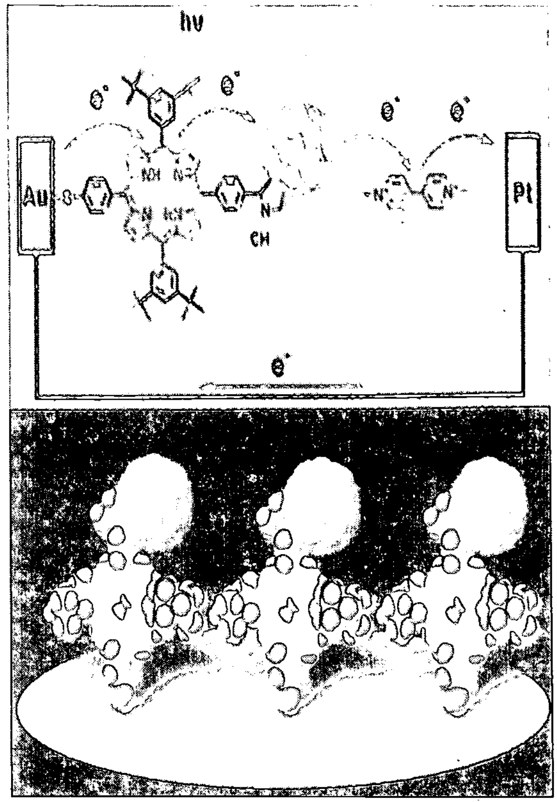
Researchers in the field of space physics are working to explain the evolution and structure of the universe, starting with the Big Bang. Progress is now being made in step with advances in particle physics. High-energy experiments using accelerators have an important role to play in this context. The observation and study of cosmic rays are also extremely important. Goals for the future include solving the solar neutrino question (why the number of neutrinos detected is about one-half of the theoretical number emitted by the sun) and elucidating the nature of superhigh-energy gamma rays and dark matter.

Researchers are working to find answers to these questions, especially in relation to solar neutrinos, using equipment like Japan's Super-Kamiokande; Canada's Sudbury Neutrino Observatory (SNO), a heavy water Cherenkov detection device; and Italy's Borexino, a liquid scintillator detector.

Solid state physics explores the diverse characteristics and phenomena exhibited by matter created through the combination of atoms and seeks to explain the mechanisms involved. It is also the basis of materials science and bioscience.

Among the substances to attract interest in recent years are high-temperature superconductors (substances that lose all electrical resistance below a certain temperature) made from copper oxides, fullerines, and carbon nanotubes, which are stable molecular structures made up of carbon atoms arranged like soccer balls or cylinders and quasi-crystalline structures that remain stable in a thermal equilibrium state. Also significant are mesoscopic substances, artificial substances of a size midway between atoms and matter that are produced using semiconductor processing technology. Research into new substances is expected to lead to new discoveries in the future.

Key tasks in this field include theoretical research into closely related areas, such as electronic superconductivity and chemical reactions, as well as the explanation of quantum effects and the development of applications. Future work could lead to the emergence of nonequilibrium and complex physics—new forms of physics and science that transcend traditional frameworks and create new paradigms.



*A monomolecular film of a porphyrin-fullerine compound collected on a gold surface.*

## 3. Information Science

Information science, which is primarily a physical and engineering science field, has communications, control, and computers as its basic elements. With the growth of networking in recent years, information science has contributed to progress and standardization in these areas, especially information processing. The capacity of telecommunications networks has been increased through the use of digital technology, and more recently, through the development of fiber optics. The motion picture expert group (MPEG) system, which is a highly efficient encoding method for large volumes of data, has meanwhile become the standard and general method for picture compression. These advances are based on research carried out in Japanese universities and other institutions. Progress is also being made in research on the simplification of protocols and on asynchronous transfer mode (ATM) technology, which allows bandwidth to be used dynamically.

Among the areas of information processing in which Japanese universities are conducting research and development and will, in the future, most likely undertake basic research are: intelligent information processing, which will give computers the power to process sophisticated knowledge; distributed processing, which raises processing capacity by linking multiple computers; multimedia technology, which utilizes a wide variety of information in large quantities; electronic libraries that utilize information technology; and parallel computing, which provides massive processing power by combining multiple processing units. Information science has converged with the life sciences and cognitive science in artificial intelligence, neural networks, and genetic algorithms. It is also becoming more deeply involved with the humanities and social sciences.

Among the key themes for future research will be complex systems, including nonlinear systems and fractals, and intelligent networking, particularly the distributed autonomous intelligent agent system and human interfaces capable of supporting multimedia and cooperative processing. Goals that have gained importance with the growth of networking include encryption and other forms of security technology and technology to support electronic financial settlements and the management of rights.

The long-term future is expected to bring increasing linkage of information-related disciplines, including the humanities and social sciences, in ways that will reflect the meaning and value of information. Promoting research for this purpose will therefore be an important priority.

## 4. Geosciences and Space Science

The geosciences aim to elucidate the basic mechanisms of all phenomena occurring in the earth's interior, on its surface, in the oceans, and in the atmosphere, giving them important implications for human life and society.

In the field of solid-state geophysics, new theories to explain the earth's inner structures are emerging from research based on the global spread of seismic monitoring using high-performance, wide-based seismometers; super-highpressure, high-temperature experiments on earth substances; and numeric simulations where conditions make experimentation impossible.

As one of the world's most seismically active and volcanic countries, Japan has, under its Earthquake and Volcanic Eruption Prediction Plans, conducted a wide variety of geophysical observations, including high-sensitivity microearthquake monitoring and the observation of artificial earthquakes. This work has yielded important benefits, including improved understanding of seismic activity and the mechanisms that produce it and of the mechanisms of volcanic eruptions and the detection of precursors. Considerable progress has also been made in understanding the structure of the Japanese archipelago and surrounding areas. An important goal in relation to earthquake prediction will be the development of models that encompass the overall process of earthquake generation from the perspective of imbalances, distortions, and stresses within the earth's crust. This will require a comprehensive approach based on close cooperation between universities and other institutions involved in this field. In the case of volcanic eruption prediction, it will be necessary to carry out basic research into such aspects as the process by which magma rises and erupts and to explain the dynamic structures of volcanoes over time.

Research in marine physics and oceanography has brought us closer to understanding the El Nino phenomenon (rise in seawater temperatures in tropical areas of the eastern Pacific) as part of an oceanic cycle encompassing the entire Pacific. A key task for the future will be the elucidation of large oceanic cycles. This is also essential to understanding the mechanisms of climate change, which will in turn contribute to the solution of the increasingly serious problems affecting the marine environment, including pollution of the oceans. Awareness of the importance of these issues is reflected in efforts to promote international cooperation and joint projects.

In the area of meteorology, research is focusing on the use of climate models to explain the mechanisms of climate change. Today's models, which integrate atmospheric, land, and oceanic cycles, are being used not only to predict climate change, but also to study climate change in geological eras and cycles of greenhouse gases, such as carbon dioxide and methane, in the atmosphere. In the future, interdisciplinary cooperation with fields like marine physics, hydrology, chemistry, and ecology is expected to improve our understanding of climate change and the accuracy of localized forecasting. Satellite monitoring provides a constant flow of quantitative data, and there have also been major advances in analysis methods and climate model simulation. This knowledge is expected to provide a more accurate understanding of the mechanisms of climate change.

Efforts to overcome global problems have been an important focus for geoscience research in recent years. This will require the integration of a wide spectrum of disciplines, from the humanities and social sciences to the natural sciences, into the new field of global environmental science, the goal of which will be to find solutions based on an understanding of the real nature of global environmental problems.

The development of scientific satellites, products of space engineering, has brought dramatic advances in space science. Contributions to this progress have also come from improvements in computer performance that have enabled researchers to process huge volumes of observation data effectively and to carry out sophisticated numerical simulations. Japan is systematically launching scientific satellites at the rate of one per year. These have brought dramatic improvements in the level of Japanese research, which is now regarded as the most advanced in the world, especially in X-ray astronomy, solar physics, and magnetosphere physics.

In addition to these fields, major progress is also anticipated in the areas of infrared astronomy and solar system science. Japan also plans to build a large-scale cosmic radio wave interferometer, which will be used for integrated monitoring of radio waves from astronomical bodies via multiple antennas. Future research is likely to include the interior of the moon, the atmosphere of Mars, the interiors of Mercury and Mars, and the exploration of comets. The development of exploratory and monitoring equipment will become increasingly important in this context.

## 5. Materials Science

High-temperature superconducting oxides have been the focus of intense research efforts throughout the world over the past few years, and considerable theoretical research has been conducted regarding the mechanisms of superconductivity. The giant magnetic resistance (GMR) effect has also been the focus of both theoretical and applied research that has already resulted in the development of magnetic heads for high-density magnetic recording media. There has also been progress toward the synthesis of various substances, including fullerines and carbon nanotubes that enclose clusters of metallic atoms, conductive polymers, and high-performance polymers. Other research themes include the development or enhancement of functions, including molecular shapes, recognition capabilities, and self-organization characteristics. Products of this work include inclusion compounds, supermolecules, high-selectivity asymmetric synthetic catalysts, and artificial bimolecular membranes.

Biochemical research has brought greater understanding of biomolecular structures, including the mechanisms of energy exchange proteins, and there is a growing tendency to explain life phenomena at the molecular level. Higher functions, such as cerebral and neural processes, are also likely to be explained in terms of molecular science. Future research is also expected to lead to the molecular design of artificial proteins and sugar chains with new functions, such as the ability to suppress the emergence of genes.

New developments in the area of measurement and analysis technology include the use of charge-coupled devices (CCDs) in X-ray crystallography, spectroscopic analysis of radiation light, and the detection of localized magnetism by means of microporous elements attached to monocrystals. Research is also focusing on methods that target single chemicals or molecules, such as ultramicroanalysis and laser manipulation.

## 6. Electrical Engineering

Research based on quantum effects has yielded numerous advances, including physical research into the behavior of electrons in ultramicroscopic structures, the development of applications like semiconductor lasers and other optical devices, and improvements in the performance of electronic devices. The focus now is on achieving clearer quantum effects through an improved understanding of low-level quantum effects and on using this knowledge in high-performance electronic devices. New areas, such as single-electron devices and electron wave devices, may be opened up in relation to the technologies of semiconductor microprocessing and crystal-growing, which are essential to the creation of quantum structures.

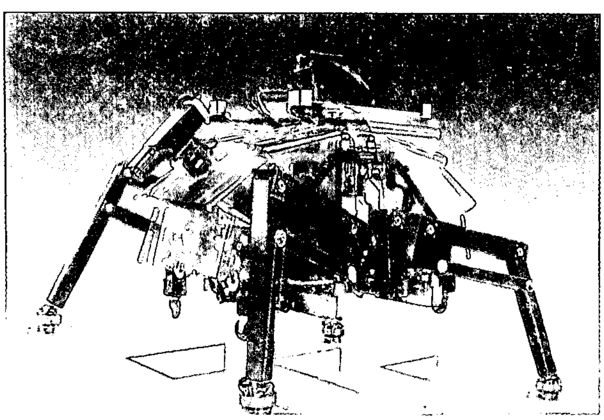
Japan leads the world in optoelectronic engineering. Continuous oscillation of surface emitting laser diodes at normal temperatures has been achieved, and efforts are now focused on developing applications, such as fiber-optic communications, high-speed parallel processing, and optical interconnections. Intensive research has also been devoted to large-capacity data storage devices, such as optical disks and magnetic recording media, and commercial products based on this technology are already in wide use.

A new field known as "organic electronics" has been established, and applications, based primarily on thin-film formation technology, are being developed in such areas as control of the electrical and optical characteristics of organic molecules, as well as sensors and other electronic devices. Research relating to the development of circuits for semiconductor devices and invertors (frequency conversion systems) for use in electric power applications is meanwhile contributing to the efficient utilization of electrical energy.

Japanese research is producing highly sophisticated advances in the field of superconducting oxides. The priority in this area is the development of devices and application equipment. This work is expected to influence a wide range of other fields in the future.

A priority in accelerator science will be the control of beam instabilities in the B Factory and SPring 8 (a large-scale synchrotron radiation facility). Future research and development goals include the creation of a large-scale hadron collider, a linear collider, a muon collider, and a coherent light source with matched phases. Work in these areas will also involve international cooperation.

There has been considerable research relating to fusion science, or plasma engineering, and nuclear mechanics. Tokamak-type facilities have already been brought to a critical state and are a probable candidate for the development of a practical system. Research on a large-scale helical device (LHD) developed by the National Institute for Fusion Science is meanwhile making a valuable contribution to our overall understanding of the generation and control of steady-state plasmas and the characteristics of torus plasmas. Osaka University's Institute of Laser Engineering has raised the level of compression to 600 times solid-state density. The results of plasma research are used in the dry processing of semiconductors (microprocessing using gases). In the future, this work is also expected to contribute to advances in the science of complex systems, including nonlinear and nonequilibrium theories.



*A four-legged, ambulatory intelligent robot*

## 7. Structural and Functional Engineering

Both basic and applied research in structural and functional engineering focuses on artificial objects, such as mechanical products or structures. Three common characteristics span this entire area:

(i) Research focuses on miniaturization, as typified by micromachines. Considerable research activity is being done in areas like microprocessing, microscopic mechanical structures, microlevel materials, friction, heat, and fluidity.

(ii) Awareness of the global environment and global problems is reflected in research relating to the design and production of artificial objects, resource recycling, and the efficient utilization of energy.

(iii) Computational mechanics is being developed into a sophisticated and comprehensive analysis tool for fields like structural mechanics, fluid mechanics, and thermal engineering.

Technological advances, including improvements in computer capabilities and the development of the scanning tunneling microscope (STM), have opened the way for research into atomic-level constituent analysis and the modification of the structure and form of materials at the nanometer (a billionth of a meter) level. Such research is relevant to designing materials and analyzing their physical properties.

Research trends are also being influenced by the development of intelligence and information technology. New research tools, such as artificial intelligence, fuzzy logic, fractals, neural networking, and genetic algorithms, are helping to advance research in areas like advanced control technology for devices and systems, intelligent robots, and intelligent computer-aided design (CAD). Moreover, the Great Hanshin-Awaji Earthquake has brought renewed awareness of the importance of seismic engineering and earthquake-resistant engineering, leading to an upsurge of activity in these fields.

Future trends are likely to take two directions:

(i) Research will probably focus on achieving greater precision in methods and knowledge systems. Key research areas will include microstructural materials at the subnanometer level, design and processing technology, device control, and micromachines. Research in computational mechanics will be based on increasingly precise models.

(ii) The direction of research is also likely to be influenced by society's demands. Areas focusing on the needs of the welfare society will include people-friendly intelligent machines and brain engineering. Research will also focus on things like design, production, maintenance, and recycling, as well as overall systems, taking into account artificial environments and public access to knowledge. Because of the growing environmental and social significance of engineering and technology relating to artificial objects, it will probably be necessary to build basic research fields around new concepts that transcend traditional engineering fields.

## 8. Bioscience

Bioscience in general, including medicine, has been the focus of intense research activity using the tools of molecular biology, especially genetic analysis and manipulation. These methods are leading to the formation of a common infrastructure that spans all levels from basic biology to clinical medicine.

Researchers are moving toward a better understanding of plant chloroplasts and mitochondria (cellular organelles involved in respiratory functions within plant and animal cells) and even human genetics. Research into the evolution of genes and molecules is also making progress. Medical research is leading to a better understanding of the genetics of cancer, AIDS, and other diseases, and physicians are now employing genetic diagnosis and therapy. Of course, genetic manipulation is also raising ethical issues, and in some cases it will be necessary to achieve a social consensus. In addition to their efforts to explain cellular functions at the molecular level, including the molecular functions of cellular mechanisms, especially apoptosis (cell death) and other functions of immunological cells, researchers have also cloned individual experimental animals and produced model animals using trace DNA amplification techniques and embryological engineering.

Cancer will be one focus of medical research, but there is also likely to be considerable research relating to the brain and the mechanisms of aging. In addition, researchers will work to overcome infectious diseases, such as mad cow disease (bovine spongiform encephalopathy) and other diseases caused by prions (protein elements that can cause infections). In the area of clinical medicine, the progress of therapeutic science will be aided not only by genetic therapy but also by advances like noninvasive surgery, which will reduce the physiological impact of surgery by utilizing increasingly precise image-based diagnosis methods, including endoscopy, ultrasound scanning, and cerebral blood-flow monitoring.

In the area of bioorganic chemistry, improved understanding of microorganisms and other bioactive trace substances in insects and microorganisms will lead to the fusion of biochemistry and molecular biology. Applications of this knowledge are expected to include the prevention of diseases and pests. In addition, the techniques of chemistry, biochemistry, and molecular biology are likely to be used to advance sugar-chain engineering and protein engineering.

Research in the multidisciplinary field of food and nutrition will probably focus on developing functional foods (foods with ingredients capable of producing specific physiological adjustment functions), and on the functioning of food ingredients in relation to cancer, aging, adult diseases, and allergies.

Ecological research is leading to advances in evolutionary ecology, which holds that ecological phenomena are the result of adaptive evolution driven by natural selection. There is also considerable activity in the area of synecology, which focuses on things like interaction between species. This research, which emphasizes cooperation and coexistence rather than competition and predation, is already yielding results. Biodiversity research is another field in which there has been significant progress. A focus of future research will be the relationship between biodiversity and self-organization in ecological systems. It will also be necessary to develop large-scale ecological modeling systems that can accommodate changes on a global scale, including climate change.

# Section 3: Science Policy in Other Countries

## 1. Discussion by the Group on the Science System of the OECD Committee for Scientific and Technological Policy

### (1) Situation in OECD Countries

The Group on the Science System (GSS) is a working group established within the Organization for Economic Cooperation and Development (OECD) to monitor the effects that changes in the international situation and social and economic conditions have on universities and other research organizations and on research policy in member countries, and to study effective ways to deal with them.

Through information exchanges and studies of universities and other institutions of higher education, the GSS is currently attempting to assess the impact of various factors on scientific research in the 21st century. The Group has reported that the following patterns appear in many OECD countries.

**(a) Declining government research and development expenditure:** In many OECD countries, there has been a downtrend in government research and development expenditure that is also affecting university research and development expenditure. Traditionally, scientific research in universities has been recognized as a public commodity and financed by government. With the decline of government research and development financing, however, it has become necessary to seek new sources of funding.

**(b) Qualitative changes in government financing:** Government funding for university research is increasingly being invested in projects that are of a mission-oriented nature, which leads to more short-term and market-oriented university research and development.

**(c) Increase in research and development financing by industry:** Through joint projects, contracted research and development, and funding researchers, private industry is financing an increasing share of research in universities. This leads to research that is more directed to potential commercial applications.

**(d) Increased pressure for an economic contribution:** There is growing pressure for universities to contribute more relevantly to economic development and technological innovation, creating tensions in traditional discipline-based university research organization.

**(e) Networking:** The trend toward joint research with industry, government laboratories, and other research institutes has engendered increased networking among research institutions, changing the institutional context of research.

**(f) Globalization of university research:** The internationalization brought about by advances in telecommunications technology is affecting the research environment and research and development activities, as well as escalating international competition and increasing specialization.

**(g) Problems in training and recruiting research personnel:** There is growing concern about the recruitment of researchers as the present research workforce ages and science loses popularity with young people, coming at a time when methods of training researchers are changing.

### (2) The Situation in Japan

Reports from Japan have highlighted (1) the progress of university reform; (2) the formulation of the Science and Technology Basic Plan and an increase in research funds, especially competitive funding; (3) a trend toward cooperation between universities and industry; and (4) a trend toward internationalization. Reports from other countries indicate that, with the exception of Finland, science and technology budgets are stagnating in most European and North American countries. There is thus considerable interest in the sustained increase in Japan's science and technology budget under the Science and Technology Basic Plan, and in Japan's efforts to encourage basic research at a time when other countries are focusing on research of a mission-oriented nature. It has also become clear that Japan shares a number of tasks with European and North American countries, including maximum encouragement of basic research, which is the main mandate of universities,

**OECD, "Science, Technology and Industry: Scoreboard of Indicators 1997"**

**Trends in Government-Financed R&D as a Percentage of Total Government Expenditure**

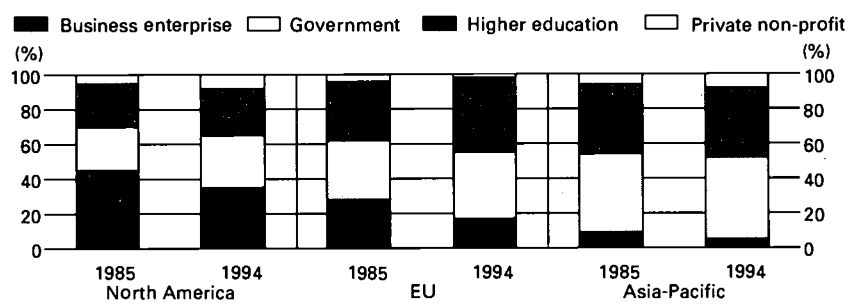
"Most OECD governments spend between 2.5 and 3.5 percent of total government expenditure on R&D carried out on national territory. . . . The shares are somewhat higher in the United States, France, Australia, and the Netherlands and distinctly lower in Greece, Portugal, and Ireland. OECD governments have generally converged towards this range, with the indicator falling in France, Germany, the United Kingdom and the United States, but rising in Spain and in many smaller countries. During the 1990s, the priority attributed to R&D, as reflected by this indicator, has tended to level off or to decline. The main exceptions are Australia, Austria, Finland, and Spain."

Note: In Japan, science and technology expenditures accounted for about 1.6% of the national budget in 1996.

**Increase in the Share of the Higher Education Sector in Government-Financed R&D**

"Government-financed R&D in the higher education sector has continued to increase in the 1990s in all three zones (allowing for the changes in reporting methods in 1990 and 1991 in the United States). In the Asia-Pacific (OECD) zone, support did level off temporarily in 1994. Over the decade 1985–95, the share of government-financed R&D carried out in the sector grew from about one-third to nearly one-half in the European Union, from about one-quarter to one-third in North America, but remained at about 40 per cent in the Asia-Pacific (OECD) zone. Some two-thirds or more of government-financed R&D is performed in this sector in Austria, Belgium, Sweden, Switzerland, and Turkey."

**Shares of Performance by Sector in Government-Financed R&D, 1985 and 1994**




despite financial constraints, and balancing education and research in an environment of mass access to higher education.

## 2. Science Policies in Major Advanced Nations

Historical background and other factors create differences in different countries' science and technology administration systems and research setups. Studying the mechanisms of scientific administration and the role of universities in scientific research in other countries, and monitoring trends in science policy, facilitates a review of Japan's science policy from an international perspective. The following analysis is based on surveys of the United States, the United Kingdom, Germany, and France (Figure 4-5, Table 4-3).

### (1) The United States

**(a) Administrative system for science and technology:** In the United States, at the federal government level, universities are under the aegis of the Department of Education, which provides information and financial subsidies. With the exception of 13 higher education institutions under federal jurisdiction, including the military academies, universities are established by either state governments or private organizations.

Under the American system of science and technology administration, federal government departments, independent agencies, and state governments implement research and development in line with their respective administrative objectives in research institutes under their jurisdiction and also award research commissions or grants to universities. Federally Funded Research and Development Centers (FFRDCs), which are funded by the federal government but managed by universities, also play a role.

In 1995 universities used 59% of basic research funding. The biggest source of research grants to universities is the federal government, which accounts for 60% of funding. Funds are provided not only by government departments, such as Agriculture, Commerce, Defense, Health and Human Services, and Energy, but also by independent agencies like the National Aeronautics and Space Administration, and by the National Science Foundation, which maintains no research facilities of its own and concentrates on allocating grants. At present, the biggest provider of funds is the National Institutes of Health (NIH), which is under the jurisdiction of the Department of Health and Human Services. NIH accounts for about 50% of all government research grants to universities. Federal government scholarships, which are awarded mainly by NSF and NIH, play a major role in providing assistance to doctoral students and postdoctoral researchers.

The Office of Science and Technology Policy is part of the Office of the President. With a staff of about 30, it provides advice about science and technology to the President and government departments and agencies. It also serves as secretariat for the National Science and Technology Council and the President's Committee of Advisors on Science and Technology. The former, established in 1993, is chaired by the President and made up of the secretaries of relevant departments; it coordinates the activities of various departments and agencies. The latter, a committee of private sector experts, exists to provide private sector input for government policies. Both NSTC and PCAST are consultative organizations established to facilitate cooperation from a national perspective. They have no role in implementing or funding research.

**(b) Trends in science policy:** Since World War II, partly due to the Cold War, federal government departments and agencies have been actively involved in research and development and have competed in providing vast research funds to universities. This funding also covers personnel expenses and indirect costs, and receiving such funds affects research organizations, including researchers and supporting staff, researcher training, and facilities and equipment. Universities frequently do not provide day-to-day funding along the lines of Japan's unit cost per professor system. Of the more than 3,600 universities in the United States, however, this kind of research is being undertaken on a significant scale in only about 125 "research universities" that put particular emphasis on their research activities and doctoral programs.

In addition to traditional research organizations, such as departments, centers, and institutes, as well as FFRDCs, there are also specially organized research units, such as university-industry cooperative research centers and the engineering research centers. These research units are supported by NSF and, in principle, are dissolved when their five-year federal grants expire, unless they can find private funding or become self-supporting.

Funds for university research have increased steadily, with the federal government consistently the biggest source in the postwar era. The targeting and composition of research funding are changing, however, including a relative decline in defense-related expenditure and, in recent years, an increase in funding by industry.

**(c) Research evaluation:** In general, basic research is evaluated through peer reviews. In the case of research and development for government departments and agencies, administrative assessments are made by the government office or officials in charge of it. NIH, for example, decides grant allocations through a process that consists of peer reviews by panels of outside experts, followed by screening by an advisory committee that includes nonscientists. It also makes interim evaluations based on written reports or on-site observation visits.

### (2) The United Kingdom

**(a) Administrative system for science and technology:** The Department for Education and Employment is in charge of funding universities. The Office of Science and Technology, which was established within the Cabinet in 1992, was placed under the Department of Trade and Industry in 1995. This step was taken to facilitate the transfer of high-level basic research results to industry. The head of the Office, who is appointed by the Prime Minister, is the Government's Chief Scientific Adviser. The Office allocates research grants to universities through the Research Councils. It also produces annual reports and forecasts. Government departments, including the Department of Trade and Industry, carry out applied research relating to their administrative objectives in research institutes under their jurisdiction.

Funds are distributed to universities under a dual system. Basic and regular funds are allocated through the Higher Education Funding Councils, while more competitive funds are allocated through the RCs. Education-related expenditure is estimated to have accounted for approximately 64% of funds distributed by the HEFCs in fiscal 1995~96, and research-related spending for about 18%. The RCs include six specialist councils responsible for the allocation of research funds in specific fields, and another council that administers joint-use facilities. Scholarships paid through the RCs play a central role in providing support to doctoral students and postdoctoral researchers.

The Council for Science and Technology is made up of experts in various fields, including people from the business sector and academia. It advises the Prime Minister on science and technology policy.

**(b) Trends in science policy:** The government emphasizes a strategic approach. For example, since 1993 it has published a science and technology white paper, *Technology Foresight,* and an annual report. In recent years it has sought to strengthen industrial-academic cooperation by expanding competitive funding. A comparison between the budgets for fiscal 1986~87 and 1994~95 shows that competitive funds provided through the RCs have increased by 105% (from 600 million to 1,220 million pounds). The government has also introduced and expanded a system under which RC subsidies are paid on condition that private sector companies provide a certain level of funding, and it is introducing systems with similar conditions for priority areas identified in *Technology Foresight.*

**(c) Research assessment:** Funding from both HEFC and the RCs is directly linked to evaluations, which are highly formalized. The quality of research is basically determined by peer reviews conducted by outside experts, although apparently efforts are being made to develop objective criteria that would be equivalent to peer reviews.

Projects funded through HEFC are subject to assessment by field-specific evaluation committees, which evaluate departments according to a seven-stage scale (five stages until 1995). RC-funded research is evaluated through a combination of document screening and panel reviews by the field-specific committees, with final decisions made by program managers.

### (3) Germany

**(a) Administrative system for science and technology:** Under Germany's federal system, each state has its own functions similar to those fulfilled by the national government in Japan. The state governments are responsible for the establishment and management of universities. However, the university system as a whole is administered by the federal government, while the promotion of academic science and technology that goes beyond the state level, including support for scientific research in universities, is administered jointly by the state and federal governments. With the exception of military research and a few major projects, the science and technology administration at the federal level has mostly been integrated under the Federal Ministry for Education, Science, Research and Technology (Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie), which was established in 1994 through the merger of the Ministry of Education and Science (Bundesministerium für Bildung und Wissenschaft) and the Ministry of Research and Technology (Bundesministerium für Forschung und Technologie).

Policies relating to higher education and science and technology, including research grants, are handled by the Federal-State Comission for Education Planning and Research Grants (Bund-Länder-Kommission für Bildungsplanung und Forschungsförderung; BLK), which was established under an agreement between the federal and state governments. It coordinates activities on the basis of recommendations from the Science Council (Wissenschaftsrat, WR), which was established under the same agreement. The Ministry for Defense (Bundesministerium der Verteidigung) and the Ministry for Economy (Bundesministerium für Wirtschaft) conduct research themselves in research institutes under their jurisdiction or commission research to private enterprises or other organizations. The states provide universities with basic and regular education and research funds. General coordination is handled by the Standing Conference of State Culture Ministers (Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland; KMK). Scholarships for doctoral candidates are provided by state governments and a private foundation subsidized by the federal government. Postdoctoral researchers receive scholarships mainly from the German Research Society (Deutsche Forschungsgemeinschaft; DFG).

In 1995 the Council for the Innovation of Research and Technology (Rat für Forschung, Technologie und Innovation; RFTI) was established. Chaired by the Prime Minister, this group is made up of federal and state ministers and representatives of academia, industry, and labor. Its task is to provide advice on important issues. It has no role in implementing research and development or allocating research funds.

Organizations dedicated to the promotion and subsidization of science include DFG, the Max Planck Society (Max-Planck-Gesellschaft), and the Blue List Science Society (Wissenschaftsgemeinschaft Blaue Liste). Funds and subsidies distributed to universities and affiliated research institutes by these organizations are paid for jointly by the federal and state governments.

**(b) Trends in science policy:** After the reunification treaty took effect in October 1990, universities and research institutes in the former socialist East Germany were restructured, and many teachers in the humanities and social sciences were dismissed. New teachers were appointed from the former West Germany or other countries. The reorganization of research institutes in the former East Germany was based on strict evaluations, carried out mainly by WR. A significant number of institutes were abolished.

In November 1996 WR produced recommendations on research in universities, in which it called for the development of closer links between industry and academia, including personnel exchanges, joint research, the establishment of venture companies, and the utilization of patents to facilitate transfers of knowledge and technology from universities.

**(c) Research evaluation:** A project to evaluate all 82 Blue List research institutions (Blaue Liste-Institute) between 1995 and 1999 is currently in progress. This task is being carried out by the WR Blue List Committee (Ausschuß 'Blaue Liste'), which is made up of outside experts, WR committee members, and federal and state government officials. The evaluation groups that have been established for each research institute are producing reports based on inspection visits and hearings. The Blue List Committee will prepare and publish recommendations based on these evaluation reports. Final decisions on implementing the recommendations will be made by BLK.

DFG has an evaluation committee made up of outside experts who are appointed for four-year terms. The committee carries out prior documentary assessments and then issues a decision and general opinion. Approved projects are subject to an interim evaluation after two years.

### (4) France

**(a) Administrative system for science and technology:** Changes of government are frequently accompanied by a restructuring of state administrative organizations, and the organizations responsible for science and technology administration have gone through a number of changes. Under the present structure, the allocation of research funds and subsidies to universities, *grandes écoles*, and government research institutes has been almost entirely integrated under the Ministry of National Education, Higher Education and Research (Ministère de l'Education Nationale, de l'Enseignement Supérieur et de la Recherche); in June 1997 this was renamed the Ministry of National Education, Higher Education, Research and Technology (Ministère de l'Education Nationale, de la Recherche et de la Technologie), which was established through the amalgamation of the Ministry of Research

(Ministère de la Recherche et de la Technologie, established in 1982 under the Mitterand administration) with the Ministry of National Education and Higher Education (Ministère de l'Education Nationale). The National Center of Scientific Research (Centre National de la Recherche Scientifique; CNRS) plays an important role in relation to universities. Personnel and educational expenses in universities are allocated by the ministry. The ministry and CNRS play a central role in providing scholarships for doctoral students.

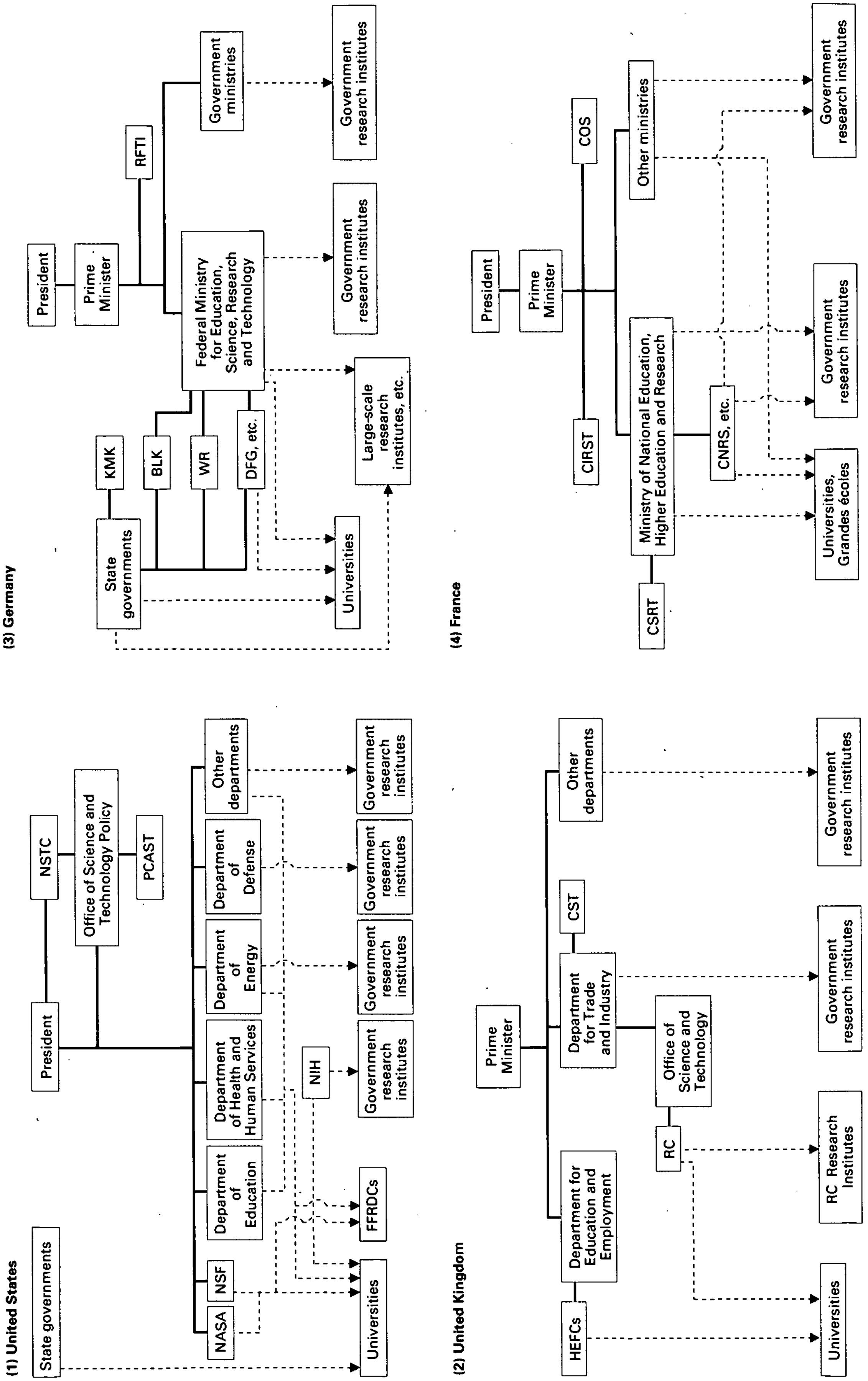
In addition to the High Council of Research and Technology (Conseil supérieur de la Recherche et de la Technologie; CSRT), which advises the ministry on science and technology in general, there is also the Interministerial Committee of Scientific Research and Technology (Comité Interministériel de la Recherche Scientifique et Technique; CIRST). This group, which is chaired by the Prime Minister and made up of ministers with relevant portfolios, is the government's supreme decision-making organization for science and technology policy. In 1995, the Council of Strategic Orientation (Conseil d'Orientation Stratégique; COS), a panel of experts from many fields, was formed to conceptualize long-term policies and advise the government. These committees have no role in implementing research and development or allocating research funds.

**(b) Trends in Science Policy** Research and development in France is carried out mainly by public research institutes, and the military, in particular, accounts for a large portion of research activity. In the past, universities were the nucleus for educational functions, while CNRS was the hub of research activities. In recent years, however, there has been a significant improvement in universities' research capabilities, and research collaboration between CNRS and universities has increased. A feature of the research grants allocated to universities by CNRS and other organizations is that funds are provided to research groups rather that to projects. Block grants are provided under four-year contracts.

**(c) Research evaluation:** The evaluation of universities and other institutions is carried out by the National Committee of Evaluation (Comité National d'Evaluation; CNE), which was established in 1984 and is composed of members appointed by the President. The National Committee of Research Evaluation (Comité National d'Evaluation de la Recherche; CNER) is responsible for the evaluation of research institutions and major projects. It was established in 1989 and is part of the President's Office. Recently CNE and CNER have collaborated to evaluate relationships between universities and research institutes in bioscience.

CSRT evaluates France's overall research system. It submits its findings to the National Assembly in the form of annual reports.

**Figure 4-5: Administrative Organizations for Science in the United States, the United Kingdom, Germany, and France**




Note: Dotted lines denote principal flows of funds.

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**Table 4-3: Numbers of Scientific Research Organizations and Researchers in the United States, the United Kingdom, Germany, and France**

(1) United States (fiscal 1993)

| Type of organization | Number of institutions (schools) | Number of researchers (full-time faculty) |
|---|---|---|
| Universities<br>Other four-year colleges | 2,190 | Approx. 536,000 (universities, other four-year colleges and two-year colleges combined) |
| Two-year colleges | 1,442 | |
| FFRDCs | 18 | |

(2) United Kingdom (fiscal 1993)

| Type of organization | Number of institutions (schools) | Number of researchers (full-time faculty) |
|---|---|---|
| Universities | 87 | 55,950 |
| Colleges of higher education<br>Colleges of further education (advanced courses) | 634 | — |
| RC research institutes<br>RC research institutes | 111 | 5,676 |

(3) Germany (fiscal 1994)

| Type of organization | Number of institutions (schools) | Number of researchers (full-time faculty) |
|---|---|---|
| Universities | 82 | 131,514 (universities and colleges) |
| Colleges | 76 | |
| Fachhochschulen (ct. 1995 White Paper) | 167 | 16,224 |
| Max Planck research institutes | 98 ('96.1) | 4,034 ('93) |
| Braunhoffer research institutes | 64 ('96.1) | 3,878 ('93) |
| Large-scale research institutes | 16 ('96.1) | 10,135 ('93) |
| Blue List research institutes | 83 ('96.1) | 5,260 ('93) |

(4) France (fiscal 1994)

| Type of organization | Number of institutions (schools) | Number of researchers (full-time faculty) |
|---|---|---|
| Universities | 103 | 52,749 |
| Technical junior colleges (1995 WP) | 88 | 7,968 |
| Grandes écoles | — | — |
| University centers of teacher education (1995 WP) | 26 | — |
| CNRS | 1,462 universities<br>2 research institutes | 11,736 |

Notes: 1. In the United States, Federally Funded Research and Development Centers are funded by the federal government and managed and administered by universities. 2. The number of university researchers in France refers only to those in national universities.
Sources: MESSC, "International Comparison of Education Indicators" (1996).

United States: Department of Education, "Digest of Education Statistics 1995;" NSF, "Academic Science and Engineering: R & D Expenditures, 1994."

United Kingdom: Department for Education and Employment, "Education Statistics for the United Kingdom 1995;" OST, "Science, Engineering and Technology Statistics 1996."

Germany: Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie, "Grund- und Strukturdaten 1995/96 1996/97," "Bundesbericht Forschung 1996."

France: Ministère de l'Education Nationale, de l'Enseignement Supèrieur et de la Recherche, "Repéres et Références Statistiques sur les Enseignements et la Formation 1996," "Projet de loi de finances pour 1996: état de la recherche et du développement technologique;" UNIPS, "Indicateurs de Politique Scientifique, No. 3, 1995."

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