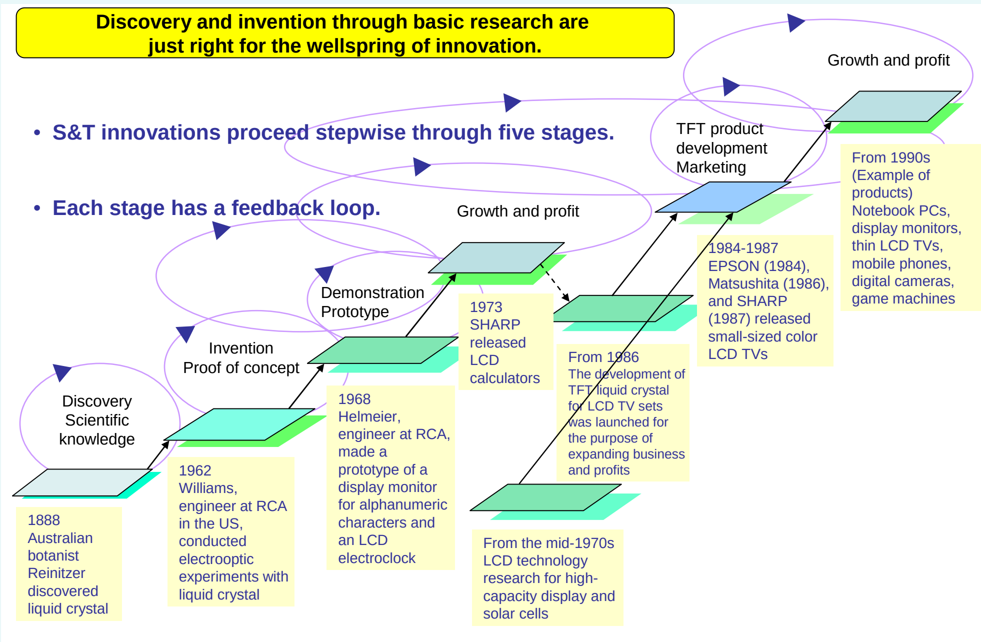
Chapter 3 Searching for a New R&D System

1 Comprehensive Approach to Enhancement of Basic Science Capability as the Wellspring of Innovation

Basic research has played a major role as the source of innovation by bringing about discoveries and inventions which are different from the existing framework of knowledge. For example, the development of the liquid crystal display was triggered by an innovative invention some 80 years after the discovery of liquid crystals (Figure 1-3-1). As the world is in a full-fledged period of transformation, the enhancement of basic science capability[1] is required to realize innovations. And the development of a system that puts the bud of innovative technology brought forth through basic research into practical use is also required. Considering the many problems that are to be resolved through S&T as in the field of global environmental problems, it is important to promote creative basic research for clear targets and R&D with practical application in mind as well as research driven by the free ideas of researchers.

Figure 1-3-1 Innovation Process for Liquid Crystal Display Monitors



Source: Prepared by MEXT based on materials by Center for Research and Development Strategy, Japan Science and Technology Agency

1 The comprehensive capability that is related to science and technology, and that is required for promoting research activities to discover new knowledge and findings and new inventions. In addition, the activities for promoting the public understanding of science and technology should be considered as part of the enhancement of basic science capability.

1 Basic Research and Innovation

Basic research is an activity designed to bring forth new knowledge from plain and honest exploration for the truth in a process of trial and error. Through discoveries and the comprehension of principles and phenomena, deep knowledge has been accumulated. The combination of the creation and accumulation of such diverse knowledge has not only contributed to the development of academics but it has also brought about great socioeconomic transformations, and the realization of numerous innovations. This can be seen quite clearly from the linkage between the practical use of new technologies and the many Nobel Prize-winning research achievements. For example, the research in solid-state physics by Shockley, Bardeen, and others, who were awarded the Nobel Prize in physics in 1956, led to the invention of transistors, which triggered a shift to the information-oriented society (Table 1-3-2).

Table 1-3-2 Major Examples of Nobel Prize-awarded Achievements Leading to Practical Applications

Examples of practical applications	Nobel Prize
Magnetic resonance imaging (MRI) scanner	Bloch, et al. (Physics 1952)
	Lauterbur and Mansfield (Physiology or Medicine 2003)
Semiconductor (transistor)	Shockley, Bardeen, et al. (Physics 1956)
Insulin	Sanger (Chemistry 1958)
Semiconductor (tunnel effect)	Leo Esaki, et al. (Physics 1973)
Computed tomography (CT)	Cormack, Godfrey, et al. (Physiology or Medicine 1979)
Monoclonal antibody	Jerne, Köhler, et al. (Physiology or Medicine 1984)
Conductive polymer (backup cell for mobile phone)	Hideki Shirakawa, et al. (Chemistry 2000)
Asymmetric synthesis (manufacturing of menthol)	Ryoji Noyori, et al. (Chemistry 2001)
Proteinomics instrument	Koichi Tanaka, et al. (Chemistry 2002)
GMR head (reproducing head of HDD)	Fert and Grünberg (Physics 2007)
Knockout animals	Capecchi, Evans, et al. (Physiology or Medicine 2007)
GFP fluorescent markers	Osamu Shimomura, et al. (Chemistry 2008)

Source: Prepared by MEXT

A typical example of the remarkable results of basic research in Japan is the discovery of electroconductive polymers[1], which was made by Hideki Shirakawa, Professor at the University of Tsukuba and recipient of the 2000 Nobel Prize in Chemistry. This discovery defied the common wisdom that plastics were nonconductive and led to the practical use of polymer batteries as, for example, portable-telephone backup batteries. With support of the Grants-in-Aid for Scientific Research and the Exploratory Research for Advanced

Source: MEXT *Education Materials for Information Equipment and Information Society Mechanism* [literal translation]

1 Polymers or multimeric complexes that are produced by polymerizing many monomers

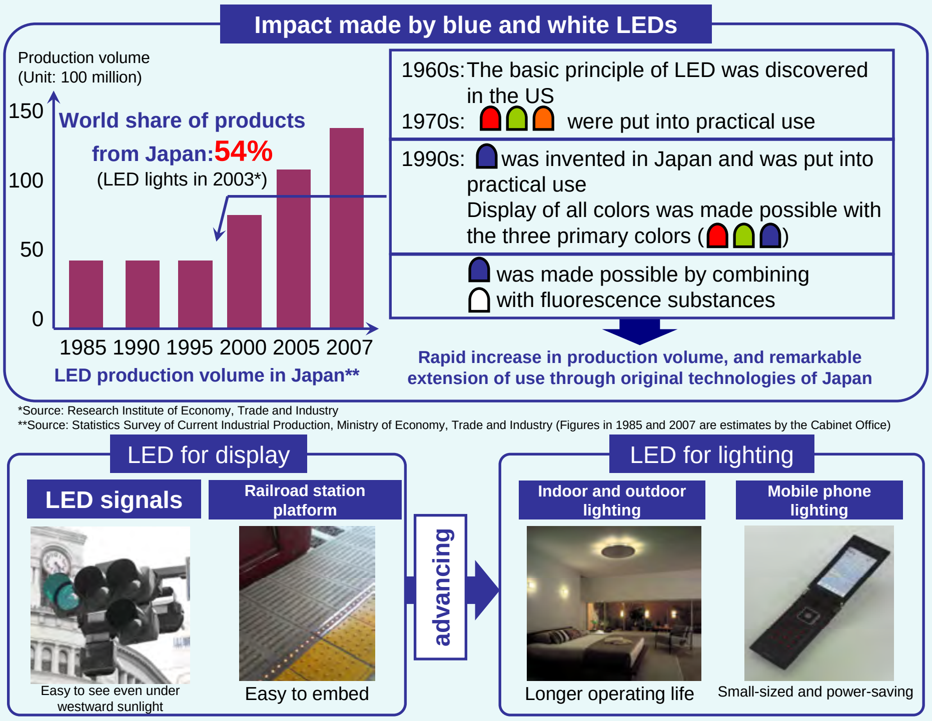
Technology (ERATO) Program[1], metallic glass[2] was developed after long basic research by Akihisa Inoue, President of Tohoku University. Metallic glass is now used in various products such as golf-club heads and high-performance sensors because its strength and flexibility are far superior to metal.

This basic research has also brought about effects that were unintended. For example, the photocatalyst effect of titanium oxide, which was discovered in 1967 by Kenichi Honda and Akira Fujishima, Emeritus Professors at the University of Tokyo, has been established through joint research with a number of corporations as a technology for cleaning dirt with light when the original research was intended to develop hydrogen manufacturing technology. This technology has been used for products such as tiles, glasses, and automobile mirrors, and it has become one of the predominant technologies from Japan. Further, carbon nanotubes (CNT)[3], which were discovered in 1991 by Sumio Iijima, Senior Research Fellow of NEC Corporation and Professor at Meijo University, have found wide application in electronic components as well as structural materials for their good electric and heat conductivity. CNT capacitors exhibit much better charge/discharge features and a much longer life than the conventional capacitors. These capacitors are expected to gain a dominant market share in a predicted 140 billion yen market for capacitors in 2009. Furthermore, with the seamless supports of the Grants-in-Aid for Scientific Research or the Project to Develop "Innovative Seeds", the blue LED, which was put into practical use by Isamu Akasaki, Research Professor [literal translation] at Meijo University, led to white LED by combining it with the yellow fluorescent body. According to JST, the direct economic ripple effect from cooperative LED development with industry through original series business will have totaled as much as about 350 billion yen in 17 years since 1997, bringing great value to Japan's economy through the expansion of its application from "display LED" for traffic lights to "lighting LED" for indoor lightening, portable telephones. (Figure 1-3-3).

Self-cleaning tiles using photocatalysts
Photo: TOTO Ltd.

1 The current name is JST Basic Research Programs.
2 A kind of amorphous metals, that is, liquid-state metals having no crystal architecture
3 Extremely small tubes made of regularly arranged carbon, with a diameter of 0.4 to 100 nanometers

Figure 1-3-3 Major Trends and New Developments surrounding LED Technology



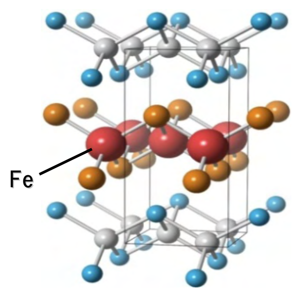
Source: Prepared by MEXT based on materials (prepared by the Cabinet Office) at the 72nd session of the Council for Science and Technology Policy (December, 2007)

Basic research as a source of innovation has led to many types of growth and changes. It can be said that the role of basic research in creating innovation has become more and more important due to the fact that the tendency to quote scientific papers in patents has become higher, as explained in Chapter 1, Section 1.

2 Basic Science Capability of Japan

(1) Level of basic research

A historical event occurred in 2008: Four Nobel laureates in physics and chemistry were from Japan (Table 1-3-4). Eight researchers from Japan have received Nobel Prizes in natural sciences since 1999. This ranks No. 2 in the world and next to the US. The research that led to the prizes was all carried out in the past, but the latest marked research was reported in an article entitled “Breakthrough of the Year” in Science Magazine in 2008. In this report, No.1 on the list was the preparation of human iPS cells by Prof. Shinya Yamanaka, Kyoto University, who is expected to contribute to regenerative medicine. In addition, the discovery of new iron-based high-temperature superconductor by Prof. Hideo Hosono, Tokyo Institute of Technology, was selected among the best 10. This shows that the level of Japanese research in basic research is extremely high. Related to the above superconductor



New iron-based high-temperature superconductor ($LaFeAsO_{1-x}F_x$)
Source: Prof. Hideo Hosono, Tokyo Institute of Technology

research, the papers written by Yoichi Kamihara et al., postdoctoral fellow at Tokyo Institute of Technology were the most quoted in 2008[1].

Table 1-3-4 Nobel Laureates from Japan in Natural Sciences

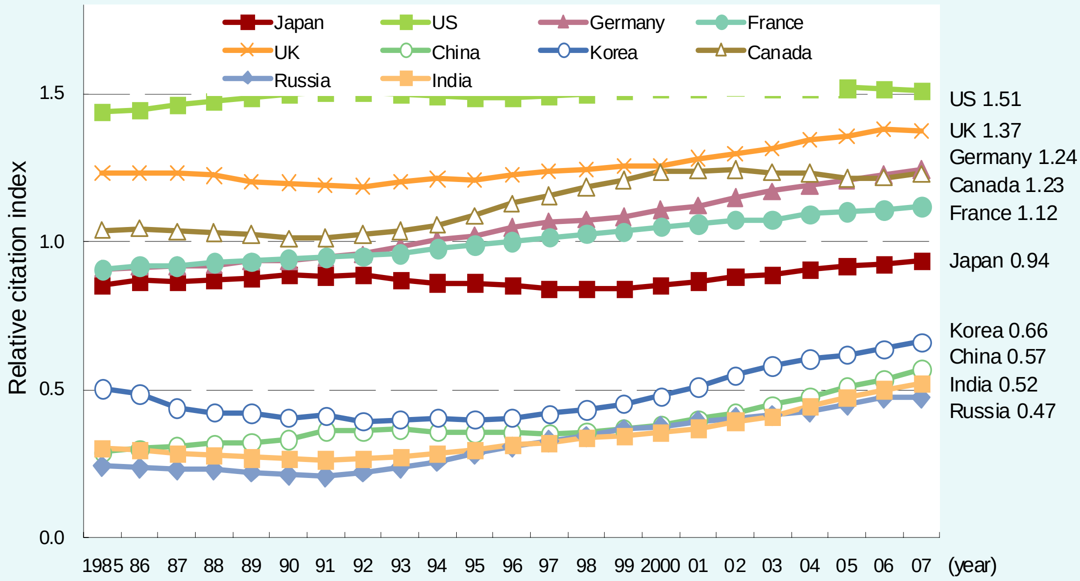
Laureate	Year of birth	Research achievement	Year of achievement published	Field	Year awarded
Hideki Yukawa	1907	Theory of mesonic	1935	Physics	1949
Shinichiro Tomonaga	1906	Theory of renormalization	1946	Physics	1965
Leo Esaki	1925	Discoveries regarding tunneling phenomena in semiconductors	1957	Physics	1973
Kenichi Fukui	1918	Theory of frontier electron	1952	Chemistry	1983
Susumu Tonegawa	1939	Investigation of immune system in molecular biology	1976	Physiology or Medicine	1987
Hideki Shirakawa	1936	Discovery and development of conductive polymers	1977	Chemistry	2000
Ryoji Noyori	1938	Research of asymmetric chirally catalysed hydrogenation reactions	1980	Chemistry	2001
Masatoshi Koshiba	1926	Pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos	1987	Physics	2002
Koichi Tanaka	1959	Development of methods for identifying and analyzing the architecture of biological macromolecules	1987	Chemistry	2002
Yoichiro Nambu	1921	Discovery of spontaneous broken symmetry in particle physics and nuclear physics	1960	Physics	2008
Makoto Kobayashi	1944	Discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature	1972		
Toshihide Masukawa	1940				
Osamu Shimomura	1928	Theory of mesonic	1962	Chemistry	2008

Note: Dr. Nambu became a US citizen in 1970.
Source: Prepared by MEXT

However, the Expert Survey on S&T Activities by Fields by the National Institute of Science and Technology Policy (NISTEP) in March 2009 argues that the level of Japanese science has deteriorated faster than expected in 2006, showing that the news about basic research is not all good. The trends in relative citation impact[2] is improving but still below 1 (Figure 1-3-5). In order to assure that the splendid achievement of those four Nobel Laureates will not be a one time affair, it is important to bolster the basic research level now.

1 Results of investigation by Thomson Reuters
2 The relative citation impact indicates how many percent more or less citations the publications of a certain country have received in comparison with the citation impacts in the world (index=1).

Figure 1-3-5 Trends in Relative Citation Impact in Selected Countries



Notes:

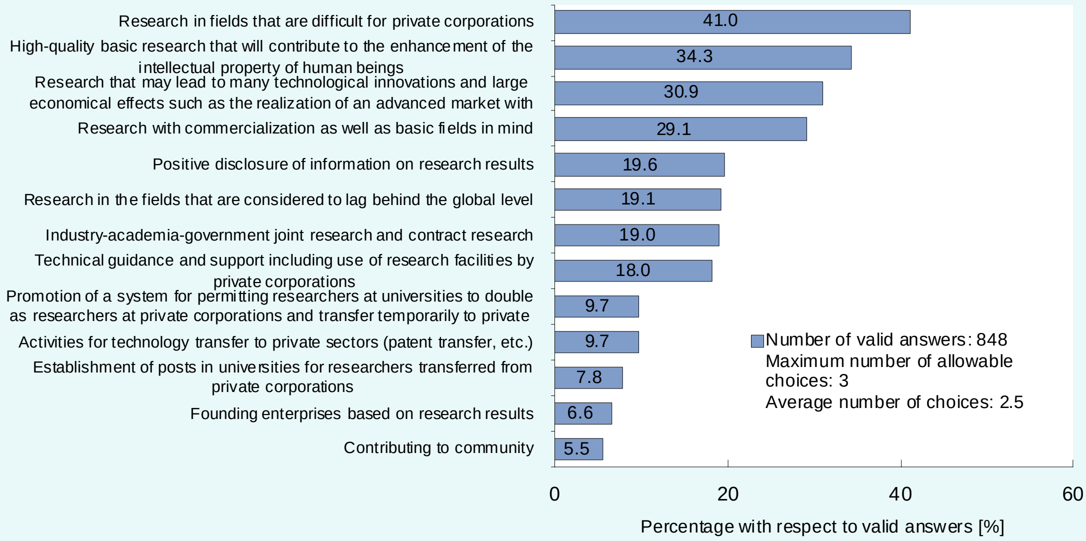
1. The fields of humanities and social science are excluded.
2. The figures for respective years are based on 5-year-window data to compare citation data on the same basis. For example, the figure for 1985 is based on that for years 1981 to 1985.
3. Multinational co-authored papers are double-counted for inclusion in the figures of relevant countries.

Source: Compiled by MEXT based on Thomson Reuters Scientific classification of Essential Science Indicators of *National Science Indicators, 1981-2007 (Standard version).*

(2) Government assistance for basic research

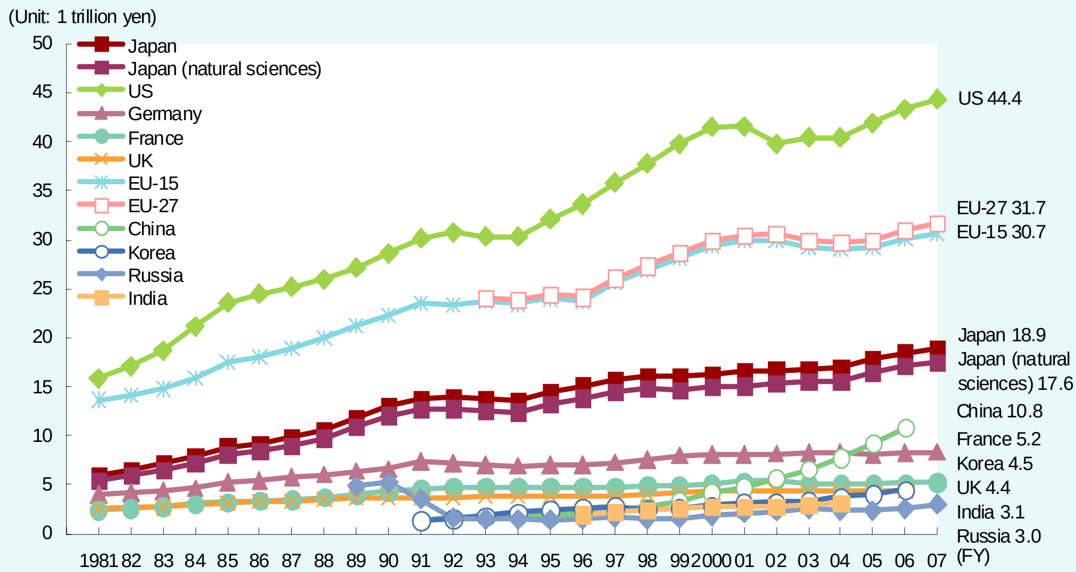
As explained in Chapter 1, Section 1, in the current of open innovations, corporations have a tendency to keep core technologies to themselves while basic research is given out to colleges or R&D institutes. This is also shown in what the corporations expect domestic colleges to do in the future: The expectation is that domestic colleges engage in "research in the fields difficult for private corporation to deal with in their research activities" and "high-quality research capable of contributing to the expansion of the intellectual properties of humankind" (Figure 1-3-6).

Figure 1-3-6 High Expectations for Domestic Universities (Japan)



Source: MEXT *Survey on Research Activities at Private Corporations (FY 2006)* [literal translation]

Figure 1-3-7 Trends in R&D Expenditures in Selected Countries/Regions (On PPP-basis)



Notes:

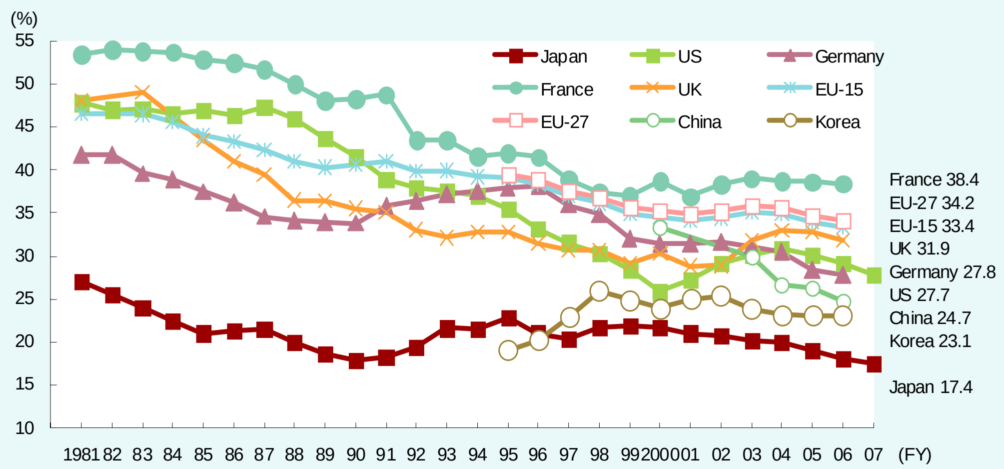
1. For international comparison, R&D expenditures of all countries other than South Korea include those of Humanities and social sciences. Japan's R&D expenditures for the natural sciences are also shown.
2. The US figure for FY 2007 is provisional.
3. The Germany figures for FY 1982, 1984, 1986, 1988, 1990, 1992, 1994-96, 1998, and 2007 are estimated values.
4. The France figures for FY 2006 and after are provisional.
5. The EU figures are estimates by Eurostat.
6. The India figures for FY 2003 and 2004 are estimates by the Indian government. As the OECD PPP list does not cover India, the figures are cited from the World Bank PPP list.

Sources:

Japan: Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*
EU: Eurostat
India: [R&D expenditures] UNESCO Institute for Statistics S&T database
[PPP] The World Bank *World Development Indicators CR-ROM-2007*
Other countries: OECD *Main Science and Technology Indicators Vol. 2008/2*
OECD-PPP: OECD *Main Science and Technology Indicators Vol. 2008/2*

On the other hand, although research funding in Japan is on the increase, the rate does not come up to the rapid increase of funding in the US and China (Figure 1-3-7), and the rate of government expenditures, which should play the main role in basic research assistance, is lower than that of the other countries (Figure 1-3-8). In addition, the rate of basic research funding use out of the total amount of research funding in Japan has decreased from 15.0% in 2002 to 13.8% in 2007. The tight financial situation has also pressed the budget: basic research funds such as government subsidies for national university corporations and financial aid to private educational institutions have decreased year by year while the Grants-in-Aid for Scientific Research, the typical competitive funding for basic research, has also seen its average amount distributed per theme drop and the number of newly adopted research dropped. After the R&D-Capacity Strengthening Act [literal translation] was established, the range of the researchers who were outside the total employment cost reform based on the Act on Promotion of Administrative Reform for Realization of Small and Efficient Government in R&D institutes was expanded; however, the allowance for researchers employed on operating cost grants is insufficient. As explained in Section 1, for many research projects bringing forth achievements contributing to the society, their embryonic period was supported by basic research funds and the Grants-in-Aid for Scientific Research, and the above situation is causing a serious problem for the cultivating of the next generation of research that will lead future innovation.

Figure 1-3-8 Trends in Ratio of Government-financed R&D Expenditures in Selected Countries/Regions



Notes:

1. For international comparison, R&D expenditures of all countries other than South Korea include those of Humanities and social sciences.
2. The US figure for FY 2007 and France figure for FY 2006 are provisional.
3. The Germany figures for FY 1982, 1984, 1986, 1988, 1990, 1992, 1994-96, 1998, 2000, and 2007 are estimated values.
4. The UK figures for FY 1981 and 1983 and EU figures are estimated values.
5. EU-15 (following 15 EU countries: Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Denmark, Ireland, UK, Greece, Portugal, Spain, Austria, Finland, and Sweden)
6. EU-27 (EU-15 plus the following 12 countries: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, and Romania).

Sources:

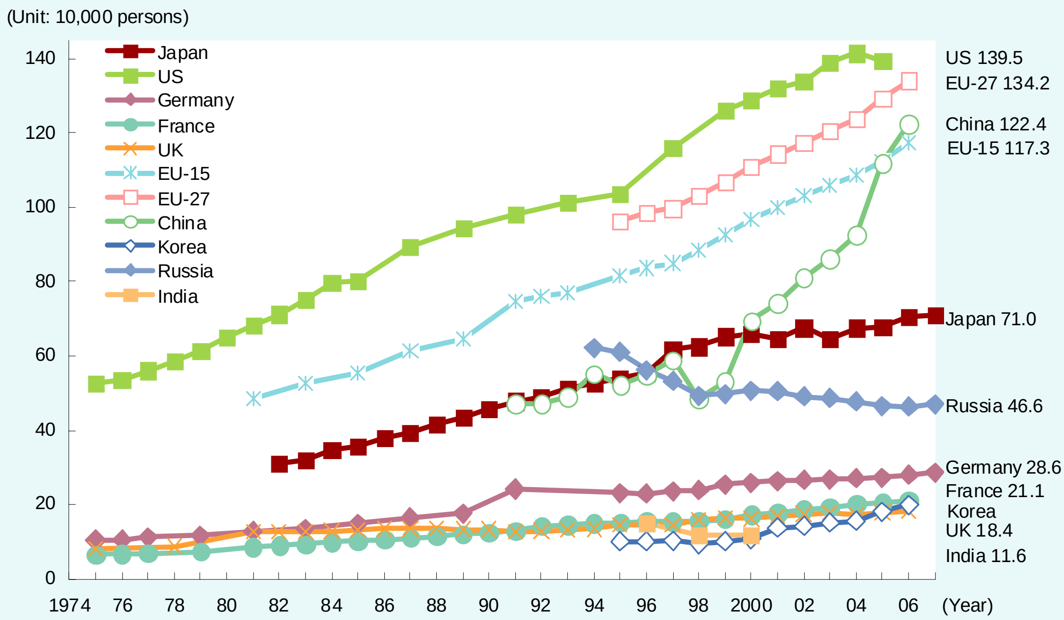
Japan: Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*

US, Germany, France, UK, China, and South Korea: OECD *Main Science and Technology Indicators Vol. 2008/2*

(3) Present status surrounding human capitals conducting research

The number of researchers in Japan has been increased continuously and the US and EU have a similar tendency; however, the number of researchers in China increased remarkably (Figure 1-3-9). In the results of investigation by NISTEP explained in (1), the top responses in all fields show that the most insufficient human resources at present are human resources at the basic research stage. Therefore, there is a possibility that sufficient researchers are not being secured at the basic-research stage. As there is a long-term trend for reduction in the number of applicants to science and engineering departments (Figure 1-3-10), this is considered a serious problem from the viewpoint of fostering researchers and engineers who will lead future science and technology. Considering that the entire nation's concern about science is increasing due to Japanese Nobel Prize winning, it is important to effectively foster, by enhancing math and science education, scientifically and mathematically inclined children.

Figure 1-3-9 Trends in Number of Researchers in Selected Countries/Regions



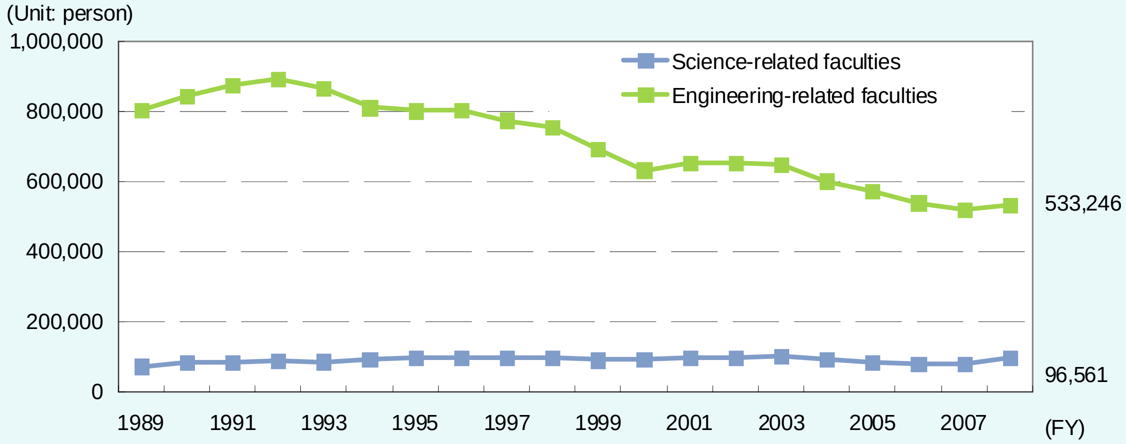
Notes:

1. For international comparison, R&D expenditures of all countries other than South Korea include those of Humanities and social sciences.
2. For international comparison, the Japanese figures are on a full-time equivalent (FTE) basis, and the figures for FY 1996 and before are estimates by OECD.
3. The Japanese figures for FY 2001 and before are those as of April 1, and the figures for 2002 and after are those as of March 31.
4. The Germany figure for FY 2007 is estimated by the German government.
5. The UK figures for FY 1983 and before are the sum of employees of industry (scientists and engineers) and national research institutes (degree holders or higher), but these figures do not include the figures of universities and private research institutes.
6. The EU figures are estimates by OECD.
7. The China figures are not necessarily based on the OECD Frascati Manual.

Sources:

Japan: [FTE-basis] OECD *Main Science and Technology Indicators Vol. 2008/2*
Other countries: OECD *Main Science and Technology Indicators Vol. 2008/2*

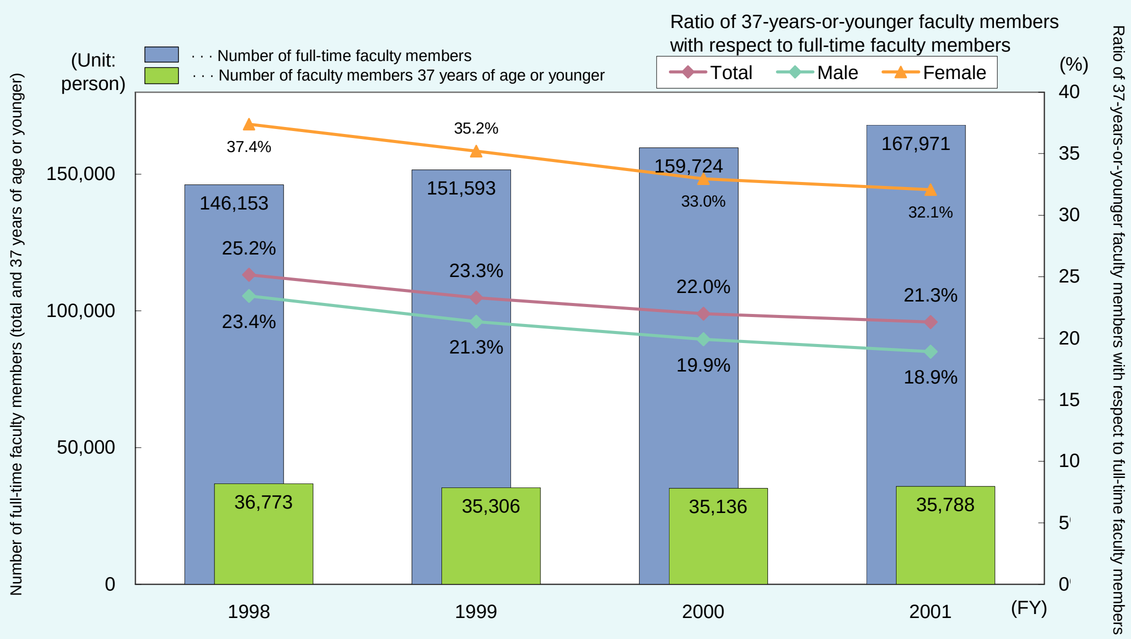
Figure 1-3-10 Trends in Total Number of Applicants for Science/Engineering Faculties



Notes:
Science-related faculties are: science, life sciences, information sciences, bio-science, bio-chemistry
Engineering-related faculties are: engineering, science and engineering, environmental and urban engineering, system engineering, fundamental engineering, biochemical engineering
Source: MEXT *School Basic Survey*

As shown in Table 1-3-4, much of the research that led to winning the Nobel Prize was conceived in the researchers' early careers. Improving the environment in which young researchers can carry out research creatively requires that Japan enhance basic science capability. However, the ratio of 37-year-old or younger faculty members at universities and colleges has decreased (Figure 1-3-11), and there is concern about employment cost reduction in incorporated administrative agencies and a reduction of scale in corporate laboratories. Thus, we cannot say that an adequate environment for young researchers exists.

Figure 1-3-11 Status of Early-career Faculty Members at Universities

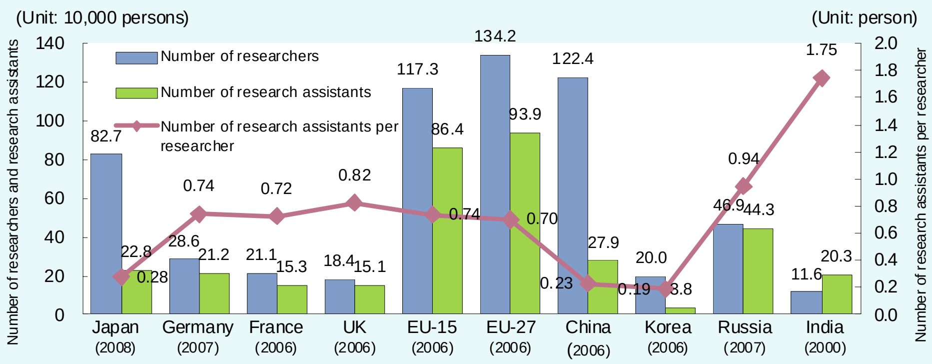


Source: MEXT *School Teachers Survey*

In addition, the number of research assistants per researcher in Japan is smaller than in other countries. It is smaller than half the number, for example, of European countries (Figure 1-3-12). The survey of the State of Japan's Research Activities (FY 2005) [literal translation] by MEXT states that 63% of researchers have too much assistant work to concentrate on their research activities. To prevent this problem, enhancing the researcher support environment is necessary.

Creating innovation requires not only researchers but various types of S&T-related competent persons, for example, persons who can create socioeconomic value from the results of creation of wisdom through conducting basic research. In this regard, some researchers in the private sector, at universities, and in government agencies point out a serious feeling of a shortage of the connoisseurs that can identify applications of research results at high quality and quantity levels (Figure 1-3-13).

Figure 1-3-12 Number of Research Assistants per Researcher, by Selected Country



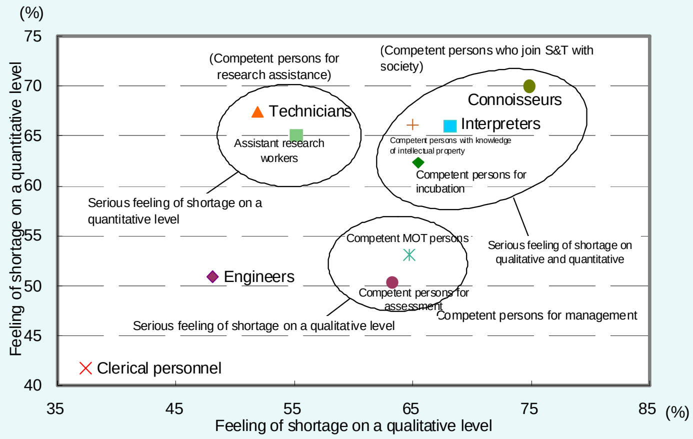
Notes:

1. The number of research assistants per researcher is estimated from the number of researchers and research assistants by MEXT.
2. For international comparison, R&D expenditures of all countries other than South Korea include those of Humanities and social sciences.
3. Research assistants are those who assist researchers, provide technical services associated with research, or perform research-related clerical duties. In Japan, they are called "assistant research workers," "technicians," or "clerical and other supporting personnel" as appropriate for their functions.
4. The Germany figure for FY 2007 is estimated by the German government. The UK and EU figures are estimates by OECD.

Sources:

1. Japan: Statistics Bureau, Ministry of Internal Affairs and Communications *Report on the Survey of Research and Development*
2. Germany, France, UK, EU, China, Korea, Russia: OECD *Main Science and Technology Indicators Vol. 2008/2*
3. India: UNESCO Institute for Statistics S&T database

Figure 1-3-13 Feeling of Shortage of S&T-related Personnel (Roles)



Note: Researchers' feeling of shortage implies the ratio of researchers who have a feeling of shortage of the relevant persons or roles.
Source: MEXT *Survey of the State of Japan's Research Activities (FY 2005)* [literal translation]

3 Comprehensive Efforts in Europe and the US

(1) Efforts in the US

1) Efforts by the Obama administration

US President Obama (right), Vice President Biden (left)
Photo: Executive Office of the President of the United States

As explained in Chapter 1, Section 1, the US doubled the budget of NIH in the five years from 1998 to 2003. In addition, various investment enhancements for basic science have been made in the US; for example, the increasing of the R&D budget of NSF, through the American Competitiveness Initiative (Executive Office of the President in February 2006) and the America COMPETES Act (enacted in July 2007, and validated in August). Under such circumstances, Senator Obama became the 44th president of the US, and a Democrat administration was brought into power; eight years have passed since the former Democrat administration left office. President Obama thought that basic research was a reliable way to advance all fields such as information and communications, medical services, economy, and security, and also thought that math and science education was necessary for the nation to maintain democracy. He made a public commitment to double the basic research budget over 10 years, making the tax credit for experiment/research funds permanent, and supporting Science, Technology, Engineering, and Mathematics (STEM) Education (Table 1-3-14). It can be expected that efforts for enhancing basic science capability will be advanced more powerfully.

Figure 1-3-14 Outline of Campaign Promises by President Obama and Vice President Biden

Five elements	Main contents
Reconstruction of fair S&T policies	1. Appointment of an Assistant to the President for Science and Technology Policy 2. Appointment of experts in S&T to key posts
Enhancement of investment in basic research	1. Doubling federal funding for basic science research over 10 years [NIH, NSF, DOE/SC, National Institute of Standards and Technology (NIST)] 2. Promotion of high-risk research, provision of grants to early-career researchers, promotion of interdisciplinary research
Enhancement of math and science education	Elementary and secondary education: 1. Improvement of the number and capacity of teachers, establishment of a math and science education committee in the Office of Science and Technology Policy (OSTP) 2. Combining of the public (especially young people) with science (great discovery) by utilizing media and the internet Higher education: 1. Creation of a Community College Partnership Program to increase the numbers of students transferring to four-year institutions 2. Creation of a new college affordable credit ensuring students that the first $4,000 of a college education is free. Recipients of the credit will be required to conduct 100 hours of community service. 3. Tripling the NSF Graduate Research Fellowship, support of participation of women and minorities
Promotion of innovation in the private sector	1. Permanent implementation of the tax credit of experiment and research expenses (expires in December 2009), and capital profit tax credits for venture and small-sized enterprises 2. Improvement of green card and temporary business visa to attract science talent from abroad 3. Reform of the patent system, expanding of next-generation broadband's reach to every community in America
Towards grand challenges for the 21st Century	1) Available clean energy, reduction of dependence on imported petroleum, and tackling global warming - Doubling federal R&D budget for clean energy within 10 years - Creation of a cap and trade system with the goal of reducing all carbon emissions by 80% by 2050 compared with the level of 1990 2) Improvement of national medical care - Doubling federal budget for NIH within 10 years (for stem cell research, individual medical care, preventive medicine) - Promotion of translational research (shortening the development period from discovery in laboratories to practical application in hospitals) 3) Enhancement of national and homeland security - Promotion of long-term high risk research by the Defense Advanced Research Projects Agency (DARPA), regeneration of the Homeland Security Advanced Research Projects Agency (HSARPA) 4) Recovery of competitiveness of manufacturing industry - Doubling funding for the Manufacturing Extension Partnership (MEP, for supporting SMEs) of NIST 5) Promotion of information technology 6) Establishment of next-generation transportation system 7) Enhancement of US initiative in the space field 8) Maintenance and increase of agricultural productivity

Sources: Prepared by MEXT based on materials by National Graduate Institute for Policy Studies; Center for Research and Development Strategy, Japan Science and Technology Agency

In February 17, 2009, President Obama signed the Economic Stimulus Act of 2008 aiming for an economic turnaround by using new S&T and efficient energy with a low environmental load. He then adjusted the S&T budget (21.5 billion dollars in total) that included an NIH budget (10.4 billion dollars) and an NSF budget (3.0 billion dollars). This budget applies mainly to basic research, medical, energy, and environmental fields. This budget was epoch-making because the NIH budget, which had decreased from FY 2004, was increased, and the budget doubling plan for NSF, DOE/SC and NIST, which was specified in the America COMPETES Act and which was said to have been unachievable, was moved back on track.

In his Address to Joint Session of Congress on February 24th, President Obama made clear again his emphasis on basic research by stating “We have also made the largest investment in basic research funding in American history”. The Budget of the United States Government FY Year 2010, which was submitted to the US Congress two days after the above administrative policy speech, specifies doubling the NIH cancer research budget, increasing the scholarship program funds of NSF graduate school, enhancing the investment to basic research of DOE/SC, and other enhancement programs. In addition, in March 2009, the Executive order to lift a ban on the government subsidy for embryonic stem (ES) cell research was signed at a ceremony which Shinya Yamanaka, Professor at Kyoto University, who generated induced pluripotent stem (iPS) cells attended.

2) Advanced efforts for enhancing basic science capability

In the US, the advanced efforts described below are being made in addition to the budget increasing efforts described in 1), which largely affects the science and technology policy in the world.

a) Support of high-risk research

The Defense Advanced Research Projects Agency (DARPA) has supported high-risk research, and successfully developed stealth planes and the ARPAnet, which produced the basic technology of the internet. In addition, federal support for high-risk research has been on the rise in recent years. Such support is, for example, the Pioneer Award by NIH, in which the influences on science and society are emphasized in screening and higher amounts of support than usual, NSF's support for the Transformative Research that has a high probability of failure but may also prove innovative for existing research fields, and the Technology Innovation Program for high-risk research on serious social problems that could not be overcome in the past. Also, many federal departments and agencies other than the Department of Defense are establishing institutes like DARPA. In addition to the foundation of ARPA-E in 2003, a budget of 0.4 billion dollars was allocated for the first time as the supplementary budget related to the Economic Stimulus Act.

Federal Demonstration Partnership logo
Source: FDP

b) Improvement in competitive funding

In the US, the concept of a fiscal year is different from that of an award year[1] related to research funds. In award years, research funds can be used without regard to fiscal years, and multiple award years can continue to provide flexible research funding. From 1986, universities, and fund distribution agencies worked together to form a framework called the Federal Demonstration Partnership (FDP)[2] to exchange honest opinions for improving the competitive funding system. The improvement plans found in FDP can be executed on a trial basis at some universities to confirm the effects, and then can apply generally. FDP has achieved many results: carrying over research funds across award years, diverting research funds to other expense items, distribution of research funds before the research term starts, and extending research terms up to one year, and other activities can be permitted by the decision of research administrators (RA) of universities, without permission from fund distribution agencies. In recent years, the peer review system[3] has been examined. In NIH, the work time system was made flexible from FY 2009 in order to assure the participation of excellent estimators, to relax the restrictions of application form counts, and to favor the first applications of researchers.

Column 10 Research Administrators in the US

One of the reasons why US R&D system is boasting extremely high research efficiency is the existence of sufficient numbers of research administrators (RA).

A research administrator is the expert who manages the research including the handling of joint industry-academia projects joint and regulations. The main job of RA is to acquire and manage competitive funding. Researchers can concentrate on their research because RA performs research management. There are about 150 thousand RAs in the US. There are also professional organizations such as the National Council of University Administrators Certification (NCURA), established in 1959 and comprising some 8,000 members. These RAs handle a broad range of activities.

50th anniversary logo of NCURA
Source: NCURA

While working as RA doesn't require any specific qualification, there is a Certificate Research Administrator (CRA) system, which is a qualification system useful for transfer between universities. The Research Administrators Certification Council (RACC), which is a nonprofit organization founded in 1993, has performed CRA testing for those who worked as RAs for a certain number of years. As research levels have become higher, and the knowledge and techniques required of RAs have become more specialized and complicated, the rate of non-teacher specialists such as RAs in universities has increased and new qualification systems specialized for some research management jobs have been established. It is estimated that RAs will play an important role in R&D systems in the US in the future as well.

3) Advanced efforts to combine basic research with innovation

The US has implemented advanced measures for establishing a system of putting the results of basic researches into practical use and promoting R&D as well as for enhancing basic science capacity.

1 A research year or a year for supplying competitive funds. In the US, an award year is one year beginning from the start of subsidization, and can be set without regard to fiscal years or calendar years.
2 FDP means the Florida Demonstration Project from 1986 to 1988, the Federal Demonstration Project from 1988 to 1996, or the Federal Demonstration Partnership from 1996. At present, 120 universities, and 14 fund distribution agencies are participating.
3 Review by researchers belonging to nearer fields of specialization

a) Establishment of government venture capital

The government venture capital "In-Q-Tel," which was established in 1999 by the Central Intelligence Agency (CIA) prior to other departments and agencies established such capitals, has successfully acquired many technologies by supporting the overcoming of serious problems, the "Valley of Death," [1] by venture enterprises by utilizing the merit of making the investment specific to technologies satisfying its purpose. Considering such success, the United States Army established "On Point Technologies" in 2003, and the National Aeronautics and Space Administration (NASA) established the Red Planet Capital, both government venture capitals.

b) Utilizing the competitive funding of reward type

DARPA and NASA have competitive funding systems of the reward type, by which funds are supplied to the research groups that have reached the set targets. Such a system is operating in the programs for developing unmanned long-distance-running vehicles, lunar modules. Such a trend also applied to the Federal Aviation Administration (FAA) to plan the competitions for developing hydrogen technology and reusable jet fuel.

(2) Efforts in Europe

In Europe, the Seventh Framework Programme for Research and Technological Development (FP7) has been active from 2007 to support cooperative research across member countries for the establishment of the European Research Area (ERA). The yearly research funds based on FP7 are 41% higher than FP6. Out of these funds, 7.46 billion Euros will be supplied to support individual researchers via the European Research Council (ERC), which is expected to contribute significantly to the enhancement of European basic science capability. Concrete support applies mainly to young researchers and advanced and high-risk research including basic research to establish excellence of knowledge. The competition rate of support screening is very high.

The European Technology Platform (ETP), which was organized mainly by the industrial world, made the industrial world participate in FP7 positively, and attracted global attention as it supplied a new framework to discuss medium- to long-term strategies on a public occasion by private sectors, universities, and government agencies (Table 1-3-15).

1 Refers to stages between basic research and product development, where the support for R&D is insufficient.

Figure 1-3-15 European Technology Platform Synopsis

Configuration	- Relevant persons gathered for each field at the initiative of industry for enhancement of Europe's competitiveness, and ETP was established in a bottom-up approach. - Enterprise CEOs and government authorities must always participate in ETP, and stakeholders of all the related industry and academia are welcome to participate in it.
Role	- Creation of fair and transparent visions about technology of the targeted fields, and establishment and execution of strategy research agenda - Standardization of technologies, and establishment of networks on national and regional levels (by attracting investment) - Supply of information on acts and regulations as obstacles to commercialization, and supply of means for eliminating these obstacles - Proposition of education and training required for technology development.
ETPs	- Innovative Medicines Initiative - Nanotechnologies for Medical Applications - Food for life - Forest-based Sector Technology Platform - Global Animal Health - Plants for the Future - Water Supply and Sanitation Technology Platform - Mobile and Wireless Communications - Networked European Software and Services Initiative - Networked and Electronic Media - Embedded Computing Systems - European Technology Platform on Smart Systems Integration - Photonics21 - European Nanoelectronics Initiative Advisory Council - Future Textiles and Clothing - European Steel Technology Platform - Advanced Engineering Materials and Technologies - European Construction Technology Platform - Future Manufacturing Technologies - Robotics - Sustainable Chemistry - Photovoltaics - Zero Emission Fossil Fuel Power Plants - ZEP - European Biofuels Technology Platform - European Technology Platform for the Electricity Networks of the Future - European Technology Platform for Wind Energy - Hydrogen and Fuel Cell Platform - European Road Transport Research Advisory Council - European Rail Research Advisory Council - Advisory Council for Aeronautics Research in Europe - Waterborne ETP - Industrial Safety ETP - European Space Technology Platform - Integral Satcom Initiative

Source: Prepared by MEXT based on materials by Center for Research and Development Strategy, Japan Science and Technology Agency

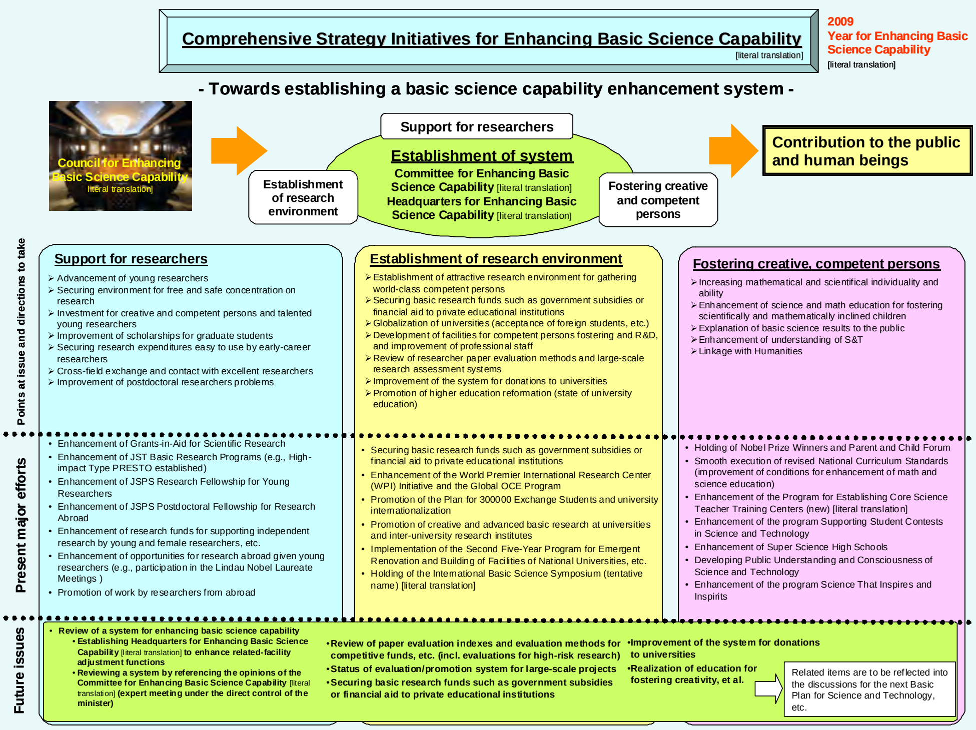
4 Towards Enhancing Basic Science Capability

(1) Formulation of Comprehensive Strategy for Enhancing Basic Science Capability

The winning of the Nobel Prize by several Japanese researchers in 2008 led to the establishment of the Council for Enhancing Basic Science Capability [literal translation], headed by the Minister of MEXT and consisting mainly of experts including Nobel Laureates. The council had discussions about the direction of various problems from the viewpoint of support for researchers, development of research environment, fostering of creative human capitals. Based on the findings of the discussions, MEXT compiled the Comprehensive Strategy Initiatives for Enhancing Basic Science Capability [literal translation] (Figure 1-3-16) in December 2008[1]. Designating the year 2009 as the "Year of Enhancing Basic Science Capability"[literal translation], MEXT is advancing further reviews by holding meetings such as the Committee for Enhancing Basic Science Capability [literal translation] consisting mainly of experts, in order to establish the Comprehensive Strategy for Enhancing Basic Science Capability [literal translation] that gave shape to the above initiatives. Systematic efforts are important to enhance basic science capability, and comprehensive efforts including ones for medium- to long-term issues are necessary.

In February 2009, the Long-Term Measures Reviewing Working Group for Basic Research Enhancement [literal translation] was established under the Expert Panel on Basic Policy Promotion of the Council for Science and Technology Policy, to begin reviewing research system reform for enhancing basic research.

Figure 1-3-16 Comprehensive Strategy Initiatives for Enhancing Basic Science Capability



Source: Prepared by MEXT

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1 Partly revised in January 2009

(2) Promotion of research driven by researchers' free ideas

All research activities should be based on the free thinking or curiosity of the researcher. Learning can advance and innovation can be come about only when there is a thick accumulation of old knowledge that will bear new knowledge. It is very difficult to forecast the route from an earlier research stage to future innovative technology. Innovative technologies can only be generated by various research trial and error and friendly competition. In a modern society that is growing in diversity and changing rapidly, it is extremely important to make research based on free thinking that is not mired in conventional rules and common conceptions. Flexible thinking and fresh ideas are expected not only to create results that contribute to future social development but also to create a new sense of values that will allow societies to avoid being stuck in a rut. We have advanced research based on the researchers' free thinking, by supporting basic expenditures, the Grants-in-Aid for Scientific Research. Acquiring the necessary funding to achieve the goals of government R&D investment, which is about 25 trillion yen[1] specified in the Third Science and Technology Basic Plan (Cabinet decision: March 2006), the investment that supports its groundbreaking years must be positively increased. In this case, as social understanding of basic research not related to short-term benefits is deepening because Japanese researchers were awarded the Nobel Prize, further deepening such social understanding is very important.

(3) Establishment of a system covering a range from basic research to innovation by industry, academia and government

Joining the results of basic research to innovation requires more than advancing many research projects based on the free ideas of researchers. That is, such joining requires not only advancing creative basic research of the problem set type, which contributes to the solution of social problems, but also advancing R&D for future practical use. In addition, for such joining, a system for the creation of innovation must be established by the private sector, universities, and government agencies. In this case, considering that investment for high-risk research has been enhanced in other countries, extremely challenging research must be positively supported in Japan as well so that the bud of research which will lead to large innovation can be properly secured.

From this point of view, JST Basic Research Programs, which is the policy-problem-solving basic research system for leading to breakthroughs in addressing important policy problems, must be powerfully advanced together with support for high-risk research. For this purpose, as establishing a strategy that links policy problems to research areas is important, the Center for Research and Development Strategy (JST/CRDS) was established at the Japan Science and Technology Agency and its function has been enhanced.

Next, it is necessary to improve the base used for basic research to create innovation by both of industry and academia. The Innovation Center for the Fusion of Advanced Technologies program, which is included in the Special Coordination Funds for Promoting Science and Technology, is used for the improvement of such a base, and is positioned as an innovative

1 It is assumed that the ratio of government R&D investment to GDP during the basic plan period from 2006 to 2010 is 1%, and the nominal GDP growth rate during the same period is 3.1% in average.

research site described in the report in Column 3, “Expectations and Responsibility of Industry for Basic Research [literal translation]. This program is designed to lead system reformation, and must be enhanced to appropriately accumulate and spread knowledge and findings.

As creating industry-academia-government joint bases by considering the ETP efforts described in 3 (2) is recommended by the report Towards Promotion of Problem-solving-type Innovation Contributing to International Competitiveness Enhancement” [literal translation] (May 2008, Japan Business Federation) and by the above-mentioned report, it is important to improve sites at which processes from basic research to innovation can be examined by industry and academia together.

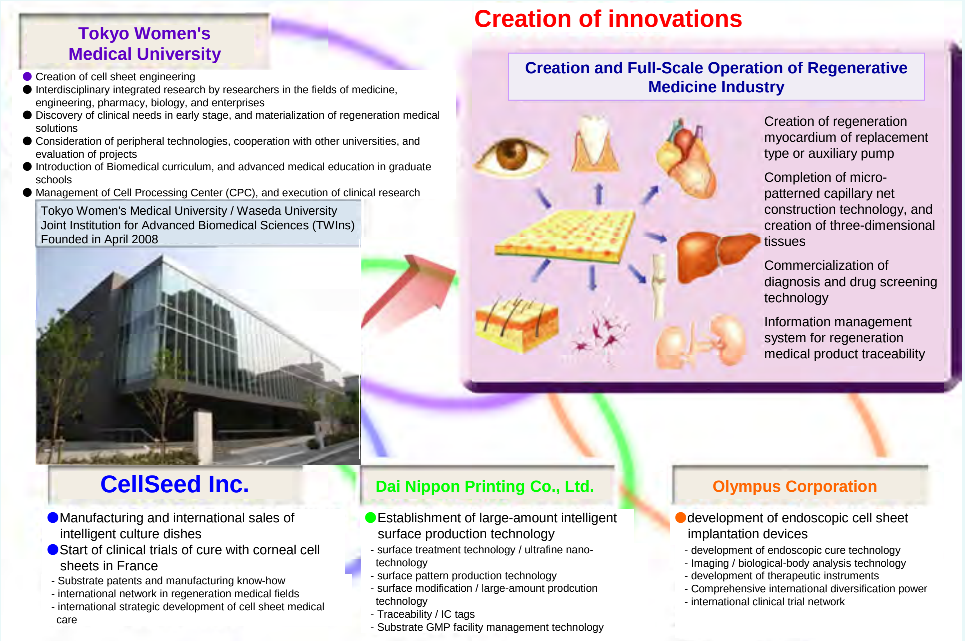
It is also important to enhance the function of “joining” research results with each other by additional linkage of a technology-practical-use-support system with a basic-research-support system, by improving the system for linking expert human resources with one another, and by supplying investment-factor-included funding by the government. In addition, establishing a subsidy system of the reward type is important to directly prompt the development of advanced technologies that can lead to practical use. In particular, the fostering and expanding of the bud of technology have been supported by the program Collaborative Development of Innovative Seeds and the Project to Develop "Innovative Seeds". To make optimal business expansion possible, private sectors, universities, and government agencies must cooperate to plan and execute more flexible efforts depending on individual technology buds.

Appointment of postdocs in industry-academia-government joint research, corporation R&D, is very important and should be positively expanded because it advances industry-academia-government joint activities and advances the diversification of future career paths of postdocs (systematic path of business type and post). Its positive expansion is expected.

Column 11 Innovation Center for Fusion of Advanced Technologies Program

The Innovation Center for Fusion of Advanced Technologies is the program of the Special Coordination Funds for Promoting Science and Technology (SCF). With support by this program, universities can make efforts, from the basic stage under cooperation with corporations, for executing the R&D for innovation such as new industry creation in advanced interdisciplinary research areas. Twenty-one projects were adapted from FY 2006 to 2008. The universities and institutes of which projects were adopted advanced R&D energetically, and some projects succeeded in realizing practical application of the results. The following figure shows some examples of success. As this program is a large-scale program for which the government will give 6 billion yen support for up to ten years, further results are expected.

Advanced Technology Fusion Center for Full Scale Regenerative Medicine [literal translation]



- Advanced Interdisciplinary Technology Center for Full-Scale Regeneration Medical Care (Tokyo Women's Medical University)

The cell sheet engineering was developed by the Tokyo Women's Medical University. The university cooperates with CellSeed Inc., which is a university venture, Dai Nippon Printing Co., Ltd., which has micro fabrication techniques, and Olympus Corporation, which is in charge of the development of endoscopic transplantation instruments [literal translation], from the basic research stage in order to apply safe and effective regeneration medical technologies for clinical application in creating innovation in the regeneration medical industry. Until now, this group center succeeded the mass production of temperature-responsive culture dishes that enabled the peeling and recovery of the cell culture sheets with cell-adhesive protein, for which sales system was established in the world. They also succeeded the establishment of the epithelial-cell culture system which does not need patient autoserum for incubation. In Europe, they are performing clinical trials with regenerated corneal epithelium cells. Also clinical research on an artificial ulcer cure was started, at its medical school hospital, by transplanting oral-mucosal epithelial cell after esophagus cancer removal. Clinical research on paradentium regeneration using periodontal membrane sheets is now under way. The center also works on the establishment of cell culture plants conforming to the Good Manufacturing Practice (GMP) standard[1], and the development of the cell-sheet tracking technology using transplantation instruments and dedicated tag indicators. These measures aim for the world's first cell-sheet regeneration cure and its dissemination to the world, and future development is sure to attract attention.

Source: Tokyo Women's Medical University

1 Standard of manufacturing control and quality control of medicines and quasi drugs

(4) Development of an environment to enable advanced research, and establishment of a system so that researchers can concentrate on their research

Masatoshi Koshiba, Honorary Professor Emeritus at the University of Tokyo, successfully detected neutrinos using the experimental system Kamiokande equipped with about 1000 high-performance photomultipliers and received the Nobel Prize in Physics in 2002 for his efforts. In addition, the correctness of the theory proposed by Makoto Kobayashi, Honorary Professor Emeritus at KEK, and Toshihide Matsuyama, Professor Emeritus at Kyoto University, who were awarded the 2008 Nobel Prize in Physics, was proven in experiments using the B-factory (KEKB) by which electrons and positive electrons could be made to collide with each other at a high frequency. As shown by these facts, improving the advanced research facilities and providing an easy-to-use environment are important factors in enhancing basic science capability. Sharing the large-scale, high-performance advanced research facilities, which can enhance the value of research in a variety of fields, should be advanced under the direction of the nation government. For this purpose, MEXT submitted to the Diet the Bill for Partial Revision of the Act on Promotion of Shared Use of Specified Large-scale High Technology Research Facilities that positioned the Super Photon ring-8 GeV (SPring-8), next-generation supercomputer, and neutron science facility of J-PARC as specified large-scale high technology research facilities. Spring-8 produced various results such as the practical use of new intelligent catalysts[1] and the development of new hair-care products. Raising the expectations for J-PARC, the efforts for enacting the bill are necessary and supporting the universities to enable them to open their own advanced research facilities and equipment to the public is important to advance utilization by corporations.

In addition, acquiring excellent research supporters is further demanded so that researchers can concentrate on research in order to demonstrate their creative abilities. Also, the support system enhancement, including the appointment of postdocs, is required. As for reducing the load of office work related to competitive funds is a serious problem, efforts for solving this problem are required. On the other hand, improving the competitive funding system is important to reduce the business load. The R&D-Capacity Strengthening Act [literal translation] specifies the improvement of the unified use standard of the funds related to the open recruitment type R&D, and specifies the control transfer, to incorporated administrative agencies, of the jobs that are related to the open recruitment type R&D. As the study meeting for effective use of research funds is being held at present mainly by the Cabinet Office and by R&D corporations, universities, the generation of deepened examination results is expected.

Furthermore, creation of a completely new system giving researchers the first priority is required in order to improve the support system that allows researchers to concentrate on research and utilize research funding applied over multiple years freely. For this purpose, the Bill for Partial Revision of the Act on the Japan Society for the Promotion of Science, Independent Administrative Institution was submitted to the Diet in order to establish the funding for a five-year intensive promotion of R&D that can provide results that lead the world in the fields of

1 Catalyst having self-renewal function to keep catalyst activity. Used for cleaning automobile exhaust emissions

advanced science and technology.

Figure 1-3-17 Funding Program for World-Leading Innovative R&D on Science and Technology

Sources: Cabinet Office; MEXT

2 Towards Developing Globally Open, Highly Appealing Research Environment

1 Efforts by Other Countries to Develop Research Environments

(1) Promotion of measures for acquiring competent persons in other countries

As described in Chapter 1, Section 2, other countries have positively advanced receiving policy and improvement of environments for the creation of innovation in order to attract high-talent personnel. These measures include the improvement of immigration control systems, sending and callback of domestic researchers to and from other countries, positive receiving of overseas researchers, international PR activities for domestic researchers living abroad, and other various activities (Table 1-3-18).

Out of these counties, the US in particular has attracted capable researchers from various countries around the globe for a long time, and has led the world in the creation of innovation. However, after a series of terrorist attacks in September 2001, the Immigration and Nationality Act was revised so that the upper limit of the number of visas that could be granted for professions requiring special skills (H-1B Visa) was reduced to 65,000, and the screening criteria for overseas students and researchers was made more rigorous. The act for granting additional visas was later enacted for applicants with master's or higher academic degrees; however, there are increasing demands for a further relaxing of the visa granting limit because movement of overseas students and researchers may be continuously restricted in the future.

In China, where "Innovation through self-developed technology (China's original innovation)" has been announced and an emphasis has been put on science and the development of technology and the creation of innovation, the policy to call back capable domestic researchers from other countries and the policy to invite overseas researchers to China are being positively developed to improve the level of S&T and to catch up with other developed countries. Some experts have pointed out that such researchers have taken a central role in R&D activities within China.

Table 1-3-18 Major Policies in Selected Countries for Acquiring Competent Persons

	System of receiving researchers	Typical policies for inviting overseas competent persons
US	• Receiving permanent residents with work visas Receive workers in professional and technical fields classified into five categories according to ability. • Receiving foreign workers with residence limits Issuing special technician visas (H-1B visas) to residence-limited workers of occupations special technique such as mathematics, engineering, physics, and medicine	• Summit on International Education Held by the Department of State in January 2006 together with 50 US university presidents. Promotion of receiving capable overseas students and researchers with cooperation between government and universities. * The measures for acquiring excellent researchers depend on voluntary efforts by government agencies (e.g., NSF), research institutes, and universities.
UK	• Highly Skilled Migrant Programme (HSMP) Accept university graduates, medical physicians, and financial experts. Introduction of a point-based system (by counting academic background, career, past income, performance in desired field) in the acceptance examination. Permission for permanent residence can be applied for after five-year residence.	• Research Merit Award Provide UK universities with additional support to attract outstanding researchers or to retain those who might seek to gain higher salaries. * The strategy compiled at the Global Science Innovation Forum in October 2006 specifies "excellence in research" as one of the priority areas, and demands enhancement of international cooperation and the attraction of excellent researchers to the UK.
Germany	• Receiving highly skilled immigrants Receive highly skilled immigrants such as scholars, professors, scientists, experts having income above a certain level, corporation executives (Supply of unlimited residence visas) according to Das Zuwanderungsgesetz [the new Immigration Act (2005)] • The overseas students who formally completed their academic work are permitted to stay for one year after graduation in order to seek employment within Germany.	• Excellence Initiative To establish internationally known, core research institutes, the government supports universities that are superior in science. • Expansion of measures calling back competent persons Enhancement of efforts for calling back competent persons by improving the research environment in order to prevent brain drain to the US and the UK
France	• Measures for relaxing immigration conditions and receiving procedures of highly skilled technicians Issuing temporary stay permits quickly to newly arriving senior executives or highly skilled workers from overseas who satisfying fixed conditions	• Improvement of the treatment of young researchers in Centre national de la recherche scientifique (CNRS) in order to prevent researcher drain to overseas countries and to attract excellent overseas researchers

	System of receiving researchers	Typical policies for inviting overseas competent persons
EU	• EU Blue Card For free worker movement inside the EU. Worker movement from newly acceding countries to old acceding countries is permitted based on the EU Accession Treaty (signed up in April 2003) as a transitional measure for seven years maximum.	• Enhancement of the Marie Curie Action Program for increasing mobility of researchers in the whole EU region mainly by utilization of a scholarship system for fostering researchers in the entire EU. For suppressing brain drain and for acquiring and calling back external researchers.
China		• Plan 111 (inviting more than 1,000 scientists from the world's top 100 universities and research institutions to organize approximately 100 joint research teams with prominent domestic researchers) • Execution of competent persons policy for promoting excellent researchers from inside and outside China, based on the One Hundred Outstanding Young Chinese Scientists by CAS and the Changjiang Scholarship Program by the Li Ka Shing Foundation • Worker sending to overseas countries under the condition of future return to China Program for dispatching students (at the doctoral or higher level) to overseas countries, under the condition of future return to China, based on the National High-Level Researcher Public-Funds Dispatching Project [literal translation] and the Visiting Scholar Public-Funds Dispatching Project [literal translation].
South Korea	• Gold Card (for eight fields such as nanotechnology, biotechnology, and environment fields), IT Card, and Science Card (master/doctor) Introduction of a card system for the promotion of the acceptance of competent persons. Supplying various merits such as extension of the visa expiration date of the card holders. Remarkable shortening of visa issuing time	• Study Korea Project Tripling the number of foreign students by 2010. This goal was achieved in 2007. • Brain Pool Project Keeping excellent overseas scientists and engineers for two years maximum in public or private research institutes • New Science and Technology Investment Strategy of the Government [literal translation] Inviting 1000 overseas researchers to South Korea by 2012 • World Class University (WCU) Inviting excellent overseas researcher with high research ability to the research fields that universities must enhance in the future, in order to increase the education and research competitiveness of universities in South Korea to the international levels
Singapore	• P Pass and Q Pass System for accepting workers who have a certain academic background or qualification, work in professional or technical fields, and have income above a certain level. The number of these workers is not restricted. The P Pass is for business executives, and the Q Pass is for high-level professions, administrators • Positive supply of permanent residency, citizenship to competent persons	• Contact Singapore Establishing overseas offices in Boston, London, Shanghai, Sydney to supply Singapore work information • Maintenance of research platform for attracting overseas or multinational corporations • Positive invitation of prominent research resources by utilizing personal connections of the high officials of A*STAR • Establishment of the Singapore Talent Recruitment Committee for actively inviting overseas competent persons

Sources: Prepared by MEXT based on materials by Center for Research and Development Strategy, Japan Science and Technology Agency; National Institute of Science and Technology Policy; Cabinet Office, and OECD *The Global Competition for Talent: Mobility of the Highly Skilled*

Singapore is known as a country that receives many competent persons from other countries. In Singapore, government agencies, especially the Singapore Workforce Development Agency (WDA), have various preferential treatment policies; for example, inviting many world-renowned personnel from abroad, introducing their knowledge and technologies to domestic organizations and corporations, inviting excellent young students from Southeast Asian countries to universities in Singapore, and fostering and granting Singapore citizenship to them.

Column 12 Efforts in the "Contact Singapore"

In Singapore, not only are prominent R&D centers such as Biopolis maintained at the initiative of the government but policies for inviting world-famous personnel from overseas are actively pursued. In particular, "Contact Singapore" by the government-established Singapore Talent Recruitment Committee (STAR) is remarkable.

Contact Singapore, which was founded about 10 years ago, established overseas offices in Boston, London, Shanghai, Chennai, Sydney and is now supplying the following information on returning to and residence in Singapore, to overseas Singaporeans and overseas nationals, by telephone and the internet:

1. Information on going to Singapore for overseas education
2. Information on consultation for searching jobs in Singapore, and online application for jobs
3. Information on how to acquire various types of visas
4. Information on the housing situation and child education

Thus, Contact Singapore contributes significantly as a unified window to encourage overseas Singaporeans to return home and to invite overseas nationals, to acquire competent persons.

In South Korea, the National Science and Technology Council announced in May 2008 the New Government's National R&D Investment Strategy [literal translation] to invite 1,000 overseas researchers with high ability of research. Also the World Class University project (WCU) was started with the major goal of increasing domestic university education and research competitiveness up to the world level by inviting overseas researches.

(2) Efforts by other countries to establish research centers

In the US and Europe, universities and other research institutions on both the national and state levels are working to establish highly attractive, top-class research centers in order to secure many capable researchers. To realize this goal, they are carrying out wide-ranging system reforms. Since each research center has its own distinct historical background and process of establishment, it is not possible to make simple comparisons; however, it can generally be said that top-class research centers possess the following characteristics:

1) Existence of a world-class leader and a clear vision as a research center that attracts researchers

One example of a research center with such a world-class leader and vision that has succeeded in attracting a great many excellent researchers is the MIT Media Lab in the US. Advancing richly creative, far-sighted research within a rapidly digitizing society, the MIT Media Lab attracts researchers by virtue of its stature and reputation as a research leader of the world's highest level in the fields of physics, computer science, and mathematics[1]. It also attracts talented people by incorporating within its vision a philosophy that answers two questions: Are we creating new trends that haven't existed to date? And are these new trends of significance to society?

1 The number of times that papers in the fields of physics, computer science, and mathematics have been quoted is No.1, No.2, and No.8 respectively in the world.

2) Execution of unique innovative efforts

One example of a research center that has attracted researchers by unique innovative efforts is Bio-X of Stanford University. This center has undertaken innovative efforts to promote field fusion research into important problems in life science by joining multiple fields such as biology, medicine, engineering, physics, and chemistry at the university. Concretely, the center has the environment for widening researchers' view and creating new flows on both the software and hardware sides. Examples of the hardware environment are the research rooms of which structure can be flexibly changed according to research style, and comfortable rooms for stimulating conversation. Examples of the software environment are the projects that join fields across sections and which are executed any time day or night, and the intention to use the same general-purpose technical terms in conversations instead of technical terms that researchers in other fields cannot understand. Researchers are attracted by these unique innovative efforts that may lead to new discovery or creation.

3) Research environment attractive for researchers

One example of top-class research centers with attractive research environment is the MRC Laboratory of Molecular Biology in the UK. This laboratory is the notable center that has produced 12 Nobel laureates. Many researchers are attracted by the efforts of this center. For example, research funds can be distributed so that important high risk research can be continued for the long term, and an optimal environment is established so that excellent young researchers can become group leaders and can concentrate on their own research by reducing the need to handle administrative activities.

2 Towards Establishing Outstanding Research Centers and Acquiring Research Personnel

(1) Towards developing environment in order to attract overseas students and researchers

To attract overseas researchers and students to Japan, the goal of the Plan to Accept 100,000 Foreign Students was established in 2003 and efforts for relaxing the restrictions for receiving information technology engineers were made. However, Japan's status of receiving foreign students is poor as compared with other major developed countries as described in Chapter 1, Section 2. Japan has received overseas students mainly from Asian countries, but it is said that high-talent personnel in Asian countries have a tendency to select the US or European countries as a first choice.

In light of this, the Plan for 300,000 Exchange Students[1] was established in 2008. The plan aims to achieve a goal of receiving 300,000 overseas students by around 2020 and is working to develop a global strategy for making Japan more open to the world and enhancing the flow of personnel, things, money, and information between Asia and the world. This plan aims for further advancement of acquiring excellent overseas students as compared with the past years, and

1 Outline of the Plan for 300,000 Exchange Students (In July 2008 by MEXT, Ministry of Foreign Affairs, Ministry of Justice, Ministry of Health, Labour and Welfare, Ministry of Economy, Trade and Industry, and Ministry of Land, Infrastructure, Transport and Tourism)

comprehensively promotes efforts for information transmission to motivate overseas study, for developing unified customer services for students requesting overseas study, for improving the entry conditions (entrance examinations, admissions, and immigration), for improving the receiving system of universities, other education agencies, and society, and for improving the exit conditions (employment support after graduating). Thus, overseas education to Japan is facilitated.

In addition to the above programs for the acquisition of overseas students, it is also important to receive researchers according to the purpose and stage of research in each university. For this purpose, the Japan Society for the Promotion of Science (JSPS) has executed various types of invitation programs to attract excellent personnel, from young overseas researchers to prominent researchers of the Nobel-prize level, such as, Postdoctoral Fellowship for Foreign Researchers, Invitation Fellowship Programs for Research in Japan, and JSPS Award for Eminent Scientists, according to the research stage and invitation purpose. This has improved the level of science research via Japan's internationalization of its research environments or joint research.

In the future, it is necessary to form a network between overseas researchers and research institutes by maintaining and widening such efforts.

(2) Towards establishing attractive centers for acquiring competent persons from all over the world

For acquiring excellent domestic and overseas researchers and for improving Japan's level of research among fierce international competition, it is necessary to establish the top-level research centers that are attractive to researchers. For this purpose, MEXT launched the World Premier International Research Center Initiative (WPI Program) in 2007 in order to establish internationally-respected, "globally visible research centers" that attract internationally remarkable front-line researchers, by providing excellent research environments and achieving an extremely high level of research.

Key to the feasibility of the WPI centers is the existence of a center director who can exercise strong leadership and the existence of an administrative director who can strongly support a center director and researchers at the center. For this purpose, this program proposes to give strong leadership to the center director, the face of the "globally visible research center." This program also proposes to invite excellent principal investigators (PIs) at the professor or associate professor level from abroad under the leadership of the center director so that the number of overseas PIs will reach about 10% to 20% of the total number of PIs. In addition, the number of the overseas researchers, including short-term visiting researchers, should always be about 30% of the total number of researchers. The administrative director is strongly required to provide environment so that the center director and researchers can concentrate on their research. To achieve the goals above, each center is required to make various efforts voluntarily such as (1) offering to center director a salary equal to or higher than that of the university president, (2) center director's authority concerning recruiting teaching staffs and project determination, (3) secretariat to work in English and technical staffs with a wealth of experience to provide support in English, and (4) employment of specially appointed teaching staff after retiring as an exceptional basis and flexible contract terms of researchers. In addition, positive efforts can be made to provide research environment improvement including livelihood support for overseas researchers.

To realize a top world-level research environment, each center must vigorously advance system reform without regard to conventional systems and customs, and the facilities and equipment of each center must be enhanced and expanded.

Column 13 Towards Establishing a "Globally Visible" Top World-level Research Center

Prof. Hitoshi Murayama is a person working to create a “globally visible” top world-level research center. The Institute for the Physics and Mathematics of the Universe (IPMU) at the University of Tokyo was established as a center supported under the World Premier International Research Center Initiative (WPI Program), which was launched by MEXT in FY 2007. Every day, more than 1,000 elite researchers, selected via international recruitment, conducting research at IPMU. In the brief period of 1.5 years from its establishment, IPMU has assembled a body of researcher that is over half from overseas. Two-thirds of them are European and the US researchers, including Nobel Prize or Fields Medal winners. In this way, IPMU has started its operation as a center open to the world. The following are some excerpts paraphrased from an interview with Prof. Murayama, IPMU Center Director. He talked about various issues related to establishing the institute and building up its operation.

IPMU members
(Center director Hitoshi Murayama, middle, front row, as of October 2008)
Photo: Institute for the Physics and Mathematics of the Universe, The University of Tokyo

・Promotion of Researcher Exchange In and Out of IPMU

While working to assemble excellent researchers from overseas, IPMU carries out an active program of both sending and receiving researchers with an eye to making itself a “globally visible” research center. In its new facilities under construction, a communication space is being prepared and rooms arranged in a spiral configuration so as to make it easy for researchers to communicate with each other. Research integration is promoted by researchers from different fields participating together in seminars and by conversing with each other during a coffee break held at 3 o’clock every day. To advance a proactive interchange of researchers, IPMU is also working to establish exchange agreements with leading research institutions in Germany, the US and France.

In addition, all IPMU researchers, including those employed full-time, are obliged to go abroad for one to three months every year. Doing so gives overseas researchers working at IPMU a clearly needed chance to go out and disseminate the results of their research. On the other hand, the system also provides a valuable opportunity for the Japanese researchers, some of whom rarely go abroad, to acquire higher “visible” overseas. In Japan, researchers, particularly assistant and associate professors, tend to be tied to work in their laboratory, creating a situation in which only postdocs can easily go abroad. IPMU, however, established this system because it believes it important for even researcher in full-time or tenured posts to go abroad. International conferences held by the institute every other month also provide good opportunities for non-IPMU Japanese researchers to gain international experience.

・Competition for Talent in the US

In the US, there are frequent changes in the ranking among the top 10 or so universities. They vie fiercely for talent personnel.

The salaries of researchers in the US are determined via direct negotiation with their superiors. For example, when offered employment by another university, researchers may discuss the offer with their supervisors, who are authorized to negotiate salary and working conditions in an effort to retain the researcher. As a result, the salary of a researcher who receives other offers may steadily increase via such negotiations.

Major conditions underscoring a researcher’s decision to transfer may be as follows: (1) ample supply of research funding (assurance of investment in his/her field of research, including start-up funding), (2) ample space for research work, (3) 20% to 30% higher salary, (4) subsidy for children’s schooling, (5) low-interest housing loan, and (6) good impression of the new organization.

・Problems in Acquiring Good Researchers at IPMU

In employing overseas researchers at IPMU, we offer competitive salaries based on overseas standards, pay half of the cost for children’s international school enrollment, provide housing, and assist accompanying spouses in job searches. We have had to exert considerable effort in helping overseas researchers apply for credit cards as most do not have a credit history in Japan and each case must be handled individually. We have greatly strengthened our support system, including assistance by voluntary interpreters, but are still grappling with problems of housing, children’s education, and spouses’ job placement. Moreover, the University of Tokyo does not at present permit IPMU to give overseas researchers tenure (the right to be a permanent faculty member, without having to periodically renew an employment contract). This has an especially big impact on being able to attract competent young researchers from overseas. We also lose a lot of good researchers whom we want retain because of this policy.

・Desirable Approach to Hiring Overseas Researchers in Japan

What is important in hiring researchers from overseas is to clearly explain to them the circumstances under which they will be employed. In Japan, the feeling exists that an applicant should not reject an offer after having been screened and accepted. In the US, however, employers and applicants have a more equal footing in the hiring process. According, they may spend two full days in interviews evaluating each other. It is important to keep such differences in mind when looking to hire researchers from the US and other Western countries.

3 Towards Expanding Research Opportunities Overseas for Japanese Researchers

Creating innovation through revolutionary science and technology is an urgent issue for Japan. The basics of innovation belong to a "person." Researcher's experience through friendly competition with other researchers with a different sense of values and different cultural backgrounds is very important because it helps to develop the researcher's creativity and ability to take a larger view. For fostering a competent person who has a potential of being active internationally with a global network, it is required for Japan to tackle the big challenge of expanding research opportunities overseas to enhance the mobility of domestic researchers at home and overseas.

(1) Efforts in Europe and the US

As the international mobility of researchers has been emphasized, the open-type recruitment based on merit or a competitive system is strengthened at universities and research institutes in the US. Therefore, researchers can not be always be employed by the universities they graduate from. Young researchers usually work at different research institutes before gaining tenure. This promotes the personnel mobilization. In addition, there are cases where researchers employed by a university are only paid for a portion of the year by their organization and must obtain other funding to cover the rest of the year. Such a situation prompts researchers to conduct research and make presentations outside of their organization. Thus, the US has grounding in increasing the mobility of researchers.

In Europe, the program for building careers of researchers who live in Europe and abroad is implemented in FP7: brain drain is suppressed and the acquisition and callback of researchers from outside the region are promoted by increasing the mobility of researchers within Europe and by increasing research opportunities.

In addition, the courses and programs for students and young researchers to experience education and research at overseas institutes are enhanced in the US and Europe. For example, NSF launched the Partnership for International Research and Education (PIRE) program to enhance the opportunities overseas for students and young researchers. In Europe, the Marie Curie Initial Training Networks (ITN) is a part of the above FP7, to support the systematic exchange and fostering of young researchers at institutional level.

(2) Towards expanding research opportunities overseas for Japanese researchers

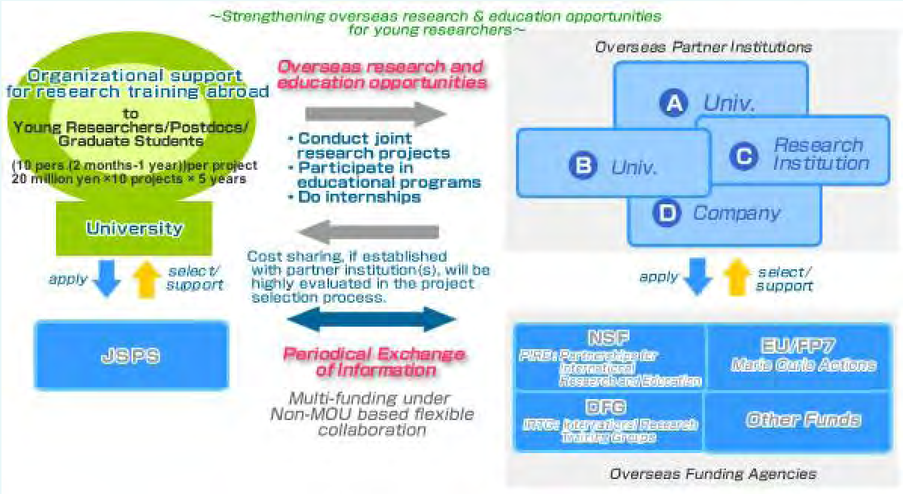
Also in Japan, overseas opportunities for domestic researchers, including autonomous efforts by various universities, have been supplied. For example, the JSPS Postdoctoral Fellowship for Research Abroad has supported excellent young domestic researchers so that they can be sent to overseas universities for two years and concentrate on their research based on their own research plans. The program aims to foster and acquire excellent researchers capable of bearing Japan's future with an international view. MEXT started the JSPS International Training Program (ITP) in FY 2007 (Figure 1-3-19) to systematically supply to young researchers the opportunity to participate in research and education activities at overseas universities or partner institutes. ITP is designed for young researchers such as graduate students, postdocs, and assistant professors to enhance both the supply of research opportunities for younger-generation researchers and the support of their systematic dispatch to overseas institutes. That is, ITP supplies the opportunities for participation in research and educational activities at partner institutes to young researchers via systematic linkage of universities in Japan to overseas partner institutes.

However, as described in Chapter 1, Section 2, the number of domestic researchers' moving to overseas institutes is insufficient. When considering the increasing international mobility of researchers, it is feared that domestic researchers in Japan may be left behind in the international researcher networks. To solve this problem, the R&D-Capacity Strengthening Act [literal translation] specifies the need to promote the utilization of researchers' ability and promote personnel exchanges by introducing a leave system for researchers at universities and R&D corporations. Also the Committee on Human Resources of the Council for Science and Technology (CST) points out the importance of fostering young researchers from a long-term perspective, and recommends that the environment that supports the move of excellent domestic researchers to overseas institutes be further improved, a system by which excellent researchers who are sent to overseas institutes can return to jobs in Japan should be established, and networks for domestic researchers at overseas institutes should be further promoted.

In the Survey on Mobility of Science and Technology Researchers in Japan (January 2009), many experts comment that the mobility of domestic researchers to overseas institutes is low because there is anxiety about finding a post after coming back to Japan and that the connection for moving to overseas institutes is insufficient (Figure 1-3-20). According to 2008 Expert Survey on Japanese S&T System and S&T Activities by Fields, the major reasons that young researchers do not work or conduct research at overseas universities are that there is anxiety about taking a post after coming back to Japan, and that overseas activities do not pay economically. This means that experience overseas does not always act as a positive factor for continuing research activities, and does not sufficiently contribute to the establishment of researcher careers. In addition, it is also pointed out that the research institutes to which young researchers belong do not positively recommend research opportunities overseas because a serious reduction in research potential may occur when the young researcher moves to an overseas institute, reducing the potential for acquiring competitive funds.

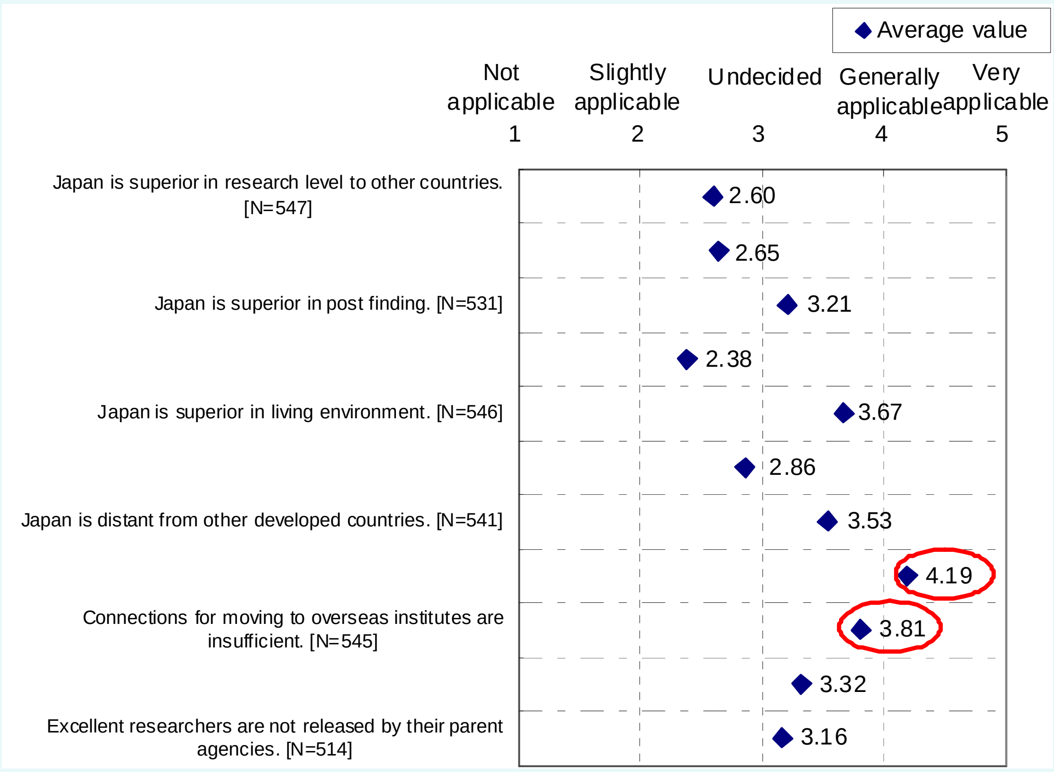
To solve this problem, research opportunities overseas must be enhanced drastically and human resources, the source of Japan's international competitiveness, must be fostered; for example, the young researchers, graduate students, university students, who will bear the future of Japan must be faster and collectively dispatched to overseas institutes. It is also important to provide opportunities to researchers returning to Japan by considering the following: the development of domestic universities and R&D corporations overseas; sufficiently securing posts for returnees; considering each researcher's experience when offering posts or screening for competitive funding; reviewing the support for establishing networks to dispatched overseas institutes.

Figure 1-3-19 JSPS International Training Program Synopsis



Source: Prepared by MEXT

Figure 1-3-20 Reasons for Low Mobility of Japanese Researchers Going Overseas Compared with Major Developed Countries



Source: National Institute of Science and Technology Policy and MEXT *Survey on Mobility of Science and Technology Researchers in Japan (Report No. 163)*

3 Promotion of Research Field Integration for Solving Complicated Social Problems

1 Necessity of Promoting Research Field Integration

For solving extremely complicated issues such as global-scale problems and for promoting research field integration between science and innovation, and between Monodzukuri and services, wisdom in various fields across research fields must be collected and problems must be set and solved from a completely new viewpoint: new research fields need to be created or research field integration needs to be performed. For example, solving global environmental problems requires integration of meteorology, ecology, and energy engineering.

On the other hand, much effort is required for cooperation between different fields and for the development of new fields. To advance learning and research, deep thought by individual researchers and deep discussions between different-field researchers is essential. There are no research boundaries between the phenomena in nature and problems in society today. As society develops and becomes more complicated, researchers who remain in their own specialized fields will prevent themselves from being able to play a major role in contributing to the solutions for various problems.

Before considering what efforts can effectively promote field integration in such a situation, let's see examples of efforts in overseas countries.

2 Efforts for Research Field Integration in Overseas Countries

Efforts for research field integration have been made as national strategies in overseas countries. In the European countries and the US especially, research in interdisciplinary fields created by integrating multiple fields has been promoted traditionally and also researchers themselves have aggressively entered emerging research fields.

(1) US

It can be said that the US has favorable circumstance for conducting interdisciplinary field research because research in various S&T fields is already advanced there. Efforts called Strategic Initiatives began in around 2000 to concentrate research across the existing research fields, mainly in some universities. These efforts then spread to the institutes in other areas in the US. In 1990's, the research trend largely changed to support large-scale research because research funds were allocated with priority, based on the linkage between federal departments, to gain the goal specified by the Clinton administration at that time. As a result, universities started the Strategic Initiatives in order to support new fields as national research goals, such as biotechnology and nanotechnology.

The actual contents of these efforts depend on each university. The common characteristics are as follows: (i) university-wide cooperation system is established by selecting research projects initiatively, concentrating resources such as research funds, facilities, and personnel on these projects, and reorganizing the existing organizations into new ones across research fields when necessary, (ii) the research environment necessary for respective interdisciplinary field research such as buildings is prepared with universities' own funds including contributions.

A typical example is the Whitehead Institute for Biomedical Research, which was founded in 1982 as an affiliate laboratory of MIT in order to promote interdisciplinary field research such as biomedical science. The Institute, as a small-scale independent institution, gives young investigators broad freedom to pursue new ideas and implements pioneering research programs in stem-cell and regenerative biology, cancer, immunology, and genetics and genomics. In 1985, the MIT Media Lab was established in MIT in order to research creative use of digital technologies in the current society. In 1999, the Stanford University Bio-X was established to promote interdisciplinary research in bioscience by integrating engineering, computer science, physics, and chemistry to biology and medicine (see Chapter 3, Section 2).

(2) Europe

A typical example of the institutes that have positively supported interdisciplinary research in Europe is the Engineering and Physical Sciences Research Council (EPSRC) in the UK. EPSRC, which is the largest of the UK's seven Research Councils, maintains and develops a strong research base in engineering and the physical sciences, and its research portfolio is wide-ranging, such as mathematics, physics, material sciences, information technology, and structural engineering.

Its Cross-disciplinary Interfaces Programme mainly supports the cross-cutting research such as complexity science[1] and basic technology derived from the life sciences, and fosters the researchers engaged in it. ERSRC leads the UK Research Councils' Energy Programme, which conducts user-led multidisciplinary research activities in partnership with other research councils and UK Government. Through Towards Next-Generation Healthcare programme, ERSRC not only funds prevention, medical diagnostics and aging-related research, but funds fellowships to the students in doctor's courses for the purpose of fostering young researchers in interdisciplinary fields.

3 Towards Promoting Further Research Field Integration

(1) Concrete efforts

In Japan, the following efforts are being made for promoting research field integration:

1) Medicine-engineering collaboration field

To advance innovation by supporting the highly developed medicine-related fields such as medical care, welfare, and care in the low-birth aging society, engineering theories and techniques need to be introduced, that is, integrating medicine and life sciences with engineering and information technology is indispensable. By this integration, the conventional R&D based on medical care demands is led to the development of advanced medical equipment such as magnetic resonance imaging (MRI) scanners and led to the creation of new medical care, new

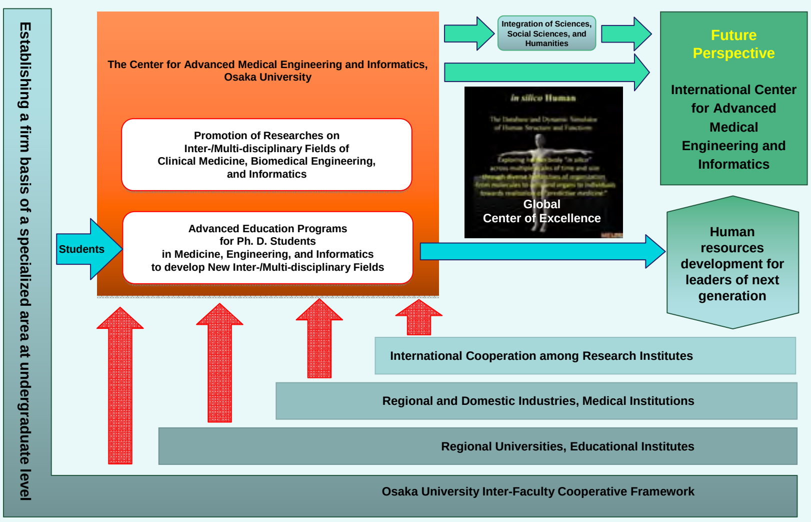
1 Learning field to find universal principles and laws by examining the existing independent learning fields such as chemistry, physics, biology, economics, .from the cross-field viewpoint.

therapeutic agents, and new healthcare business via establishment of IT-utilizing network for medical database.

With respect to medicine-engineering collaboration, the research of advanced biomaterial base and medical network for IT-supported medical care in the near future is promoted by the Division of Research Promotion of the Center for Advanced Medical Engineering and Informatics of Osaka University that executes the education and interdisciplinary research of clinical medical-density engineering with information sciences. As an example of interdisciplinary research, the advanced measurement and diagnosis system and the advanced medical care system for externalizing clinical processes are developed. Thus, developing the strategic system for directly linking research results to medical care and industry is being executed (Figure 1-3-21).

A Center of Excellence for an *In Silico* Medicine-oriented Worldwide Open Platform, which is of the education/research center under the Global COE Program since FY 2007, promotes interdisciplinary research between medicine, dentistry, pharmacy, engineering, and information science via cooperation with education and research institutes within and outside Japan, in order to realize "*in silico* medicine" (medicine in computers) as an predictive medicine platform. The databases and simulators of human functions established at the center enables systematized decision making to be done in the intellectual processes concerning human life and welfare in the development of new medicines and medical equipments, and in medical diagnostics and treatments which have been made based on clinicians' experiences. This will lead to predictive medicine for proposing possible choices logically or quantitatively, and will suppress the R&D and commercialization expenses increasing caused by the vast amount of experimental data.

Figure 1-3-21 Medicine-engineering Collaboration Research System in the Center for Advanced Medical Engineering and Informatics, Osaka University



Source: Center for Advanced Medical Engineering and Informatics, Osaka University

2) Mathematics and mathematical sciences field

Mathematics, referred as "the Queen of the Sciences," is the learning as a base of various sciences. It is thought that integrated research between mathematics and other sciences will provide significant advance in R&D in many fields. In fact, there are many examples of computing, signal analysis, image processing, and financial theories and techniques that could not be directly useful at the beginning of research but remarkably contributed to society as theoretical support after a long period. The research field integration of mathematics and mathematical sciences has advanced smoothly, and the support for the field has been enhanced.

The Alliance for Breakthrough between Mathematics and Sciences (ABMS)[1] is a grant program established for supporting mathematical scientists who conduct their research in cooperation with scientists in different fields and make a scientific breakthrough for the purpose of proposing new research topics arising from social needs and exploring mathematical approaches to those topics. Priorities are given to an embryonic, but challenging and creative research topic, which develops not only new mathematical ideas through the study of natural or social phenomena in a field of science while applying existing mathematical methods to that study, but contributes to the integration of mathematical and experimental sciences, or handles various problems from a completely new mathematical viewpoint.

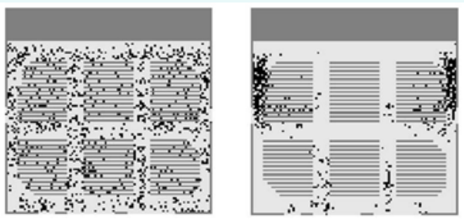
1 Funded by the JST Basic Research Programs by the Japan Science and Technology Agency under the national strategic sector Search for Breakthrough by Mathematical / Mathematical Sciences Researches toward the Resolution of Issues with High Social Needs (Focusing on Collaboration with Wide Research Fields in Science and Technology) (Research Director: Prof. Yasumasa Nishiura, Research Institute for Electronic Science, Hokkaido University.

Column14 Jammology and Wasteology

Prof. Katsuhiro Nishinari

Prof. Katsuhiro Nishinari, School of Engineering, The University of Tokyo, is a first-stage research grantee of the Japan Science and Technology Agency's PRESTO program, received under the Alliance for Breakthrough between Mathematics and Science (ABMS). His research theme is "Unified Analysis on Various Transportations and Solution of Their Traffic Congestion."

The term "jammology," coined by Professor Nishinari, embodies a wide periphery of meaning that goes beyond mere traffic jams: It includes crowding at sports and entertainment events, lines at cash registers, evacuations during disasters, delays in bus and train schedules, the movement of elevators, internet and mobile phone communications, blood circulation within the human body, and nerve-cell paths. He uses a cross-disciplinary approach in these investigations, one that integrates mathematics and science to analyze a myriad of congestion phenomena and solve related problems.



Evacuation simulation

Over the course of Professor Nishinari's more than 10-year study of "jammology," he was led to also investigate what he calls "wasteology," which provides a cross-disciplinary method for analyzing the causes of waste, on one hand, and the efficient use of time and material, on the other. The method integrates science, engineering, economics, management theory and psychology among other fields. The method integrates science, engineering, economics, management theory and psychology among other fields. Triggering this study was work initiated by Professor Nishinari to improve management efficiency by ameliorating inventory gluts caused by over-production in factories and to eliminate waste in manufacturing processes. His investigations on "wasteology" include such familiar topics as the appropriate distance between cars on a road, the tracking of ants carrying food to their colony, and white space on the pages of books.

As both a mathematician and physicist, Professor Nishinari has own laboratory, called the Nishinari Lab, where he researches and teaches. His wide sphere of activities includes writing books for the general reader and articles for newspapers and magazines and giving lectures. At a rate of about once a month, he also goes to product-development organizations, where he uses numerical formulas to assist their technicians in solving design problems.

Crowding experiment

Car traffic jam experiment

Source and photos: Professor Nishinari

(2) Review and efforts for promoting further research field integration

For solving various problems in many fields in society today, not only logical review and problem organization must be performed but also researchers in different fields are required to set one common issue and to continue their discussions for solving it by trying to find a common language among them. JST/CRDS reviewed what kind of field integration should be promoted in the future, and compiled the intermediate results in February 2009 as the *Report on Emerging and Interdisciplinary Research Fields: Solving Social Issues and Expanding the Frontiers of Science and Technology*.

Column 15 Attempt and Proposition for Promoting Further Research Field Integration

To start with, the Study Group for Emerging and Interdisciplinary Research of JST/CRDS selected 10 Challenges for the kind of issues that can only be solved by cooperation between different fields and for tackling various problems that are positioned as complexity. The group considered various examples of each problems as many as possible, and extracted the emerging and interdisciplinary research fields as listed below:

	Emerging and interdisciplinary fields which help to solve multiple problems	Disciplines to be integrated
1	Handling huge amounts of data	Mathematical science, information science (these two disciplines will play a major role in this interdisciplinary field), physics, chemistry, biology, medicine, engineering, sociology, economics, the humanities, etc.
2	Understanding human psychology and behavior	Mathematical science, information science, cognitive science, neuroscience, biology, sociology, economics, the humanities, engineering, etc.
3	Accommodation to evolution, mutations and degeneration	Mathematical science, information science, biology, physics, chemistry, medicine, engineering, sociology, economics, the humanities, etc.
4	Overcoming system complexity	Information science, mathematical science, engineering, sociology, economics, the humanities, biology, physics, etc.
5	User-oriented services design and evaluation	Mathematical science, information science, sociology, economics, cognitive science, the humanities, engineering, medicine, etc.
6	Risk governance	Mathematical science, information science, engineering, sociology, economics, the humanities, etc.
	Emerging and interdisciplinary fields which provide solutions to individual problems	**Disciplines to be integrated**
1	Controlling and making predictions about living organisms, society, etc. based on medical knowledge	Life science, information science, mathematical science, ecology, clinical medicine, microbiology, immunology, public health studies, demography, epidemiology, the study of infectious diseases, engineering, physics, chemistry, sociology, economics, ethics, etc.
2	Environmentally friendly cutting-edge material science and ultra-long life material engineering	Environmental science, mathematical science, chemistry, material engineering, material nanotechnology, chemical engineering, mechanical engineering, electrical engineering, biology, physics, chemistry, energy engineering, economics, international political science and economics, etc.
3	Science for studying changes in shapes and structures	Mathematical science, biology, physics, chemistry, electronic and electrical engineering, medicine, information science, mechanical engineering, economics, etc.
4	Science for studying changes in shapes and structures	Meteorology, ecology, agriculture, environmental sciences which are related to water (civil engineering and hydrology), resource engineering, energy engineering, mathematical science, economics, social science psychology, etc.

The group mainly made the following proposals by considering the reform for establishing the interdisciplinary system which transcends traditional disciplines and existing organizational frameworks in order to continuously promote emerging and interdisciplinary research:

- Establishment of system for promoting the problem-solving research by industry-academia-government cooperation as well as the conventional individual discipline-based research depending on researchers' free ideas and intellectual curiosity
- System reform that can rightly evaluate the participating young researchers from the viewpoint across fields, setting the attractive research themes that provide researchers with strong incentives for them to leave the existing academic fields and to tackle emerging and interdisciplinary research fields, and enhancement of efforts for presenting a clear career path

- Efforts by research institutes such as universities
  - Establishment of a graduate school faculty or a research organization based on a new ideology that can flexibly respond to emerging and interdisciplinary research fields
  - Establishment of a graduate school faculty or a research organization based on a new ideology that can flexibly respond to emerging and interdisciplinary research fields
  - Education for learning both graduate school specialized fields and peripheral fields or education for learning two different specialized fields in depth
  - Execution of education integrating the humanities and sciences from the early stages of their undergraduate course curriculum
- Efforts by academic societies and other academic bodies
  - Establishment of system for properly evaluating emerging and interdisciplinary research fields and problem-solving research
  - Reform of current system and methods for the operation of academic societies, the publication and peer review of academic papers
- Efforts by funding agencies
  - Establishment of a new open recruitment which aims to develop a new emerging research fields, and a evaluation system not depending on traditional mechanism

Source: Study Group for Emerging and Interdisciplinary Research, Center for Research and Development Strategy, Japan Science and Technology Agency *Report on Emerging and Interdisciplinary Research Fields: - Solving Social Issues and Expanding the Frontiers of Science and Technology*

From now on, as the conventional system in Japan has not sufficiently promoted research in emerging and interdisciplinary fields, various efforts such as effective distribution of research funds, support enhancing emerging research and competent persons fostering are needed to be performed by referring to the above report.

In addition, as described in the efforts in Europe and the US [see Section 3, 2 (1) and (2)], promotion of research field integration must be positioned as a national strategy, and project-led research must be positively supported in cooperation with related organizations.

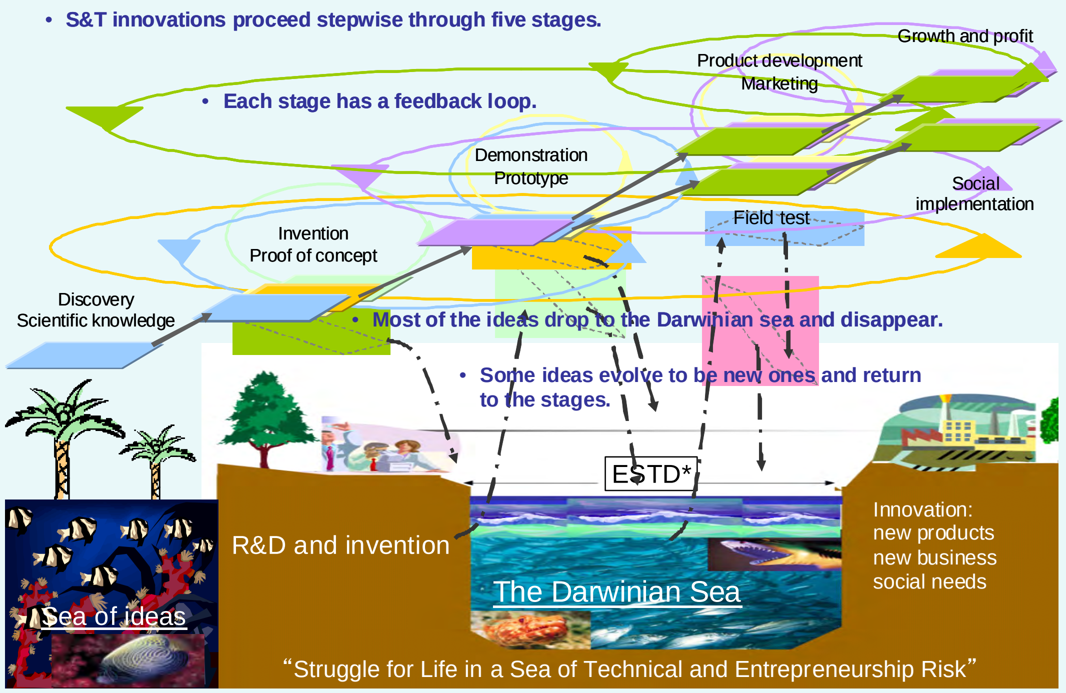
Promoting research field integration and creating emerging fields for solving more complicated and difficult problems, as described in this section, will dovetail with the trend of integration of Monodzukuri with services as a new field with high value added (Chapter 2, Section 2) and the trend of promotion of service science and engineering for improving productivity of service industry by introducing scientific and engineering techniques to services (Chapter 2, Section 3).

4 Towards Further Developing Science and Technology Policy

For effectively utilizing restricted R&D investment under such severe financial conditions, efforts for further development of science and technology policy must be made, such as focusing on structural socioeconomic changes and strategic management of R&D investment for the scientists to effectively conduct research.

For achieving a creation of innovation, there are two severe stages: the Valley of Death, a stage with insufficient support in the period between basic research and application development, and the Darwinian Sea, a stage of severe competitions with tough competitors before becoming successful in industrialization (Figure 1-3-22). In a series of processes from research, development, and commercialization to industrialization, comprehensive measures are need to be made such as public investment regulation reform, standardization of technologies with a vision of international development, and an effective use of intellectual properties of universities and research institutes. Moreover, innovation-oriented public procurement and enforcement of platforms supporting it, or R&D system reform must be continuously advanced.

Figure 1-3-22 Science and Technology Step & Loop Model



*ESTD: Early-Stage Technology Development

Source: Prepared by Center for Research and Development Strategy, Japan Science and Technology Agency based on illustration by Dr. Lewis M. Branscomb, et al.

1 Movement from Science and Technology Policy to Science, Technology, and Innovation Policy

Movement to comprehensive science, technology, and innovation policy for smoothly and effectively leading research results to innovation can be seen in overseas countries; however, such movement is not yet seen in Japan.

For example in the UK, the Department for Innovation, Universities and Skills (DIUS)[1] was created to establish the R&D and innovation promotion system for seamlessly handling competent persons fostering, science, technology, and innovation in the reorganization of government departments by the Gordon Brown Administration in June 2007.

Innovation Nation
Source: Department for Innovation, Universities and Skills

Based on various recommendations such as the report *The Race to the Top: A Review of Government's Science and Innovation Policies* (*Sainsbury Review*) about S&T system in the UK, DIUS released White Paper *Innovation Nation* in March 2008 in order to continuously join basic research, which was traditionally superior in the UK, with innovation and in order to propose the science, technology, and innovation policy framework including innovation-oriented public procurement beyond the conventional framework of S&T policy.

Innovation Nation specifies the comprehensive efforts to be executed as follows: Each Government Department will include an Innovation Public Procurement Plan to increase the purchase of innovative products and services; DIUS will reform the Small Business Research Initiative (SBRI)[2]; commercialization by industry-academia-government cooperation must be performed using the Innovation Platforms[3] of the Technology Strategy Board (TSB). As a result, UK Government seeks to achieve an innovative solution by promoting a R&D beneficial to its needs through these efforts. In addition, the effectiveness of the efforts in order to trigger innovation for motivating corporations to make a new R&D by efficiently implementing regulations must be examined in cooperation with Government Departments.

On the other hand, the European Commission launched the Lead Market Initiative for Europe in December 2007 in order to induce innovation and to develop the whole Europe by developing the market in which everyone can enjoy societal and economic value equally in Europe. The initiative specifies the six markets that will expand in the future: "eHealth" (computerized medicine, for example, medical services via the internet), "Sustainable construction," "Protective textiles," "Bio-based products," "Recycling," and "Renewable energy." To bring down barriers and reduce the time-to-market of new products and services, comprehensive

1 DIUS is committed to promoting innovation for making the UK the leading place in the world which to be an innovative business, public service or third sector organization and to build an Innovation Nation in which innovation thrives at all levels – individuals, communities and regions, working with partners across and outside government.

2 SBRI aims to drive innovation in SMEs by providing them with procurement opportunities regarding public R&D and increasing a high-level R&D that meets government needs. The programme defines that each Government Department should procure 2.5% or more of its R&D from small businesses.

3 The Innovation Platforms is the comprehensive efforts for commercialization by industry-academia cooperation. These platforms specify procurement, regulation, and R&D investment to tackle global-scale challenges and to control government's support for corporations and organizations involved in developing new products. In addition to the five platforms at present such as Intelligent Transport Systems and Services, Low Impact Buildings, Assisted Living, Network Security, and Low Carbon Vehicles, five new Platforms will be brought forward.

efforts for legislation, regulation reform, public procurement, standardization, labeling, and certification must be executed.

The Organisation for Economic Co-operation and Development (OECD) is being drawing up the OECD Innovation Strategy, which aims to propose an effective mechanism for a sustainable economic development by innovation, from the comprehensive and cross-governmental viewpoint. The strategy, its final report is due in 2010, will include the following measures to be contributed to future policymaking in the member countries: investigating an innovation role for tackling global-scale problems of environment and health; fostering competent persons capable of creating innovation; introducing a cross-government and interdisciplinary viewpoint to the evaluation of innovation policies in the member countries; and establishing intellectual property right protection system for the promotion of innovation.

Column 16 Innovation-oriented Public Procurement System in Europe and the US

In European countries and the US, public procurement has been performed as policy measures for efficient innovation promotion together with positive utilization of new technologies of SMEs and venture enterprises.

In the US, Small Business Innovation Research (SBIR) started in 1982. At present, 11 federal departments participate in it, and the yearly subsidiary amount reaches 2 billion dollars[1]. SBIR is the three-phase program: [Phase I] Experimental/theoretical investigation on the feasibility of the project concept; [Phase II] Investigation on product developments that can be commercialized; [Phase III] Pursuing commercial applications of the government-funded research (III is to be conducted with non-SBIR funds). As clearly shown in many successful examples of preferential measures in procurement of SBIR-funded deliverables by the related federal departments and in sales enhancement support of deliverables, its effectiveness and ripple effect of SBIR as a policy are high[2].

In the UK, the mechanism of public procurement was radically reviewed in 1986. After this, it is said that the UK is highest advanced, out of all EU member countries, in innovation-oriented public procurement reformation. Based on the thought “Government is the single biggest customer in the UK economy,” considering “Value for Money” is always requested to execute the public procurement with the large purchasing power of 150 billion pounds on goods and services. The Office of Government Commerce (OGC) that plays a central role in the reformation released the Strategic Procurement in which the mechanism for having both procurement risk and reward is used by enhancing the interactions with the purchasers (public agencies) by making suppliers (enterprises) participate from earlier stages before procurement, keeping transparency and fairness of the procurement of the products that may lead to innovation with high probability.

In the Netherlands, which is more positive in public procurement reformation next to the UK, the reformation has been made from the late 1990s mainly by the Ministry of Economic Affairs. The typical efforts are Professioneel en Innovatief Aanbesteden, Netwerk voor Overheidsopdrachtgevers (PIANOo), which supplies the network and electronic procurement system with which experts and persons in charge of procurement share common problems about procurement, and Small Business Innovation Research Programma,[3] which supports commercialization by advancing the technologies of SMEs as suppliers to purchasable levels.

1 Sum including the amount of Small Business Technology Transfer (STTR) Program (in which five federal departments participate in) started in 1992

2 In Japan, Small Business Innovation Research (Japanese version of the US SBIR Program) was introduced in 1999 based on the New Business Creation Promotion Act (Act No.152 of 1998) [literal translation] by referring to the SBIR Program in the US. Also in the UK, Small Business Research Initiative (SBRI) was launched in 2001 by using the same program as a model.

3 Started in 2004 on a trial basis by referring to the SBIR Program in the US. This pilot scheme is executed by SenterNovem under control of the Ministry of Economic Affairs. The scheme consists of two phases of “feasibility studies” and “R&D projects.” The intellectual property rights of deliverables all belong to the SMEs concerned.

2 Promotion of Scientific Evidence-based Science and Technology Policy

In the US, the science, technology, and innovation policy promotion system has been rapidly established by a series of released reports and enacted acts: The *Innovate America: Thriving in a World of Challenge and Change* (the *Palmisano Report*), which was compiled by the Council on Competitiveness in December 2004; The *Rising Above the Gathering Storm*" (the *Augustine Report*), which was released by the National Academies in October 2005; The *American Competitiveness Initiative*, which was contained in the State of the Union Address by ex-President Bush in 2006, and The America COMPETES Act, which was enacted in August 2007.

In line with the above progress of the policy for creating innovation, John Marburger, the ex-Science Advisor to the President and Director of OSTP, proposed the introduction of "Science of Science Policy" at the 2005 Annual AAAS Forum on Science & Technology Policy held in April 2005 by the American Association for the Advancement of Science (AAAS). This concept is the quantitative research of science and technology policy by enhancing interdisciplinary research consisting of economics, social sciences, and information sciences in order to sufficiently capture the dynamism of innovation and to make R&D policy evaluation more effective. In 2006, the Science of Science Policy Interagency Task Group comprised 17 federal department was established, and The Science of Science Policy: A Federal Research Roadmap was compiled in November 2008 to report the status of efforts and issues on science policy analysis. The Science of Science and Innovation Policy (SciSIP) program, funded by NSF, and the Innovation Measurement by the Department of Commerce, were launched to advance necessary research so that the economic impacts that could not be sufficiently captured with the conventional macro (nation-level) indicators would be able to be correctly confirmed and the scientific evidence-based S&T policy could be realized.

(1) Science of Science and Innovation Policy

The SciSIP program aims to implement the following activities: development of usable knowledge and theories to be scientific evidence-based platform for S&T policy, improvement and expanding of existing science metrics, datasets, and analytical models and tools, development of a community of practice focusing on SciSIP across the federal government, industry and universities, research by an networked organization across fields and regions by use of cyberinfrastructure,[1] and grants for the science, technology, and innovation-related research by using competitive funds. NSF will release the next Science and Engineering Indicators[2] 2010, which will include the findings acquired by SciSIP.

(2) Innovation Measurement

To figure out how innovation affects productivity and economic growth contributes to the

1 Research environment in which large amount of data can be stored, shared, and analyzed via network by using high-performance computers

2 Comprehensive statistics on science and engineering

policy making for US sustainable growth and prosperity. Based on it, the Department of Commerce established the Advisory Committee on Measuring Innovation in the 21st Century Economy in August 2006 so that private sectors, universities, and federal departments could measure its effects, and it performed various reviews. The findings were compiled in January 2008 in the report *Innovation Measurement: Tracking the State of Innovation in the American Economy*, proposing the government, industry, and researchers to understand innovation and improve innovation measurement.

3 Efforts for Further Developing Science and Technology Policy in Japan

Also in Japan, science and technology policy must be linked to related policies by considering not only S&T promotion and but the creation of innovation.

(1) Towards the creation of innovation

After the Third Science and Technology Basic Plan was established to provide strategically prioritized S&T for the persistent creation of innovation and to reform the system for disseminating the results to society, the government formulated the Long-term Strategic Guidelines Innovation 25 (Cabinet decision: June 2007). The Innovation 25 shows Japan 2025 through innovation as a model to the world) and declares the social-system reform strategy including social environment improvement for the creation and promotion of innovation for realizing "Japan based on innovation." The guidelines also aim to integrally promote measures based on the roadmap for technology innovation strategies including the reinforcement of R&D system that propels innovation.

The Council for Science and Technology Policy formulated the Strategy for Innovative Technology in May 2008, in which prioritized promotion of innovative technologies capable of realizing a top world-level, sustainable economic growth as well as a rich society: electronic device technology, intellectual robot technology, and regeneration medicine technology. For the creation of innovation, the strategy also includes various efforts of developing a new structure and R&D system such as the establishment of the Innovation Technology Promotion Fund and the use of the Super Special Consortia system.

In addition, the R&D-Capacity Strengthening Act specifies the comprehensive reform of R&D system covering practical applications of R&D results: the flexible distribution of resources required for the government's S&T advancement and the enhancement of competition; the removal of unfair impediments for practical applications of R&D results; and appropriately dealing with the international standards. They reflect a global shift from science and technology policy to science, technology, and innovation policy.

Column 17 Super Special Consortia

The Super Special Consortia is the system in which parallel consultation is performed experimentally, with the authorities in charge of research fund exceptions and regulations, in order to remove the factors that inhibit innovative technology development. The system is not conventional specific district as administrative one, but the project theme-oriented consortia (complex consortia created by researchers connected at multiple centers via network).

The initial project was made in FY 2008 under the cooperation of the related four ministries: Cabinet Office, MEXT, Ministry of Health, Labour and Welfare (MHLW), and METI: Super Special Consortia for supporting the development of cutting-edge medical care. The 24 projects listed in the following table are adopted via open recruitment.

Super Special Consortium for supporting the development of cutting-edge medical care

	Consortium name [literal translation]	Representative /Organization
iPS cell application	iPS-Cell Medical-Care Application Acceleration Project	Shinya Yamanaka, Kyoto University
	Establishment of New *in vitro* Toxicity Evaluation System Using Human iPS Cells	Hiroyuki Mizuguchi, National Institute of Biomedical Innovation
Regenerative medicine	Advanced Medical Care Development Project for Regeneration Medical Care of Central Nerves – Mainly for Spinal Cord Injury –	Hideyuki Okano, Keio University
	Project of Regeneration Medical Care Using Cell Sheets	Teruo Okano, Tokyo Women's Medical University
	Development Project for Quick Spreading of Three-Dimensional Composite Regeneration Tissue Products as Advanced Surgical Implants	Tsuyoshi Takato, The University of Tokyo
	Practical Use of New Decay and Pulpitis Cure by Dentine and Pulp Regeneration using Pulp Stem Cells	Misako Nakashima, National Institute for Longevity Sciences
	Realization of Regeneration Medical Care by ICR Promotion	Shin-ichi Nishikawa, Foundation for Biomedical Research and Innovation
Development of innovative medical equipment	Establishment of Build-to-Order Model for Respective Artificial-Joint Patients to Realize Bio Amalgamation	Koichi Kuramoto, Nakashima Propeller Co., Ltd.
	Project for Creating Only-One or Number-One Medical Equipment for Satisfying Social Needs	Susumu Satomi, Tohoku University
	Innovation of Minimum-Risk Radiation Therapy Machine Development by "Advanced Radiation Therapy Technology Packaging"	Hiroki Shirato, Hokkaido University
	Information-Type Advanced Medical Care System Development Based on Unique Technology Produced in Japan (Development of Innovative Medical Equipment)	Kenji Sunagawa, Kyushu University
	Advanced Medical-Care Development Practical Application Project by Medicine-Engineering Cooperation	Ryozo Nagai, University of Tokyo
	Cross-Sectional Integrated Research of Development, Clinical Application, and Commercialization of Advanced Circulatory-Organ Cure Equipment	Nobuo Hashimoto, National Cardiovascular Center
	Project of Innovative Medical Equipment Creation by Imaging Technology – From Ultra-Early Diagnosis to Advanced Cure –	Masahiro Hiraoka, Kyoto University
	Development of Seeds Practical Application Based on Medical Photonics	Yasuhiro Magata, Hamamatsu University School of Medicine
Development of innovative biotechnology-based medicines	Advanced Immunity Medicine Development Project – Advanced Antibody Medicine and Adjuvant Innovative Technology Development	Tadamitsu Kishimoto, Osaka University
	Cancer Peptide Vaccine Cure Method Development for Quick Drug Discovery	Yusuke Nakamura, The University of Tokyo
	Strategic Development Research of Composite Cancer Vaccine	Hiroshi Shiku, Mie University
	Next-Generation Infection Vaccine Innovation Project	Koichi Yamanishi, National Institute of Biomedical Innovation
R&D of medicines and medical equipment for cure and diagnosis important for national health	Early Clinical Development Project for Cancer Medicines and Medical Equipment	Hiroyasu Esumi, National Cancer Center Hospital East
	Project of Advanced Medical Development of Digestive Endoscopes n	Koichi Tanaka, Foundation for Biomedical Research and Innovation
	Drug Discovery by Inter-Cell Signal Transmission Control by Targeting Intractable Disease	Kazuwa Nakao, Kyoto University
	Development of Medicines and Medical Equipment for Conquering Incurable Diseases in Mental Sickness and Nervous Diseases	Teruhiko Higuchi, National Center of Neurology and Psychiatry
	Development of Cross-Sectional Diagnostic Treatment Integration Less-Invasive System for Early Systematic Treatment of Acute Stroke	Hiroshi Furuhata, Jikei University School of Medicine

As a result, the personnel expenses of some staffs of R&D corporations were excluded from the total personnel expenses reform due to the Innovation 25 and the R&D-Capacity Strengthening Act [literal translation]. Thus, the R&D capacity for the creation of innovation has been positively enhanced. However, as system reform for innovation has been energetically performed in foreign countries as described before, a series of reformation should not be relaxed in Japan. The supplementary provisions of the R&D-Capacity Strengthening Act [literal translation] specify that the status of the R&D system must be examined and necessary efforts must be made in order to further enhance R&D capacity and to promote R&D efficiently. Also the House of Representatives Committee on Education, Culture, Sports, Science and Technology and the House of Councillors Committee on Cabinet passed resolutions for investigating the most appropriate status of R&D corporations.

When considering the above results, the future problems to be solved in Japan are to examine the appropriate status of R&D system and to enhance the R&D system for the creation of innovation by practical applications of R&D results. Also utilization of regulations, efficient execution of public procurement, protection of intellectual property, promotion of distribution, and appropriate efforts to international standards must be considered in Japan.

(2) Efforts for science of science and technology policy

The necessity of scientific evidence-based policymaking is widely recognized as shown in the efforts for innovation measurement and reflection in policies (Section 4, 2). In this respect, Japan is also not an exception. NISTEP collects data for innovation measurement, developing the analysis method, and creating Science and Technology Indicators[1].

Source: National Institute of Science and Technology Policy

NISTEP is a national research institute that was established in July 1988 to support S&T policy making. The institute has three major roles: (i) Implementing voluntary and deepened survey and research by predicting problems to be occurred in the future, (ii) Executing agile survey and research based on authorities' demands, and (iii) Supplying various types of data to be used as research basis for other research institutes and researchers.

The large-scale technology foresight survey, which was implemented by the then Science and Technology Agency, NISTEP has been in charge of the survey from the fifth one in FY 1991. In the eighth survey from FY 2003 to 2004, an attempt was made to deepen the foresight techniques by using both extrapolative methods and normative methods[2] for wide range of fields in basic science and socioeconomic demands as well as the conventional Delphi Analysis (Science and

1 Basic measures for quantitatively and objectively grasping science and technology activities by comprehensively compiling the data from input (investment) of science and technology funds and human resources to output (results) of researcher infrastructure, and paper and patent. NISTEP has sequentially advanced the indicator system via theoretical research and indicator collection and processing, and has published reports every year.

2 Extrapolative method: Objective methods for predicting by applying the past tendency to the future
Normative method: Subjective methods for examining by retrieving the method to reach the specified goal

Technology Foresight Survey)[1]. Upon completion of the survey, NISTEP has continued the development of new techniques for predicting S&T panoramically.

In FY 2008, the 20th anniversary of its establishment, NISTEP implemented the interim follow-up investigation of the Third Science and Technology Basic Plan, according to the relegation by CSTP, in order to formulate the next Plan.

Column 18 NISTEP 20th Anniversary International Symposium

In the 20 years after its establishment of NISTEP in 1988, the environment surrounding science and technology has changed drastically. As the world today is facing a number of complicated and intractable problems such as global warming, the public now expects that science and technology will be utilized to help cope with these problems.

Under the circumstances, policy makers are required to create policies based on data and analysis. The need for "science-based science policies" is now recognized. In order to perform investigation for data collection and analysis, international cooperation is indispensable.

Based on this recognition, NISTEP held the international symposium The Science of Science Policies in the New Global Era in November 14, 2008, on 20th anniversary of its establishment.

Group photo of speakers, et al.
Photo: National Institute of Science and Technology Policy

For the symposium, Dr. Taizo Yakushiji, Executive Member of the Council for Science and Technology Policy, and Dr. Lewis M. Branscomb, Professor Emeritus, Public Policy and Corporate Management, Harvard's John F. Kennedy School of Government were invited as keynote speakers, and other world-leading overseas researchers were invited as speakers.

As described above, developing science, technology, and innovation policy for efficient and effective creation of innovation is important for sustainable growth of Japan, which is facing drastic socioeconomic changes.

JST/CRDS held the session Planning and Evaluation of Evidence-based Science, Technology, and Innovation Policy' – Towards its Measurement and Evaluation System Development [literal translation] in March 2009 at the ESRI International Forum 2009 New Innovation Policy Focused on Social Needs held by the Economic and Social Research Institute (ESRI) of the Cabinet Office for activating the Science of Science, Technology, and Innovation Policy for the above purpose. In the session, the opinion was expressed that it was important to accumulate scientific evidences for contributing to making science, technology, and innovation policy based on social needs by resolving innovation processes in the past and the present and their structures, by developing the science, technology, and innovation policy evaluation methods, and by developing models and methods for economical and social effect prediction for future innovation. As for the development of indicators related to science, technology, and innovation, discussions are being made at the Working Party of National Experts on Science and Technology Indicators (NESTI) under OECD in order to adjust and give advice on S&T-related indicators. Japan must always watch these international trends and to appropriately tackle them.

1 Delphi analysis is an interannual one using the following method: The same-content questionnaires are periodically sent to the same experts by presenting the results of the previous one. And then they are again requested to give reconsiderations to each questionnaire.