Chapter 4 Enhancement of Basic Research and Human Resources

Section 1 Drastic Enhancement of Basic Research

The significance and importance of basic research have increased in recent years as basic research plants the seeds for driving innovation (seedbed for diversity), extensively creates new intellectual and cultural values, and makes direct and indirect contributions to social development. In order to ensure the basis of STI in Japan, it is essential for Japan to focus on creative, diversified basic research and world-class basic research. It is also necessary to aggressively promote those projects; therefore, the government will implement efforts to drastically enhance basic research.

1 Enhancement of Creative and Diverse Basic Research

Basic research that is rooted in intellectual curiosity and the spirit of inquiry among researchers, and that is conducted based on their initiative and creativity, will lead to the creation of intellectual assets common to humankind and to the accumulation of profound knowledge. The government will, therefore, strengthen efforts to promote such creative, diversified research extensively and consistently.

(Grants-in-Aid for Scientific Research)

Grants-in-Aid, offered by MEXT and the Japan Society for the Promotion of Science, are the only competitive research funds that cover all kinds of academic research (research based on researcher's creative ideas) across the entire spectrum of scientific fields, ranging from the humanities and social sciences to the natural sciences. By supporting creative research activities while maintaining the diversity of research, the grants play important roles in promoting the expansion of the range of scientific research, the development of long-term studies and the accumulation of profound academic knowledge. In the main research categories, about 26,000 applications were selected through peer review from approximately 93,000 new applications, and approximately 70,000 cases are being supported, including research projects that continue for multiple years.

In some research categories, researchers are allowed to use the grants over multiple years at their discretion. This system started in FY 2011, and the categories were expanded in FY 2012 to include newly selected projects in 1) Scientific Research [B] and 2) Grant-in-Aid for Young Scientists [A]; the funding for these grants must be used for a portion of the research expenses, but shall not exceed a total of five million yen for projects 1) and 2) combined. (The amount of the grants in FY 2012 amounted to 230.7 billion yen out of a budget of 256.6 billion yen.)

(Strategic Basic Research Programs)

The Japan Science and Technology Agency (JST) is conducting "Strategic Basic Research Programs (the creation of new technological seeds)" to promote innovation-orientated, problem-solving basic-research (objective basic research). The agency is carrying out these programs by collecting suggestions from researchers at universities and other institutions regarding the strategic objectives of

research fields established in a top-down fashion, based on social and economic needs, as well as by forming time-limited consortia across institutional boundaries (Virtual Research Institute).

MEXT established the following five strategic objectives in FY 2012:

- the creation of a theory, a mathematical model, and fundamental technology to establish a cooperative distributed energy-management system, which enables the optimization of supply and demand for various energies, including renewable energy
- the integrated clarification of the maintenance and change mechanisms of dynamic homeostasis in the body and the creation of technology to better understand and regulate complex dynamic homeostasis in order to achieve preventive medicine, appropriate diagnosis and treatment
- the creation of new technologies for achieving breakthroughs in understanding and predicting biological activities and intermolecular interactions by means of a "Novel Structural Life Science" that contributes to new medical treatments and to the prevention of various diseases, food safety enhancement and environmental improvement
- the establishment of molecular technology, using the free control of molecules to bring innovation to environmental and energy materials, electronic materials, and health and medical materials
- the creation of advanced catalytic-transformation technology to solve various challenges related to the environment, energy and drug design

(Promotion of the Joint Usage/Research System in Universities and Inter-University Research Institutes)

Inter-university research institutes and joint-usage research centers in universities (there were 83 centers in 34 universities, as of April 2012) have large facilities and adequate equipment as well as valuable materials and data. MEXT is promoting the Joint-Usage Research system, which allows researchers to jointly use assets for their research, regardless of the organization to which each of them belongs.

In particular, for large-scale academic research projects in which many researchers participate from home and abroad, MEXT has established the "Large-scale Academic Frontier Promotion Program" (budget for FY 2012: 28.9 billion yen, supplementary budget for FY 2012: 13.3 billion yen) in order to support the improvement and operation of large-scale research facilities needed for those projects. Through this program, MEXT is promoting the establishment of research centers that can achieve research results which will lead global academic research and that can attract excellent researchers from home and abroad; in the meantime, MEXT is also cultivating young researchers from around the world.

In FY 2012, MEXT supported seven of the world's most advanced research projects[1], all of which tackle research tasks that had never been accomplished by any human-being, including a project to discover new physical principles using the further improved B-Factory accelerator at the High Energy Accelerator Research Organization, which contributed to winning the Nobel Prize in physics.

1 These projects include the "Exploring Physics beyond the Current Particle Theory with Super B-Factory" to figure out the identity and origin of mass of disappeared antimatter and dark matter, the "Development of Neutrino Research with Super-Kamiokande" to find out the identity of neutrino, the "Large-scale Cryogenic Gravitational Wave Telescope (KAGRA) Project" to make the world's first observation of gravity wave (distortion of space-time), the "Promotion of ALMA Project" to investigate the formation of galaxies immediately after the Big Bang and the beginning of life with a large radio telescope, the "Promotion of Material/Life Science and Nucleus/Particle Physics Research with the Japan Proton Accelerator Research Complex (J-PARC)" to develop the world most advanced research using various particle beams (mesons and antiprotons), the "Joint Use/Research with Subaru, a Large Optical Infrared Telescope" to observe the farthest galaxies and explore the mysteries about planets beyond the solar system, and the "Demonstration of Stable Operation of Ultra High-Performance Plasma" to study scientific principles aiming to achieve nuclear fusion.

(Promotion of Seeds Creation by the Ministry of Agriculture, Forestry and Fisheries)

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has been developing DNA-assisted selection-marker methods that use a massive amount of genetic information obtained through the progress of genome analysis in order to identify and utilize many genes from various crops that are important in agriculture (making them resistant to disease and pests, etc.).

MAFF is also conducting the creation of technological seeds that are intended to identify, and then utilize genes that are associated with complex agricultural characteristics, such as yielding ability and quality, by using the ultra-high-speed sequencer[1] with a dramatically improved genome sequencing speed.

In addition, the genome research has been promoted and allowed to apply its results to livestock and insects in order to create new demands for medical materials.

2 Enhancement of World-Class Basic Research

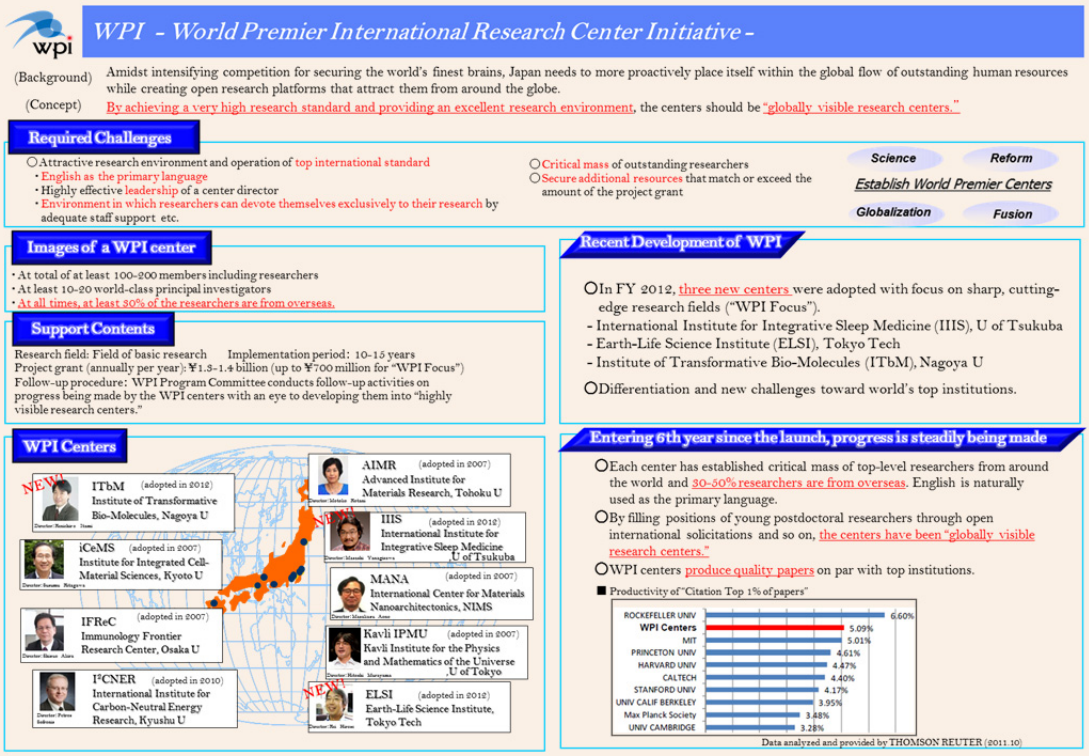
Over recent years, global competition in recruiting the best and brightest researchers has intensified. In order to maintain and improve Japan's scientific and technological standing, we need to position ourselves within the global flow of outstanding human resources while creating research platforms that will naturally attract and amass such human resources in Japan. We also need to focus our support on the formation of a cluster of universities that conduct research on international levels. The government is, therefore, further promoting the creation of research centers having international-level research environments.

(Establishment of World Premier International Research Centers)

Concerning this issue, MEXT has promoted the "World Premier International Research Center Initiative (WPI)" which aims for the establishment of "globally visible research centers," each of which provides an excellent research environment and a high level of research capable of attracting top-level researchers from around the world. Each research center receives 1.3 to 1.4 billion yen per year (up to 0.7 billion yen for the centers selected in FY 2012), and this support is scheduled to continue for 10 years (15 years to a center with outstanding results). Currently, nine centers are in operation (Figure 2-4-1). This program also aims to realize the creation of "globally visible research centers," which will verify progress and take other appropriate actions, by building a strong follow-up system centered on the "WPI Program Committee" (chaired by Hiroo Imura: ex-president of Kyoto University) as its main organization.

1 Device for reading base sequences that compose DNA

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



Source: Created by MEXT

Section 2 Development of Human Resources that can Lead S&T

Innovation is the key to the continuous growth of Japan, and it is essential to constantly foster and secure human resources who will develop innovation. We should take measures so that the young generation who will lead the future of our country can proactively enter the fields of STI with vision and hope. Therefore, we are actively making efforts to foster and secure human resources who are able to demonstrate their capabilities at home and abroad, who can lead the world in their respective specialties, and who can lead the next generation.

1 Development of Human Resources Capable of Working Actively in Diverse

(1) Drastic enhancement of graduate school education

In modern society, where S&T have been highly advanced, knowledge has been increasingly specialized and fractionalized, and international competition has intensified. Our urgent issue is to foster human resources who have a profound professional knowledge and a wide range of practical skills that can be applied to new fields of study and rapid technological innovation. Graduate schools should play a key role in developing such human resources, and the number of their students has increased by a factor of 2.7 in the 21 years from FY 1991 to FY 2012. The quantity has been increased satisfactorily, and the quality of their education should be improved further in the future.

In light of the situation, while understanding social needs, each graduate school needs to clarify the

aims of its courses, organize and practice a systematic education program that leads students to academic degrees in accordance with the aims, and be thorough in the management and clarification of the process in order to enrich and enhance the education offered at each of the graduate schools (systematic enhancement of education).

MEXT drew up two documents, entitled "Graduate School Education in the Globalized Society" (Report of the Central Council for Education, January 31, 2011) and the "Second Platform for the Promotion of Graduate School Education" (endorsed by the Minister of Education on August 5, 2011), to take measures for improving the quality of graduate school education.

Based on this platform, and in order to support the establishment of "Leading Graduate Schools" that can train leaders who will work broadly and globally across industry, academia and government, the "Program for Leading Graduate Schools" was launched in FY 2011 and was continuously supported in FY 2012. In addition, in order to establish a systematic doctoral course education, the Standards for the Establishment of Graduate Schools were revised in March 2012, and the "Basic Skills Review for Doctoral Thesis Research" was added as a requirement for completion of the master program of the doctoral course. MEXT also started the "Grant-in-Aid for the Establishment of Leading Graduate Schools" program in FY 2012 to promote measures for the enhancement of graduate school education. This program provides graduate schools that have a leading educational or research center with the funds necessary for doctoral students to devote themselves to their study and research; this is done both in order to attract excellent students and to create an environment that will foster researchers who can actively work in the international community.

MEXT and the Ministry of Economy, Trade and Industry also hold the "Industry-University Cooperative Roundtable Meeting for Human Resource Development" in order to create an effective connection between graduate training and accomplished professionals, such as doctors, who will become the leaders of Japanese society. In the meeting, 20 companies that lead Japan's industries in terms of research and development, and global deployment, as well as 12 universities working on the development and globalization of doctoral/master course education participated in a discussion to take concrete actions beyond the conventional boundaries that separate industry and academia. The second meeting was held in May 2012 and an action plan was released.

As requested by MEXT, in July 2010, the Science Council of Japan (SCJ) discussed the quality assurance of university education by field and offered an opinion on the development of the "Guidelines for Curriculum Formation," which was focused on the basic education all students should acquire in order to fulfill the expectations of MEXT. Based on this report, the SCJ continued discussions in FY 2012 and released the Guidelines for Curriculum Formation in the three fields of management studies, linguistics/literature and law for the quality assurance of a university education in each field. MEXT has requested that SCJ continue discussions for the development of the guidelines and is currently discussing the development of the guidelines for other fields of study.

(2) Support for entry into doctoral courses and the diversification of career paths

In order to encourage talented students to pursue graduate school doctoral courses, it is necessary to ensure various types of career paths so that students can use their expertise not only at their universities but also in industrial sectors or local communities after graduating from their school; it is also necessary

to provide economic support to students while they are studying at their respective graduate schools. For this reason, the government is promoting both economic support and career support for current doctoral course students as well as for those who have graduated.

1) Support for entry into doctoral courses

MEXT is expanding competitive research funds that can be used for the Teaching Assistant (TA) program, which lets graduate school students do educational assistant work to enhance their professional education, and for the Research Assistant (RA) program, which lets doctoral course students participate in research projects run by universities.

The Japan Student Services Organization (JASSO) is conducting a scholarship program to support students who have academic ability but who find it financially difficult to attend a university; furthermore, students who have achieved exceptional performance are exempted from repayment.

In addition, the Japan Society for the Promotion of Science is conducting the "Research Fellowship for Young Scientists (DC)," which offers research funds to those students who have remarkable research ability and who are doctoral students in the latter stages of graduate school so that they can fully devote themselves to their research.

2) Diversification of career paths

MEXT is making efforts to train leaders who will work globally across industry, academia and government (refer to Part 2 Chapter 4 Section 2, 1 (1)).

MEXT is also carrying out the "Career Development Program for Postdoctoral Fellows" to support universities that build career-development support systems so that postdocs[1] can secure a variety of career paths both at home and abroad, and so they have the possibility of becoming a faculty member or researcher at independent administrative organizations focused on research and development. Thus, in FY 2012, 36 organizations made efforts toward these goals, such as conducting long-term internships, which exceeded three months.

In addition, in order to improve the environments for the activation of research activities, to enhance the management of research and development at universities and to prepare diverse career paths beyond the limited scope of research jobs for human resources in S&T, MEXT is supporting the establishment and development of human resources on research management (research administrator) at universities.

JST is providing a researchers database[2] that lists information on researchers who are looking for a job and recruitment information regarding research jobs in the industry, academia and government to support the development of diverse career paths.

It is necessary to provide industry with leading researchers who have a profound knowledge in their field of specialty in addition to having a strong communication ability and the cooperative attitude necessary for working together with professionals in different fields. The National Institute of Advanced Industrial Science and Technology is, therefore, conducting "AIST Innovation School" to provide postdocs and doctoral students with a practical education, which includes participation in classroom

1 This refers to those who are working as fixed-term researchers at a university or a research institute and who have obtained a doctorate or have left a doctoral course after being a student for at least the normal term of study and who have obtained designated credits (with the exception of professors, associate professors, lecturers, assistant professors, assistants, leaders of research groups and principal investigators).

2 http://jrecin.jst.go.jp/

training, research projects at AIST, and internship program at companies.

(3) Engineer training and skill development

Industrial sectors and the engineers supporting them play a core role in the promotion of STI. In addition, in accordance with the advancement and integration of technologies, the qualities and skills required of engineers are becoming increasingly sophisticated and diversified. For this reason, the government is making efforts for the training of leading engineers and for skill development in response to such changes.

MEXT provided universities with support for the improvement and enhancement of their engineer training, as it informed universities of the results of the "Research study on how to set performance objectives of each field regarding engineer training," which was produced based on the international standards for engineer training at four-year universities.

MEXT also provides the "Professional Engineer" system, which grants the certification of "Professional Engineer" to engineers who conduct practice on matters of planning, design, etc., that require advanced professional practical abilities in scientific and technological matters.

In order to become a Professional Engineer, engineers must pass the Professional Engineer examination held in 21 disciplines every year and obtain registration. The Professional Engineer examinations are divided into the First-Step Professional Engineer examination, which requires the same level of professional knowledge as the science and engineering graduate has, and the Second-Step Professional Engineer examination, which requires enough advanced professional practical abilities to become a Professional Engineer. In FY 2012, 10,881 candidates passed the First-Step Professional Engineer examination, and 3,409 candidates passed the Second-Step Professional Engineer examination. The successful candidates in each discipline of the Second-Step examination are shown below (Table 2-4-2).

Table 2-4-2/ Successful Candidates in Each Discipline of the Second-Step Professional Engineer Examination (FY 2012)

Technical Disciplines	Applicant (Persons)	Certified (Persons)	Rate of certified people (%)
Mechanical Engineering	898	210	23.4
Marine & Ocean	10	2	20.0
Aerospace	24	5	20.8
Electrical & Electronics Engineering	1,260	193	15.3
Chemistry	118	29	24.6
Textiles	33	6	18.2
Metals	114	25	21.9
Mining	23	6	26.1
Civil Engineering	13,432	1,748	13.0
Water Supply & Sewerage	1,526	246	16.1
Environmental Engineering	580	92	15.9

Technical Disciplines	Applicant (Persons)	Certified (Persons)	Rate of certified people (%)
Agriculture	719	164	22.8
Forest	261	53	20.3
Fisheries	134	29	21.6
Industrial Engineering	150	37	24.7
Information Engineering	509	69	13.6
Applied Science	637	104	16.3
Biotechnology & Bioengineering	50	19	38.0
Environment	599	88	14.7
Nuclear & Radiation	117	19	16.2
Comprehensive Technical Management	3,654	265	7.3

Source: Created by MEXT

In addition, the JST offers on-line self-teaching materials[1] regarding each discipline and the common area of S&T to help engineers learn a wide range of basic S&T knowledge.

2 Training for Creative, Quality Researchers

(1) Establishment of fair and highly transparent assessment systems

In order to train creative, quality researchers, it is necessary to provide young researchers with opportunities for independence and to increase the number of posts for them so that they may establish a career path.

MEXT is supporting the "Tenure Track System[2]," which allows quality human resources to be employed by universities and public research institutes through a fair and highly transparent employment system (refer to Part 2 Chapter 4 Section 2, 2 (2)).

(2) Improvement of career paths for researchers

In order to train quality researchers, it is necessary to improve career paths for young researchers as

1 http://weblearningplaza.jst.go.jp/

2 System where young researchers are employed through a fair and highly transparent selection process and are able to gain experience as an independent researcher by having special employment conditions, such as working for a specific period of time, and then moving onto a more stable profession after they have gone through review.

well as to secure posts for them. In so doing, it is important to increase the mobility of researchers in order for them to accumulate experience in various research environments and to expand their human networks and broaden their views as researchers. On the other hand, it is pointed out that, in some cases, efforts to improve mobility may actually discourage young researchers from working on research, so the government will also develop career paths that can provide stability to researchers, while still ensuring opportunities for a certain level of mobility.

In order to promote the improvement of the environments that allow young researchers to conduct research independently, MEXT is carrying out the "Program to Disseminate the Tenure Track System," which provides universities conducting the Tenure Track System with startup research expenses so that tenure-track teachers can establish the system and broaden its scope. In 2012, 141 teachers in 42 organizations became new tenure track teachers and, thus, eligible for the support.

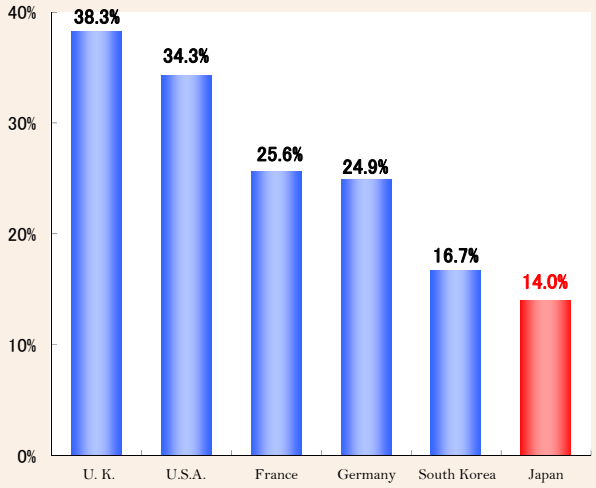
The Japan Society for the Promotion of Science is conducting the "Research Fellowship for Young Scientists" program, which provides young, quality researchers with opportunities to devote themselves to their research; it also lets them independently select study subjects with no conceptual restrictions in order to develop and secure creative researchers who will lead the future of Japan's academic research.

The National Agriculture and Food Research Organization (NARO) has set up special reserves in the budget to support the development of technical seeds by young researchers in its "Basic Research Promotion Program for Creation of Innovation."

(3) Promoting the work of female researchers

Under the 4th Basic Plan, Japan has been promoting the appointments of female researchers and their work by trying to quickly achieve the numeric targets for the adoption of female researchers as they were set under the 3rd Basic Plan (25% for the natural sciences as a whole) and aims to raise the target to 30%. As a result, the number of female researchers is increasing year by year, but is still at a low level when compared to foreign countries (Figure 2-4-3). The appointment of female researchers is very significant for both improving gender equality and for improving organizational creativity through the adoption of various viewpoints and ideas and for stimulating research activities. For this reason, the government is improving the research environment to allow for further appointments of female researchers and the promotion of their work.

Figure2-4-3/ Percentage of Female Researchers in Various Countries



Note: 1. The Ministry of Internal Affairs and Communications' "Report on the Survey of Research and Development" (Japan: as of 2012), OECD's "Main Science and Technology Indicators" (The U.K.: as of 2010, France: as of 2010, Germany: as of 2009, South Korea: as of 2010), NSF's "Science and Engineering Indicators 2006" (The U. S. A.: as of 2003)
2. As for The U. S. A., "female researchers" refers not only to researchers but also to scientific specialists (those who have a bachelor's degree or an advanced degree in science and engineering and who are engaged in a profession related to the sciences, including the social science.)

Source: Created by MEXT

MEXT is conducting the "Program to Support the Research Activities of Female Researchers," which provides funding for universities that improve the environments for researchers who are facing the challenges associated with childbirth, childcare and nursing care. The fund helps with expenses for employing coordinators who promote support activities and for employing research assistants who support research activities while researchers are in childbirth, raising children or caring for elderly relatives. As of FY 2012, the program had been supporting 31 organizations.

Since FY 2006, under the "Research Fellowship for Young Scientists" program, the Japan Society for the Promotion of Science has been offering research scholarships to quality researchers so that they can smoothly return to their research after taking a leave of absence from their work because of childbirth and childcare.

The National Institute of Advanced Industrial Science and Technology (AIST) has organized Diversity Support Office (DSO), a consortium consisting of 19 universities and research institutes nationwide. DSO promotes dissemination and expansion of knowledge and information on gender equality by sharing information and exchanging opinions regarding work-life balance and career development among participating organizations.

As one of the efforts to develop human resources that will lead the next generation, MEXT is conducting the "Program to Encourage Female Students of Lower/Upper Secondary Schools to Follow the Science Career Paths," which creates opportunities for girls to interact with female researchers and engineers who are actively working in the field of S&T. The project also provides classroom laboratories and visiting lecturers to encourage female students to follow science career paths.

The Cabinet Office is offering students information about science and engineering fields in a program entitled the "Challenge Campaign—Getting Female Students at High Schools and Universities to Pursue Degrees in Science and Engineering."