

**Keynote Speech for the Sixth U.S.-Japan
Science Policy Seminar
November 8, 1993
Honolulu, Hawaii
Dr. Edward E. David, Jr.**

It is a pleasure to address this eminent audience. I see many old acquaintances, both Japanese and American. That makes me think that we might be just reinforcing our common ideas about research.

However, I was comforted to read the papers circulated by Pat Tsuchitani. The Japanese and American papers were very distinct in their content. The Japanese papers focused on expanding their basic research activities. The U.S. papers noted efforts in the opposite direction -- moving toward applied, goal-oriented research. In the U.S. mind, that is moving toward Japan's way. I found myself wondering if ten years hence, the Japanese research system would look like the U.S. system of today, and vice versa. Regardless, this apparent opposition of trends does give us something to talk about. Let me lay out the U.S. dynamic.

Indeed, this is an auspicious time to ask the questions posed by this Seminar because in the United States the roles of basic research, indeed the roles of the principal performers of basic research, namely the universities and colleges are being questioned. The most serious questioners are the funders, making many in our communities uncomfortable to say the least. Fundamentally, these events foretell a struggle to control the U.S. research agenda -- scientists and engineers or politicians and social engineers.

U.S. science policy has from its inception addressed primarily the subject of financial support by government of academic research. Now, a new dimension of this subject has been introduced. That dimension measures the relative priorities of so-called strategic research on one extreme and investigator-initiated research on the other. The Vannevar Bush paradigm, which has dominated basic research since World War II, is hinged to investigator initiative. Industrial research on the other hand has been hinged to the strategic goals of companies. It has been proposed by influential people that universities move more toward the strategic end. A recent study of the health of university research by the House Science and Technology Committee expressed this view. That was followed by a strongly worded report from the Senate Appropriations Committee, which made it clear that NSF should orient its priorities to specific goals, goals related to societal needs. To give you the flavor of these demands, let me quote from the Senate report: "The NSF can be at the heart of helping to shape the Administration's science and technology policy in pursuit of specific national goals or it can diminish into ... nothing more than a national endowment for science," and later in the report, "NSF should set specific milestones for Federal critical technology programs." "If NSF chooses not to do this, future Federal R&D budgets should be allocated to agencies who will." These are tough words, but perhaps the principal issue here is who will set these goals and the priorities that must accompany these goals? But, I think the intentions of the advocates of the goal-oriented approach are clear enough. We have had a degree of micromanagement of research by Washington authorities for years, but this new thrust goes to the macro-level -- to the research system itself.

There is a plethora of arguments against the move away from the Vannevar Bush paradigm. I won't go into a comprehensive recitation of these but a few

comments are worthwhile. First, the successes of U.S. research have traditionally been animated by individual ingenuity. Any move to constrain that will likely make research less, not more productive. Indeed, many of the most successful of mission-agency programs have been germinated by unsolicited proposals. Many of these had their beginnings in so-called IR&D, and more recently SBIR's, even though IR&D was opposed by people who wanted more oversight of Federal defense expenditures. Indeed, individual ingenuity is an essential driving force in research. Let me say that ingenuity is essential, too, in development even though development is much more structured, as it must be for success.

My second comment concerns the incompatible time constants of research and goals set by societal concerns. The time constant for productive research tends to be much longer than that of societal goals, which wax and wane with regularity. We see this in the rough-and-tumble of corporations driven by market dynamics. Markets are fluid and R&D often cannot keep up with their gyrations. That is why we see corporations calling for just-in-time technology while abandoning central research laboratories, or slaving them to product-line managers. Many times, the R&D degenerates to technical service.

A final comment concerns the career-long, in-depth experts who are prime resources for solving critical problems that arise inevitably in goal-oriented product and service activities. Such experts are the product of devoted disciplinary research over years of effort. Sustaining a reservoir of expertise is essential and it must be done outside goal-oriented teams.

Despite these doubts about a goal-oriented paradigm, there are obverse arguments. One concerns the research frontier, which has broadened dramatically

since Vannevar Bush's days. The number of tempting possibilities is so large that most observers think they cannot all be attacked at once. In other words, some selectivity must be exercised. Frank Press, recently retired NAS President has said as much as did a recent report from NAS on the research frontier. As I said earlier, a principal issue is who will do the selection and using what criteria. We have a hint in the foolish arguments aired in front of the Congress before they canceled the Superconducting Supercollider (SSC).

It is true, too, that goal-oriented research has produced important results in the past. NIH research and DARPA research have been far from barren. Both sponsor what might be called strategic research. And if we look at one of the pre-eminent research laboratories in the world, the Bell Telephone Labs, we see a strong record of accomplishment. I am a graduate of that institution and have a sense of its modus operandi. Let me talk a bit about it. A top official of Bell Labs has said that its success is due to its clear objective, namely to improve electronic communication. In other words, its research has been purposeful -- oriented toward its goal. The term used internally is that Bell Labs research has the "integrity of purpose." The purpose was broad enough to encompass many disciplines: materials, mathematics, condensed-matter physics, and so on. Furthermore, the researchers knew how to evaluate the significance of their work in the context of purpose. Not to be forgotten is that Bell Labs had an intensive recruiting system for securing the top people coming out of research universities. Thus, purpose and goals in themselves are not the death knell of fundamental research. I suspect that the same conclusion can be drawn from other great industrial research labs.

We all realize that there have been precipitous changes in the world situation that affect research and technology. Principal among these is the end of the cold war. But, close behind is the increasing competitiveness in world trade, which has shortened the allowable lead time for introducing new or improved products and services. The acceleration has made many industrial laboratories too slow moving. Many corporations are outsourcing technology -- that is going after what they need in the marketplace of technology. Despite the competitive influence, however, there is a slowing in demand for new technologies. There is more emphasis on incremental technological improvement than on entirely new technologies. This emphasis is related to the product cycles from introduction to obsolescence. Such cycles are shortening. Introducing new technology is a lengthy and risky process and so is less frequently employed.

This dynamic can be looked at from a larger perspective. The peace-time economy that we are inheriting just does not absorb new technology as rapidly as the old cold-war one did. There is not the survival instinct that so animated defense research people. Their philosophy permeated far beyond the purely defense sector. The United States has not had a peace-time economy in 55 years. Our expectations for insatiable technology demand may be much too great. Japan has had much more experience with a peace-time economy than the United States has, and it will be important for us to have their view of this point.

There are other arguments for goal orientation as well. These tend to focus on presumed or declared crises on the social front. These include environment and green issues, health crises worldwide, food supply, and so on. It is not clear just how effective research can be in approaching such demands. But, it is clear that goals will be set. Witness the recent green-automobile summit in Washington.

Note that it is goal-oriented and any necessary research remains to be formulated, let alone executed. Regardless, we (meaning scientists and research engineers) should be thinking how to respond to such demands.

This sort of thinking points to economic- and managerial-driven trends that will affect the structure and activities associated with research. Some 14 months ago, I outlined some of these in a speech before a science policy symposium in Washington. I have updated these and will present them to you. Note that these are end points, assuming that current trends continue to their logical conclusion.

1. Corporate central research laboratories will be eliminated.

The currently fashionable R&D paradigm is a teaming approach aimed at realizing specific products and services. Teams are made up of all necessary specialists including research through marketing and distribution as recommended by management expert Peter Drucker. Teaming shortens lead time but another development emphasis is on incremental, not revolutionary, improvements in products and processes. Corporate research labs are viewed as anachronisms, isolated from the critical activities of the corporation. They are seen as expensive and unresponsive. Downsizing has been progressing for some time. Corporations are increasingly lean, mean, and stupid.

This trend raises the question: how will new science and technologies be generated? There are several possibilities, none guaranteed effective. One is increased Federal funding of so-called pre-competitive research. The NSF-NIH-NIST-DARPA-National Labs coalition aims in this direction. The recently announced green-automobile initiative is not an example despite use of the term

"pre-competitive." Another possibility is opening "windows on technology" through venture capital activities. Still another is a further expansion of the SBIR program. But, none of these is pointed at true fundamental, investigator-initiated research. That means academia must become the prime source of such research, leading to the second major trend.

2. Academic research will become completely integrated with corporate and national strategies.

For many years, DOD practiced this version of research sponsorship, originally through ONR and AFOSR, and then through DARPA. Bell Labs and IBM, among others, also used this paradigm. To be effective, it must be integrated into an overall plan of corporate or national action, but leaving room for investigator-initiated research. Cooperative research consortiums such as MCC and EPRI show how difficult this balancing act can be. But, the basic idea of investigator-initiated research within a broad mission or field is appealing. But that field or mission must have promise -- no perpetual-motion machines, or other fringe ideas based upon Congressional or Public Interest Group fancy.

3. Research grants will be replaced by contracts with specific deliverables.

The ratio of Federal R&D contracts to research grants has been growing in both numbers and funding amounts. Targeted R&D is becoming dominant. Peer review is losing credibility as political influences increase. Reinforcing this trend is the confrontation concerning integrity and misconduct in research. Scientists and engineers have largely lost their credibility as objective advisors and "friends of the court" in Washington. The same trend toward contracts with deliverables is

appearing in corporate-university relations. Note that DARPA has been the model for effective Federal R&D. Their dominant mode of operation is contracting, not granting. Both industrial and academic parties participated with DARPA, and NSF seems to be moving, if glacially, in this direction.

4. The total national investment in R&D will shrink by 25 percent to 30 percent.

The economy is continuing its movement toward services. Manufacturing by some measures is maintaining itself (about 20 percent of the GNP), but employment and GNP are becoming service dominated.

Service industries traditionally do little or no R&D. They depend on their suppliers for technology innovations. About 95+ percent of all R&D funds are spent by manufacturing firms or by labs pointed at manufacturing. As innovation in manufactured products and manufacturing employment declines, so will R&D spending. There are a few established R&D operations in service industries, for example, Bellcore, EPRI, and Cable Television Labs. The disciplines of systems integration and experimental psychology as well as testing and demonstration of new services, are critical to such operations. Universities can play an active role in such research, but there is little at present.

5. The Federal laboratory system will be reduced to about 30 percent of its present size.

The collapse of the USSR and demise of nuclear power have robbed many Federal labs of their missions. There is every reason to expect shrinkage despite

valiant efforts to convert labs to peace-time activities and to couple them to industrial innovation. There will be political resistance to downsizing, but eventually Federal labs will be treated like excess military bases. There will be closings recommended by consensus. Especially vulnerable are labs administered by NASA, DOE, and DOD.

There is the possibility, too, that at least some of these labs will be privatized. The transition from guaranteed base funding to entrepreneurial self-support is not as unlikely as it might appear. For example, the Sarnoff Laboratory, formerly RCA Labs, has made such a transition. Over a five-year period, Sarnoff, now owned by SRI, has found a cohort of paying customers, both commercial and Federal. The transition was eased by phase-out contracts from GE and Thomson, the latter still a significant customer.

6. Strict guidelines for preventing and detecting misconduct in science (research), funded by the Federal government, will be established and administered by legal mechanisms; inspector generals offices as auditors and investigators; the Justice Department as prosecutors.

Relations between the Federal government and research organizations including academia are becoming increasingly adversarial. The anti-trust suit against MIT, the Ivies, and investigations of 15 others indicates the trend. The contention over the definitions of misconduct-in-science is also indicative. Righteous attitudes among scientists and engineers can aggravate the situation. This matter cannot be swept under the rug or washed away. Relations between scientists and engineers and certain political and administration people are at a low point. Punitive actions are likely to increase. The NSF IG's office has already

begun unannounced on-site inspections of academic research laboratories. And the DOD has asked Carnegie Mellon for all its records going back to 1986, to be delivered in six weeks! These are sinister omens for the future of academic research.

7. There will be an increasing oversupply of scientists and engineers in the United States, resulting in downsizing and elimination of academic departments and schools.

Despite projections of coming shortages, the opposite seems to be in prospect. The level-of-effort in research is slowing in response to the lower technology absorption rate by industry and government. Furthermore, there is a significant influx of scientists and engineers from the CEE and CIS countries, China, India, and third-world countries. Yet, I know of no up-to-date, believable projections of supply and demand. Perhaps there are such but the number of out-of-work scientists and engineers is still increasing. I know firsthand about this trend in New Jersey and California. Downsizing and layoffs are likely to continue.

There are increasing demands for qualified people in some fields, for example, in environmental remediation and prevention, and toxicology. The transfer of people from field to field hinges upon their flexibility and willingness to start new careers. This matter dominates the conversion to a peace-time economy.

Also worth noting is the idea that a scientific and/or engineering education is potentially prime preparation for careers in business, teaching, management, and

others. For this idea to become effective, students must believe it, and curricula must be broadened.

8. Industrial policy is upon us.

It will be formulated by government after consulting critical technology lists of diverse origins, and so-called national needs. Policies will be executed by the same list of Federal agencies mentioned earlier. It is not clear is how this effort will be reconciled with market information, and how the separation between R&D and commercialization will be bridged.

R&D consortia will be favored by both industry and government to achieve cost and risk sharing. Because of anti-trust considerations, their role in commercialization is in question. This restriction may in the end doom consortial research. The situation is aggravated by competing interests of the consortial members themselves.

9. Technology transfer abroad and joint activities between U.S. and foreign firms will require licensing by the Commerce and Defense departments.

Protectionism and nationalism are surging around the world including the United States: The European Community now knows this all too well with Denmark and England already opting out of currency reform. There are proposals in the Congress to restrict private international technology transfer since they are burgeoning. The idea of a global economy is questioned because of local effects on jobs and economic development. Despite the Administration's push for

NAFTA, international consortia and joint activities are not favored by governments because of loss of control.

CONCLUSION

I hope that most of these trends will not go to the extreme end points I have projected. However, several of them are proceeding apace and are driven by strong convictions from managerial, political, and economic forces, not to mention doctrinaire ones. The driving forces will overwhelm science and technology issues and are broad based in the polity. Yet, the issues affect deeply the character and effectiveness of both research and education. Furthermore, the trends call into question several of the valued concepts long held by our community, including the separation of basic and pre-competitive research from development, the ecumenical nature of science, and the self-starting aspect of research. There are others as well.

The point is that we as a community have not yet put forward a comprehensive view of policies responsive to the imperatives behind these rather worrisome and sinister trends. We should confront these matters and make some definitive statements on which policies can be based, and be aware that some of our own proposals could lead unexpectedly to draconian ends.

What should be done? That is a major puzzle for this Seminar. Let me point out a possible starting point. It concerns our concept of basic research, and is addressed in Professor Nate Rosenberg's paper. The current definition of basic research is based on the motivation of the researcher. This definition, long held, has caused major damage to the utilization of science and technology and has

often poisoned relations between academia and industry. A first step, which would be welcomed by the Congress and industrial leaders, and would herald a new attitude by researchers, would be to change the definition to the following: basic research aims to create new knowledge for archives and applications. Thus, the new definition would be based on the content and methodology of the work, not on the motivation of the researcher or the funder. Let us push on the governmental and academic authorities to get this done with fanfare soon. Such an action would be quite compatible with Vannevar Bush's vision.

A next step might be to move increasingly to contracts for academic research. This change does not have to be precipitous, but it does need to be resolute. Again, such a transition would be seen as evidence of concern by researchers for productive effort.

These and subsequent steps may be distasteful to academic people. But, I believe that such steps would not change the substance of research significantly in most cases. However, evidence of concern by researchers for the judgments of political and industrial leaders is essential if research people are to continue to control their own research agendas.

**Opportunities and Challenges for Universities in Providing Basic Research
to Support High-Technology-Based Economy in Next 25 Years
---A Japanese Perspective---**

Hiroshi Inose

Professor Emeritus, University of Tokyo

Director General, National Center for Science Information Systems

1. Introduction

The prosperity which the world is enjoying today can be attributed to a large extent, to rapid technological innovation and industrial development, and to the ensuing economic growth that has been taking place over the last 40 years. In order to maintain and enhance such economic and industrial development for coming 25 years, scientific and technological basis should continue to be strong. Among others, universities which have been the prime mover for the promotion of basic research, should play a crucial role for expanding human intellectual assets and for producing technological innovation.

Needless to say, private corporations play a leading role in technological innovation, particularly in Japan. The private business sector in Japan accounts for 84% of the total R&D expenditures, compared to about 65% in major industrialized countries. The private industry is as much applauded for its commitment and the government is to be blamed for its negligence.

As Japan continues to make strides in technological innovation, it has also come under increasing criticism for what is perceived as its free ride in basic research. Japan is accused of investing too little in basic research, and too much in applications, compared with the other leading countries. As a result, it is now being urged to make a contribution to basic research more commensurate with its standing as an economic and industrial power. Criticisms are mounting that hardly any Japanese universities or state-run research institutes are true centers of excellence where top scholars congregate from all over the world to carry out basic research and that this results in a significant imbalance in the flow of researchers and scientific information between Japan and the other leading countries.

Clearly, the Japanese government should drastically increase public funding for universities and state-run research institutes which are mainly responsible for conducting basic research. Until recently, however, any substantial increase in public funding in this respect did not take place because the top priority of the Japanese government was to eliminate the budget deficit. Now that voices urging the improvement of the situation are increasingly heard not only internationally but also from national industrial and academic circles, the government has made a cabinet decision, "the General Guide Lines for Scientific and Technological Policy", in April 1992, which calls for doubling financial support for basic research in earliest possible date. In fact, the government expenditure for promoting science and technology in the Fiscal Year 1993 reached 2,267 billion yen as compared to 2,023 billion yen for the previous Fiscal Year. Further, the amendment of the national budget that took place in June 1993 for the purpose of revitalizing domestic economy, turned out to include substantial expenditures for strengthening "new societal infrastructure", which implies the deployment of high-performance networks including national backbones and local area networks, and

the installation of basic research facilities including supercomputers, in addition to construction and renovating university buildings.

The present paper first describes the present state of the university research system in Japan and then outlines current changes taking place in strengthening the research function, namely, increase in budget, restructuring faculties and attached research institutes, creation of graduate universities, enhancing university-industry ties, etc., with some of the author's personal experiences, observations and proposals for a brighter future.

2. University Research System in Japan, Present State

(A) Organization

Figure 1 depicts the administration of university research system in Japan. Ministry of Education, Science and Culture (Monbusho) consults the Science Council in formulating policies for the promotion of scientific research. The Council is organized to deal with various aspects of scientific research policies that include appropriation of research grants, identification and promotion of priority areas, etc., as shown in Figure 2.

National, private and public universities and their attached research institutes, inter-university research institutes and research institutes attached to Monbusho form the major part of university research system in Japan as shown in Figure 1. The number of university researchers by their affiliation and by their fields is shown in Table 1.

One of the specific features of the university research system in Japan is the existence of the research institutes attached to national universities and the inter-university research institutes. Table 2 shows the number of these research institutes by their status and by their fields. The most conspicuous among them are the inter-university research institutes which have been set up as national research centers open to all universities. As shown in Table 3, these institutes provide large-scale research facilities for shared use, promote joint studies of researchers in specific fields, collect and disseminate scientific information nation-wide. Emphasis has also been placed on promoting cooperative research and joint use of facilities in research institutes attached to national universities. Table 4 shows the list of such research institutes and their year of inauguration. In addition, there have been about 400 research centers and facilities attached to national universities, some of which are for inter-departmental use on open for nation-wide service.

Many private and public universities also have their own research institutes, the number of which

is now close to 300. Some of them have a long history and are well-known for their distinguished achievements. While the majority of the research institutes attached to national universities are in the area of natural sciences, two-thirds of those attached to private and public universities are in the fields of social sciences and humanities.

(B) Funding

University research in Japan has been supported by the following funds:

- (a) general and basic funds allocated to researchers in accordance with a standard formula
- (b) specific funds to universities in support of research facilities, research projects, etc.
- (c) research grants awarded directly to individual researchers or groups of researchers in accordance with their merits.

In addition, university researchers acquire research funds from non-governmental foundations and through corporate research contracts and donations. For private universities, tuition fees and government subsidies are also major sources of income.

Total budget of the Japanese Government for science and technology in the fiscal year 1993 amounts to 2,266.8 billion yen among which Monbusho's related budget is 1,046.3 billion yen. As shown in Table 5, the budget includes 24.4 billion yen for strengthening university research facilities. Substantial part of the budget is also allocated to big sciences, namely 22.7 billion yen for high energy physics, 20.6 billion yen for space science, 9.1 billion yen for nuclear fusion studies, 5.4 billion yen for astronomy, 5.0 billion yen for polar research, etc. The budget estimates for the university-industry collaboration are: 5.0 billion yen for joint research, 9.6 billion yen for contract research and 50.2 billion yen for corporate donations. The total budget of research grants in the fiscal year 1993 reached 73.6 billion yen, an increase of 9 billion yen as compared to the previous year.

In addition, the Japan Society for the Promotion of Science (JSPS), which is an independent body under the auspices of Monbusho and is responsible for fellowship programs and international exchanges has the budget amounting to 9.0 billion. Further, the June 1993 amendment of the national budget provided an increase of 158 billion yen for enhancing university research and education system.

3. Current Changes for Strengthening Japanese University Research System

(A) Financial Support

As shown in Table 6, reflecting current recession and budget deficit, the rate of increase of Monbusho's budget in the Fiscal Year 1993 was 2% as compared to the previous Fiscal Year. The budget increase in support of university research, however, was much higher than this average. For example, the rate of increase of the Grants-in-Aid for Scientific Research was 14%. It is expected that the amount of the grants will reach 100 billion yen within a few years. Likewise, the budget increase of the JSPS was 17%. Rate of increase of budget for strengthening university research facilities, etc. was also substantial. Above all, the 1993 Amendment of the national budget is providing a phenomenal thrust for enhancing research infrastructure.

(B) University Reform

For the purpose of advising the Minister for university reform, Monbusho established the University Council in September 1987. Since then, the Council has been intensively examining various issues and problems associated with Japanese higher education and successively published more than 10 reports, including the following:

- allowing more flexibility to the existing systems of graduate schools (December 1988)
- a review of the existing system of academic degrees and the evaluation of graduate schools (February 1991)
- the improvement and enhancement of graduate schools (May 1991)
- the quantitative development of graduate schools (November 1991)

In response to these reports, Monbusho has been working towards the implementation of relevant reform measures, so as to meet diversifying societal demand and to establish centers of excellence worthy of international esteem. And quite a few Japanese universities have been tackling to reorganize themselves.

(C) The RCAST, A Personal Experience

Some of the research intensive universities including the University of Tokyo has been reorganizing its Faculties to give priorities to graduate studies, while initiating restructuring of research institutes attached to them. An example of such restructuring was the demolishing of the Research Facility for Interdisciplinary Studies attached to the Faculty of Engineering and the creation of the Research Center for Advanced Science and Technology (RCAST) that took place in May, 1987 at the University of Tokyo. The RCAST was inaugurated as an interdisciplinary, international, high-

mobility and open research center for high technology studies. Its intention was to fully utilize the wisdom and human resources of all Faculties and Research Institutes belonging to the University of Tokyo, so as to cover not only natural sciences but also social sciences and humanities to promote advanced science and technology studies.

As the Dean of the Faculty of Engineering at that time, the author was at the forefront to carry out this transfiguration and found that considerable efforts had to be expended to make the concept, which is characterized by the above four keywords, a reality. Because of the unanimous support of the University Senate and owing to the enthusiastic participation of professors transcending academic disciplines, interdisciplinary feature of the RCAST has been installed at the outset. The high-mobility feature of the RCAST has also been realized owing to the understanding of major Faculties and Research Institutes in dispatching the best of all professors to the RCAST for several years on rotation basis.

The International and open features, on the other hand, required a new system to be implemented. Although the University of Tokyo already has acquired a sizable financial support through untied research grants and objective oriented research contracts from industries, and also has accepted considerable number of researchers from industries, it was felt that something had to be done to intensify university-industry collaboration. As to the international feature, it was felt that, although no restriction existed in appointing foreign professors to the government-funded chairs, the shortage of such chairs as well as the insufficient support for housing and other fringe benefits could not be attractive to competent foreign researchers.

As a significant means of solving the above problems, a completely new type of chairs endowed by industries was conceived. Such chairs if endowed, could not only strengthen university-industry ties, but also make it possible to invite competent foreign scholars by providing less restrictions and better stipend, housing and other conditions. The difficulty was that the University of Tokyo had never had any endowment chair until that time because of such obstacles as ivory tower, academic freedom and other traditional concept. However, ideological prejudice were going to ruin, and the Monbusho was just setting out to encourage endowment chairs.

Our proposal of having a foreign scholar to chair the endowment supported by corporate donation without any strings attached, was favorably accepted by all parties concerned, namely academics, industries and the government. Thus the first four chairs, namely the Computer and Communication Chair endowed by Nippon Electric Co. (NEC), the Telecommunications Chair endowed by Nippon Telegraph and Telephone Co. (NTT), the Information Science Chair endowed by CSK Corporation, and the Advanced Materials Chair endowed by Nippon Steel Corporation have been established.

At the outset, however, finding competent foreign scholars who were willing to occupy

endowment chairs were somewhat difficult. However, owing to the strenuous efforts of Professor Takanori Okoshi, the founding director and other professors of RCAST, as well as the generous understanding of the foreign scholars and their employers, the four endowment chairs were started up smoothly. For instance, the first endowment chair which is the Computer and the Communications Chair endowed by NEC scored a great success and set a standard for the succeeding endowment chairs which now amount to nine. The success has been notably attributed to the whole hearted devotion of Professor Enrique A. J. Marcatili, the first chair professor, and the magnanimous support of his employer, the AT&T Bell Laboratories, and in particular, Dr. Ian Ross the then President and Dr. Arno Penzias, the Vice President. Dr. Marcatili, through his outstanding leadership over an extended period of time, not only demonstrated how an endowment chair should be operated, but also realized the international and open features of such chairs by appointing Dr. Katsunari Okamoto of NTT Research Laboratories to the Associate Professor of his chair. Thus it turned out that the endowment chair given by NEC was occupied by an AT&T Bell Laboratories professor and an NTT associate professor, while these three enterprises are often competing and cooperating in the world market and scientific studies. Since then the Computer and Communications Chair has been successfully run by Professors Ivan P. Kaminow, Hisashi Kobayashi, Paul R. Prucnal, Andrew Jordan and others, and has kept on achieving a great deal scientifically while promoting international understanding and cooperation.

The RCAST, supported by Monbusho and encouraged by domestic and international scientific communities and industries, has kept on growing and achieving significantly in a variety of high-technology areas and is gaining recognition as a center of excellence in Japan.

(D) New Graduate Universities

In addition to the restructuring of existing universities, a new concept of establishing graduate universities was born. The first among these is the Graduate University for Advanced Studies, which was established in 1988. The national inter-university research institutes cooperate closely with this Graduate University by providing their research staff and facilities for graduate education and research in their respective fields.

Following this, Advanced Institutes of Science and Technology, one in Hokuriku in 1990 and another in Nara in 1991, were inaugurated as independent graduate schools focused on such high-technology areas as information science, material science and bioscience.

(E) Collaboration with State-Run and Corporate Research Institutions

Universities are increasingly working together with state-run research institutions and professors are intensifying their involvement in government research and development projects. The University of Tsukuba has developed joint research programme with state-run research institutes in Tsukuba Science City area, which are under the auspices of Ministry of International Trade and Industry (MITI), Science and Technology Agency (STA), Ministry of Agriculture, Environmental Protection Agency, etc. The Institute of Physical and Chemical Research (RIKEN) which is under the auspices of STA, now has close ties of the graduate school of Saitama University, while maintaining its traditional collaborations with professors at research intensive universities. Number of university professors participating in research projects sponsored by MITI, STA and other government sectors keeps on increasing.

University-industry collaboration has also been intensifying. Joint research projects with industries, contract research projects, corporate donations in support of university research, endowment chairs, etc. have been steadily increasing, in spite of the sustaining economic recession. For instance, Figure 4 shows in time the increase of corporate donations given to national universities. In addition, since 1987, Monbusho has established more than 20 Centers for Cooperative Research at national universities to encourage joint research, contract research, etc. with industries. The number of endowment chairs donated by industries now amounts to 60.

(F) International Cooperation

International scientific cooperation has also been progressing. In addition to cooperative research projects based on inter-governmental agreement and programmes of international governmental and non-governmental organizations, research grants for international cooperative studies now permit researchers work more closely with their colleagues abroad. Efforts have also been made to improve the imbalance in exchange of researchers by increasing the number of fellowships and scholarships for foreign researchers who want to conduct their studies in Japan. Scientific cooperation with Southeast Asian Countries has also been intensified and similar programmes has been initiated to cover Argentina, Bangladesh and India. As to the cooperation with the United Nations University which has been conducting studies on such major global problems as human survival, development and welfare, in addition to the majority of its endowment fund, the Japanese Government with the assistance of the Tokyo Metropolitan Government has provided a new headquarters building in Central Tokyo for the purpose of enhancing its activities.

(G) Leveling-Up of Japanese Scientific Research

Some of the recent studies conducted in Japan and elsewhere on the levels of Japanese scientific studies reveal that at present, the United States ranks the top both in basic research and applied research while Japan ranks the second in applied research and basic research, although it breaks even with the U.K. and Germany in basic research; and that after ten years, the gap between the U.S. and Japan will get narrower although the U.S. still ranks the top both in basic research and applied research, while U.K., Germany and other European countries will lag behind Japan in basic research.

An example of such studies was published in January 1992 issue of the Japanese Scientific Monthly published by JSPS. The paper, which was authored by Professor Akio Yamamoto of the Tokyo Institute of Technology also contains results of bibliometric studies using the Science Citation Index of the Institute for Scientific Information and the Science Literature Indicators of the Computer Horizon Inc. As an example, Figure 5 shows the number of citations of Japanese papers for the period of 1981-1985 in 9 selected areas taking the number of citations of U.S. papers as a reference. The selected areas and their abbreviations are the following.

Sold State Physics	(SSP)
Organic Chemistry	(OCH)
Polymers	(PLM)
Agriculture, Food Science	(AFS)
Biochemistry, Molecular Biology	(MBI)
Immunology	(IMM)
Cancer	(CAN)
Electrical Engineering, Electronics	(EE)
Computers	(COM)
Average	(AVG)

Assuming that the trends shown in the figure continue for the following ten years, namely 1986-1995, so far as citations are concerned, a considerable level-up in Japanese scientific research will be observed.

4. Aiming at a Better Future

As has been described, owing to the strenuous efforts expended by the academia, government and industries, strengthening of Japanese basic research has just taken off both financially and organizationally. However, the current economic recession which has been sustaining for the last two years, seems to continue at least for a few more years, bringing huge deficit in national budget as

well as serious business slump in domestic market. As a result, the strengthening of Japanese basic research which has just taken off, may go into a stall due to the lack of financial resources in public and private sectors. Under such circumstances, all parties concerned should consolidate their resources and efforts to tide over the difficulty.

Especially, strengthening of university research is crucial for the entire operation, because of the facts that universities provide the right atmosphere for free and creative thinking, that Japanese basic researchers are overwhelmingly belong to universities, and that universities are major source of supply of young basic researchers not only for universities themselves but also for state-run and corporate research laboratories. This however does not mean that university professors should fortify themselves in ivory towers or sanctuaries, rather, they should be encouraged to open their doors more widely to researchers from state-run and corporate research institutions, and they should also be encouraged to participate more closely in basic research projects sponsored by state-run and corporate research institutions.

One of the urgent issues in strengthening Japanese university research is the restructuring and improving, both qualitatively and quantitatively, graduate schools, as pointed out in the reports of the University Council. Current situation is that, while master-courses of research intensive universities are full of students, doctor-courses are much less popular. This may indicate that master-courses are regarded by students mainly as an extension of undergraduate studies to acquire professional knowledge and that doctor-courses are observed as seriously underfunded to carry out research so that research-oriented students prefer state-run and corporate research laboratories. Despite the fact that most of research intensive universities have thesis requirement in their master-courses, students tend to spend more time in class rooms rather than conducting their own research work. If this trend continues, master-courses may be centered around professional education while doctor-courses, strengthened financially as well as organizationally and combined with post-doctoral studies, may constitute the major part of university research.

Needless to say, drastic increase in financial support is crucial in revitalizing university research. However, under the prevailing circumstances, there will still be limits to public funding, so that private funds will have to be introduced to fill the balance. In this regard, the Japanese government should provide tax and other incentives more generously to private sectors so as to increase donations for universities and to scale-up Japanese not-for-profit foundations which are an order of magnitude smaller than their counterparts in U.S. and Europe. Research institutes run by business corporations are a part of their profit-seeking activity and are not designed to serve primarily for scientific interests. Nevertheless as the depth and width of their research activities are bound to grow, their degrees of public contribution will rise as a result. Japanese companies are often criticized as inferior to their U.S. and European counterparts in social service. While financial aid to cultural and welfare

programs is an established form of social service by private corporations, consolidating and strengthening their research institutes in collaboration with universities so as to extend the horizon of human knowledge, should also be considered as a very legitimate form of social service.

The Japanese society is aging quickly, with fewer young generations and rapidly increasing senior citizens. In addition to the extension of retirement age, continuing education should be provided systematically to maintain the present level of societal activities. In particular, in the light of very quick obsolescence of scientific and technological knowledge, education and training to refresh knowledge of scientists, engineers and technicians should be drastically enhanced. The University on the Air sponsored by Monbusho, should be strengthened by permitting the use of a broadcast satellite channel and by putting more emphasis to its curriculum on scientific and technological education.

As to the international cooperation, one of the urgent issues is to intensify Japanese language education for the benefit of visiting foreign researchers, both nationally and internationally. An effort comparable to that of French and German governments should be expended by Japanese government to deploy foreign language education centers in major cities of the world. Further, in view of the fact that scientific and technological studies are increasingly dependent upon information, drastic improvement will have to be made for information infrastructure, namely networks and databases. International networking should be intensified and more information in international languages should be disseminated.

Despite all their skills in innovation, production, commerce and warfare, the Japanese people have been internationally assessed as belonging to a second-rate citizen, without any really significant contributions in thought, religion, science, or art to its credit. Such an assessment has been a big constraint on Japanese international activities in science, diplomacy, trade, and all the rest. We should try our best not to leave this negative legacy to our future generations.

Japan has had the good fortune to come into possession of robust economic and superb technological prowess. The history of human civilization shows that periods of economic prosperity have allowed science, art, and culture to blossom, as in ancient Athens, the Saracenic dynasty, and Renaissance Italy. There is no reason why Japan should be an exception. Japan today has established impressive economic power and has accumulated reserves of technology that have generated this power. The people still abide by the spirit of industriousness, and by their commitment to pacifism, egalitarianism, and liberalism. If we succeed in solving the problems inherent in ourselves, we will be able, with confidence and with justice, to assert ourselves in the twenty-first century, and make genuine and lasting contributions to the international community.

Table 1. Number of university researchers by fields

	National	Public	Private	Total
Humanities	8,153	1,487	19,002	28,642
Social Sciences	5,153	1,215	13,985	20,353
Science	12,886	1,176	6,285	20,347
Engineering	18,506	1,183	9,878	9,567
Agriculture	6,481	567	2,048	9,096
Health	38,442	6,910	36,835	82,187
Other	5,721	1,062	12,923	19,706
Total	95,342	13,600	100,956	209,898

(note)

The figures include those of full-time researchers, doctor course students and medical staff.

(source)

Report on the Survey of Research and Development 1991

Table 2. Research institutes of the university

(as of fiscal 1991)

	NATURAL SCIENCES					HUM. & SOCIAL SCI.	OTHERS	TOTAL
	SCI. & ENGI.	MEDI.	PHAR.	AGRI.	SUB-TOTAL			
INTER-UNIVERSITY RESEARCH INSTITUTE	8	1		1	10	4	1	15
INSTITUTE ATTACHED TO NATIONAL UNIV.	33	15	1	4	53	10		63
FOR JOINT USE	12	1			13	1		14
NOT FOR JOINT USE	21	14	1	4	40	9		49
TOTAL	41	16	1	5	63	14	1	78

Table 3. Inter-university research institutes

INSTITUTES	RESEARCH OBJECTIVES	ESTABLISHED
National Laboratory for High Energy Physics (KEK)	Research into elementary particles using high energy particle-accelerators, research by synchrotron radiation facilities and other related researches	1971
National Institute of Japanese Literature	Investigation, collection, classification and safekeeping of books and other reference materials on Japanese literature	1972
National Institute of Polar Research	Comprehensive scientific research of the polar regions and observation activities thereon	1973
Institute of Space and Astronautical Science (ISAS)	Research of space science and engineering and their application, including development and launching of scientific satellites	1981
National Institute of Genetics	Comprehensive research of genetics	1984
Institute of Statistical Mathematics	Research into mathematical principles of statistics and their application	1985
International Research Centre for Japanese Studies	International and interdisciplinary research into Japanese culture and research cooperation with Japanologists abroad	1987
National Observatory	Research of astronomy and its related fields, observation of astronomical phenomenon, compilation of almanacs, "Japan Standard Time Casting", etc.	1988
National Institute for Fusion Science	Research of plasma of nuclear fusion and their application	1989
Okazaki National Research Institutes		1961
Institute for Molecular Science	Research into structures and functions of molecules	1975
National Institute for Basic Biology	Comprehensive study on basic biology	1977
National Institute for Physiological Sciences	Comprehensive study on physiology	1977
National Center for Science Information System (NACSIS)	Collection, classification and provision of scientific information as well as research and development of the scientific information system	1986
National Museum of Ethnology	Collection and safekeeping of materials on various races in the world as well as their exhibition before the public and research of ethnology	1974
National Museum of Japanese History	Collection and safekeeping of materials on Japanese history as well as their exhibition before the public and the research of history, archeology and folklore	1981

Table 4. Research institutes attached to national universities for joint use

UNIVERSITIES	RESEARCH INSTITUTE	ESTABLISHED
Tohoku	Institute for Material Research	1987
Tokyo	Institute for Cosmic Ray Research	1953
	Institute for Nuclear Study	1955
	Institute for Solid State Physics	1957
	Ocean Research Institute	1962
Tokyo Foreign Studies	Institute for the Study of Languages and Culture of Asia and Africa	1964
Nagoya	Solar Terrestrial Environment Laboratory	1990
Kyoto	Research Institute for Fundamental Physics	1953
	Research Institute for Mathematical Sciences	1963
	Research Reactor Institute	1963
	Primate Research Institute	1967
Osaka	Institute for Protein Research	1958
	Welding Research Institute	1972
Nagasaki	Institute of Tropical Medicine	1989

Table 5. F.Y. 1993 budget

Total National Budget for Science and Technology : 2,266.8 billion yen
 Total Monbusho Budget for Science and Technology : 1,046.3 billion yen

Major Spendings for University Research (billion yen)

Strengthening University Research Facilities : 24.4
 High Energy physics : 22.7
 Space Science : 20.6
 Nuclear Fusion Studies : 9.1
 Astronomy : 5.4
 Polar Research : 5.0
 Joint University-Industry Research : 5.0
 Contract Research : 9.6
 Corporate Donations : 50.6
 Research Grants : 73.6
 JSPS : 9.0

(Excluding June 1993 Amendment)

Table 6. Total government budget and Monbusho budget

(Amounts in Billion Yen)

Fiscal Year	Total budget of the government in general accounts					Monbusho budget		Percentage of Monbusho budget	
	Total budget		General purpose budget**		Proportion of general purpose budget	Amount	Rate of increase	in the total government budget	in the general purpose budget
	Amount	Rate of increase*	Total amount	Rate of increase					
'81	46,788.1	9.9%	32,050.4	4.3%	68.5%	4,468.7	4.73%	9.6%	13.9%
'82	49,680.8	6.2	32,620.0	1.8	65.7	4,584.8	2.60	9.2	14.0
'83	50,379.6	1.4	32,619.5	Δ0.0	64.7	4,533.8	Δ1.11	9.0	13.9
'84	50,627.2	0.5	32,585.7	Δ0.1	64.4	4,572.0	0.84	9.0	14.0
'85	52,499.6	3.7	32,585.4	Δ0.0	62.1	4,574.1	0.05	8.7	14.0
'86	54,088.6	3.0	32,584.2	Δ0.0	60.2	4,572.2	Δ0.04	8.5	14.0
'87	54,101.0	0.0	32,583.4	Δ0.0	60.2	4,573.7	0.03	8.5	14.0
'88	56,699.7	4.8	32,982.1	1.2	58.2	4,576.6	0.06	8.1	13.9
'89	60,414.2	6.6	34,080.5	3.3	56.4	4,637.9	1.34	7.7	13.6
'90	66,236.8	9.6	35,373.1	3.8	53.4	4,798.7	3.47	7.2	13.6
'91	70,347.4	6.2	37,036.5	4.7	52.6	5,055.9	5.36	7.2	13.7
'92	72,218.0	2.7	38,698.8	4.5	53.6	5,319.5	5.21	7.4	13.7
'93	72,354.8	0.2	39,916.8	3.1	55.2	5,426.5	2.01	7.5	13.6

Note:

* "Rate of increase" means the rate of increase over the previous year.

** "General purpose budget" represents the amount of the total budget excluding government debt service, "local allocation tax" grants and a transfer to the Industrial Investment Special Account.

Figure 1. Organization of national research administration

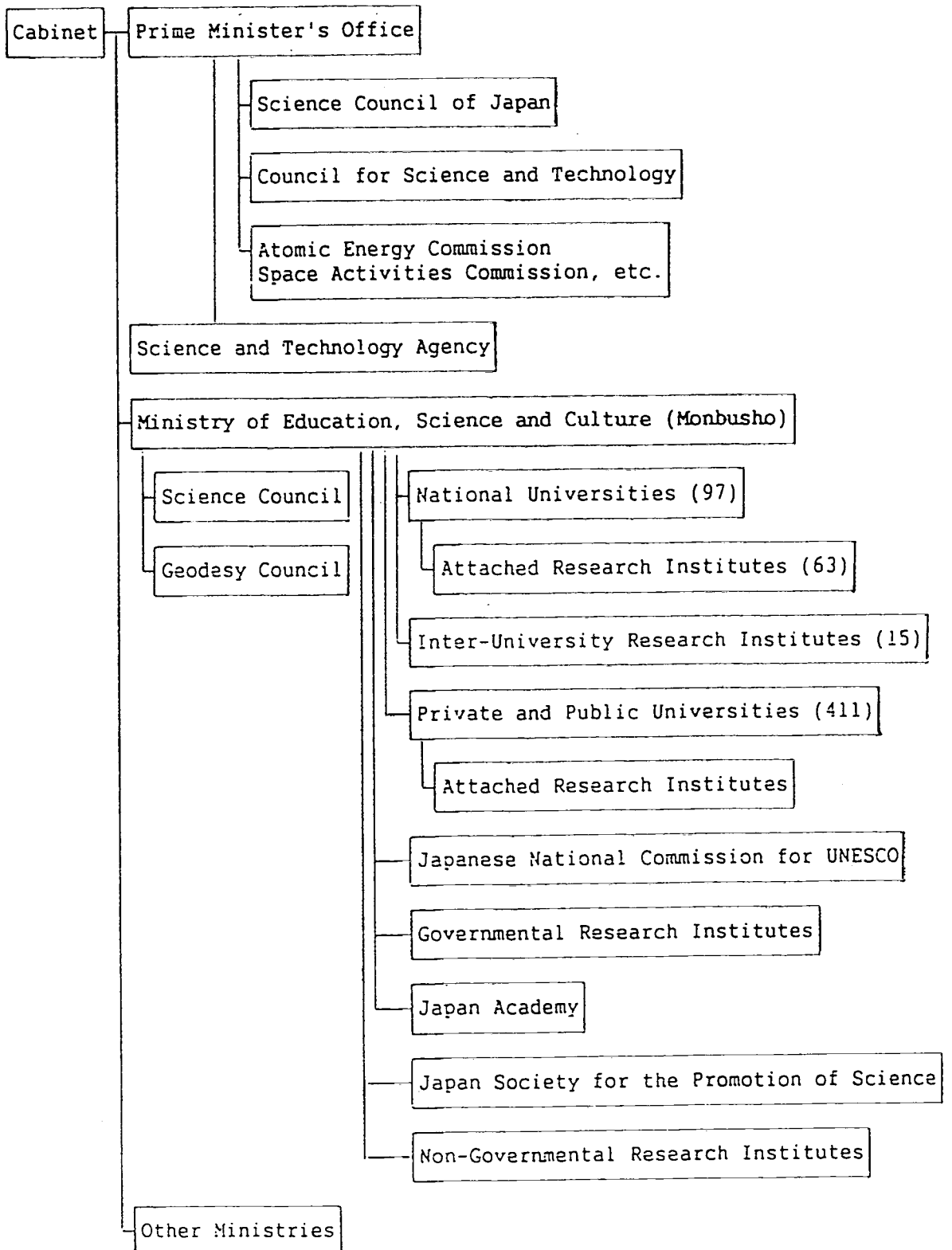


Figure 2. Organization of the Science Council

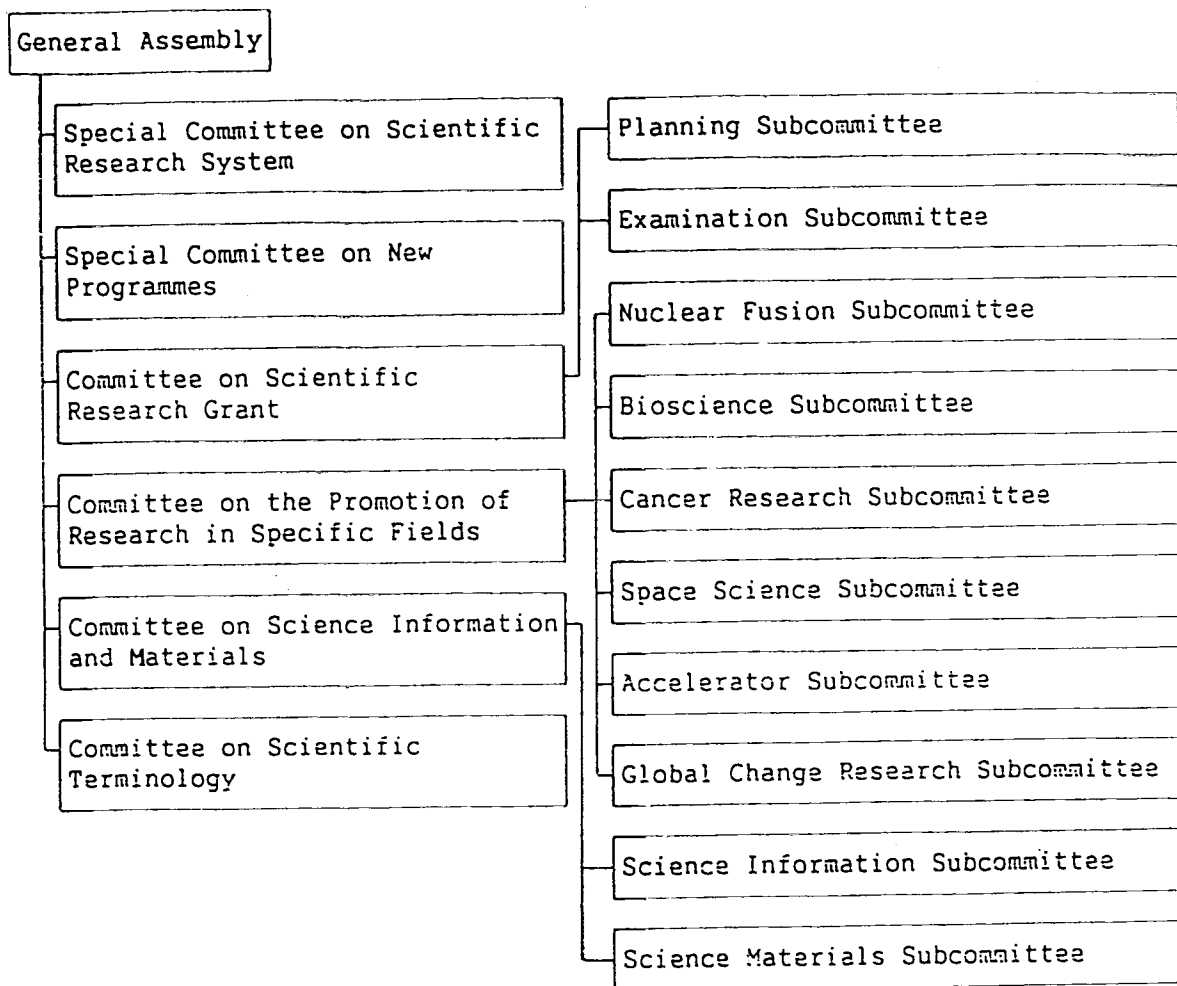


Figure 3. Trends in the Monbusho Budget for Grants-in Aid for Scientific Research, in the Number of Grants Proposed and Those Approved

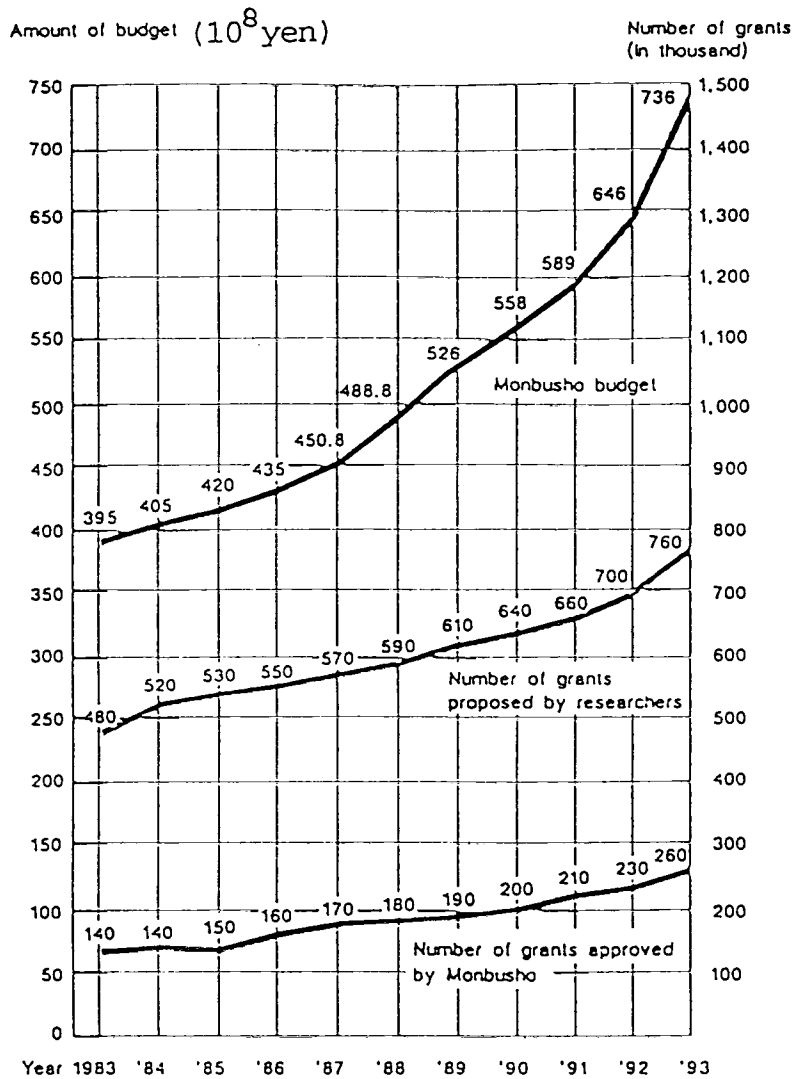


Figure 4. Amount of donations received by national universities

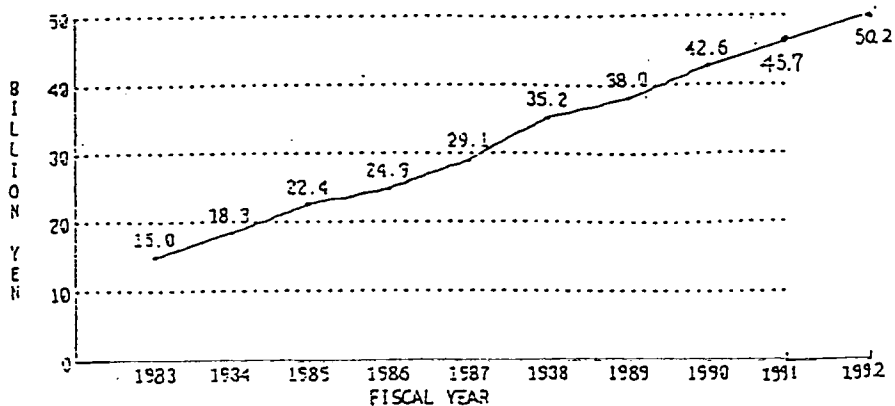


Figure 5. The number of citations of Japanese papers for the period of 1981-85 in 9 selected areas taking the number of citations of U.S. papers as a reference.

