

Basic Research and the New Realities

George H. Heilmeier
President and CEO, Bellcore

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The research community in the U.S. faces a new reality. Conditions today demand that universities go beyond teaching and basic research as their principal missions. They must also proactively concern themselves with the economic and social impact of their research.

Industry isn't funding basic research at the levels that it used to do, either. Most companies have narrowed their research emphasis to areas of more direct commercial potential. Even the National Science Foundation is favoring research that has commercial potential.

The three decades from 1950 to 1980 were a kind of golden age in the U.S. for industrial research done in central laboratories. My industry of telecommunications certainly was a focus of that golden age, but other industries had their shares of the glory too. IBM, for instance, made some phenomenal advances. Texas Instruments grew up around that kind of research. RCA and General Electric both made important contributions. You could point to almost any of the pharmaceutical companies, and to leaders in a host of other health-related industries.

But not only is that golden age over, we're unlikely to see another like it any time soon. The number of U.S. industrial corporations that will be able to maintain their own central laboratories for basic research is very small. Industry's efforts have shifted heavily to applied research and development. That leaves much more of the load for basic research to be borne by universities.

It's also important to note that, no matter how basic some of the research done by those central laboratories was, behind it was an assumption that it would be applied sometime. No company could put too much of its resources into research that might never have a payoff. The difference today is that the proportion of its resources that a company is willing to put at risk in

research is much smaller, and the time line for the payoff is much shorter. A project that will pay off in three years is now considered long term.

Let's look at another source of support for basic research, the government. Overall government support of basic research has begun to and will continue to shrink. Cuts in defense-related research will not be made up by other agencies. And the system of broad government grants to investigators or groups of investigators in universities is likely to shift to one of contracts for more closely targeted research.

How can universities bear this greater burden with less government support? I believe the most likely answer is in cooperative efforts between universities and industrial enterprises. And I'd like to suggest that we do what we can to encourage that approach. In the U.S., I'd like to see the government offer a tax deduction for industry funding of research at universities.

Universities must respond to the new realities of a greater burden for basic research as industrial research decreases and of decreasing governmental support for basic research. They must assume more responsibility for the transfer of knowledge — for seeing it through to concrete developments that have effects in the real world and the lives of real people.

Publication alone is no longer enough. Even highly theoretical research often has identifiable practical implications. A research advance that doesn't address those implications must, I believe, be viewed as incomplete. President Clinton has recognized these changes and is moving his science policy and the National Science Foundation in a direction to respond to them.

The Ph.D. of the future may require an additional dimension, beyond scholarship and research excellence. That dimension is the capability to evaluate, in at least a preliminary way, the potential implications of a particular line of research. This new kind of researcher must constantly ask, "What will it mean if my research succeeds?" "What effects might it have?" "Where might it lead commercially, economically, and socially?" And researchers may need to make cost-benefit evaluations.

We've been discussing these basic problems for the last day and a half. Where does it lead us in terms of educating scientists and engineers who can continue the progress in basic research that lies behind every practical advance ever made? I think the rise of partnership between industry and academia for basic research is inevitable, and I think it will demand a new approach by professors and their graduate students.

Partnership is actually not a new idea. It was alive and well, for instance, at Princeton

University in the 1960s. I earned my Ph.D. in that environment. But the collaboratory relationship between the university and industry was killed by faculty who were not equipped to be effective partners.

The culture of rugged individualism among research faculty needs to be modified to face the new realities. In an environment of tight funding, research faculty must be the leaders of the partnership with industry.

I don't mean to advocate the death of academic freedom. But academic freedom must accommodate the new realities. We must redefine academic freedom as these partnerships become reality. Some have already ventured into this new realm. In addition to the independence of thought that nurtures basic research, we need to know how to work more closely with the companies that will make research matter outside of academia. These needs can be reconciled, and I believe they must be.

Research faculty will also have to be more active partners with each other, seeking the interdisciplinary links behind their research. Cooperation, collaboration, and consultation among faculty are more important now than ever before.

These changes in the culture of research faculty will have clear implications for the culture of graduate students and researchers. The primary implication is the one I spoke about at the start of this paper: We must begin to cultivate in students the ability and the willingness to see beyond the elegant algorithm, the petri dish, the scanning tunneling microscope, to examine cost-benefit relationships. Students must strive to understand how these relationships affect industrial partners to university research and a wide variety of institutions. They must also understand the cost-benefit implications for society as a whole.

The cultural transformation of academic basic research will also be facilitated by actively pursuing the concept of "virtual universities." This also happens to be an area in which telecommunications will make all the difference. In a networked world, with a rich and capable national information infrastructure at their command, a faculty member will no longer be tied to one school. Many students in diverse places and times can benefit from exposure to the talents of the most capable and creative educators. Researchers — both faculty and students — will also have access to expanded communities of interdisciplinary dialogue.

The promise lies in "just-in-time" education using such information-access technologies as video on demand and hypermedia. Lectures, papers, discussions, exercises, and all the other kinds of interactions that nurture scientific exploration can be warehoused and tapped by each

researcher at the times they are needed most. And as the volume of such information continues to expand, it can be stored in new ways, with the links from one resource to another and the paths to synthesis ready and waiting for the pursuit of some discoverer.

No one has sought the conditions that are bringing us to this new culture. No reasonable person does seek contraction and constraint. But sometimes contraction can lead us to new ways of moving forward.

I believe that we can embrace the new research culture that is emerging from the contraction of commercial and government funding for basic research. I believe that, if we do embrace it, this culture will lead to development of a new breed of scientist who is also a new kind of industrialist. And I believe that the new realities will foster research that both advances human knowledge and improves the practical conditions of human lives.

Current Status and Problems of Basic Research Funding Systems in Japan

Tadashi Amemiya
Deputy Director-General
Minister's Secretariat
Ministry of Education, Science and Culture (Monbusho)

Abstract

Scientific research is promoted mainly in universities and their related research institutes. Research in the university is supported primarily by a) general and basic funds allocated in accordance to a standard formula, b) specific funds for specific organizations and c) research grants in aid to researchers. External resources are also mobilized through cooperation with industry and they have become a vital financial source for research activities at universities.

The severe financial strain of recent years has kept government expenditures for higher education and research at an insufficient level. This situation has severely affected the facilities and equipment of universities and research environments of university researchers. Under such circumstances, many university researchers, the business and industry circle as well as the policy makers shared the concern that unless the conditions of university education and research is urgently improved, the basis of economic and cultural development of this country would be jeopardized. The Government has begun to recognize that the research facilities and equipment be regarded as social infrastructure and the investment into them as the social investment. The finance authorities agreed to allocate additional resources from the supplementary budget to the improvement and construction of university facilities and equipment in 1992 and at the same time a special quota was secured to the new budget proposal for such expenditures.

Scientific research has to rely on public support. Monbusho makes efforts to increase public financial support to university research. At the same time, efforts should be made to increase various forms of funding from private sectors. Universities are encouraged to explore possible external resources by fully utilizing their property, know-how and service capacities with more flexible management. In order to secure supports from both public and private sectors, university needs to build up the firm social trust in its education and research activities.

I. The System of Financing University Research

(1) Universities and research institutes

1. There are 535 universities (4 years) of which 99 are national universities (University of the Air included). Monbusho is fully responsible for both finance and management of national universities as the founder. As for the private universities, Monbusho provides subsidies in the amount of 265.5 billion yen for their current expenses. In addition, Monbusho provides them with low-interest long-term loans for the improvement of educational and research facilities and equipment.

2. Scientific research is promoted mainly in universities and their related research institutes, i.e., university faculties, graduate schools, research institutes attached to the faculty, research institutes attached to the university, and national inter-university research institutes. It is important to note the fundamental views of Monbusho's policy for the promotion of university research, that is, university education and research are inseparable and they should be developed in an integrated manner. This view is characteristic in Japan and it is an important element in analyzing and discussing university research system.

3. There are 63 research institutes attached to national universities (as of 1993), 34 institutes to local public universities and 254 institutes to private universities (1991). National inter-university research institutes are set up as governmental research centers and are not affiliated with specific universities. They are open for joint use to all university researchers in Japan. At present there are 16 such research institutes.

(2) Research funds of Japan

4. According to the Report on the Survey of Research and Development of the Management and Coordination Agency, the total sum of research expenditures in Japan in FY 1991 amounted to 13.772 trillion yen. Out of this total, 9.743 trillion yen or 71% was spent by the private-industry sector, while the Government spent 4.029 trillion yen or 29%. Comparing the total amount of national research expenditures in Japan, the United States, the United Kingdom, Germany (formerly West Germany) and France, Japan is surpassed only by the United States. However, as to the percentage share of public funding in the gross national product, Japan (0.54) lags behind all of these nations (US 1.38, UK 0.80, Germany 0.94, France 1.15). As to research expenditures in the university sector, Japan stands in second place behind the United States in the total amount, but it mostly stands lower than any of the previously listed countries in the percentage of public funding in the total research expenditures, etc. (*see page 11, The University Research System in Japan*)

(3) Monbusho's budget for Science and Technology

5. In FY 1993 the Government budget for science and technology, excluding the humanities and social sciences, amounts to 2.266 trillion yen. Included in this is the budget for scientific research for Monbusho which amounts to 1,046 billion yen or 46% of the total science and technology budget. The great majority (80%) of Monbusho's budget for scientific research goes to national universities. The expenditures related to national universities, including the salaries of teachers, running expenses for research activities, and costs of research facilities and equipment, etc., are disbursed through the Special Account for National Educational Institutions.

6. Research in the university is supported primarily by the following funds;
(a) general and basic funds to the researchers allocated according to a standard formula
(b) specific funds to be allocated for the specific research organization, facilities and equipment, research activities, etc.
(c) research grants in aid to be awarded directly to researchers or groups of researchers with excellent research projects.

7. The special account appropriation (a), (b) of FY 1993 amounts to 816 billion yen, primarily comprising allocations to the national universities covering their general and basic research expenditures, traveling expenses, special research expenses, staff salaries, expenditures for facilities and equipment, and so on. The budget for general and basic research expenditures amounts to about 115 billion yen, the budget for staff salaries amounts to about 392 billion yen, the budget for special research expenses amounts to about 207 billion yen and the budget for expenditures for facilities and equipment amounts to about 100 billion yen. The budgets for general and basic expenditures are calculated using a standard formula based on the number of researchers in a national university and applied to its ordinary research expenses for facilities and equipment, book and materials, printing and publication, expendable, wages, utilities and so on.

(4) Grants-in-Aid for Scientific Research

8. The system of grants-in-aid for scientific research is designed to further enhance the nation's academic and scientific standards. Funding is granted on the basis of competitive applications by individual researchers and groups of researchers belonging to universities and institutions of higher education. These grants-in-aid, one of the primary sources of funds for the promotion of science, have greatly contributed to the advancement of scientific research by producing many original and innovative achievements, fostering outstanding groups and cultivating new research areas. In 1993, 75,512 applications were submitted, of which 26,015 were accepted.

9. Among various grant categories, the category of general scientific research occupies major part of the budget and it is regarded as a core grant to promote general and basic research activities. On the other hand, research activities of priority areas or of social importance are also promoted. Adding to these categories, Monbusho has recently introduced a new category entitled "New Program System" whose aim is to form the basis for advancing research in new scientific fields. In this category, research themes are selected by the Science Council of Monbusho reflecting both the new trend of international scientific activities and the direction of Monbusho's science policy. To conduct these selected research activities, Monbusho channels necessary personnel, funds and facilities and equipment into group and research programs. The increase in grants has continued even under unfavorable financial circumstances, and as a result, the

relevant budget for FY 1993 amounts to 73.6 billion yen. (see page 12 and 13, *The University Research System in Japan*)¹⁰
(5) Mobilization of external resources -- University-Industry Research Cooperation

10. Another way to finance university research is the mobilization of external resources through cooperation with industry. Currently there are three systems set up to facilitate cooperation between universities and industry.

11. The first system brings together researchers from both sectors to conduct joint research on common subjects and on equal footing with each other. The second system of research cooperation with industry is the so-called "contract research" under which researchers in national universities conduct, as their official duties, the research commissioned by industrial firms and other external bodies. The third system is the so-called "contract teachers" which provide researchers and engineers in industry with the opportunity to conduct graduate-level research in national universities to enhance their research abilities. The scale of the cooperation in these categories has been enlarged year by year. (see page 18, *The University Research System in Japan*)

12. Besides these, national universities are now authorized to receive donations from outside sources, such as private companies, for the purpose of encouraging scientific research in the universities. The donations have been flexibly utilized for research and educational activities in accordance with the objectives of the donors. The total amount of donations is increasing every year (50.1 billion yen in FY 1992).

13. The total amount of these resources received by universities amounted in 1992 to 63.0 billion yen and the ratio of its increase in these ten years is about 550% that is more than that of grants-in-aid (180%). These external resources, particularly private donations, have become one of the vital financial sources for the research activities at national universities.

II. Unfavorable Financial Situation of National Universities and the Government's Response

14. The severe financial strain of recent years has kept government expenditures for higher education and research at an extremely insufficient level. The Government has been taking the stringent measures to clean the budget deficit by keeping the increase rate of the new budget as low as possible, that is, all the ministries and agencies have been allowed to propose their new budget proposal only within the level of the previous year's budget (with some exceptions, such as ODA).

(1) The Special Account for National Educational Institutions

15. The financing system of national university is managed through the Special Account for National Educational Institutions as mentioned above. The revenue for the Account consists of transfer from the General Account, and self-generated income such as tuition fees. Under severe financial situation, the ratio of the transfer from the General Account remains stagnant or decreased, which has led to the substantial increase of the dependence on the self-generated income. This means, in real terms, that the budget of national universities moves in the direction

of more independent, self-financing one. Due to the increase of the numbers of researchers and students, the total amount of the general and basic expenditure has increased, but its increase is at the rate lower than that of cost of living. The general and basic expenditures for research have suffered from the cut in terms of expenditure per capita for many years. As a result, the general and basic expenditure for research per capita deflated by the consumer price index (CPI) have dropped from 3.54 million yen of 1981 to 3.10 million yen of 1990.

16. This situation also has severely affected the facilities and equipment of universities and the research environments of university researchers. Since 1980s, the scale of increase of the Special Account has been stagnant, while the expenditure on personnel and general consumption has soared up. This has led to the substantial decrease of expenditures on facilities and equipment. The ratio of facility and equipment budget to the Special Account has dropped from 15% of 1970 to 7% of 1990.

17. Two grave aspects need to be addressed. One is the extreme space problem of education and research facilities. Since the establishment of the standard of university facilities in 1960, there has no major adjustment to it, while the number of students has increased, the experiment equipment has become bigger and the number of books and references maintained at laboratories has increased. The other aspect is the deterioration of the university building condition. Today, 10% of university buildings are more than 30 years of age since the construction, about 40% of them are more than 20 years and less than 30 years of age. All of these need urgent repair. According to the simulation analysis, the ratio of university buildings of more than 25 years is currently about 30%, but it will be about 50 % in 2001, 60% in 2011.

(2) Grants-in-aid

18. Although the budget of the grants-in-aid for scientific research has been increased year by year, tripled in last 15 years, the adoption rate of new research proposals remains around 22-25%. There is a tendency to need the grants-in-aid permanently to maintain the general and basic research.

(3) Concerns of researchers -- sense of crisis of university research

19. Under such circumstances, many university researchers began to express their concerns and since around 1990 various groups or leading figures have started mobilizing public opinions as well as appealing to the Government. National research institutes of other ministries or agencies also have suffered from the unfavorable financial situation and faced to the same kind of problems with universities. The business and industry circle as well as the policy makers shared this concern and considered the situation seriously. There prevailed general understanding among them that unless the conditions of university education and research is urgently improved, the basis of economic and cultural development of this country would be jeopardized. Ministries and agencies concerned such as MITI, STA and Monbusho, in close cooperation, worked on policy makers, the public as well as the finance authorities for their understanding of the situation and importance of scientific research. Much concerned, Monbusho's Science Council as well as the Science Council of Japan issued urgent appeals to the Government, requesting the drastic increase of the necessary budget to alleviate the situation. The Government's Council for Science and Technology reported to the Prime Minister in its "Basic Policy for Science and Technology"

of April 1992 that "the Government will make efforts to double its own R&D investment as soon as possible, taking account of its financial conditions".

(4) Government's responses

20. The Government shared the expressed views with researchers and began to have the understanding that the research facilities and equipment be regarded as social infrastructure and the investment into them as the social investment. The finance authorities agreed to allocate additional resources as special complementary budget to the improvement and construction of university facilities and equipment in 1992 and at the same time a special quota was allocated to the new budget proposals for such expenditures. In 1993, there is no such special quota for the FY 1994 budget proposal, but the additional resources far more than those of last year has been allocated from the special complementary budget to the university facilities and equipment.

21. By modifying relevant rules and regulations regarding national properties, Monbusho established a new mechanism to transact university properties and utilize the revenue from such transaction for the improvement of university facilities. Monbusho also encourages universities to take more flexible management to fully mobilize available resources. Monbusho's Science Council submitted its report last year which expressed its strong hope that the budget of grants-in-aid should be increased up to 100 billion yen soon. Monbusho is making best efforts in augmenting university research budget including the grants-in-aid and it is now in the process of the FY 1994 budget negotiations with the financial authorities.

III. Issues Concerning Research Funds and the Direction of Improvement

(1) Increase of the Government's expenditure

22. Because of its fundamental nature, scientific research has to rely on public support. Therefore, public expenditures in this regard should be steadily increased. In spite of the severe financial situation, Monbusho will seek understanding of the wider public about the importance of scientific research at universities and it will do its best in increasing financial support to researchers and universities. The general and basic frameworks of university education and research have been upgraded by shifting the main emphasis to or concentrating resources on the graduate schools, which is expected to substantially contribute to enhancement of research activities and training and to securing researchers at universities.

23. One of the targets of Monbusho's measures is to increase the amount of grants-in-aid budget up to 100 billion yen as soon as possible as an interim goal. As mentioned before, it remains as a critical issue to increase the budget for university facilities and equipment for their urgent improvement. Further, it is necessary to make efforts to secure operating expenses for scientific research and to prioritize distribution through appropriate assessment. In relation to the improvement of research environments, training and securing of young researchers is another important issue. The fellowship program for young researchers sponsored by the Japan Society for the Promotion of Science, known as the Fellowship Program for Young Japanese Researchers is highly valued by universities and other institutions as a good system for training and securing young researchers who sustain scientific research in Japan. Together with the scholarship programs for graduate students in general, JSPS's Fellowship Program needs to be expanded.

(2) Diversification of resources: increase of outside funding and partnership

24. Efforts should be made to increase various forms of funding from private sectors including donations and endowments. Universities are encouraged to increase their funding by introducing outside resources and explore ways to generate new incomes by fully utilizing their property, know-how and service capacities. National universities are basically under the administrative and managerial supervision of Monbusho, but it encourages initiatives and sincere efforts of universities to improve their funding as well as their education and research.

25. Universities are now actively responding to social demands and cooperate with private sectors in many fields. As mentioned before, university-industry research cooperation will continue to increase. In recent years, governmental research institutes and research centers in private industry have tended to attach an importance to basic research. As a result, their relations with universities are becoming closer than before. Research cooperation and the exchange of researchers among the institutions in different sectors should therefore be encouraged. For example, some universities have already started such cooperation by establishing new faculties at their graduate schools.

26. Donations from private companies or other outside sources which complement substantially the public support to university research will be further sought. It is important to pay special attention to the fields of study which have little access to the outside resources. In order to facilitate such contributions and partnership, the universities' system of accepting financial resources from outside sources should be improved. Accepting and disbursing procedures should be made simpler and more flexible. Moreover, other means for promoting cooperation, such as information networks dealing with activities of university researchers as well as research demands of social and industrial sectors should be improved and expanded.

(3) Building up of social trust in university education and research

27. Having said all about the budget increase and resource mobilization from outside sources, it is considered essential that the significance and necessity of basic scientific research at universities be well understood by the various stakeholder groups such as policy makers, finance authorities and the public. In order to secure supports from both public and private sectors, university needs to build up the firm social trust in its education and research activities. For this, it is important to develop and promote the activities for the public relations with and the dissemination and presentation of research outputs in a visible manner to the broad audiences.

**University Research in the United States
Cornelius J. Pings
President, Association of American Universities**

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Summary

Over the last fifty years, a large and successful basic research enterprise has grown in a small group of major research universities in the United States. Much of the support has come from the federal government. That arrangement has been called into question largely because of changes in the national security policies of the United States and because of major changes in the economy.

As we meet in Honolulu this November, we are well into the 1990s, and the end of the 20th Century is fast approaching. Looking back, we can see that the last four-and-a-half decades have constituted an era of extraordinary growth and prosperity for basic science and engineering research in the nation's major universities. But looking ahead, we can also see that we may be at the end of that era, unless our leadership can restate a rationale for the role of university science in the American scene.

One of the purposes of this presentation is to identify some of the forces for change that are currently affecting U.S. universities and their science programs. We will also speculate about the risks of ignoring those forces and also about the benefits of recognizing those forces and responding to them realistically. But first let us review the recent past to establish the context for these forces for change.

Looking Back

There has been a long tradition of federal government support for science in the U.S. Even when the nation was very young, the Lewis and Clark expeditions that helped open our western frontiers had a strong component of exploration and scientific observation. And the nation was still young in 1862, when the Congress passed, and President Lincoln signed into law, the Morrill Act that created our land-grant university system and initiated a massive program of agricultural research, arguably the most successful applied research endeavor in the history of man.

But federal support for university science programs was modest until the late 1940s. The turning point was Vannevar Bush's 1945 report entitled Science, The Endless Frontier. In this report, Bush called for sustained public investment in scientific research to assure a strong national defense, to make progress in the fight against disease, and to foster an expanding economy. This became our national policy, and programs of federally sponsored

research began to increase among our universities and in the national laboratories. Industrial concerns also began to support research on university campuses, sometimes in simple direct relationships or, occasionally, in joint endeavors encouraged or partially sponsored by the federal government.

Through four decades, the basic research programs of U.S. universities continued to expand in these ways. Long-established institutions saw their departments grow, both in terms of numbers of faculty and graduate students, and in terms of the volume and sophistication of the research being performed. Many new laboratory structures rose on university campuses during the 1950s and 1960s. The funding for these facilities came from a variety of sources: from state governments in the case of public institutions, from philanthropic organizations in the case of private institutions, and, occasionally, from industry in both cases. In addition, the federal government was a periodic contributor to these expansions of scientific physical plant, usually through matching grants.

During this interval there was a concurrent, massive expansion of higher education enrollment in the U.S. Existing universities expanded, and many entirely new campuses, mostly state supported, emerged as well. As a result, there was also a significant increase in the number of universities involved in substantial programs of scientific research.

The Association of American Universities was founded in 1900 by 14 of the nation's leading Ph.D.-granting institutions. In 1940, the AAU had 39 members, and those institutions accounted for the vast majority the scientific research being performed in the nation's universities. Today, the AAU has 56 U.S. members, but there are perhaps another 125 U.S. universities that conduct significant levels of research and have substantial Ph.D. programs in the sciences. So university-based science in the U.S. has grown by a factor of at least four since 1945. Several universities that did not even exist in 1900 are now among the dominant players in the U.S. science scene, such as Carnegie-Mellon University in the East and UCLA in the West.

The federal government's role in fostering this great growth in university science was distributed through several agencies. Finally authorized in 1950 after a protracted debate, the National Science Foundation has continued through the years as the primary source of support for university basic research in the natural sciences, physical sciences, and engineering. A number of mission-oriented agencies also have provided sustained support for basic and applied university research, including the Department of Agriculture, the National Institutes of Health, the Department of Defense, the National Aeronautics and Space Administration, and the Department of Energy. Except for the major programs in the Department of Agriculture, most of the research funding that has come to campuses from these mission-oriented agencies has been awarded on the basis of competitive proposals submitted by individual faculty members or small groups of scientists.

Through the years, this federal funding for university science programs has continued to grow, often advantageously compared to other federal discretionary accounts. This growth has tended to be a result of attitudes and commitments that have seemed largely nonpartisan, even apolitical. Currently, the level of federal support to our nation's universities for research is between \$10 billion and \$11 billion per year. Even this year, with a very tight budget situation, both the NSF and the NIH have received Congressional appropriations which represent real growth.

One of the marvels of the U.S. research university is that it is such a joint endeavor. It not only fosters the development of new knowledge through research, it also trains a new generation of researchers by allowing graduate students to serve in sophisticated research apprenticeships as they earn advanced degrees. And at the same time, almost all of these institutions have large enterprises in undergraduate education. Indeed, some of our largest and most prominent research institutions are also among the institutions most sought after by students for their undergraduate experience. All in all, the nation's research universities probably enroll 2.5 million undergraduates every year.

The U.S. research university has been a remarkable success story. There is no need here to recount these institutions' scientific output, which has been prodigious by any measure: papers in the literature, new discoveries, patents and copyrights, Nobel prizes, and all other forms of national and international recognition. Over the years, U.S. university research has not only contributed to the national defense and to a thriving economy, but also contributed to stunning advances in medicine and to the emergence of entirely new fields of endeavor in microelectronics, information systems, materials, and biotechnology.

Over the last 20 years, these institutions have also been turning out upwards of 30,000 Ph.D.s per year. These individuals have flowed into industry and government laboratories, back to the faculties of our research universities, and—very importantly—to the faculties of the nation's other 3,000 institutions of higher education.

So for nearly fifty years we have developed, grown, and maintained a great system of scientific research and education. Costs have been shared, and all sectors have seemed to benefit.

For the federal government, this investment has resulted in a steady flow of new knowledge and stable supply of trained personnel.

The universities themselves have been able to build departments and programs which they could not otherwise have afforded.

Industry has received the trained and educated personnel it needed, as well as new discoveries to feed a base of new technologies.

And individuals—the present author included—have been able to enter academic science with reasonable assurances of stable career paths.

But this great system of scientific research has more and more been called into question in recent years, and today it stands in considerable jeopardy.

What has changed? Why does the change seem so abrupt? What are the sensible responses?

Forces for Change

There are two dominant factors contributing to the current reexamination of the national commitment to science. These factors are the end of the Cold War and the restructuring of the American economy. Actually, these two factors may well be somewhat interrelated, and there may be a third contributing factor, namely a growing populist political mood. This new

egalitarianism is calling into question many of our established institutions, and institutions that speak to leadership, or intellectual excellence, or both seem particularly vulnerable.

There is no doubt that Vannevar Bush's 1945 call for a new investment in science was based significantly on the premise that science could make a major contribution to a strong national defense. Mind you, our universities did not do "military research." They did not develop or test weapon systems. But our science programs contributed mightily to the new technologies and devices. Equally important, they contributed sophisticated manpower, both by providing a steady stream of new Ph.D.s and by allowing university science and engineering faculty to serve as consultants to the defense industry and as advisors to the military establishment.

The U.S. is not abandoning its military services or terminating all expenditures for weapon systems. But, in the wake of the collapse of the Soviet Union in 1991, our defense sector is surely shrinking in size. It remains to be seen whether this shrinkage really will reduce this sector's dependence on scientists and engineers. Some have argued persuasively that as our military forces become smaller in size, they will have to become more sophisticated technologically, and that this will make scientific and engineering expertise even more important to the defense sector. Be that as it may, there is now a different mood toward defense among the general public, and this has translated into a political reality of less emphasis on defense expenditures. And those who would justify science on defense grounds are being driven to seek alternative rationales.

Meanwhile, even as we have been sorting out our defense priorities, our national economy has been severely tested. We are slowly recovering from a recession in many regions, but the state of California and some other regions are still struggling. The budgets of almost all the 50 states are still under severe pressures, and those pressures are translating into constrained or significantly reduced operating budgets for almost all the publicly supported universities across the nation.

At the federal level, the Congress and the Administration have imposed a discipline on federal expenditures that will result in no real increase in discretionary spending for the next five years. Almost all federal support for science falls within discretionary categories. Therefore, if there is to be any growth at all in federal support for science during the next few years, it will have to come at the expense of other domestic programs, such as those that provide assistance to veterans, or those that provide housing for the needy. In reality, the advocates of science will need to be alert—and likely very aggressive—just to ensure that science holds its own in this context.

As though these pressures were not enough, much of U.S. industry is going through massive restructuring. The firms affected by this have included many manufacturing and high-technology companies. Some of these firms are reducing their work forces by tens of thousands. This, in turn, is constraining the ability of many firms to support university research.

So our universities and colleges, big and small, public and independent, are all suffering the consequences of severe budgetary constraints in all the various sectors from which research support has historically come: state government, federal government, and industry. Furthermore, in a sour economy, many individual families are expressing increasing difficulty in paying tuition costs, particularly at private universities.

Rather severe consequences are already flowing from this situation. Most of our large universities are considering reducing programs and closing some departments, or have already done so. Even in ongoing departments, the size of faculty is often shrinking, often by foregoing or delaying assistant professor appointments.

Another factor contributing to the general unease about the status of university science is a growing concern over economic competitiveness. Some, in Congress and elsewhere, have taken the position that the U.S. has failed to reap fully the benefits of all the basic research it supports. "Why," these individuals ask, "do our research discoveries seem to fuel the economies of Japan and other nations, rather than our own economy? Why have we not kept closer control of our own research?" Such concerns are partially justified, but they often follow from flawed premises. For example, in many industries the U.S. has, in fact, been very effective at transferring research results into new technologies and then into products in the marketplace. This can be seen clearly in the process industries, both in the relatively mature chemical process and petroleum sector, and in emerging biotechnology fields. Yet it must be admitted that the U.S. has not effectively held its position in many sectors involving discrete manufacturing. This has been particularly true in consumer electronics and—until the last few years—automobile manufacturing.

Any student of technology transfer knows there are many and different reasons why efforts to commercialize new knowledge sometimes fall flat. Unfortunately, those who seek or accept easy and simple explanations too often conclude that the problem lies in the initial steps of discovery, which frequently occur in the university research laboratory. The extreme reaction to such a conclusion is simply to reduce the investment in research. A more moderate, but still demanding, reaction is to try to redirect the basic research enterprise toward more applied payoffs. For example, the new appropriations bill that gives NSF a healthy increase next year was accompanied by Senate report language that forcefully directs that agency to demonstrate that a major portion of its programs are supporting specified strategic objectives.

We are accustomed to considerable direction of basic research in programs sponsored by mission-oriented agencies such as the Department of Defense and even the National Institutes of Health. But many in the U.S. science community have been surprised and challenged by the increasing Congressional pressures to show relevance for *all* forms of investment in basic research.

Some of these Congressional concerns have focused even more narrowly on the issue of foreign access to the results of U.S. university research. For example, last February Senator Richard Shelby, of Alabama, introduced, and then withdrew, an amendment that, among other things, would have prohibited universities that have "financial relationships" with foreign companies from giving those firms any direct access to any information derived from federally sponsored research. More recently, on October 28, the House Science Subcommittee held a hearing to review the foreign access issue.

It is not clear whether these various Congressional concerns will ever lead to actual constraints on universities which have contractual commercialization relationships with domestic or foreign companies. However, it is clear that these concerns signal a new willingness in Congress to link federal support of university research to increased expectations for directed outcomes.

And it must be observed that research is not the only university activity being subjected to this kind of Congressional scrutiny. There is a rapidly growing mood in Congress that the nation's colleges and universities may not be doing an adequate job of educating undergraduate students, and that, in any event, the costs of attending college have been rising too rapidly. Last year's reauthorization of the Higher Education Act provided for new levels of federal and state oversight of all U.S. higher education, including private colleges and universities. And in implementing this legislation, the new Administration has been translating it into new regulations that will significantly expand the ability of federal and state governments to exercise much greater control over all aspects of college and university activities. In addition, officials of the new Administration have indicated that they may soon propose further reforms that will require colleges and universities to provide "output" measures demonstrating the effectiveness of their educational programs. Those reforms may well be coupled with demands for cost containment and control of tuition rates. These will be difficult issues for the nation's colleges and universities, particularly the large, complex universities with joint endeavors in research. We have already had questions about how effectively research faculty are meeting teaching obligations. Increasingly, we are also hearing such questions as, "Are undergraduate tuition dollars supporting faculty research?" "Are the research universities not poorly managed and operating inefficiently and without a clear sense of mission?"

As a science and university community, we are probably late in recognizing the seriousness of such questions. We surely are not yet providing effective answers.

Changes and Adjustments

The previous paragraphs have sketched a complex and sometimes contradictory set of forces buffeting U.S. research universities. The intensity and sweep of these forces are probably not yet fully revealed to us, but it seems inevitable that there will have to be some changes and that those changes will come at a pace that is brisk compared to the previous, systematic evolution of the research university over the last four-and-a-half decades.

The following changes and adjustments seem highly likely, in my judgment:

1. Most state-supported universities will be subject to severe budget restrictions, and the major financial setbacks of the last three to four years probably will not be restored. Prospectively, state funds for science research will come under particular scrutiny.
2. Private universities will have to constrain tuition increases; in cases where they receive some measure of state support, they will suffer the same, or perhaps greater, reductions as public institutions.
3. The federal budget for research will continue to grow, but with only modest annual increases. More and more of the total allocation will be justified as supporting specified national goals, with an increased emphasis on the nation's economic welfare. There will continue to be a commitment to basic research, particularly as administered by NSF. However, even basic research will have to be justified increasingly by its ultimate relevance to broad societal needs.

4. There will be pressures for universities to show increased cooperation with industry and to demonstrate increased effectiveness in translating research results into new technology, new products, and economic growth.
5. All universities, public and private, will be subject to heightened demands for accountability. We will have to show sources and uses of funds. Cross-subsidization of programs will be under increasing scrutiny.
6. Almost all research universities will undergo comprehensive reviews of their entire programs. Many have done this already or are currently engaged in the process. Most institutions will end up selecting explicit priorities and electing to drop some departments or programs. As these processes proceed, there will be increased communication and cooperation among the research universities, and new alliances may emerge with a considerable increase in joint endeavors. This will clearly be so in the area of information technology, in the handling of data, and among campus libraries.
7. There is a need for a new rationale for a national science policy. Many current opinion makers and political leaders were not yet alive when Vannevar Bush gave us the framework of the science policy that has guided us to this point. Can we now discover and articulate a policy for our times which might sustain us for the next few decades? We perhaps have a promising start in the report, "National Goals for a New Era," issued in August 1993 by the Committee on Science Engineering and Public Policy (COSEPUP), a joint endeavor of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

I end on a note of optimism. The value of basic research to our nation's economy and our society as a whole is abundantly clear to those who work closely with the research enterprise. In those quarters, the role of the research university in enabling this research is just as clear. But the one mistake we can make is to expect the rest of the American public to accept, without question, the notion that research and research universities deserve their support. We have a profound story to tell, but we must get about the business of telling it and tell it effectively.

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Opinions of Japanese Scientists on Their Research Levels and Research Conditions

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Ken Kikuchi

Abstract

Results of a survey on the opinions of Japanese scientists with regard to their research levels and their research conditions are reported. The survey was carried out for a period from 1986 to 1988 by sending a series of questionnaires to 2062 scientists who were conducting researches in natural science field under the Monbusho's Scientific Research Grants. Responses were received from 1340 scientists who evaluated their research levels in their specialities from international standards. In the results, the US was marked as the highest in all fields and Japan received high marks comparable to the UK and West Germany. In order to raise the research levels in Japan, the respondents pointed out the importance of the increase in research funding and of keeping good research staffs and cultivating talented successors. Their requirements for equipments and laboratory space were also investigated. Various opinions were expressed with regard to the improvements of research system and research organization.

1. Purpose and Outline of the Survey

This short note reports on a survey conducted on the opinions of Japanese scientists with regard to their research levels and research conditions. In recent years, Japan has made remarkable progress in advancing modern technology and its international competitive power in the production of highly technical instruments has been particularly significant. On the other hand, it is often said that in basic research, especially that conducted at universities, Japan has not reached a level comparable with other advanced countries. In addition, a strong criticism is voted that Japan's contribution in basic research to the international communities is not on a level commensurate with its economic power. These circumstances, it was felt warranted an investigation into the state of scientific research in Japan, and the survey was initiated as a result.

The survey was carried out over three-year period from 1986 to 1988 by a group of scientists, comprising of mostly science advisors of the Ministry of Education, Science and Culture, Monbusho. The survey was performed by sending a series of questionnaires to scientists who received funding under subcategory (B) of "General Scientific Research" of the Monsusho's of Scientific Research Grants (Grants-in-Aid).⁽¹⁾

In 1986 and 1987, a preliminary survey with simpler questions was administered to about 800 subject scientists randomly selected in natural science field. In 1988, a full-scale survey was carried out for which corrected 2062 subject scientists. This was all the scientists doing work under category (B) research grants in natural science (cf. the number of such scientists doing work in all fields

including the liberal arts and social sciences was 2364). Responses were received from 1340 scientists. The questionnaire, as can be seen in the Appendix, consisted of two parts: the first part was on the evaluation of their research level vis-a-vis an international standards and the second, on their research conditions.

2. Data on Respondents

Data on the 1340 scientists who answered the 1988 questionnaire are given in Table 1(a) - (d).

Table. 1 Data on 1340 scientists who answered the questionnaire

(a) Institutions

National universities	1032	(77.0 %)
Private universities	212	(15.8 %)
Public universities	53	(4.0 %)
Laboratories of other Ministries	18	(1.3 %)
Inter-university research institutes	16	(1.2 %)
Others	9	(0.7 %)

(b) Positions

Professors	969	(72.3 %)
Associate professors	260	(19.4 %)
Lecturers	45	(3.4 %)
Research associates	34	(2.5 %)
Others	32	(2.4 %)

(c) Specialities (classified by affiliated faculties)

Pure sciences*	197	(14.7 %)
Engineering sciences	326	(24.3 %)
Agricultural sciences	151	(11.3 %)
Medical sciences	553	(41.3 %)
Interdisciplinary areas	96	(7.2 %)
Others	17	(1.2 %)

(d) Ages

30 - 40	46	(3.4 %)
40 - 50	459	(34.3 %)
50 - 60	604	(45.1 %)
60 - 70	220	(16.4 %)
Others (not known)	11	(0.8 %)

* The field includes mathematics, physics, chemistry, biology, astronomy and earth sciences.

Let's compare this line up of respondents with the overall distribution of the university scientists in Japan. In 1988, the total number of scientists at all

universities was about 120 thousands, of which 44 % were affiliated with national universities and 35 % were professors. The age distribution of scientists at all universities was as follows:

<30	6 %
30 - 40	33 %
40 - 50	27 %
50 - 60	22 %
> 60	12 %

It is evident that the positions and ages of the respondents in this survey are different from those in the overall population of university scientists. The reason for this is simply that the respondents were scientists who had received the category (B) of scientific research grants. Though the survey results do not reflect the overall opinion of all scientists at Japanese universities, the respondents did compromise an appropriate sampling of university scientists who have academic research experience and who are currently conducting active researches.

3. International Comparison of Research Levels

The first part of the questionnaire was aimed at making an international comparison of research levels in 1988 and those expected 10 years later, i.e., in 1997 and, the changes of research levels in Japan during the period between 1979 to 1988. First of all, it was necessary to define the specialties in which the comparison would be made. Two ways were employed to define the specialties of the subject scientists: (1) based on their disciplinary classification for the review process of proposals for the Scientific Research Grants under Monbusho and (2) based on their stated specialties irrespective of their disciplinary classification. In the disciplinary classification of Scientific Research Grants all academic fields are classified into 38 disciplinary areas and 190 subdisciplinary areas. The breakdown is as follows:(2)

	Disciplinary Areas	Subdisciplinary Areas
Literature	4	24
Law	1	5
Economics	1	7
Pure Sciences	9	27
Engineering Sciences	9	45
Agricultural Sciences	7	21
Medical Sciences	8	44
Interdisciplinary Areas		17
<hr/>		
Total	38	190

This system of classification was introduced for the review process of proposals for the category of General Research of the Scientific Research Grants under

Monbusho. Reviewers are selected through a rather complicated procedures normally from full professors and senior associate professors. Three "first-tier" reviewers are assigned to each subdisciplinary area, with the exception of six reviewers for several areas receiving more than 300 proposals, and two "second-tier" reviewers are assigned to each disciplinary area. This review system currently utilizes about 500 reviewers.

In this classification, a subdisciplinary area usually stands for a rather broad area of research. Take for an example the disciplinary area of "physics", which consists of the following four subdisciplinary areas as:

Code 421	Nuclear, cosmic rays and elementary particle physics
422	Solid state physics
423	Condensed matter physics, general
424	Physics, general

Subdiscipline 421 is composed of three areas and includes both theory and experiments, and 424 includes various fields such as optics, acoustics, hydrodynamics, plasma physics, lasers, etc. Very frequently a physicist will state his speciality as optics or plasma physics and not say "physics, general". This is why the survey asked the subject to state the respondent's speciality regardless of the subdisciplinary classification.

In the questionnaire, the subject was asked to evaluate the level of research in his speciality in seven countries (i.e., US, UK, France, West Germany, Canada, USSR and Japan) through a rating system of 1 through 10 (10 given to the highest and 6 to the average of the seven countries). An evaluation was made in the subject's speciality, including the subdisciplinary area and regardless of his disciplinary classification, though the latter made little difference in the survey results. A separate evaluation was made for basic research and applied research in each area, when possible.

The results of this part of the survey comparing international research levels are shown in Fig. 1 (a) and Fig. 1 (b), and the change of research levels in Japan over the past 10 years (from 1979 to 1988) is shown in Fig. 1 (c). Here, all areas of natural science are compiled into the following three fields:

Mathematical, Physical and Engineering Sciences
Chemical Science
Biological, Agricultural and Medical Sciences

When examining these data, it should be kept in mind that the evaluation is subjective and might contain some bias. With the exception of a few subdisciplinary areas, the US is marked as the highest in all fields, while Japan received high marks comparable to the UK and the West Germany. Japanese scientists admit the fact that in Japan the level of basic research is lower than that of applied research in Japan, as is generally thought. They expect this trend to continue up to 1997 (10

years after the survey). The issue is then how the level of basic research can be raised. To explore this question, another questionnaire was prepared.

4. Research Conditions

4.1 General Policy

The first question pertained a policy for raising the research level in each research area. The subjects were asked to decide priorities among the following items (for basic research and applied research respectively):

- (a) Increase of research funding (funding),
- (b) Reinforcement of equipments (equipments),
- (c) Increase of laboratory space (space),
- (d) Keeping good research staffs and training good successors (man-power),
- (e) Improvements of research organization (organization),
- (f) Others, if any.

The results are shown in Table 2. No large difference was not seen between basic research and applied research.

Table 2 Item	Average Priorities (Ranking)				
	Pure Sciences	Engineering Sciences	Agricultural Sciences	Medical Sciences	All fields
(a) funding	2.40 (2)	2.34 (2)	2.16 (2)	2.17 (1)	2.23 (2)
(b) equipments	3.25 (3)	3.04 (3)	3.33 (3)	3.37 (4)	3.26 (3)
(c) space	3.93 (5)	3.96 (5)	3.94 (5)	4.00 (5)	3.95 (5)
(d) man-power	2.10 (1)	2.20 (1)	2.20 (1)	2.25 (2)	2.22 (1)
(e) organization	3.42 (4)	3.54 (4)	3.54 (4)	3.23 (3)	3.38 (4)

The importance of (a) funding and (d) man-power was commonly pointed out in all research areas. In this context, the JSPS research fellow program for graduate students and post-doctoral fellows is expected to play an important role. There is a recent tendency for graduates in the pure and engineering sciences to find employment in industries besides manufacturing such as software related companies which did not employ such graduates in the past. In addition, companies are able to provide better research conditions, particularly for applied research, than universities. Around 1988, when the survey was made, a strong tendency in this direction was the source of growing crisis among university scientists who were concerned about how to keep talented graduate students in the universities.

Obtaining funding for research is always a matter of primary concern among scientists. It was observed that the average priority of funding was higher in the applied research than in basic research, which reflects the fact that experimental apparatus used in applied research have become increasingly more costly.

Comments by medical scientists showed that 90% of medical school graduates (six-year curriculum) wished to work in clinical medicine, such as internal medicine or surgery. This poses a serious problem as to how to cultivate young successors in basic medicine. In the medical sciences, "improvements of research system and organization" received an exceptionally high ranked (3), which appears to reflect the conservativeness of medical departments. Other significant findings are as follows: in physics (applied), geophysics (basic & applied), chemistry (applied) and biology (applied), "organization" is ranked (3) and "equipments" ranked (4); in agriculture, agricultural chemistry, fisheries science (basic respectively) and animal husbandry (basic & applied) "funding" ranked at the top.

4.2 Funding

In the next question, the subjects were asked to rank the effectiveness of modes of funding, for the basic research and applied research, respectively:

- (a) Formula-based general funding per "Koza" (Koza-hi)
- (b) Formula-based general funding per undergraduate (undergraduates)
- (c) Formula-based general funding per graduate students (graduates)
- (d) Scientific research grants, Grants-in-Aid (grants)
- (e) Research fund under contracts between universities and industries (contracts)
- (f) Donations from industries (donations)

In table 3 is shown the result averaged over the basic research and applied research.

Table 3 Item	Average Priorities (Ranking)				
	Pure Sciences	Engineering Sciences	Agricultural Sciences	Medical Sciences	All fields
(a) koza-hi	2.40 (2)	2.11 (2)	2.01 (1)	2.38 (2)	2.19 (2)
(b) undergraduates	4.86 (6)	5.04 (6)	4.67 (6)	5.16 (6)	4.98 (6)
(c) graduates	3.29 (3)	3.52 (4)	3.34 (3)	3.77 (3)	3.60 (3)
(d) grants	1.86 (1)	2.04 (1)	2.09 (2)	1.69 (1)	1.85 (1)
(e) contracts	4.58 (5)	4.39 (5)	4.40 (4)	3.80 (4)	4.09 (5)
(f) donations	4.25 (4)	3.73 (3)	4.16 (5)	3.97 (5)	3.97 (4)

Two items "koza-hi" and "grants" were highly ranked in all fields. This would appear natural that the respondents, who had received the category (B) scientific research grants, would place a high priority on "grants". It is significant that "koza-hi" was ranked as high as "grants".

The "koza-hi", to be more exact "Kyokan Atari Kohi", is based on the Japanese academic organizational component known as "koza". A koza is the unit, headed by a professor, which is responsible for the teaching and research in the disciplinary speciality. In a university which has the koza system, each department has several kozas. Under each professor is typically one associate professor and one or two research associates. The koza-hi is distributed to universities based on the number and types of kozas they have. Among the types of koza are included Ph.D level, masters level and undergraduate level programs. These are further divided into non-experimental, experimental and clinical categories for Ph.D and experimental and non experiment for Masters' and undergraduates'. Each koza receives an allocation according to its category, with the medical school koza getting the largest amount and undergraduate programs in non-experimental fields such as the social sciences getting the smallest amount. Typical amount of a koza-hi is about 7M ¥ for an experimental koza and about 2M ¥ for a non-experimental koza in a Ph.D course. Universities which have a non-koza departmental arrangement receive their shares on a strict per-capita basis, according to the rank of the staff member, the categorization of the department's work as being experimental or nonexperimental and the level of the degree program. The "koza-hi" is designed to guarantee a minimal basic support to individual scientists and to improve the standard of research and education.

As a matter of fact, each koza and individual scientist does not receive the full amount of koza-hi, as a significant part is used to cover the overhead for the university general operation including electricity, water and telephone expenses. Nevertheless, the koza-hi is considered to play an important role to keep the research activities, partly due to the extreme difficulty in obtaining the grants. (In recent years, only 22% of the applications for the scientific research grants have been approved).

In the engineering sciences, "donations" is ranked (3) which is indicative for the fact that it is relatively easy to obtain donations from industries in this field compared to other fields. "Donations" is ranked higher than "contracts" which are similar in nature to donations, probably because of their greater flexibility in expending. There was a difference in the ranking of external funding sources between basic research and the applied research as is shown in Table 4. This is due to the fact that it is easier to obtain external funding sources for applied research than basic research.

Table 4 Item	Averaged Priorities					
	Basic Research			Applied Research		
	Pure Sciences	Eng. Sciences	Medical Sciences	Pure Sciences	Eng. Sciences	Medical Sciences
Contracts	4.84	4.78	4.05	3.62	3.69	3.29
Donations	4.35	4.45	4.02	3.92	3.63	3.88

4.3 Cultivating Young Scientists

The results of the survey on general policy indicated the importance of training good successors. The next question was designed to explore the most effective way to cultivate good successors. The subjects were asked to set priorities among the following programs:

- (a) Undergraduate programs (undergraduate)
- (b) Master course programs (master)
- (c) Doctoral course programs (doctor)
- (d) Post doctoral programs (post-doc)
- (e) Others, if any.

The results are shown in Table 5. The importance of doctoral course was indicated in all fields. In the medical sciences which has a different system for graduate course, the "post-doc" program was considered to be more important than the master program. This is partly due to the fact that most MD's leave the university after receiving their doctoral degree.

Table 5 Item	Average Priorities (Ranking)				
	Pure Sciences	Engineering Sciences	Agricultural Sciences	Medical Sciences	All fields
(a) undergraduate	3.22 (4)	3.27 (4)	3.28 (4)	3.06 (4)	3.14 (4)
(b) master	2.23 (2)	2.15 (2)	2.24 (2)	2.68 (3)	2.36 (2)
(c) doctor	1.94 (1)	1.71 (1)	1.77 (1)	1.76 (1)	1.77 (1)
(d) post-doc	2.61(3)	2.69 (3)	2.64 (3)	2.18 (2)	2.42 (3)

4.4 Equipments

In this survey, the term "equipments" is used to mean equipments and small facilities necessary for conducting specific research and education activities. Specific funds are allocated for purchasing equipments that are not affordable within the amount of the Scientific Research Grants. Requests for such funds are carefully examined by Monbusho before it includes them in its budget request to the Ministry of Finance.

The survey investigated the level of perceived equipment sufficiency among the subject scientists. The respondents were asked to indicate their degree of contentment with their equipments, as follows:

- (a) sufficient
- (b) moderately sufficient
- (c) insufficient
- (d) extremely insufficient

They were also asked to estimate the cost of equipments that they want to procure and to indicate annual amount of funding necessary for purchasing equipments:

- less than 3 M ¥
- between 3M ¥ and 10 M ¥
- more than 10 M ¥

The results are shown in Tables 6 and 7.

Table 6 Level of Equipments Sufficiency

Level	Pure Sciences	Eng. Sciences	Agricultural Sciences	Medical Sciences	All Fields
Sufficient	1.5 %	0 %	0.7 %	1.3 %	0.9 %
Moderately sufficient	22.8	20.7	24.5	33.3	27.2
Insufficient	61.4	61.9	58.3	56.6	59.0
Extremely insufficient	14.2 (197)*	17.3 (323)	16.6 (151)	8.7 (549)	12.9 (1220)

*() indicates number of scientists who answered.

Table 7 Annual Amount of Funding Necessary for Equipment

$\leq 3M\text{¥}$	6.8 %	5.6 %	9.8 %	7.8 %	7.3 %
$3M \leq \leq 10M$	34.9	24.6	46.4	40.6	35.8 %
$\geq 10M$	58.2 (146)*	69.8 (252)	43.0 (112)	51.5 (357)	57.0 % (867)

* () indicates number of scientists who answered.

In order to promote so-called big sciences, the Monbusho has established inter-university research institutes to construct and operate large experimental facilities, such as accelerators and the nuclear fusion test facility, which appear to satisfy the universities' requirements to some extent. On the other hand, experimental apparatus necessary for small sciences, such as electron microscope and X-ray analyzers, are becoming more and more costly, and the specific funds for equipments purchasing are no longer sufficient to satisfy the scientists' needs.

4.5 Laboratory Space

The following question was asked to determine how much space scientists need to perform their research activities. The subjects were asked to indicate their degree of contentment with their laboratory space, as follows:

- (a) sufficient
- (b) moderately sufficient
- (c) insufficient
- (d) extremely insufficient

They were also asked to estimate the amount of the laboratory space they need:

- 1.5 times more that they have now
- 2.0 times
- 2.5 times or more.

The results are shown in Tables 8 and 9.

Table 8 Level of Laboratory Space Sufficiency

Level	Pure Sciences	Eng. Sciences	Agricultural Sciences	Medical Sciences	All Fields
sufficient	0 %	0.9 %	1.3 %	2.9 %	1.7 %
moderately sufficient	18.2	15.8	14.6	16.1	16.2
insufficient	53.0	52.9	53.0	53.0	53.0
extremely insufficient	28.8 (198)*	30.3 (323)	31.1 (151)	28.0 (547)	29.1 (1220)

* () indicates number of scientists who answered.

Table 9 Laboratory Space Needed

	Pure Sciences	Eng. Sciences	Agricultural Sciences	Medical Sciences	All Fields
1.5 times	28.4	25.0	22.8	16.7	21.6
2.0 times	39.5	45.1	52.0	44.8	44.9
2.5 times or more	32.1 (162)*	29.9 (268)	25.2 (127)	38.5 (447)	33.4 (999)

* () indicates number of scientists who answered.

Laboratory space is determined by standards based upon the number of kozas for departments with a koza-system and upon the number of staff and their titles for departments without. Reflecting the desires of scientists, Mombusho is requesting a larger budget for building space in the 1994 fiscal year, so as to increase the standards by 20 %.

4.6 Research Systems and Organizations

Since it would appear to be difficult and divergent to ask general comments on improving research systems and organizations, six items were prepared to seek opinions of the subject scientists. A variety of opinions were expressed in response to each item and in some cases there was a wide distribution. The responses are summarized below.

(1) Increase in the mobility of scientists, in particular of young scientists.

(a) To strengthen post-doctoral fellowships, such as JSPS's research fellowship.

- (b) To introduce an appointment system with a specific term (contract system), in particular for young research associates. To avoid employment in a position at the same university from which the applicant graduated.
 - (c) To issue general announcements for a new position so as to receive a wider scope of applicants.
 - (d) To change the attitude of scientists who wish to remain at one university.
 - (e) To improve social conditions, such as housing and the educational environment.
- (2) Introduction of appointment system with a specific term (contract system) for university staff members. Both positive and negative responses were received. Typical comments were as follows:
- (a) A system with a term of from 5 to 7 years should be applied to all staff members.
 - (b) The system must be applied to only younger scientists. Tenured position should be offered to senior scientists.
 - (c) Who should evaluate scientists when their term of appointment expires.
 - (d) Would not be possible to introduce such a system unless all universities utilize it.
 - (e) In some fields of basic research, stable positions are necessary to permit continued and long-term research activities.
 - (f) Through this system, mobility would become greater only for scientists with high qualities, which might result in weakening some research organizations.
- (3) To make the roles of staffs clear and to separate research-oriented staffs from education-oriented staffs. The majority of the respondents appeared to be against the system. This is probably due to the fact that they are active researchers who instruct mostly graduate students. There were some, however, that partially agreed with the proposal.
- (a) It is reasonable for a scientist to move from one institution to another during his career.
 - (b) Older scientists may, upon requests, move from research-oriented to the education-oriented position.
 - (c) It is reasonable to apply a contract system to research-oriented staffs.
 - (d) In Japan, research is considered to be more highly ranked than education. It is of primary importance to establish a higher status for education-oriented staff members.
 - (e) The system is necessary to cultivate excellent education-oriented scientists.
- (4) To provide young scientists with research conditions that will allow them to conduct their research freely.
- (a) The research activity of a young scientist should not be confined or restricted by the koza system. Young scientists should be allowed to join appropriate research groups.
 - (b) Young scientists should be allowed to present their opinions freely, and their professors should listen to them.

- (c) A certain amount of research funding should be allocated to young scientists. (JSPS research fellows can receive scientific research grants)
 - (d) Senior staffs should be careful to avoid involving young scientists in miscellaneous jobs.
 - (e) Having opportunities to conduct research at foreign institutions is very beneficial for young scientists.
- (5) Introduction of the sabbatical system. In Japan, very few universities utilize this system.
- (a) This system is needed not for a rest but to perform effective research.
 - (b) It is recommendable to spend a sabbatical term at a foreign research institute.
 - (c) Short term, 3~6 months, sabbaticals are desirable. One year is too long.
 - (d) Humans are lazy by nature. Scientists must exercise strong self control.
 - (e) Introduction of a sabbatical system increases the burdens on other staff members, particularly, in the education. An increase in the number of staff members will be needed to implement this system.
 - (f) This system is not necessary.
 - (g) To take shorter vacations, when necessary, is more desirable.
 - (h) Even if this system is introduced, few scientists will make use of it.
- (6) On research systems and organizations. It was difficult to deduce a general opinion, since management and operation are separate and differ by department, school and university.
- (a) Research systems should change according to the progress made in research.
 - (b) The koza system should be abandoned.
 - (c) The koza system is necessary to organize a research group.
 - (d) Effective methods for operating the koza system are essential.
- (7) Other comments.
- (a) Scientists are too involved in miscellaneous jobs.
 - (b) It is important to establish a research support system, such as secretaries, operators, and technicians.
 - (c) The present koza system sometimes makes it impossible to organize a research group for new projects, particularly in interdisciplinary fields.
 - (d) The US has made remarkable achievements in various fields of science and we should learn from them. However we have to be careful in introducing the US system into Japan, as the two countries have different historical backgrounds and cultures.
 - (e) A rigid koza system is not acceptable, but an organization in which individual scientists conduct research activities independently can be even worse in some cases.
 - (f) A significant increase in positions for research associates is necessary.

Notes:

(1) Category (B) of General Scientific Research (Ippan-Kenkyu):

General Scientific Research is funded to research projects to be performed individually or by a group of researchers within the same institution. This category is further divided into three subcategories by the amount of research funds required as follows:

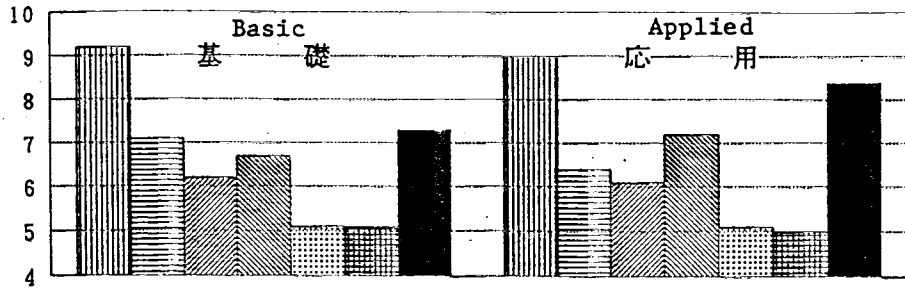
- (A) Projects requiring 10 - 50 M¥
- (B) Projects requiring 3 - 10 M¥
- (C) Projects requiring less than 3 M¥

cf. Statistics of General Scientific Research in 1988 are as follows:

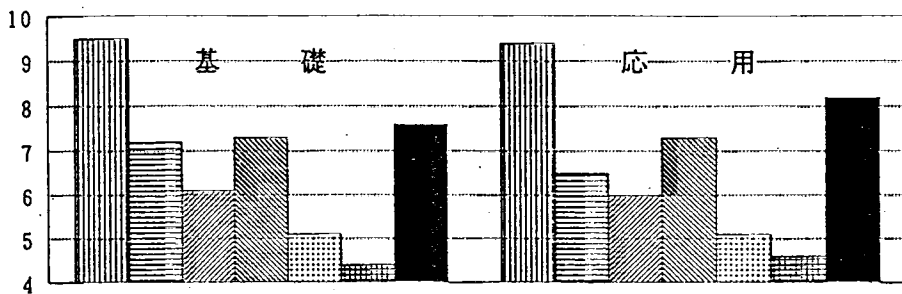
Subcategory	No. of Proposals	No. of Approved Proposals	Average Amount of Funding
(A)	1469	580	8.52 M¥
(B)	7718	2364	3.19 M¥
(C)	22889	5765	1.47 M¥

(2) The classification shown here was recently modified and the total number of subdisciplinary areas was increased to about 230.

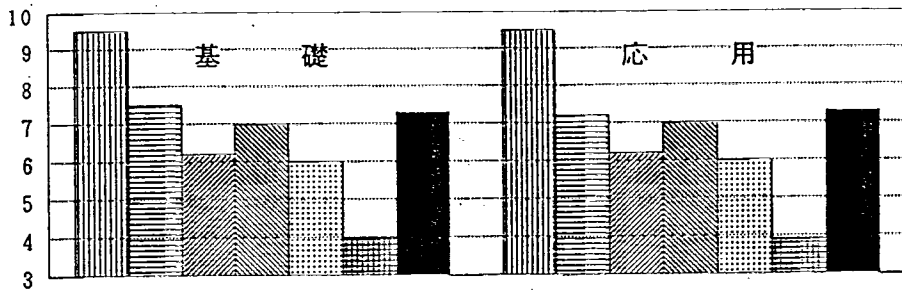
Fig.1 (a) International Comparison of Research Levels in 1988.
 Mathematical, Physical and Engineering Sciences



Chemical Sciences (including chemical engineering)



Biological, Agricultural and Medical Sciences



Average of all fields

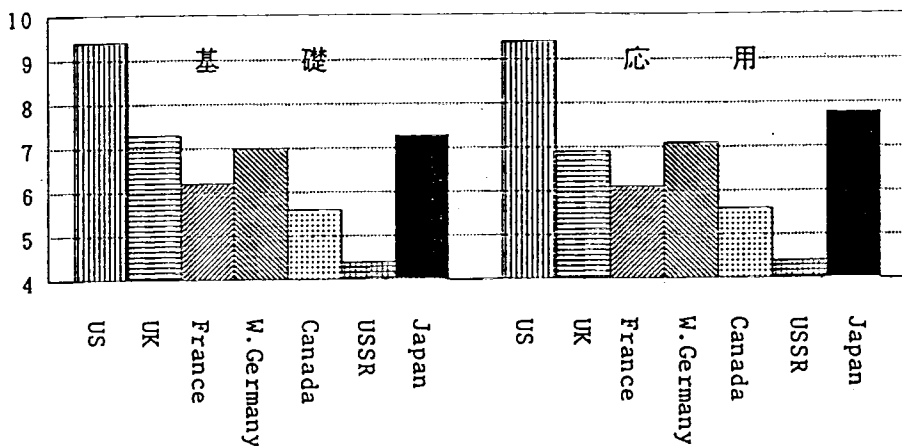
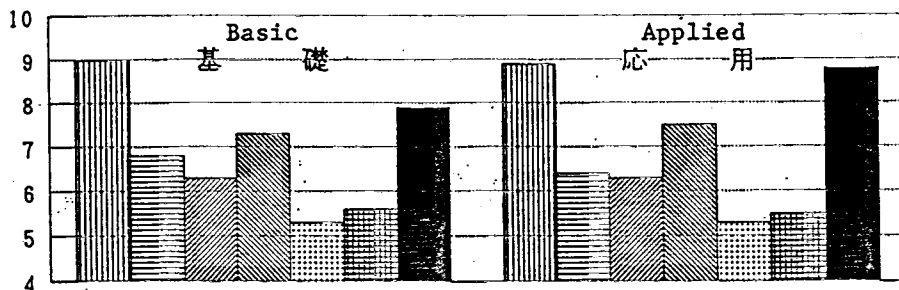
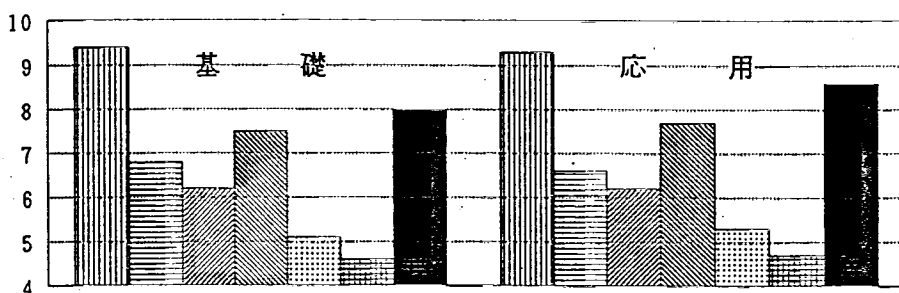


Fig.1 (b) International Comparison of Expected Research Levels in 1997.

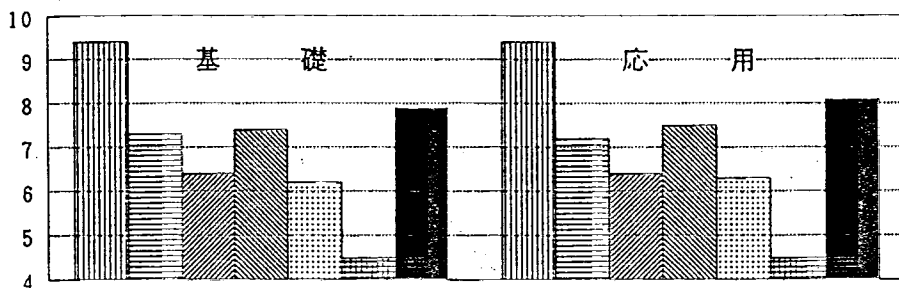
Mathematical, Physical and Engineering Sciences



Chemical Sciences (including chemical engineering)



Biological, Agricultural and Medical Sciences



Average of all fields

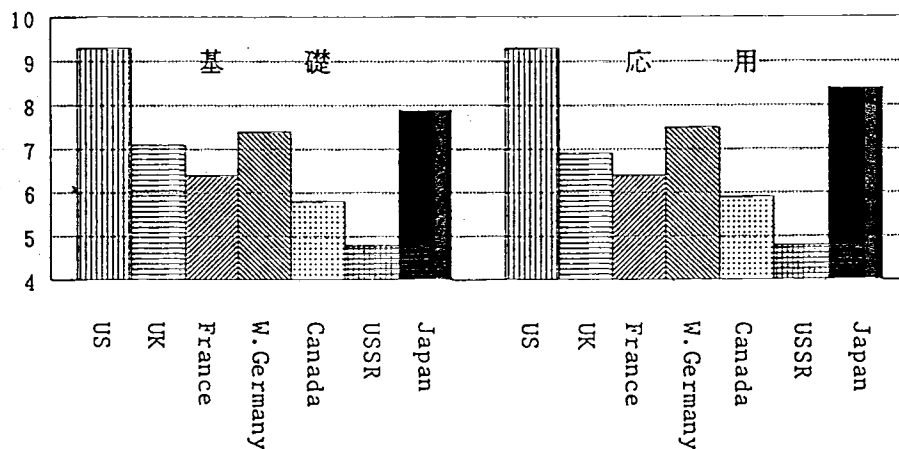
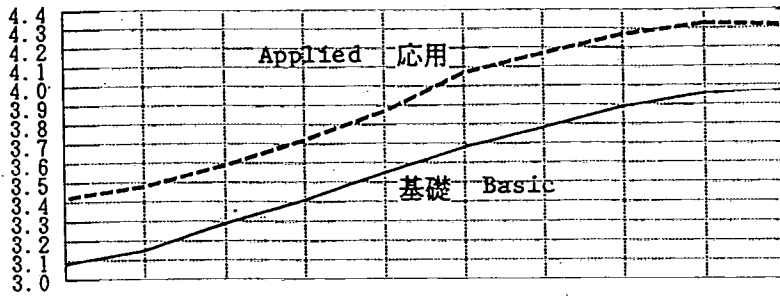
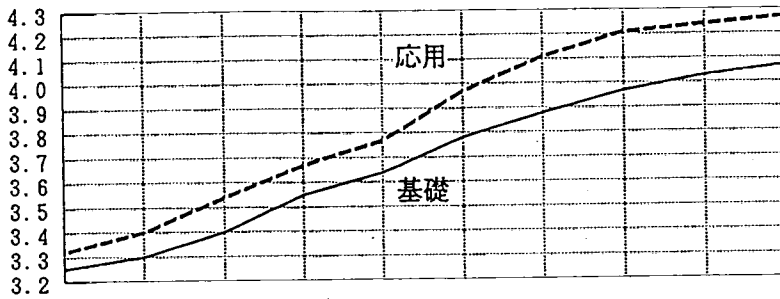


Fig.1 (c) Change of Research Levels in Japan from 1979 to 1988.

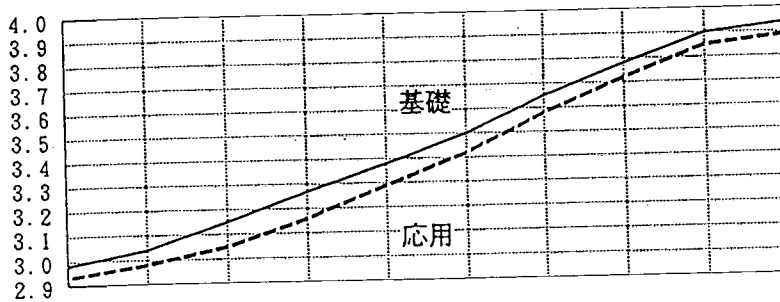
Mathematical, Physical and Engineering Sciences



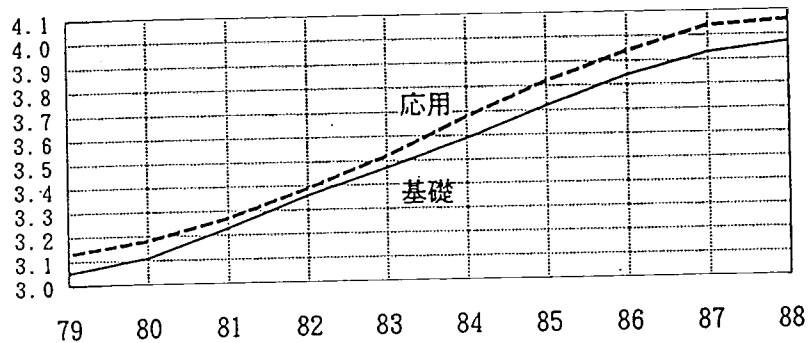
Chemical Sciences (including chemical engineering)



Biological, Agricultural and Medical Sciences



Average of all fields



APPENDIX QUESTIONARE ON RESEARCH LEVELS AND RESEARCH CONDITIONS

Respondent's Name _____ Age _____
 Affiliation _____
 Title _____
 Address _____ Tel. _____

- | | | |
|------------------------|------------------------|-------------|
| 1. National University | 3. Private University | |
| 2. Public University | 4. Other Laboratory | |
| 1. Professor | 2. Associate Professor | 3. Lecturer |
| 4. Research Associate | 5. Researcher | 6. Other |

I. Speciality

1. Indicate your speciality based on the disciplinary classification code for the review processes of proposals for Scientific Research Grants (Grants-in-Aid, Kagaku-Kenkyu-hi) under Monbusho:

Subdisciplinary area _____ Code _____

2. Indicate your speciality irrespective of your disciplinary classification:

Speciality _____

II. International Comparison of Research Levels

1. Evaluate the present level of research in your speciality in the following seven countries, through a rating system of 1 through 10 (10 given to the highest and 6 to the average of the seven countries). In case it is difficult to separate applied research from basic research, indicate in the basic research.

(1) Subdisciplinary area based on the disciplinary classification.

Basic research

US	UK	France	W. Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

Applied research

US	UK	France	W. Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

(2) Speciality irrespective of the disciplinary classification.

Basic research

US	UK	France	W. Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

Applied research

US	UK	France	W. Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

2. In the same way as above, evaluate expected levels of research in 10 years from now (1997) in the following countries:

(1) Subdisciplinary area

Basic research

US	UK	France	W.Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

Applied research

US	UK	France	W. Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

(2) Speciality

Basic research

US	UK	France	W.Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

Applied research

US	UK	France	W.Germany	Canada	USSR	Japan	Others
()	()	()	()	()	()	()	() ()

3. In your speciality, evaluate the change of research levels in Japan over the past 10 years (from 1979 to 1988) by marking on the basis of 5, 5 given to the highest of the world and 3 to the average of the world. In case it is difficult to discriminate applied research from basic research, indicate in the basic research:

Basic research

1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
()	()	()	()	()	()	()	()	()	()

Applied research

1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
()	()	()	()	()	()	()	()	()	()

4. List up five (at the maximum) world-level academic achievements made by Japanese scientists in your speciality for past 10 years;

- 1.
- 2.
- 3.
- 4.
- 5.

III. Research Conditions

1. What action is needed in five years from now, in order to raise the research level in your speciality ? Decide priorities among the following items:

Basic research

- (a) Increase of research funding
- (b) Reinforcement of equipments
- (c) Increase of laboratory space
- (d) Keeping good research staffs and training good successors
- (e) Improvement of research organization
- (f) Others, if any

Applied research

- (a) Increase of research funding
- (b) Reinforcement of equipments
- (c) Increase of laboratory space
- (d) Keeping good research staffs and training good successors
- (e) Improvement of research organization
- (f) Others, if any

2. Which mode of research funding will be most effective in order to raise the research level in your speciality ? Rank the effectiveness of modes funding, as follows:

- (a) Formula-based general funding per "Koza " (Koza-hi)
- (b) Formula-based general funding per undergraduate
- (c) Formula-based general funding per graduate student
- (d) Scientific research grants, Grants-in-Aid.
- (e) Research fund under contracts between universities and industries
- (f) Donations from industries

for basic research and applied research respectively.

3. Which program is most important to cultivate young scientists ?

Indicate priorities among the following programs:

- (a) Undergraduate programs
- (b) Master course programs
- (c) Doctoral course programs
- (d) Post doctoral programs
- (e) Others, if any.

4. With regard to equipments for research, indicate your degree of contentment with your equipment, as follows:

- (a) sufficient
- (b) moderately sufficient
- (c) insufficient
- (d) extremely insufficient

Estimate the cost of equipments which you want to procure and indicate annual amount of funding necessary for purchasing equipments:

- less than 3 M¥
- between 3 M¥ and 10 M¥
- more than 10 M¥

5. With regard to laboratory space, indicate your degree of contentment with your laboratory space, as follows:

- (a) sufficient
- (b) moderately sufficient
- (c) insufficient
- (d) extremely insufficient

Estimate the amount of the laboratory space you need:

- 1.5 times more which you have now
- 2.0 times
- 2.5 times or more

6. With regard to research systems and organizations, give your comments on the following issues:

- (1) increase in the mobility of scientists, in particular of young scientists.
- (2) introduction of appointment system with a specific term (contract system) for university staff members.
- (3) to make the roles of staffs clear and to separate research-oriented staffs from education-oriented staffs.
- (4) to provide young scientists with research conditions that will allow them to conduct their research freely.
- (5) introduction of the sabbatical system.
- (6) on research systems and organizations.
- (7) other comments

ACADEMIC RESEARCH SUPPORT: A NEW COMPACT?

J. Thomas Ratchford
Professor
International Science and Technology Policy

International Institute
George Mason University
Arlington, Virginia

Support of academic research in the United States has a long history. Science, but not academic research, is mentioned once in the U.S. Constitution. Article I, Section 8 states that "To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries..." thus establishing an intellectual property regime. But it was Europe where basic research was done, and European universities were the centers of academic research.

There were in the 1830's in the United States widespread problems with explosions of steam boilers on ships. The political pressures resulting from the heavy loss of life from these newsworthy events led to the support by the federal government of academic-type research at the Franklin Institute of Philadelphia. This was just a precursor of things to come much later.

Academic research in this country received a great boost with the enactment in 1862 of the Morrill Act, signed by President Lincoln, establishing "land-grant colleges" throughout the United States. These academic institutions, aimed primarily at the agricultural and mechanical arts and sciences, evolved into some of the greatest American universities. They also trained engineers and scientific agriculturalists in great numbers, and initiated an agricultural research and extension tradition that has served the nation well.

The federal government's role in other areas of academic research was more limited. For example, by the turn of the century the federal research and development (R&D) budget contained only \$100,000 for the National Bureau of Standards; the Coast and Geodetic Survey's budget was about \$1 million, reflecting the relevance of this segment of science to the needs of society at that time. The "old pragmatism" in respect to the support of public sector research is not unlike the "new paradigm" of today.

The picture of federal research support, including that of academic research, would be incomplete without mentioning the role of defense science and technology. National security - the military kind - has been a driving force in the evolution of research in the U.S. The creation of the National Academy of Sciences in 1863 was due to military imperatives. The same is true for the National Research Council in 1916, and military R&D provided support

for science and engineering in periods of war and peace. The Naval Observatory, for example, was a "center of excellence" long before the term was invented.

World War II and After

It was World War II that really changed things for academic science in the U.S. Federal expenditures for R&D shot up from about \$70 million in 1940 to \$1.6 billion in 1945. The success of the Office of Scientific Research and Development (OSRD) was unprecedented, and the political leadership and general public were aware of it.

Success in the development of technology was not new for the U.S. Many of the great inventions of the 19th century were by Americans, and translation of knowledge into products and processes that were important economically and militarily was common. What was new about the experience with OSRD was that academic scientists were the leaders in this successful effort, not the traditional tinkerer in the garage.

The flush of victory, driven by the applications of basic science, changed American Science for at least two generations. The Director of OSRD, Vannevar Bush, was asked to apply the lessons learned during the war to the post-war world. His 1945 report, Science - The Endless Frontier, laid out a vision of a new world. In that new world support by the federal government for basic research would lead to economic payoff just like the application of basic science to military challenges led to revolutionary weapons and to victory.

A vision, of course, is not enough. There have to be architectural drawings and steel girders as well. Some of this was provided by the Steelman report in 1947 on "Science and Public Policy." Its recommendations for a strong federal role in the support of basic research, and the need to establish a central federal scientific agency, were accepted by the President and Congress. In short order, the establishment of the Office of Naval Research, the Atomic Energy Commission, the National Science Foundation, and other agencies were accomplished.

The result was a practice of massive (by pre-war standards) support of academic research by the federal government, but with no federal responsibility for general university support. This compact between the federal government and the universities resulted in an extremely robust graduate education system as well. Indications are that the economic payoff has been great also, not only for the U.S., but for the entire world.

Changed Climate of the 90's

One of the driving forces behind consistent budget increases for academic research during the period following World War II was the Cold War. Intense competition with the Soviet Union in the sphere of military technology indirectly fueled increases in academic science budgets as well.

The end of the Cold war coincides with widespread public concern in the U.S. over the nation's international economic competitiveness. The trend in industrial research has been for at least a decade toward shorter time horizons in R&D programs. Many in Congress, and some in industry, called for a "Technology Policy" to support technology development in much the same way as the federal government funds research.

The federal budget also entered a state of perpetual shortage, following spiraling costs of social programs (entitlements) and massive budget deficits. Thus, even with reduced pressure for military spending, the so-called discretionary part of the federal budget continues to shrink; almost all of the civilian R&D funds appear in this category.

New Emphasis on Technology

President Clinton, in the 1992 presidential election campaign promised a greater emphasis on technology development by the federal government. On February 22, 1993, he announced the technology policy of his Administration. It called for a shift in the ratio of military to civilian research from the present approximately 60-40 to 50-50 within five years; massive increases in the funding of civilian technology development programs; a commitment to continue strong support of basic research; and a variety of other steps (fiscal, regulatory, trade, etc.) to strengthen the position of the U.S. in high-technology fields.

The fiscal year 1994 federal budget submitted by the President reflected the initial steps in this direction. Fears that basic research would be reduced to make way for increased funding of technology development programs did not materialize. For example, there were funds for both the SSC and the Space Station, and the National Science Foundation and the National Institutes of Health did well.

Congress was not so kind. The Space Station survived, but was severely wounded. The SSC is dead. All is not over for the 94 budget, but early indications are that R&D may very well lose out to social programs in competition for the shrinking portion of the budget over which Congress has real control, the discretionary sector. Congress will, no doubt, be good at subtracting R&D budgets. It remains to be seen if those funds will reappear in the right places.

Strategic Research: the "New Pragmatism"

The Administration's rhetoric about the federal role in technology development fell on fertile ground in the Congress. For example, the Senate Appropriations subcommittee with jurisdiction over the NSF has called for a wholesale shift in funds from basic research to "strategic research." The subcommittee's report states that not less than 60% of the NSF research budget should be in this category that can be more directly related to the needs of society. Punishment is threatened if the agency attempts to cloak "curiosity - driven research" in the costumes of "strategic research." The message here is that relabeling will not work.

The end of the Cold War means that it is no longer feasible to invoke national security as an argument for continued U.S. leadership in basic research. The needs of social programs and technology are threatening the post World War II tradition of generous federal funding of academic research.

Self-inflicted Wounds

The universities have been helpful to those who would like to put the academic science in its place. Scientists have fallen from their lofty pedestals in the eyes of many in the American public, with revelations of fabricated research data, improper uses of federal funds, especially from the overhead accounts, and public feuds between leading scientists. Parents of undergraduate students have become irate, as the research universities excused their professors from teaching duties and assigned graduate students to take their places.

One reflection of the loss of status by the research establishment in U.S. universities is the increased incidence of "earmarking" of funds for academic research by Congress. This practice treats research funds just like funds for public facilities, specifying the recipient institution on the basis of political influence rather than upon the results of competition and merit review. Further, university administrators and scientists alike have fueled this trend to "earmarking" of research funds through extensive lobbying of their elected representatives in Congress. The important point is that the arguments made in support of these academic research projects and facilities address not the scientific merits, but rather the economic and other benefits of the activity to the particular geographical location or institution.

The magnitude of the earmarking problem is substantial. If FY 1992, for example, about \$1.7 billion of the approximately \$75 billion federal R&D budget was earmarked. This reflects a four-fold increase in just three years, and about a fourth of the R&D pork goes to universities. Pork is perhaps the most important threat to the integrity of the Clinton Administration's plans for technology.

Response of Academia

Recognizing that there are real problems that need to be dealt with that go far beyond just jealous or irate politicians, the academic science community has introspectively examined itself over the last year or so. In January of this year, under the leadership of David Packard and Harold Shapiro, the President's Council of Advisors on Science and Technology (PCAST) issued a report on the research-intensive universities. These universities, 170 in number, award 90% of the science and engineering doctorates and spend 90% of the academic research funds in the U.S. PCAST agreed upon six findings and recommendations:

- o Universities must adapt to an era of constrained resources
- o More emphasis must be placed on teaching

- o Public trust must be restored in our universities
- o The federal government should maintain its role in supporting academic research
- o Closer ties between universities and industry are needed
- o The nation should assure the most talented students in science are provided opportunities to develop those talents

The National Academy of Sciences' Committee on Science, Engineering and Public Policy released its own vision of the federal relationship to science and technology for the years ahead. Their June 1993 report was broader than academic science, but it carried with it the same sense of constrained resources as did the PCAST report. The future would require not only the pinching of pennies, but a formal priority setting and evaluation system as well. The report called for the U.S. to set two goals for science:

- o The U.S. should be among the world leaders in all fields of science
- o The U.S. should maintain clear leadership in some areas of science

The Future

The next few years will be the most challenging for academic science in the U.S. since World War II. The reasons for this are:

- o Lack of funds in the federal discretionary budget
- o Reduced esteem for science and for universities by the public
- o An increased emphasis on technology, as contrasted to science
- o An increased perception that science expenditures are subsidies, and can be allocated for political reasons

The probability of substantial change in the system of support for academic science in the United States is very great over the next few years. The reasons for this begin with widespread dissatisfaction with the present R&D system and patterns of support. This is the case in spite of evidence that the vision of Vannevar Bush is still valid, with studies indicating that the economic rate of return on academic research to society as a whole approaches 30%.

The R&D framework may well have rusted, and priorities and agency responsibilities no doubt need reexamination. But academic research is a delicate enterprise, one in which second rate research is almost worthless and first rate research is priceless. There is real danger that political pressures, driven in part by the universities' self-inflicted wounds, will drive the academic research enterprise toward mediocrity, and the whole world will be the loser.

The key to a future with correct policies lies not only with enlightened leadership, as important as that is, but more importantly in public attitudes toward science and technology and R&D - and the institutions that create and perform them. Americans have been more supportive of science and technology than have the citizens of other nations since the 1950's. And on balance, science and technology have made life much better. The benefits of R&D, overall, have greatly exceeded the risks. And most of our academic researchers - and their institutions - have behaved ethically; those that have not must be called to task.

It is our responsibility - the responsibility of the scientific and engineering communities - to explain this to the public and to the political and business leadership of the country. Without widespread, continuing public support of academic research, its future is bleak; with that support, its horizons are limitless.

Support of Research in Universities

--A View from Industry--

Seiichi Watanabe
Director
Sony Corporation

Abstract

There are many efforts being made in Japan now to develop "centers of excellence", the advocacy of which has been led by Prof. Inose of the University of Tokyo. This calls for not only more physical plant and budget, but also the development of the role of being centers of exchange and interaction to which excellent researchers and engineers are attracted as well as sent out worldwide.

At present, Japanese universities have legal and budget restrictions, and it has been pointed out that there are issues in the evaluation of research and in the handling of intellectual property rights.

Industry needs to aim at the development of centers of excellence in its own sector as well. The laboratories of Japanese corporations, despite their top-level plant and funds in the world, are so far inadequate in their roles as centers of exchange and interaction, and need to devise ways and make efforts to better perform this role.

From the standpoint of making the effort to establish centers of excellence in both academia and industry in Japan, much contribution can be expected in both sectors by a significant increase in exchange and interaction between them.

For example, an academic person on sabbatical leave on an appointment in industry can provide stimulus to setting research themes and managing research in universities as well as provide ready access to tap the deep reservoir of knowledge in academia to industry and enlarge the breadth and depth of its research and development.

On the other hand, it is desired that the door should be much more widely open, and the opportunity more actively offered, for researchers and engineers from industry to participate in the research and teaching in the universities.

The extent of various programs of collaboration and exchange between academia and industry in Japan are reviewed, and the flow of funds among government, industry and academia are compared among Japan, the United States, Germany, France and Great Britain.

For the increasingly global industrial sector, the benefit of developing global centers of excellence will not be confined to companies of particular nationalities. Academia should also become more global in scope, as should government, which tends to be confined to the local national outlook, but can support and encourage global centers of excellence in any location by aiding exchanges and interactions. This is the most effective way to create knowledge which is the driver of the development of the world economy.

There are many efforts being made in Japan now to develop "centers of excellence", the advocacy of which has been led by Prof. Inose of the University of Tokyo¹. This calls for, in my view, not only the enhancement of the physical plant and the increased budgeting of funds, but also the development of the role of being centers of exchange and interaction to which excellent researchers and engineers are attracted as well as sent out worldwide.

Although wide-ranging efforts are under way in Japan by industry, academia and government, it is recognized that, at present, there are limitations in plant and funds available to universities because of legal and budget restrictions. It has also been pointed out that, for universities, there are issues that need to be addressed in the evaluation of research and in the handling of intellectual property rights.

I believe industry needs to aim at the development of centers of excellence in its own sector as well. The laboratories of Japanese corporations, despite

their top-level plant and funds in the world, are so far inadequate in their roles as centers of exchange and interaction, and need to devise ways and make efforts to better perform this role.

It is my view that the support and funding of research in academia can more effectively be discussed if they are positioned in the effort to establish these centers of excellence in both academia and industry.

Viewing from this standpoint the cooperative relationship between academia and industry in Japan, much contribution can be expected toward the development of centers of excellence in both sectors by a significant increase in exchange and interaction between them³. For example, an academic person can spend a certain term in industry, such as on sabbatical leave or post-doctoral appointment. Much more of this kind of exchange can take place through mutual efforts. By placing themselves at the forefront of industrial research and development, academics can take back valuable pointers useful in setting research themes and in managing research in universities.

Through this kind of exchange, universities can benefit extensively from the wide utilization of the environment of industrial research and development. It should also facilitate the large-scale contribution by industry to enhancing the research environment in universities by forming sturdy links with the top managers in industrial research and development.

For the side of industry this provides more ready access to tap the deep reservoir of knowledge in academia, generally stimulates exchange and

interaction with other organizations, and thus enlarges the breadth and depth of its research and development.

On the other hand, it is desired that the door should be much more widely open, and the opportunity more actively offered, for researchers and engineers from industry to participate in the research and teaching in the universities. This not only strengthens the research activity in industry, but also makes the research and teaching in academia more lively by widening its field of view by the stimulation from a different perspective.

Through this kind of exchange and interaction between academia and industry, the scope of funding of research in universities by Japanese industry can be widened.

Stay of Industry Researchers in Academy

Researchers from industry have opportunities to stay in the Japanese national universities through either the research collaboration program (kyodo kenkyu seido) or the contract researcher program (jutaku kenkyuin seido).

In the research collaboration program (kyodo kenkyuu), started in 1983, funds are provided both by the Ministry of Education and by industry to carry out research by professors and industry researchers on a comparable status. Figure 1 shows the rapidly increasing number of projects and industry researchers staying in universities, as well as the funds provided by the Ministry of Education.

In the contract researcher program (jyutaku kenkyuusha), researchers and engineers from industry stay in universities for research and training and, as shown in Figure 2, this number has also been increasing. For 1993, 400 million yen has been budgeted by the Ministry of Education for this program.

Substantial expansion of these programs is desired for opening the door for researchers and engineers in industry to participate in the research and teaching in the universities.

As a part of the program by which Sony Corporation has endowed the John Bardeen Endowed Chair in Electrical and Computer Engineering and Physics at the University of Illinois at Urbana-Champaign, we have had our researchers stay in the University as visiting researchers since 1990. We have found this to be a very effective way of interacting with a university.

Stay of Academics in Industry

On the other hand, much can be done to increase opportunities for academics to participate in industrial research by staying in industry. In Sony Corporation, the Sony Sabbatical Chair scheme was established in 1990 to invite university professors to stay in Sony research organizations for terms of several months. We have hosted professors from universities in the United States, Great Britain, Germany and Belgium. This scheme has proved to be very stimulating for our researchers from the standpoints both of exchange and interaction with academia and of internationalization of our laboratories in

Japan. The professors whom we have hosted have found their stays to be very useful to them in understanding the issues and concerns in industrial research. They have typically spent one third of their time visiting other organizations in industry, academia and government as well.

Based on our experience with our Sabbatical Chair scheme, I believe this form of support of academics by industry is a very effective means of promoting the mutual goals of developing centers of excellence in both academia and industry. There is no reason why this type of scheme can not take place with professors from Japanese universities as well. In many cases, the Sabbatical Chair stays have also led to collaborations between our laboratories and the professors' institutions with financial support provided to the universities by the corporation.

Contract Research

Contract research performed by the Japanese national universities has been increasing as shown in Figure 3, but most of it is for government rather than for industry, as seen in Table 1. Through increased exchange and interaction between academia and industry, much more contract research for industry will take place.

Donation of Funds

Gifts of funds to Japanese national universities, primarily by industry, have

been rapidly increasing as shown in Figure 4, and, in particular, endowed chairs and departments have significantly increased as shown in Table 2. The values are indicated in yen, and the growth rate would be much faster if the rapid appreciation of the yen, which Japanese industry is now suffering heavily from, is taken into account. This trend will accelerate as a consequence of increased interaction between academia and industry that will take place in the future.

Flow of Funds Among Government/Industry/Academia

Figure 5 shows the flow of funds among government, industry and academia in Japan, the United States, Germany, France and Great Britain. In Japan there is, on the whole, less movement of funds between sectors, and the share of funds going to academia provided by industry is the least. 51 per cent of the funds going to academia comes from government, compared to only 2 per cent from industry. This share will increase in the future as increased interaction between academia and industry lead to the development of centers of excellence in both sectors.

Thus, support and funding of research by industry can more effectively be promoted in view of establishing centers of excellence in both academy and industry.

As the industrial sector becomes increasingly global in scope, it will aim at

the development of global centers of excellence in industry. The government and academic sectors are also addressing themselves to the task of developing global centers of excellence. The exchanges and interactions need to be not only among institutions in Japan but widely involving institutions throughout the world.

To develop effective industry support and funding of universities, cross-national relationships should also be discussed. Four relations of funding need to be addressed: Japanese industry supporting Japanese or US universities and US industry supporting Japanese or US universities. There are different characteristics, motivation and advantages with respect to these four situations.

A report in 1990, "Scientific and Technological Relations between the United States and Japan: Issues and Recommendations"², prepared by Dr. Frank Press, President of the National Academy of Sciences USA, for the Commission on US-Japan Relations for the Twenty First Century, makes the following two recommendations related to the issue of funding for US university research by Japanese industry.

The first recommendation is that "mechanisms should be developed to improve access by US companies to research centers in Japan that are carrying on research similar to that under way in American universities". As the exchanges and interactions between industry and academy in Japan increase in scope with the aim of developing centers of excellence, steps should be taken by the universities to improve US access to the best Japanese university research as

well.

The second recommendation is that "US universities should take the lead in developing guidelines for foreign funding of US university research to ensure balanced and equitable treatment." In developing these guidelines, it would be important for university leaders to work with industry. Japanese universities should also consider developing such guidelines.

For the increasingly global industrial sector, the benefit of developing global centers of excellence will not be confined to companies of particular nationalities. Academia should also become more global in scope, as should government, which tends to be confined to the local national outlook, but can support and encourage global centers of excellence in any location by aiding exchanges and interactions. I believe this is the most effective way to create knowledge which is the driver of the development of the world economy.

References

1. "Center of Excellence", H. Inose (Tokyo: Nikkei Science, 1990)
2. "Scientific and Technological Relations Between the United States and Japan: Issues and Recommendations", F. Press (Washington, DC: Commission on US-Japan Relations for the Twenty First Century, 1990)
3. "Sougo ni kyouryoku, sentaa obu ekuserensu wo (Mutual cooperation for centers of excellence)", S. Watanabe, J.I.E.I.C.E. Vol. 74 (No. 8), 873 (1991)

Table 1

Contract Research

Contracting institution	National Government	Local Government	Foundations etc.	Industry etc.	Total
Number of projects	1,123	258	223	517	2,121
Share	53%	12%	11%	24%	100%

Source: Ministry of Education

Table 2

Endowed Chairs and Departments

Category	1987	1988	1989	1990	1991	1992
Institutions	2 (U)	5 (U)	10 (U)	12 (U)	14 (U) 2 (C)	16 (U) 2 (C)
Endowed chairs	1	4	14	23	39	41
Endowed departments	4	6	10	11	15	15

(U) — universities (C) — centers

Note: Numbers are as of the end of each year.
For 1992, numbers are as of April 1.

Source: Ministry of Education

Problems in funding

Recipient of funds	Source of funds	
	Japanese industry	US industry
Japanese university	<ul style="list-style-type: none">• limited rights to intellectual properties	<ul style="list-style-type: none">• limited experience
US university	<ul style="list-style-type: none">• exclusion from some consortia	<ul style="list-style-type: none">• who directs is an issue

Fig.1 Collaborative Research Projects in Japan
Between National Universities and the Private Sector

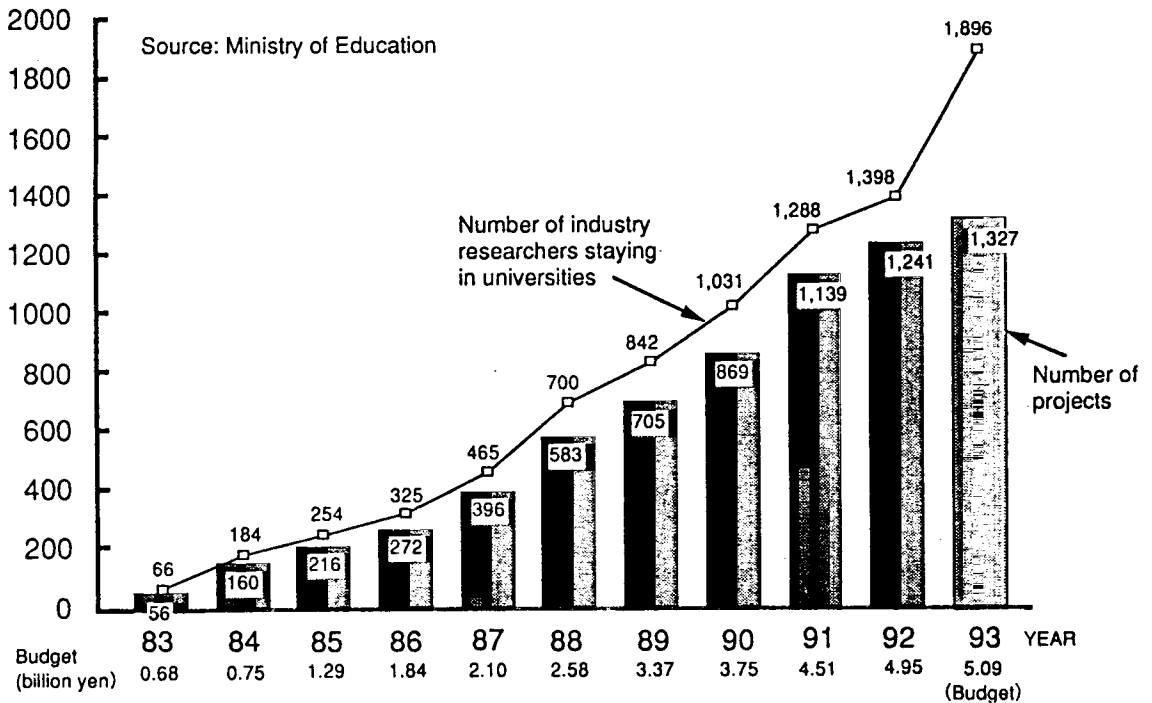


Fig.2 Industry Researchers in National Universities
in Japan Under the Contract Researcher Program

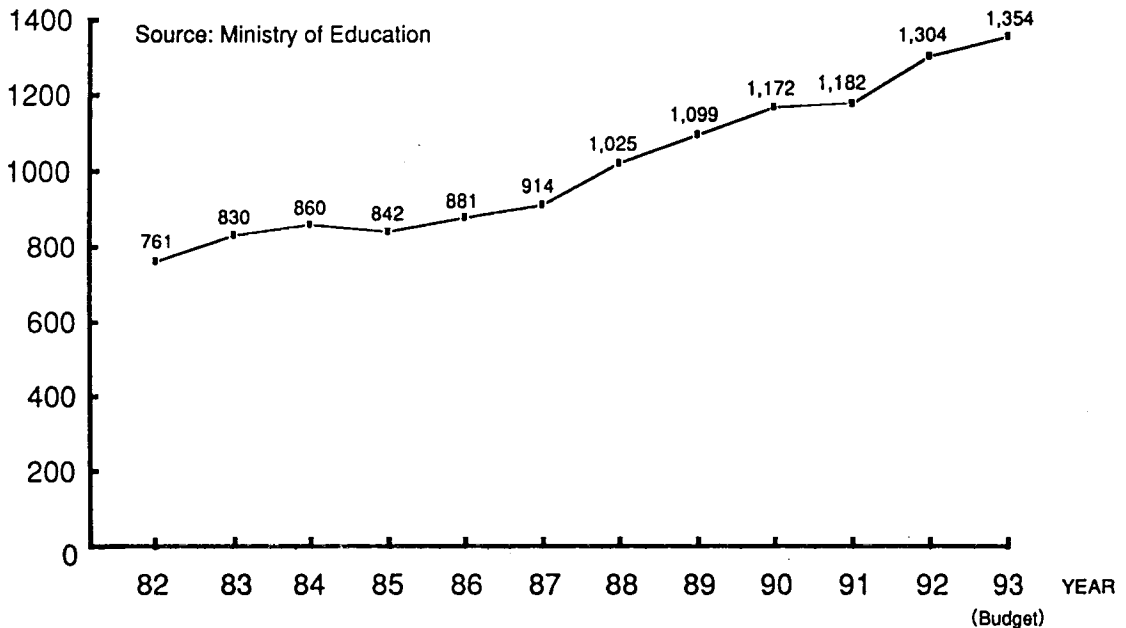


Fig.3

Contract Research by National Universities in Japan

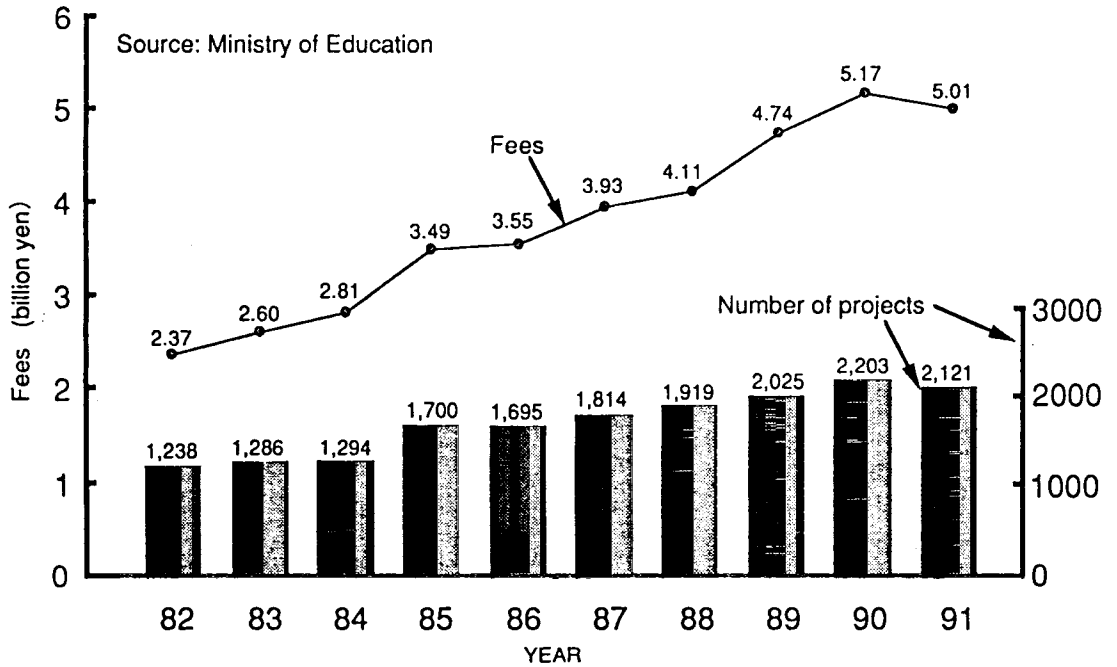


Fig.4

Gift of Funds to National Universities by Industry in Japan

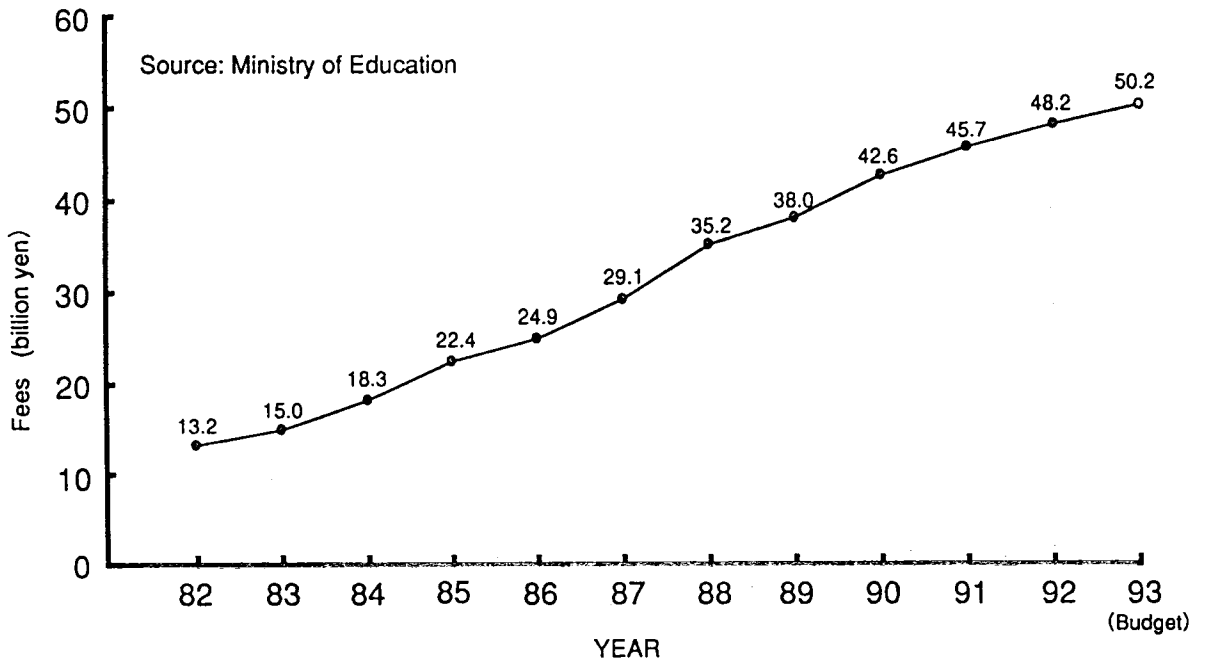


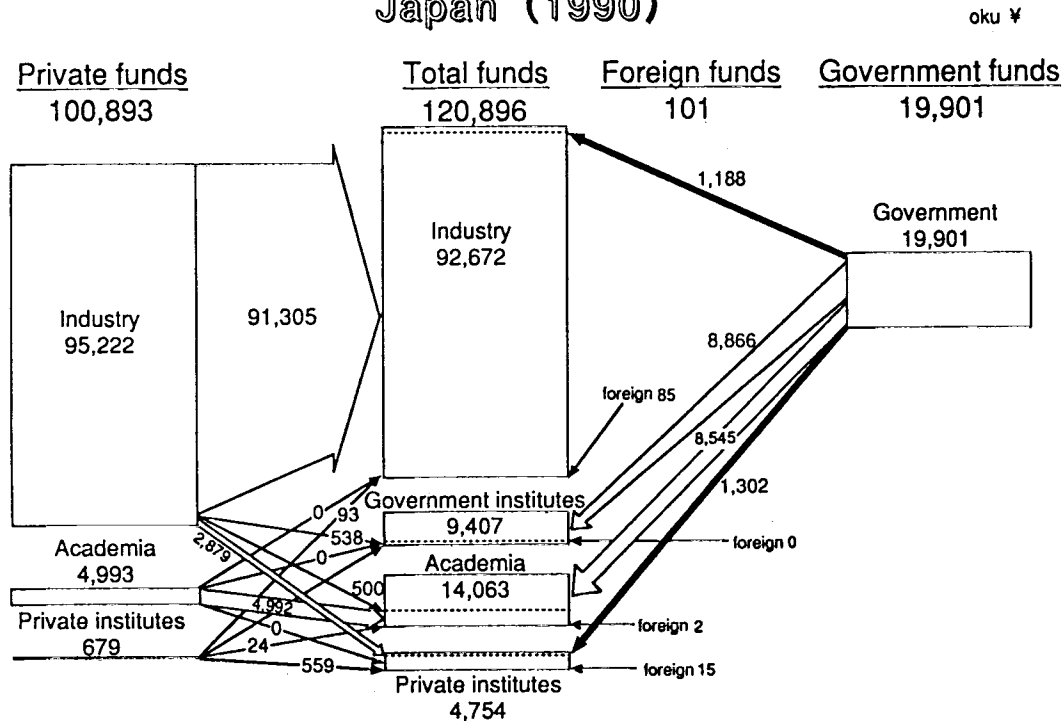
Fig.5

Flow of Funds Among Government / Industry / Academia

Source	Spending Institution	Japan (1990)		United States (1991)		Germany (1989)		France (1988)		England (1989)	
		amount	share	amount	share	amount	share	amount	share	amount	share
Government	Government	923	94	3,231	100	637	95	844	93	470	86
	Government	54	6	0	0	8	1	35	4	51	9
Industry	Industry	119	1	6,363	30	425	11	449	21	408	16
	Industry	9,131	99	15,002	70	3,489	88	1,511	70	1,742	70
	University	1,161	51	2,857	66	714	93	505	94	430	74
	University	53	2	246	6	58	7	22	4	43	7

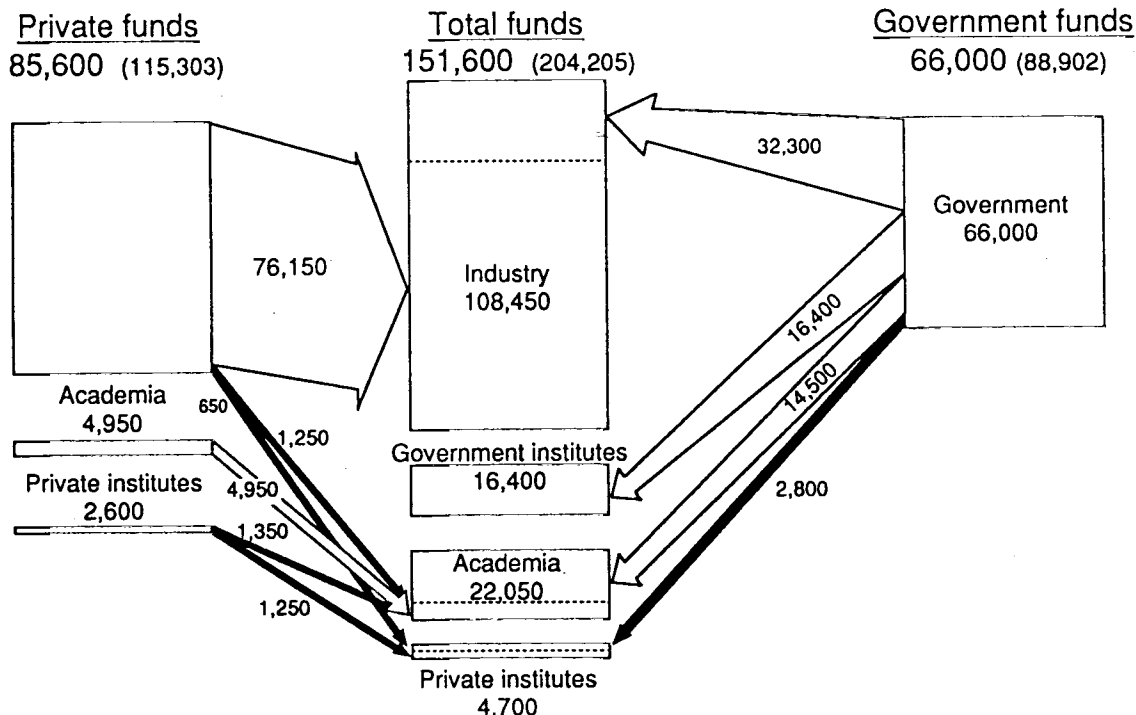
Source: 1992 White Paper on Science and Technology
Science and Technology Agency

Flow of Research Funds Japan (1990)



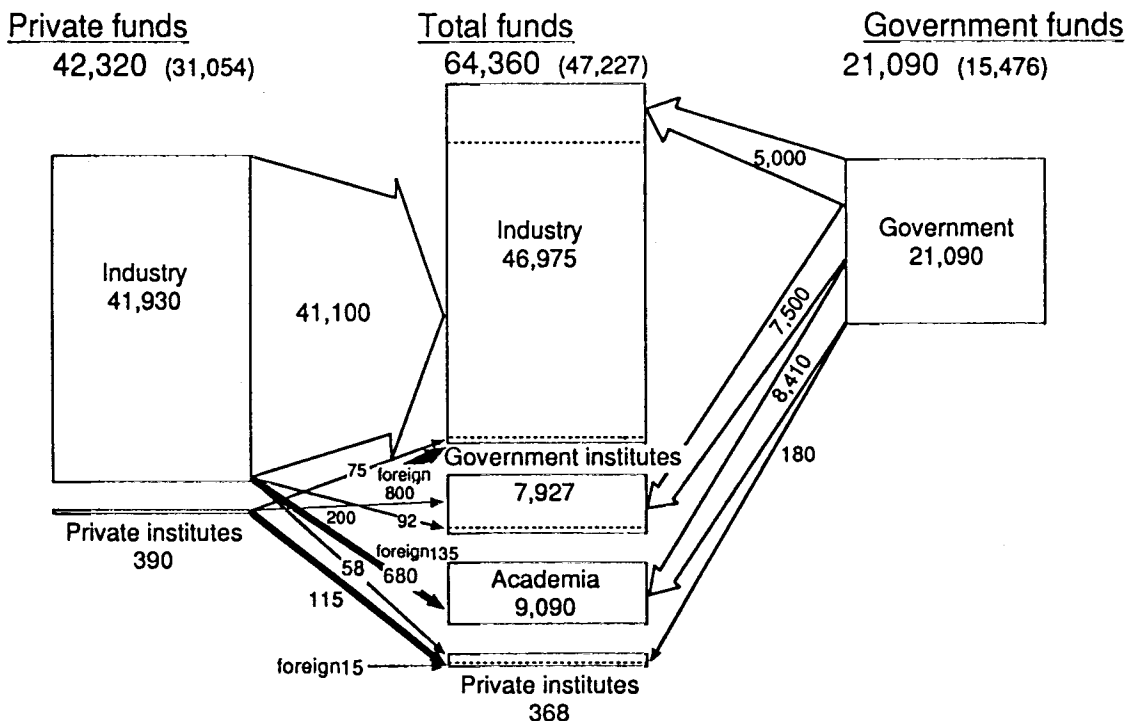
Flow of Research Funds United States (1991)

million \$
(oku ¥)



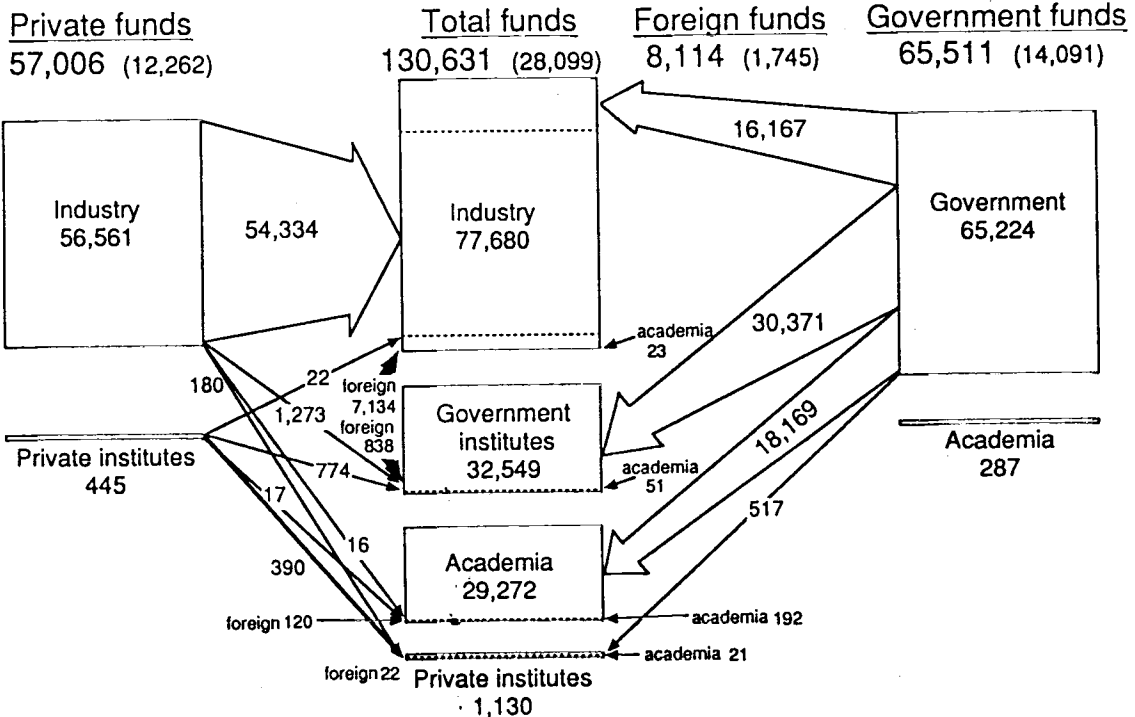
Flow of Research Funds Germany (1989)

million mark
(oku ¥)



Flow of Research Funds France (1988)

million franc
(oku ¥)



Flow of Research Funds England (1989)

million £
(oku ¥)

