Chapter 4 Enhancement of Basic Research and Human Resources Development

Section 1 Radical Enhancement of Basic Research

Basic research has become increasingly significant and meaningful, nurturing diversity by producing technological seeds that may grow into innovations. It helps create new intellectual and cultural value in a wide variety of fields, and it directly or indirectly contributes to the development of society. To solidify the foundation of Japan's science, technology and innovation (STI) it is vital for Japan to focus on, and strongly advance, diverse and creative basic research, as well as world-leading basic research. In view of this, the government has been making efforts to radically enhance basic research in Japan.

1 Enhancement of Diverse and Creative Basic Research

Researchers initiate basic research out of intellectual curiosity or an impulse to explore. They advance their research at their own initiative and in a creative way. In this way, creative research leads to the creation of intellectual property to be shared by mankind, and also to the accumulation of profound knowledge. Based on this recognition, the government has been strengthening its efforts to enhance diverse and creative basic research extensively and continuously.

(i) Grants-in-Aid for Scientific Research

Grants-in-Aid for Scientific Research (KAKENHI) available through MEXT and the Japan Society for the Promotion of Science (JSPS) are the only competitive funds provided for all research conducted according to researchers' own ideas in all sciences, ranging from the humanities and the social sciences to the natural sciences. KAKENHI has been supporting diverse and creative research, helping to broaden the base of various research activities, continually advancing research, and accumulating profound knowledge. Of the approximately 98,000 projects in major research categories that applied for KAKENHI, 26,000 research projects were newly selected in a peer-review screening process in FY2013. KAKENHI is now supporting 72,000 research projects, including the projects implemented over multiple years. (The total amounts of and the budget for KAKENHI in FY2013 are 231.8 billion yen and 238.1 billion yen, respectively.)

Grants from KAKENHI's Funding System can be used over multiple years. In order to allow for more flexible use of grants which are not from the Fund System, an Adjustment Fund was introduced in FY2013, making it possible to use single-year grants ahead of schedule or in the following fiscal year, if certain conditions are met.

(ii) Strategic Basic Research Programs

The Japan Science and Technology Agency (JST) is implementing Strategic Basic Research Programs to stimulate creation of new technological seeds. In these programs, decisions on national strategic objectives and study areas are made using a top-down approach. Research proposals are accepted from researchers at universities and other institution for conducting studies through the formation of time-limited consortia that span institutional boundaries (the virtual institute system). These programs have promoted strategic basic studies leading to innovations, and have also helped accelerate and advance research that is expected to produce promising results.

MEXT established the following five strategic objectives for FY2013:

- Creation of key technologies for innovative energy carriers available for transportation, storage, and utilization of renewable energy

- Creation of innovative key technologies through integration of material technology, device technology, and optimized nanosystems technology toward development of information devices featuring extremely-low power consumption and multiple functions

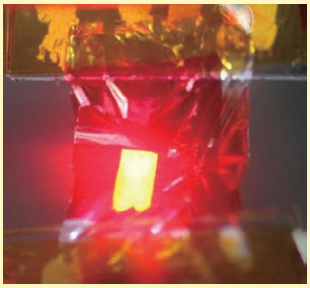
- Creation of core technologies for early-stage drug discovery through investigation of disease-specific biomolecule profiles

- Creation of new functional materials by means of technology for controlling spaces and gaps in advanced materials in order to realize selective material storage, transport, chemical separation and conversion

- Creation, advancement, and systematization of innovative information technologies and their underlying mathematical methodologies, to obtain new knowledge and insight by utilizing mega data across a variety of fields

Column 2-2 The World's Lightest, Thinnest, Flexible Organic Light-Emitting Diodes (OLEDs)

As part of the JST Strategic Basic Research Programs, a team led by professor Takao Someya, at the School of Engineering at the University of Tokyo, has been conducting research in which organic materials are used for developing devices that merge biological tissues and electronics. The group has recently established a unique technology for fabricating organic semiconductor layers on a 1-μm-thick [1] polymer film of polyethylene terephthalate (PET)[2], advancing development of soft, light flexible organic devices. Specifically, the team has adopted a conductive polymer, which can be fabricated at low temperatures with low-loss as an anode, and succeeded in the development of a polymer-based light emitting diodes only 2 μm thick, weighing just 3 g/m^2. These innovative light sources, the world's thinnest and lightest LEDs, are highly flexible and stretch-compatible. The LEDs are five times thinner than cling wrap and 30-times lighter than A-4 size printing paper. The ultra-thin LEDs are expected to be available for a variety of applications, including new OLED lightings and electronic signage that fits any surface and wearable device.



Soft, ultralight and flexible OLEDs
Courtesy of JST ERATO Someya Bio-harmonized Electronics Project

1 One micrometer is one millionth of a meter
2 PET: A form of polyethylene made into bottles and fibers.

Column 2-3

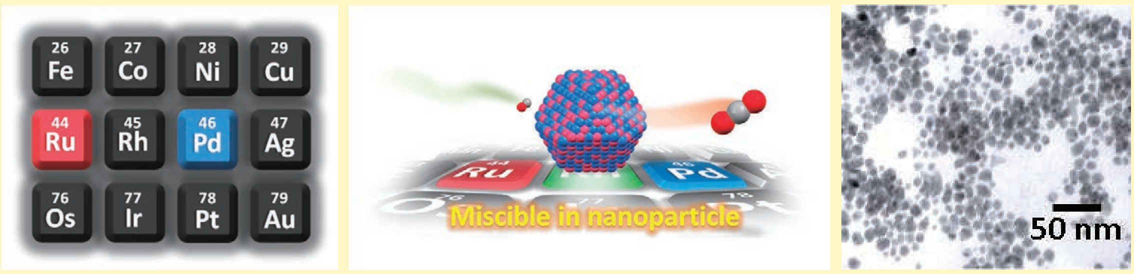
Creation of Functional Materials Based on Inter-Element-Fusion Strategy

In JST Strategic Basic Research Programs, a group led by professor Hiroshi Kitagawa, at the Graduate School of Science of Kyoto University, has been working on research in which innovative materials are created by mixing elements at the atomic level ("inter-element-fusion strategy"). These new materials have excellent properties beyond that of the original elements.

It has been widely believed that palladium (Pd) and ruthenium (Ru) are immiscible in solid state even at extremely high temperatures and, by extension also immiscible at the atomic level.

Prof. Kitagawa and his group succeeded in mixing Pd and Ru into an alloy at the atomic level by making use of a nano-size effect. Currently, in the Ene-Farm fuel cell cogeneration system for household use, Ru is used as a catalyst to prevent the contamination of the rare metal platinum. This novel Pd-Ru alloy catalyst showed a higher performance for removing toxic carbon monoxide (CO), compared with the currently used Ru catalyst. This alloy also showed a catalytic activity higher than that of rhodium (Rh), which is between Ru and Pd in the periodic table.

Currently, Rh catalysts are used for purifying automobile emissions, but Rh is the most expensive precious metal, subject to extreme price fluctuations. This novel Pd-Ru alloy is expected to exhibit a higher catalytic performance than Rh catalysts. It will also reduce the cost of catalysts because Pd and Ru are available at a relatively reasonable price. Prof. Kitagawa says enthusiastically, "As a university researcher, I want to keep focusing on starting from zero for creation." Inter-element-fusion strategy, Prof. Kitagawa's novel synthesizing technique is expected to create other innovative materials and alloys.



Left: Relative positions of Ru, Rh and Pd in the periodic table
Middle: Conceptual diagram Pd-Ru alloy mixed at the atomic level
Right: Electron microscope image of an alloy in which Pd and Ru are mixed in a 1:1 ratio

Courtesy of Hiroshi Kitagawa, professor at the Graduate School of Science, Kyoto University

(iii) Promotion of shared use and joint research at universities and inter-university research institutes

MEXT has been promoting joint research and shared use of research facilities/equipment at Joint Usage/Research Centers. These centers are located at inter-university research institutes as wells as national and private universities. In FY2013, 13 additional centers were certified by the Minister of Education, Culture, Sports, Science and Technology. As of April 2013, there were 90 centers at 41 universities. Researchers are encouraged to engage in independent or joint research at these centers, irrespective of the laboratories they belong to, by sharing facilities, equipment and valuable data/materials.

With Particular regard to large-scale scientific research projects in which many researchers from home and abroad participate, MEXT has established the Program for Promoting Large Scientific Frontier Projects (on an initial FY2013 budget of 23.6 billion yen and a supplementary FY2013 budget of 3.6 billion yen). By providing support to the development and operation of large research facilities, this program has helped researchers to produce world-leading scientific research results. This program has also been promoting creation of research centers to attract top domestic at international researchers, as well as fostering of young researchers within international research environments.

In FY2013, the Thirty Meter Telescope (TMT) Project was added to this program. It is an international cooperative project to construct an optical, infrared telescope with a 30-meter primary mirror to be utilized in finding another plant with life, studying properties of dark energy, detecting the birth of first stars/galaxies, and elucidating the cosmic dawn. The Program for Promoting Large Scientific Frontier Projects is promoting eight of the worlds' most advanced research projects[1], being conducted to open new frontiers.

2 Enhancement of Research Capacity at Universities; Creation of the World's Most Advanced Research Centers

In an environment of increasing globalization of human activities in recent years, competition for securing top researchers has intensified. To further enhance basic research in Japan, research environments must be favorable and attractive to world-leading researchers at home and abroad. Additionally, support is necessary to increase the number of universities that have the capacity to conduct outstanding, world-class research. For this purpose, the Japanese government has been promoting an increase and enhancement of universities and research centers at which the world's most advanced research can be implemented.

(i) Program for promoting the enhancement of research universities

With the aim of increasing world-class universities and also of enhancing universities' research capabilities, support is provided to prospective world-class universities based on quantitative indicators or evidence. Specifically, the government promotes intensive reform of research environments by helping these universities to employ research management personnel, including research administrators, so that the research capacity of Japanese universities will increase. In FY2013, 22 universities and inter-university research institutes were selected, with funding of 200-400 million yen provided to each of them.

(ii) Creation of world premier international research centers

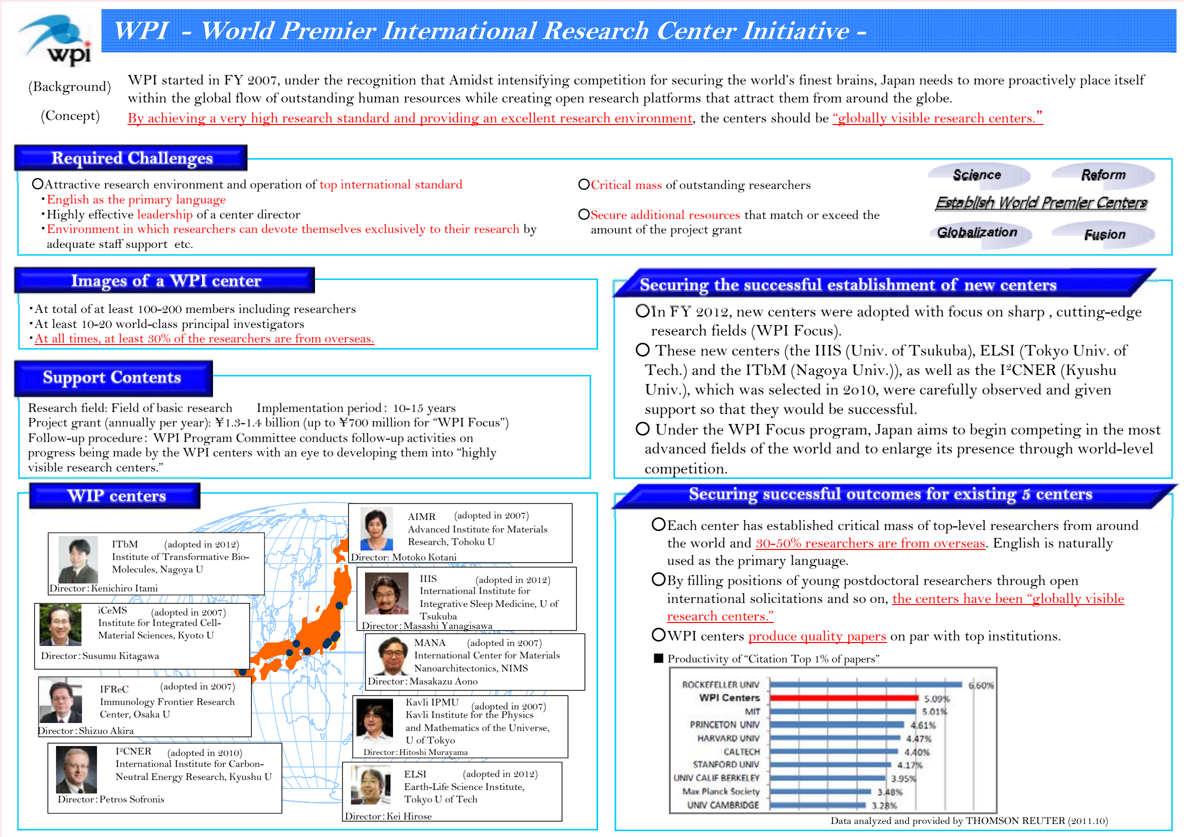
MEXT has been promoting the World Premier International Research Center Initiative (WPI[2]). Intensive, support is provided to research centers that are willing to establish themselves as the world's most advanced centers at which the best researchers play a leading role. By encouraging these centers to make independent efforts for system reforms, this initiative aims to create globally visible research centers that feature research conducted at world advanced levels in superb research environments and thereby attract leading researchers from around the world. Each of the research centers selected for this initiative

1 These eight projects are as follows: 1) Promotion of the Thirty Meter Telescope (TMT) Project that aims at exploring extrasolar planets and understanding the nature of the early universe during the cosmic dawn; 2) Exploring Physics beyond the Current Particle Theory with Super B-Factory for elucidating missing antimatter, dark matter's identity, and origin of mass; 3) Development of Neutrino Research with Super-Kamiokande for identifying neutrinos; 4) Large-scale Cryogenic Gravitational Wave Telescope Project (KAGRA) for world's first direct confirmation of gravitational waves (i.e., distortions of space-time geometry); 5) Promotion of ALMA Project for using a huge radio telescope array (ALMA) to elucidate galaxy formation shortly after the Big Bang and the beginning of life; 6) Promotion of Research in Material/Life Sciences and Nuclear/Particle Physics at the Japan Proton Accelerator Research Complex (J-PARC) for the world's most advanced research that uses various particle beams (e.g. meson/ antiproton beams); 7) Research through Shared Use of Subaru, a Large Optical Infrared Telescope for observing the farthest galaxies and investigating the mysteries about extrasolar planets; and 8) Demonstration of Steady Operation of High-Performance Plasma for studying scientific principles of fusion energy with the aim of achieving ultimate green innovation.

2 World Premier International Research Center Initiative

receive 1.3 -1.4 billion yen annually for 10 years. Research centers that produce outstanding results are supported over 15 years and the research centers selected in FY2012 are provided with up to 0.7 billion yen annually. Currently, nine research centers are supported by this initiative (Figure 2-4-1). Under this initiative, the WPI Program Committee, chaired by Hiroo Imura, ex-president of Kyoto University, is playing a central role in verifying the progress of research at the nine research centers and taking follow-up measures strictly and meticulously annually in order to ensure development of these centers into globally visible research centers.

Figure 2-4-1 / World Premier International Research Center Initiative (WPI)



Source: MEXT

Section 2 Development of Human Resources capable of Active Roles in Science and Technology Research

In order to sustain growth and to create new value while facing rapid demographic aging and population decrease, Japan must foster and secure diverse human resources capable of active roles in the creation of STI.

MEXT has been implementing systematic development of human resources specializing in science and technology (S&T) through education at elementary, junior high, and high schools, at universities and as well through programs for postdoctoral researchers. More active roles for young researchers, female researchers, and research administrators are also being promoted through various measures. All these efforts are aimed at increasing the number of people who can contribute to S&T in Japan and foster high quality researchers.

1 Development of Human Resources Capable of leadership in Diverse Fields

(1) Radical enhancement of graduate school education

The progress of globalization and knowledge-based societies has made it vital to foster highly-skilled, knowledgeable professionals who can assume leadership roles in the global society in order to help solve issues that contemporary people are facing. These professionals are expected to take a holistic view of expertise in various fields and to create or use innovations to provide new value to society.

Based on this recognition, highly-skilled professionals should be strategically developed, so that they are able to exercise leadership in the various fields of industry, academia and government at a global level. There is an urgent necessity to radically enhance the quality of doctoral programs, as well as to develop systems for providing education and research guidance in a structured manner.

As a result of the Graduate School Education in the Globalized Society (a report by Central Council for Education, January 31, 2011), MEXT formulated the Second Platform for the Promotion of Graduate School Education (approved by the Minister of MEXT on August 5, 2011) to implement measures for improving and ensuring the quality of graduate school education.

Specifically, the Program for Leading Graduate Schools was started in FY2011 to assist in efforts to develop leading graduate schools at which doctoral programs are provided consistently from the first term through the second term beyond the boundaries of different disciplines to nurture leaders who can play active roles in industry, academia, or government globally. As of FY2013, 62 proposals have been accepted as leading programs. To provide a more systematical education in doctoral programs, the Standards for the Establishment of Graduate Schools were revised in March 2012. This revision made it possible for universities, at their own discretion, to require students to pass a screening regarding their qualifications to conduct doctoral thesis research, instead of requiring them to write a master's thesis in order to complete the first term of a doctoral program. MEXT continually implements measures to improving graduate school education. For example, the Grants for Excellent Graduate Schools program started in FY2012 continues in FY2013. This program provides grants to graduate schools that have excellent educational/research infrastructure, with the aim of helping them provide educational/research environments that allow doctoral students to concentrate on their research and study, attract the best students and develop these students into researchers who can play active roles globally.

At the request of MEXT, the Science Council of Japan (SCJ) deliberated on the quality assurance of university education in each academic subject, and offered recommendations on the establishment of

Benchmark Standards for Curriculum Formulation that focus on expectation levels of graduates in terms of the abilities and skills needed to develop understanding or competence in a subject. SCJ has been requested to continue formulation of Benchmark Standards, and has published Benchmark Standards in eight subjects: business administration, linguistics/literature, law, home economics, mechanical engineering, mathematical science, biology, and civil engineering/architecture. SCJ is deliberating on Benchmark Standards for other subjects.

(2) Support for students pursuing doctoral studies and diversification of career options

In order to encourage qualified, ambitious students to continue their studies in doctoral courses[1], financial support is necessary to complete their doctoral studies. It is also important to provide various career options so that they can make use of their expertise not only in academia, but also in industry and local communities.

1) Support for students pursuing doctoral studies

As part of its efforts to financially support graduate students, MEXT has been increasing competitive research funds available for universities to employ graduate students. In consideration of educational benefit for students, these competitive funds are used to hire graduate students as Teaching Assistants (TA) or Research Assistants (RA).

Japan Student Services Organization (JASSO) have scholarship loan programs to provide financial support to students who are academically excellent but have difficulty pursuing their studies due to financial restraints. Interest-free loan recipients, recognized by JASSO as having achieved particularly outstanding results in their studies, may be exempt from repaying all or part of their loan.

To fostering top level researchers who will play major roles in future scientific research activities, the Japan Society for the Promotion of Science offers a special program under which fellowships are granted to graduate students, for example DC students, who are conducting research in Japanese university doctoral programs.

2) Diversification of career options

MEXT has been making efforts to develop leaders who can achieve active roles globally in industry, academia, or government (Chapter 4 Section 2, 1 (1)).

To increase career options for postdocs, the Promotion of Internship Program for Postdoctoral Fellow, a JST's initiative, supports universities that offer long-term, three months or longer, internship programs to postdocs[2]. This initiative provides postdocs with opportunities to make use of their expertise to play an active role at universities, public research institutions, industries, local communities, or in other countries. As of FY2013, 28 universities are supported by this initiative.

Additionally, MEXT has been encouraging development and employment of research administrators to

1 Doctoral courses refer to the two-year second term of the doctoral programs (including the third, fourth and fifth year of the five-year consistent program for the doctoral course) and to the four-year consistent program for a Ph.D in medical, dental, pharmaceutical or veterinary science, unless otherwise annotated.

2 Postdocs refer to those who are doctorate degree holders or who left school after having studied for a standard doctoral course term or longer, and have earned the required credits, engaging in research at universities or research institutions under fixed-term contracts (Note: Professors, associate professors, lecturers, assistant professors, research associates, leaders of research groups, and principal investigators are excluded).

improve research environments to provide for more active research, strengthen R&D management at university and increase career options for scientists/engineers who may not choose to become researchers.

Within JST's program for supporting use of career information, the Japan Research Career Information Network Portal (JREC-IN[1]) is operated, through industry-university-government cooperation, to provide useful information for career development and also to support efficient use of such information. The information provided is about job offers to, and applications by, researchers and research administrators.

In a project to build a medium- to long-term interexchange system for researchers, METI is supporting development of a framework and an environment for implementing medium- to long-term, two months or longer, research internships for students in master's/doctoral courses in the sciences at corporate laboratories. The aim of this project is the development of highly-skilled professionals in sciences who have expertise, a broad view of society, and the capability for project management. Creation of innovations through enhanced mobility between industry and academia is also a goal.

(3) Development of engineers and their capacity

Industries and engineers underpinning industrial activities are assuming a pivotal role in the promotion of STI. Increasingly advanced and integrated technologies require engineers to enhance their qualifications and abilities. MEXT and related agencies have been making efforts to develop engineers who can keep pace with these changing requirements and to increase their capabilities.

MEXT is promoting efforts for practical education in engineering at universities and universities are improving their educational content and methodologies. For example, students are provided opportunities to learn through hands-on experience, group exercises, presentations, debates and problem-solving learning.

At national colleges of technology, practical training in engineering is given to students shortly after graduating from junior high school. In response to the changes in industrial structures and accelerated socioeconomic globalization, these colleges are improving their education in order to foster practical, creative engineers who can satisfy regional or industrial needs, and are also developing engineers who are capable of creating innovations and playing active roles globally.

Engineers who have a high level of applied skill in areas such as S&T and an engage in planning and designing are qualified as professional engineers by the Professional Engineer Qualification System.

In order to be qualified as professional engineers, they must pass an examination which is given annually in each of the 21 engineering disciplines and then to be registered as professional engineers. The Professional Engineer Examination is divided into the First-Step Examination, which is given to confirm if examinees have the expertise expected of university graduates in science or engineering, and the Second-Step Examination, which is given to confirm that examinees have the high level of applied skill required of professional engineers. In FY2013, 5,547 candidates passed the First-Step Examination, and 3,801 candidates passed the Second-Step Examination. Data on candidates who passed the Second-Step Examination in each technical discipline are shown in (Table 2-4-2).

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1 Postdocs are those who have obtained a doctorate and are employed under fixed-term contracts. They are either 1) those who engage in research at a university or a research institution and are not a professor, an associate professor, an assistant professor, or a research associate, or 2) those who engage in research at a research institution such as an incorporated administrative institution, and are not a leader or a chief scientist of the research group to which they belong (including those who left school after having studied for a standard doctoral course term or longer and have earned required credits (drop outs without degree after fulfilling course requirements))

Table 2-4-2 / Successful Candidates of the Second-Step Professional Engineer Examination by Technical Discipline (FY 2013)

Technical Discipline	Number of Examinees (people)	Number of Passers (people)	Pass Rate (%)
Mechanical Engineering	916	209	22.8
Marine & Ocean	9	4	44.4
Aerospace	27	7	25.9
Electrical & Electronics Engineering	1,362	263	19.3
Chemistry	116	29	25.0
Textiles	40	10	25.0
Metals	109	30	27.5
Mining	24	7	29.2
Civil Engineering	12,218	1,834	15.0
Water Supply & Sewerage	1,479	268	18.1
Environmental Engineering	611	98	16.0
Agriculture	655	131	20.0
Forest	247	52	21.1
Fisheries	120	26	21.7
Industrial Engineering	160	39	24.4
Information Engineering	470	118	25.1
Applied Science	602	117	19.4
Biotechnology & Bioengineering	43	16	37.2
Environment	521	91	17.5
Nuclear Power & Radiation	101	21	20.8
Comprehensive Technical Management	3,293	431	13.1

Source: MEXT

To aid engineers in acquiring a broader range of basic knowledge about S&T, JST is providing online self-study materials[1] for learning about common S&T topics and specific S&T disciplines.

2 Development of Top level, Creative Researchers

(1) Establishment of fair and transparent assessment systems

In order to develop top level, creative researchers, positions available to young researchers must be increased to provide them with opportunities to conduct research autonomously, to play active roles and present career options.

MEXT is making efforts to establish a Tenure Track System[2] at more universities and public research institutions. It is a fair and transparent personnel system for employing high quality researchers (Chapter 4, Section 2, 2 (2)).

(2) Career options for researchers

To foster and employ excellent young researchers, it is necessary to secure positions for them, to guarantee them opportunities to obtain research funds, and to improve their research environment so they can concentrate on their research and produce results.

For the purpose of ensuring research environments in which young researchers can concentrate on autonomous research and can obtain secured positions, MEXT has been implementing the Program to Disseminate Tenure Track System that provides support to universities that newly adopt the Tenure

1 http://weblearningplaza.jst.go.jp/
2 In the Tenure Track System, young researchers selected through a fair process are employed under fixed-term contracts and can gain experience as autonomous researchers before obtaining secure positions.

Track System. As of FY2013 this program has supported 55 organizations[1].

In the Act for Partial Revisions to the Act on Term of Office of University Teachers, and also to the Act on Enhancement of Research and Development Capacity and Efficient Promotion. of Research and Development by Advancement of Research and Development System Reform (Act No.99)[2], which was enacted on December 13, 2013, university researchers were included in the job categories in the special provisions of the Labor Contract Act. This provision extended the period in which researchers can be employed under fixed-term contract to 10 years. It is expected that researchers at universities can produce research results more easily during the term of their fixed-term contracts, and that their research results can be appropriately evaluated to help them to secure permanent positions.

In the grant programs of KAKENHI, Grants-in-Aid for Young Scientists (categories A&B) are provided to support the autonomous research of young researchers.

The Japan Society for the Promotion of Science offers JSPS Research Fellowship for Young Scientists. In this program, fellowships are granted to top young doctoral students and postdoctoral researchers who will play leading roles in Japan's future scientific research.

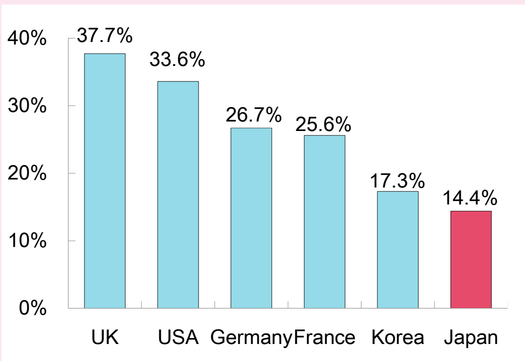
Among the Strategic Basic Research Programs of the JST, Precursory Research for Embryonic Science and Technology PRESTO is a program to which many of the applicants are young researchers.

(3) Fast Tracking (Facilitation of) female researchers'(active roles)

Fast Tracking Facilitation of female researchers' active roles for enabling women to fulfill their potential as researchers contributes to social and economic revitalization as well as to promotion of gender equality.

The 4th Basic Plan states the necessary to promptly attain the numerical target set in the 3rd Basic Plan regarding the share of female researchers in natural sciences, as well as to raise the target to 30%. In view of this, the government has been promoting employment and increasing the roles of female researchers. Although the share of female researchers has been increasing yearly, it stood at 14% as of March 2013, smaller in comparison to other advanced nations.

Figure 2-4-3 / Percentage of Female Researchers by Country



Note: 1. Data used are those as of 2010 for the USA, as of 2011 for the U.K., Germany, France and South Korea, and as of 2013 for Japan.
2. For the USA, data on scientific professionals (i.e., holders of a bachelor's/master's/doctoral degree in science or engineering, engaging in a science-related profession) are used instead of data on researchers. "Science" includes social sciences.

Source: MEXT based on *Survey of Research and Development* (MIC), *Main Science and Technology Indicators* (OECD), and *Science and Engineering Indicators 2014* (NSF)

1 This figure includes universities supported by the Program for the Promotion of Environmental Improvement to Enhance Young Researchers' Independence that was implemented by former Special Coordination Funds for Promoting Science and Technology.

2 The special provisions of the Labor Contract Act are enforced on April 1, 2014. The special provisions are applicable to researchers, engineers, and personnel who are responsible for R&D planning, securing of funds, and acquisition/utilization of intellectual property rights at universities, inter-university research institutes, and R&D institutes, and also to teachers working at universities and inter-university research institutes.

In the light of this situation, MEXT has been implementing a Support for Female Researchers program. This program supports universities that improve workplace environments to help female researchers balance work with childbearing, child care and nursing care. As of FY2013, 43 universities are subsidized by this program.

The Japan Society for the Promotion of Science has been implementing the Restart Postdoctoral Fellowship (RPD) program in order to provide research incentives to male/female researchers who have discontinued their research due to childbearing/childcare responsibilities.

The National Institute of Advanced Industrial Science and Technology has organized the Diversity Support Office (DSO), a consortium consisting of 21 universities and research institutions nationwide. DSO is promoting dissemination and increased efforts for gender equality through the cooperation of participating universities. The universities share information and exchange views about support for researchers seeking to attain work-life balance, develop their career and get motivated to pursue research careers.

As part of the effort to foster future-generation female scientists, JST has been implementing the Support for female students interested in science. Under this program, female junior and senior high school students are given opportunities to communicate with female S&T researchers, engineers, and university students, as well as to take part in experimental classes and school visit programs.

The Cabinet Office has been providing S&T-related information to female university and high-school students, who are interested in studying science and engineering, through the Challenge Campaign for Encouraging Female Students to Major in Science/Engineering program. In March 2014, the Gender Equality Bureau of the Cabinet Office updated its website and released the Rikou Science and Engineering Challenge website.

3 Development of Leading Science and Technology Human Resources of the Next Generation

To foster leading S&T human resources for the next generation, it is important to encourage more children to take an interest in science and mathematics at the elementary and secondary school levels. It is also necessary to recognize children having a talent for science and mathematics and develop those talents. To this end, education in science and mathematics has been improved.

(1) Development of intellectual curiosity in children

JST is conducting Science Leaders' Camp, at which science teachers meet at leading research institutes for lectures and hands-on sessions to learn effective skills for teaching talented students, toward their development, and to build networks of teachers. JST is also implementing the Program for Establishing Training Centers for Core Science Teachers that supports efforts made by universities in collaboration with education local boards of to foster elementary and junior-high school teachers with high competence in teaching science and mathematics, who can take a leading role as core teachers in science and mathematics education in various regions. JST also develops digital materials for use in science education and offers them online for the purpose of providing students with opportunities to learn science topics that they are curious about. Other programs promoted by JST for fostering future scientists include: the Future Scientist Program that supports universities in implementing educational programs to provide students, who have the talent and willingness to study mathematics and science, with opportunities for project studies and systematic learning the Support for school science club in which academic societies and universities support the activities of science clubs at local schools. Networks are built among researchers, teachers, and students, enabling students, with remarkable talent to be discovered and developed;.the Science Partnership Program (SPP) which supports schools, boards of education, universities, and science museums to hold teaching sessions in science and mathematics that focus on hands-on activities and problem-solving; and Science Camp that provides high school students with opportunities for learning at advanced research facilities and universities.

Improvement of science and math education is required to develop S&T professionals. Education should help students to develop an interest in science and the ability to think and communicate in a scientific manner. However, children are said to increasingly dislike science. To counter this, MEXT added science to the subjects included in the National Assessment of Academic Ability in FY2012. The survey found that students had difficulties organizing and analyzing observation/experiment results for the purposes of interpreting, considering and explaining the results. Based on this survey, MEXT has been working to improve the quality of science education with respect to observations and experiments. In FY2013, MEXT began to provide support to schools for employing assistants who help with preparations and arrangements for scientific observations and experiments at school to lighten science teachers' workloads. Additionally, research and consultation were initiated regarding the improvement of teachers' skills and competence of instructing scientific observations and experiments. Improving facilities and equipment for scientific observations and experiments at school has been also been enhanced pursuant to the Science Education Promotion Act (Act No. 186, 1953). MEXT is providing comprehensive support to the enhancement of science and math education by these means.

The National Institution for Youth Education set up a Children's Dream Fund to assist the various activities of private organizations, such as programs for giving children hands-on scientific experience.

The Japan Patent Office (JPO) has been collaborating with the National Center for Industrial Property Information and Training (INPIT) in spreading knowledge about intellectual properties, as well as in providing support to senior high schools and colleges of technology that utilize intellectual properties in practical education for human resources development.

(2) Development of the abilities of talented children

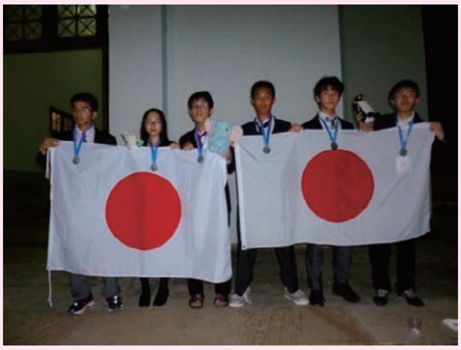
MEXT designates high schools that focus on science and mathematics education as Super Science High Schools (SSH), to which JST provides support. This initiative aims to develop S&T professionals who will assume important roles globally in the future. Specifically, efforts are being made to promote the development and practice of curricula which are not based on the National Curriculum Standards, to promote project studies, to foster future S&T professionals and to share the results of these efforts among multiple schools. In FY2013, 201 senior high schools implemented distinctive educational efforts nationwide. In 2014, the 3rd Science Intercollegiate Contest was held at Makuhari Messe International Convention Complex. This contest is an opportunity for undergraduates majoring in natural sciences to give presentations on their autonomous research, to improve themselves through learning from other students and to enter into exchanges with researchers and business people. Out of 209 applicants, 171 students/teams gave presentations at the 3rd Science Intercollegiate Contest.

JST has been supporting contests to select delegates for the International Science Olympiads, which cover mathematics, physics, chemistry, biology, informatics, geography, and earth science, and also for the Intel International Science and Engineering Fair (ISEF). JST also provides assistance to Japanese students participating in competitions abroad and international competitions held in Japan (Figure 2-4-4). JST has also been holding the Japan High School Science Championships, an annual high school science & mathematics championship, in which teams representing high schools nationwide compete against each other in demonstrating better performance in paper and skill tests. In FY2013, the 3rd Championship was held at Hyogo Prefectural Gymnasium, with Mie Prefectural Ise High School winning the championship. Japan Junior High School Science Championships was initiated in FY2013 for junior high school students. The first championship was held at the National Olympics Memorial Youth Center, where the team representing Shiga Prefecture won the championship (Figure 2-4-5).

MEXT, JPO, the Japan Patent Attorneys Association, and the National Center for Industrial Property Information and Training jointly host patent contests and design patent contests for high school/college of technology/university students. The aim is to enhance public understanding and interests in intellectual property. Students participating in these contests are rewarded for inventions and designs, and are given support when they apply for a patent or design registration in order to obtain a patent or design right.

Figure 2-4-4 / International Student Contests in Science and Technology Participants, FY2013

International Mathematical Olympiad (IMO) Participants, Colombia



From the left
Kento NOMURA, 11th grade, Senior High School at Komaba affiliated with University of Tsukuba (silver medalist)

Mayuko YAMASHITA, 12th grade, Tokyo Metropolitan Shinjuku Yamabuki High School (silver medalist)

Takahiro UEORO, 11th grade, Waseda University Senior High School (silver medalist)

Tasuki KINJO, 11th grade, Ohori Senior High School (silver medalist)

Naruki MASUDA, 12th grade, Senior High School at Komaba, University of Tsukuba (silver medalist)

Masahiro NAKAGAWA, 12th grade, Nada Senior High School (silver medalist)

International Physics Olympiad (IPhO) Participants, Denmark

From the left
Hiromitsu SAWAOKA, 12th grade, Osaka Seiko Gakuin Senior High School (bronze medalist)

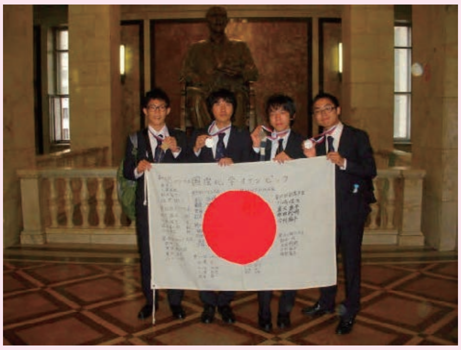
Yuichi ENOKI, 12th grade, Nada Senior High School (silver medalist)

Tasuku OMORI, 12th grade, Nada Senior High School (silver medalist)

Kenji UEDA, 12th grade, Rakunan High School (bronze medalist)

Hidenobu EMA, 12th grade, Nada Senior High School (bronze medalist)

International Chemistry Olympiad (IchO) Participants, Russia



From the left
Koichi OKAMOTO, 12th grade, Tennoji High School Attatched to Osaka Kyoiku University (Tennoji Campus) (silver medalist)

Takahiro HANEBUCHI, 12th grade, Aichi Prefectural Okazaki Senior High School (silver medalist)

Koichiro MASADA, 11th grade, Hakuryo High School (silver medalist)

Toshiya FUKUNAGA, 11th grade, Hakuryo High School (silver medalist)

International Biology Olympiad (IBO) Participants, Switzerland

From the left
Junji YOKOYAMA, 11th grade, Tokyo Metropolitan Nishi High School (silver medalist)

Kento NAKAMURA, 12th grade, Saitama Prefectural Ohmiya Senior High School (silver medalist)

Kazuyuki SANADA, 11th grade, Nada Senior High School (silver medalist)

Kazunori SHINTAKU, 12th grade, Hiroshima Gakuin Senior High School (gold medalist)

International Olympiad in Informatics (IOI) Participants, Australia

From the left

Koji RYU, 12th grade, Eiko Gakuen Senior High School (silver medalist)

Sou KUMABE, 11th grade, Senior High School at Komaba, University of Tsukuba (silver medalist)

Tsuyoki KUMAZAKI, 12th grade, Senior High School at Komaba affiliated with University of Tsukuba (gold medalist)

Yo MITANI, 12th grade, Nada Senior High School

International Earth Science Olympiad (IESO) Participants, India

From the left

Taigo ANDO, 12th grade, Nada Senior High School (gold medalist)

Yusuke KUWAHARA, 12th grade, Kaisei Senior High School (silver medalist)

Kotaro YAHATA, 12th grade, Senior High School at Komaba, University of Tsukuba (silver medalist)

Kenshiro YASUKOUCHI, 12th grade, Eiko Gakuen Senior High School (silver medalist)

International Geography Olympiad (iGeo) Participants, Japan

From the left

Masaki NAKANISHI, 12th grade, St. Viator Rakusei Senior High School

Hazuki ISHIHARA, 12th grade, Yokohama Futaba Senior high School

Misa HIRAGA, 12th grade, Oin High School (bronze medalist)

Kishin KATO, graduate, Nara Women's University Secondary School (silver medalist)

Source: MEXT

Figure 2-4-5 / The 3rd Japan High School Science Championship

Winner Mie Prefectural Ise High School

From the front left

Manami SODA (11th grade), Masayoshi OKANO (11th grade), Kanone TAKEUCHI (11th grade), Hiroko NAGANO (10th grade)

From the back left

Shin-ya YAMASHITA (11th grade), Ifu MAEMURA (11th grade), Makoto FUJIKAWA (11th grade), Junpei MORI (10th grade)

Note: Students' grades are those as of the date of the championship.

Source: MEXT

Figure 2-4-6 / The 1st Japan Junior High School Science Championship

Winner Team representing Shiga Prefecture

From the left

Naohiro OKAMOTO (8th grade), Hiroki OHTA (8th grade), Riku MATSUKI (8th grade), Mitsuki MAEKAWA (8th grade), Miyu SAJIKI (8th grade), Minori ISHIDA (8th grade)

Note: Students' grades are those as of the date of the championship.

Source: MEXT

Section 3 Establishment of a World-Class Research Environment and Infrastructure

1 Improvement of R&D Environments at Universities and Public Research Institutions

(1) Improvement of facilities and equipment at universities

Universities should have highly functional, quality facilities and equipment so that they are able to respond to demands for increasingly advanced and diverse education and research, to attract excellent human resources and to enhance global competitiveness, industry-university cooperation, local contribution and internationalization. Additionally, Japan's tight fiscal conditions and the damage caused by the Great East Japan Earthquake should be taken into consideration in promoting efforts for improving facilities/equipment at universities, as well as for stable operation of these facilities/equipment.

1) Facilities and equipment at national universities

Facilities of national universities[1] assume an important role as hubs for various activities such as creative, advanced academic research, the development of excellent creative human resources, and the

1 Including inter-university research institutes and institutes of national colleges of technology

promotion of advanced medical treatment.

In view of this, on the basis of the 4th Basic Plan, MEXT formulated the 3rd Five-Year Program for Facilities of National Universities (FY2011- FY2015) (hereinafter: the 3rd Five-Year Program) in August 2011 for promoting systematic and prioritized improvement of university facilities.

The 3rd Five-Year Program prioritizes the following projects that cover a total area of 5.5 million m^2: 1) improvement of outdated facilities, including aseismic retrofits (approx. 4 million m^2); 2) development of advanced research facilities, and improvement of cramped facilities (approx. 800,000 m^2); and 3) improvement of university hospitals responsible for advanced medical treatment (approx. 700,000 m^2). In conjunction with these projects, efforts are enhanced for formulating development plans for the entire campus (campus master plans) and for system reforms efforts that aim at strategic facilities management through the efficient use ~~of~~ and adequate maintenance of facilities.

By FY2013, the third year of the 3rd Five-Year Program, progress was made in each of the projects as follows: 1) improvement of outdated facilities: 2.06 million m^2 (52% of the target); 2) improvement of cramped facilities: 560,000 m^2 (70%); and improvement of university hospitals: 460,000 m^2 (66%). It is expected that the numerical target of each project will be mostly achieved by the end of the five-year program[1].

Improvement of the equipment at national universities is vital, as it is the infrastructure that supports advanced research and quality education.

Currently, national universities lack personnel qualified for implementing efficient and effective use of equipment and for managing aging or obsolescence of equipment. Thus, MEXT is financially supporting these universities on the basis of a medium- to long-term master plan that each university has formulated for systematic, continuous improvement of their equipment. Additionally, in the program for supporting the effective use of research equipment located at national universities, MEXT supports the efforts of universities to promote effective and shared use of their equipment.

In its Large-scale Academic Frontier Promotion Program, MEXT is also providing support to the world's most advanced research equipment developed by using creative ideas of Japanese scientists (e.g. research project on Exploration of Physics beyond the Current Particle Theory with Super B-Factory). (Chapter 4, Section 1, 1).

As part of the economic measures for realizing a positive growth cycle, MEXT secured a budget necessary for improving the equipment at national universities in the FY2013 supplementary budget. Thus, support is being provided by MEXT for reinforcing the infrastructure for advanced research and education at national universities.

1 The figures include the area improved in FY2012 by using funds diverse sources of finance such as contributions.

Figure 2-4-7 / Basic Concept of the Improvement of Facilities at National Universities

Source: MEXT

2) Facilities and equipment at private universities

Private universities make up about 80% of Japan's higher education institutions, and a variety of researchers working at these universities positively engage in distinctive research. Private universities have been playing a significant role in the advancement of higher education in Japan. MEXT is working on the enhancement of private universities' research infrastructure through implementation of the Strategic Research Foundation Grant-aided Project for Private Universities, a project for providing excellent research projects at private universities with comprehensive support to improvement of their research facilities and equipment.

(2) Promotion of the shared use and improvement of advanced research facilities and equipment

Regarding the advanced research facilities and equipment which require large expenses for improvement and operation and are suitable for shared use in multiple S&T areas, public research institutions have been playing a leading role in their improvement and operation. While these advanced research facilities and equipment are critical for producing outstanding R&D results as well as for fostering researchers, maintenance and management of these facilities/equipment have become a matter of concern because financial support to public research institutions has been decreasing. Thus, the government has been taking measures to ensure that public research institutions can continue to improve and operate advanced research facilities and equipment, and also to promote extensive shared use of them.

Support is provided by MEXT to the improvement of advanced research facilities and equipment which are expected to be useful for R&D in various S&T areas, as well as to the promotion of shared use of these facilities and equipment (Chapter 3, Section 1, 5 (2)).

2 Enhancement of Intellectual Infrastructure

For effective and efficient promotion of R&D, intellectual infrastructure needs to be improved to ensure its safety, reliability and qualitative/quantitative stability, because intellectual infrastructure supports basic research activities such as experiments, measurement, analysis and evaluation, and thus should be available to many researchers. Thus, systematization of intellectual property such as research results and research materials is necessary. Systematization of research materials, measurement standards and measurement/evaluation methods has been steadily advanced. To meet the needs of diverse users, improvement and effective use of intellectual infrastructure is being promoted while the improvement of the quality of intellectual infrastructure is also taken into account.

For the purpose of supporting research in life sciences, MEXT is developing a center of bio-resources in the National Bio-resource Project (NBRP), and the JST is implementing the Project for Promoting Integration of Life Sciences Database (Chapter 2, Section 3, 2). MEXT has been collaborating with industries and universities in promoting the development of most-advanced unique technologies and instruments for measurement and analysis that serve the needs of the world's leading researchers and manufacturers (Chapter 3, Section 1, 5(1)).

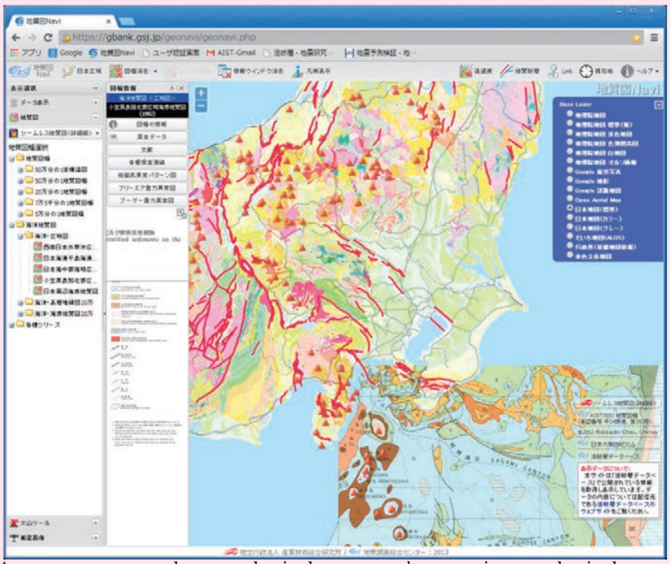
Because the 4th Basic Plan requires formulation of a new Intellectual Infrastructure Development Plan, in FY2013, METI held meetings of the special subcommittee on measurement standards and intellectual infrastructure (chaired by Koichi Kitazawa, president of Tokyo City University), which was jointly organized by the Industrial Structure Council and the Japanese Industrial Standards Committee. In March 2014, the subcommittee finalized a plan for developing intellectual infrastructure in three areas (measurement standards, microbial genetic resources and geological information), and also decided specific measures for promoting use of the intellectual infrastructure.

Regarding measurement standards, the National Institute of Advanced Industrial Science and Technology (AIST) created a standard for high-accuracy evaluation of high-energy photon beams from medical linear accelerators (i.e., linacs), and the standard was made available. This achievement is expected to help increase the safety and reliability of radiotherapy using high-energy photon beams in cancer treatment. AIST also developed a national measurement standard for the calibration of RF power meters in the 110- to 170-6Hz band for the first time in the world. The standard has been made available and is expected to be applied to uncompressed large-capacity signal transmission systems, collision avoidance radar systems, etc. The standard seawater developed by AIST as a reference material for analyzing nutrient salts is expected to help secure reliability of evaluation of material cycle in the sea.

Regarding geological information, AIST produced three 1:50,000 geological maps, two 1:200,000 marine geological maps and one 1:200,000 gravity map. AIST arranged the survey results regarding the Ishikari Lowland coastal area into a land-sea seamless geological information model of coastal areas. AIST updated its 1:200,000 seamless geological map of Japan and compiled a next-generation seamless geological map[1]. Furthermore, AIST officially released GeomapNavi, a geological map display system online, to make it possible to browse various kinds of geological information of Japan (Figure 2-4-8). In FY2013, AIST added 16,984 documents to its geological literature database, and 2,000 specimens to its geological specimen database.

1 On the basis of the width of a 1:200,000 geological map, geological maps of Japan were uniformly compiled and made available for browsing online.

Figure 2-4-8 / Display of GeomapNavi, an Online Geological Map Display System



A 1:200,000 seamless geological map and a marine geological map are displayed together with distributions of Quaternary volcanoes and active faults.

Courtesy of AIST

The National Institute of Technology and Evaluation (NITE) has been collecting, preserving and distributing biological genetic resources, and has also been organizing information on these resources in terms of their genes and genetic lineages to make the information accessible to researchers, etc. (In FY2013, 8,019 pieces of biological genetic resources were imparted.) NITE has integrated the databases of major genetic resources institutions in Japan for public release. In March 2013, a *Memorandum of Understanding* (MOU) was signed by the representatives of NITE and Myanmar regarding access to and use of microbial resources. According to the MOU, in October 2013, NITE started a project jointly with a private company for collecting and separating microorganisms in Myanmar and for transferring these microorganisms to Japan. MOUs have also been signed between NITE and other Asian countries for transferring microorganisms between governments as well as for analysis. NITE has been positively supporting preparation of biological genetic resources in Asia pursuant to the *Convention on Biological Diversity* (CBD), and also has been promoting multilateral interchanges, for the purpose of conservation and sustainable use of microbial biological resources.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) is developing a database and a system for higher-level analysis of fragmentary genomic information produced by next-generation genome analyzers, for the purpose of providing information on genes and genomes of agricultural, forestry and fishery products to breeders and researchers at universities and private companies. In its gene bank project concerning agricultural biological resources, MAFF collects, preserves, assesses and provides biological genetic resources related to agriculture, and also preserves and provides genomic resources, including DNA, of rice and other crops.

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has organized and provided Basic Map Information[1] as a result of the principal program stated in the Basic Plan for the Advancement of Geospatial Information Utilization. MLIT also conducted surveys and research on the use of geospatial information.

1 Benchmark for defining geospatial location information on digital maps

3 Enhancement of Research Information Infrastructure

Research information infrastructure is critical for research activities, as the lifeblood of research, and thus improvement of research information infrastructure in response to the rapid advancement of ICT is essential for securing the international competitiveness of Japan's R&D. As specific measures, the government has been developing and advancing networks among research institutions, and has also been creating and offering databases.

(i) Development of networks

Computer networks, which make up core systems in the contemporary world, were the product of R&D in science and technology and have been applied to other disciplines. In advancing R&D further, enhancement of network performance is required.

The National Institute of Information and Communications Technology (NICT) has been promoting R&D and demonstration tests by using the next-generation communications network test-bed (JGN-X) which NICT has developed and has been operating (Chapter 3, Section 1, 2 (2)).

The National Institute of Informatics (NII) has been improving a science information network as the infrastructure that supports scientific research and education at universities. Since April 2011 the NII has been operating the network as SINET 4[1] with enhanced speed, performance and reliability. As the needs have been increasing for advanced research using a large quantity of data as well as for information sharing in collaborative research by multiple institutions, as of FY2013, about 800 universities and research institutions in Japan are connected in networks, and networking with universities/institutions overseas is also promoted.

The MAFF has been developing and operating MAFFIN, a research network connecting research institutions related to agriculture, forestry and fisheries. As of the end of March 2014, 89 institutions are connected in MAFFIN. MAFFIN is linked to an institution in the Philippines, serving as the backbone network for the distribution of research information overseas.

(Creation and offering of databases)

Libraries and many other organizations provide access to original research papers, documents, etc. for reading, duplicating or borrowing. While the amount of information keeps increasing, creation of a database on bibliographic and whereabouts information regarding original documents owned by multiple organizations makes it possible to search online for necessary information more easily, quickly and precisely.

The National Diet Library archives all publications issued in Japan. The library creates a database on the publications, materials, etc. that it collects and keeps, and provides database information on its website[2].

To help enhance the efficiency and effectiveness of R&D activities, the NII systematically collects information on S&T necessary for creating innovations, organizes the information into an easy-to-use format and posts it online. For example, the NII has been creating and offering a database on whereabouts information regarding bibliographies of academic books and journals kept by university libraries

1 The Science Information Network 4 is the world's highest-level network deploying Japan's first 40 Gbps lines.
2 http://iss.ndl.go.jp/

nationwide, and a database on scientific papers in Japan. A common repository system is provided by the NII to research institutions and universities for helping them to develop their own institutional repository[1] for preserving and disseminating their research/educational results. The NII is operating Japanese Institutional Repositories Online (JAIRO).

JST is offering an information service, J-GLOBAL. In this service, a database on basic information is created regarding researchers, patents and S&T literature in Japan and overseas, and information is provided by linking a specific researcher, for example, to the relevant information. In FY2013, J-GLOBAL's search feature was enhanced to increase its searching speed to 2-4 times faster in comparison with the normal or maximum speed before. The user-friendliness of J-GLOBAL has substantially increased. JST has also been creating a database on the abstracts prepared by JST of S&T papers in Japanese, and has been offering the database in JDream II[2], an online paid service for literature information search. Starting in FY2013, this service has been provided by a private company in the form of JDream III, which has additional search features such as quick search and thus can be easily used by beginners. For the purpose of enhancing Japan's capacity for disseminating domestic research results worldwide, JST has developed Japan Science and Technology information Aggregator, Electronic (J-STAGE[3]), an integrated system for computerizing the entire process of submission, peer review, screening and publication of papers written for science or other journals of academic societies. Thus, JST is helping to increase global exposure of Japanese academic journals, promoting information dissemination at home and abroad. Since FY2012, J-STAGE3, an upgrade version, has been operated. In this new system, the database format conforms to international standards and the submission and peer-review process was improved. In FY2013, a feature was added to enable editors to correct articles.

MAFF has been creating and offering databases on information regarding literature on agriculture, forestry and fisheries as well as on literature's whereabouts, including the bibliographic database (Japanese Agricultural Sciences Index (JASI)) on papers published in Japanese science journals related to agriculture, forestry and fisheries. MAFF is also creating and offering databases on digitized full-text information regarding research papers published by independent administrative institutions specializing in R&D, national/public R&D institutions, and universities on the topics related to agriculture, forestry and fisheries; satellite imagery; and topics of ongoing research conducted at R&D institutions.

1 An online archive for collecting and preserving digital copies of the intellectual output of research/educational activities at a research institution or a university, and for disseminating these copies for free of charge basically.
2 JST Document REtrieval system for Academic and Medical fields II
3 Japan Science and Technology information Aggregator, Electronic

Table 2-4-9 outlines the key measures taken in relation to research information infrastructure in FY2013.

Table 2-4-9 / Key Measures Taken for Improving Research Information Infrastructure (FY2013)

Ministry /Agency	Implemented by	Research Subject
Diet	National Diet Library	Collection and organization of S&T-related documents at the National Diet Library
MIC	NICT	Development of an advanced R&D testbed network (JGN-X)
MEXT	JST	Organization of basic S&T information, and promotion of the use of such information (J-GLOBAL, etc.)
		Life Science Database Integration Program (by NBDC)
		Promotion of computerization, internationalization, dissemination, and distribution of papers on S&T (J-STAGE, etc.)
		Information service regarding literature on S&T (JDream III, etc.)
	Japan Agency for Marine-Earth Science and Technology	Operating expenses for information infrastructure
	NII	Development of the Science Information Network (SINET 4)
MHLW	National Institute of Infectious Diseases	Budget for the Infectious Disease Surveillance Center
		Research project expenses for collecting, analyzing, and assessing safety data on biological products
MAFF	Secretariat of Agriculture, Forestry and Fisheries Research Council	Operation of Agriculture, Forestry and Fisheries Research Information Technology Center (JASI, MAFFIN, etc.)
MLIT	Geospatial Information Authority of Japan	Promotion of Global Mapping Project (Development of techniques for preparing time-series data)
MOE	Biodiversity Center of Japan	Promotion of the collection, management, and provision of information on biodiversity
MEXT JPO	JST INPIT	Improvement of an integrated system for searching patent and literature information
JPO Relevant Ministry/ Agency	INPIT	Provision of a database on research tool patents (RTDB)