Chapter 4 Reinforcing the Fundamental Capability for STI

Section 1 Developing High-quality Human Resources

People drive STI. Despite increasing competition over the recruitment of highly trained personnel around the world, Japan's population of young people continues to decrease. Under these circumstances, improving the quality and exerting the capabilities of STI professionals are becoming even more important. Through various initiatives, in Japan, we are continuously developing and securing diverse and talented pool of professionals, and creating a society in which through their activities, STI professionals can play an active role as knowledge professionals in a variety of sectors, both in academia and in industry.

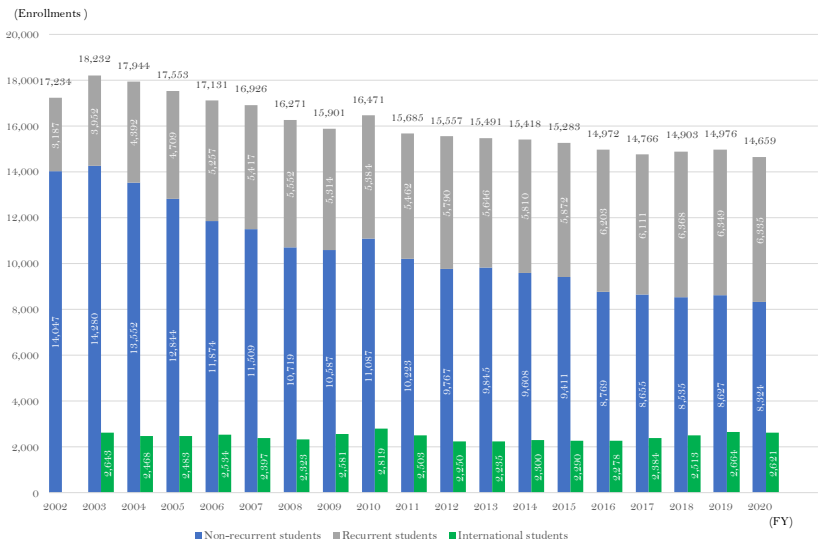
❶ Developing, securing and improving career prospects of human resources as intellectual professionals

(1) Developing and improving career prospects of young researchers

It is necessary to develop and secure excellent young researchers who are important players for STI. For this purpose, it is important to increase opportunities of research funding and improve the research environment to ensure both stable employment and mobility, to encourage excellent students to take a doctoral course for the purpose of becoming researchers, focus on their research activities and produce results.

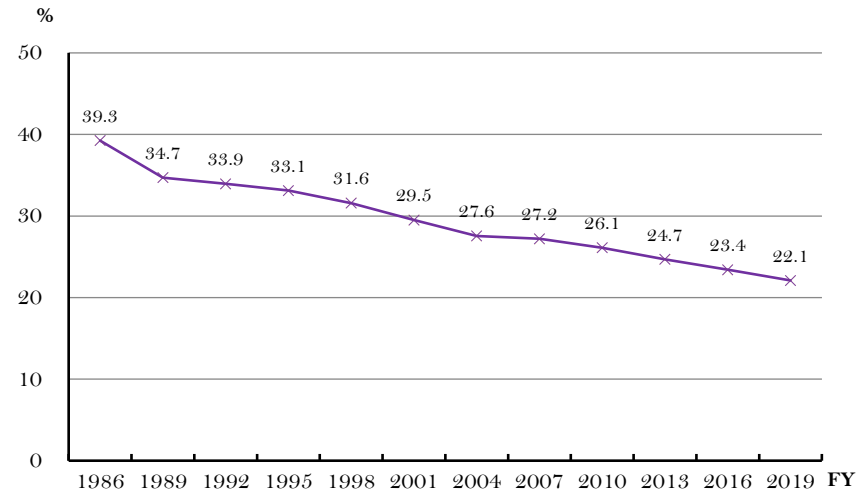
In recent years, however, there have been signs of difficult situations for young researchers in Japan, as exemplified by the downward trend of doctoral course enrollment and the declining ratio of young full-time university teachers (Figures 2-4-1 and 2-4-2).

■ Figure 2-4-1/ Changed in Doctoral Course Enrollments ■



Source: MEXT

Figure2 2-4-2/ Ratio of full-time teachers under 40 years of age in universities



Source: MEXT

In this context, the Committee on Human Resources, Council for Science and Technology (CST) set up a subcommittee on employment of post-doctoral fellows, etc. in October 2019. Based on the studies by the subcommittee, the committee formulated guidelines for institutions which incorporate employment/acceptance environment, ability development and support for career development of post-doctoral fellows, etc. in December 2020. The guidelines were provided to institutions.

A. Realization of stable and independent research by young researchers

Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the Leading Initiative for Excellent Young Researchers in FY2016 to support researchers and research institutions so that excellent young researchers can obtain a stable environment for independent research to devote themselves to voluntary and independent research at research institutions of industry, academia or government. By FY2020 at least 394 young researchers (January 31, 2021) found a stable and independent research environment at positions created under the program.

B. Diversification of career options

MEXT has been implementing the "Building of Consortia for the Development of Human Resources in Science and Technology" to secure stable employment for young researchers while increasing their mobility to help their career development, and also to support universities, etc. in constructing a mechanism to diversify their career paths. The support has been provided to 10 organizations in FY2020.

Furthermore, the "Strategic Development Program for Young Researchers" has been implemented since FY2019 and has been supporting three organizations in FY2020. The program aims to construct a well-organized system to foster researchers beyond the boundary of laboratories, and will include: incorporating

knowledge of advanced initiatives in Japan and abroad to improve research productivity in the country; developing programs for fostering of world-class researchers and; a support system for publishing in top journals and acquisition of overseas funds, for example.

The Japan Science and Technology Agency (JST) operates the Japan Research Career Information Network Portal site (JREC-IN Portal[1]) to provide researchers and assistants with information for career development including job information and to support the efficient use of such information.

C. Improvement of research environment

Under the Grants-in-Aid for Scientific Research (KAKENHI), JSPS formulated the "KAKENHI Young Support Plan" and has been working on measures to reinforce support in accordance with the career development of researchers while encouraging friendly competition in an open environment. Toward the aid program in FY2021, the duration of "Grant-in-Aid for Early-Career Scientists" will be extended from 2 to 4 years to 2 to 5 years to enable more continuous and stable research, and "Grant-in-Aid for Scientific Research (A)/(B)" will be expanded to seamlessly support researchers who have received "Grant-in-Aid for Early-Career Scientists" according to their career stage.

"The Public-Private program to discover and support young researchers" has been implemented by the New Energy and Industrial Technology Development Organization (NEDO) since FY2020. Under this program, the Ministry of Economy, Trade and Industry (METI) supports matching of young university researchers, etc. who aspire to commercialization with suitable enterprises, while subsidizing joint research with enterprises.

(2) Developing and improving career prospects of various people in STI

A. Efforts for development of research manager and promotion of their active participation

It is important to develop not only researchers but also diverse human resources and promote their participation. MEXT has been conducting survey and research on support measures for research administrators in order to improve research environments; to encourage more active research, strengthen R&D management at universities and establish diverse career options for scientists/engineers beyond research positions, for example.

In FY2018, with the aim of further strengthening the Research Administration system at universities, etc., the "Study Committee on Strengthening of Research Administrator's Activities" compiled a summary of issues toward introduction of an authorization system that will contribute to improvement of their knowledge/skills and visualization of their executive ability (September 2018). Based on the summary of issues, a survey study started in FY2019 toward introduction of an authorization system and continued in

1 https://jrecin.jst.go.jp

FY2020.

With the aim of increasing world-class research universities, the Program for Promoting the Enhancement of Research Universities has been implemented since FY2013. Under this program, the government supports employment of research management personnel including URA, as well as intensive reform of research environments of 22 research institutes including universities selected based on quantitative indices so that the research capacity of Japanese universities will increase.

The "Program for development of Program Managers (PM) and promotion of their active participation" is implemented for excellent human resources in Japan to acquire practical knowledge, skill and experience of PM. Its aim is to present and establish this new job category for innovation creation, and to show a career path to work in funds allocation organs.

B. Development of engineers and their capabilities

Industries and engineers that underpin industrial activities assume a pivotal role in the promotion of science, technology and innovation. Increasingly advanced and integrated technologies require engineers to improve their qualifications and abilities. MEXT and related agencies have been making efforts to foster 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. Universities are working to achieve qualitative enhancement of education content and method, which include: learning through problem solving using problems at partner companies, and education merging disciplines based on the industrial/social structure. At colleges of technology, integrated professional and practical training in engineering that is conducted on a consistent basis for five years is given to junior high school graduates. These colleges are strengthening cooperation with other fields and developing engineers who are capable of playing active roles globally through education based on social needs. Engineers who have a high level of applied skill in areas such as S&T and who can engage in planning and designing are qualified as professional engineers under the Professional Engineer Qualification System. The Professional Engineer Examination is divided into the First-Step Examination, which is given to determine whether the examinee has the expertise expected of a university graduate in science or engineering (6,380 successful candidates in FY2020) and the Second-Step Examination, which is given to determine whether the examinee has the high level of applied skill required of a professional engineer (2,415 successful candidates in FY2020[1]). Data on candidates who passed the Second-Step Examination in FY2020 in each technical discipline are shown in Table 2-4-3.

[1] Successful candidates of the Second-Step Professional Engineer Examination in FU2020 are not included. The same applies to the number of successful candidates and the pass rate of Table 2-4-3.

■ Table 2-4-3/Breakdown of successful candidates of the Second-Step Professional Engineer Examination by Technical Discipline (FY2020) ■

Technical Discipline	No. of candidates (people)	No. of successful candidates (people)	Pass rate (%)
Mechanical Engineering	766	140	18.3
Marine & Ocean	6	3	50.0
Aerospace	39	7	17.9
Electrical & Electronics Engineering	952	123	12.9
Chemistry	119	29	24.4
Fiber & Textiles	40	9	22.5
Metals	53	19	35.8
Mining	14	3	21.4
Civil Engineering	11,763	1,214	10.3
Water Supply & Sewerage	1,237	181	14.6
Environmental Engineering	420	32	7.6

Technical Discipline	No. of candidates (people)	No. of successful candidates (people)	Pass rate (%)
Agriculture	592	63	10.6
Forest	236	61	25.8
Fisheries	97	13	13.4
Industrial Engineering	186	22	11.8
Information Engineering	304	23	7.6
Applied Science	499	82	16.4
Biotechnology & Bioengineering	33	9	27.3
Environment	383	52	13.6
Nuclear & Radiation	44	6	13.6
Engineering Management	2,582	324	12.5

Source: MEXT

To aid engineers in acquiring a broader range of basic knowledge about science and technology, the JST provides online self-study materials[1] on common science and technology topics and specific science and technology disciplines.

(3) Promoting reforms of graduate school education

MEXT is working to improve the system of the Graduate Education Reforms to train "Professionals of Knowledge" who think for themselves and act based on sophisticated expertise and a sense of ethics, create new knowledge and values based on their knowledge, work globally and lead the future. In FY2020, the ministry promoted establishment of graduate education as a diploma program through a system amendment based on "Drastic reform of graduate school education with a view to 2040 – to respond to the demands of society and learners (summary of deliberation)" (Central Council for Education's University Division, January 2019).

In order to cultivate excellent doctoral talents and build first-rate centers for sustainable activities for human resource development/exchange and new joint research, the Doctoral Program for World-leading Innovative & Smart Education (WISE Program) started in FY2018. The program supports development of 5-year integrated doctoral programs by universities based on their strengths, utilizing the results of the reform of their graduate schools in organized coordination with other universities, research institutes, and

1 https://jrecin.jst.go.jp/

private companies, etc. at home and abroad. 30 programs of 17 universities were adopted by FY2020.

The Japan Student Services Organization (JASSO) provides scholarship loan programs to financially support motivated students who excel academically but who have difficulty pursuing their studies due to financial constraints. Interest-free loan recipients who are recognized by JASSO as having achieved particularly outstanding results in their studies may be partially or completely exempt from repaying their loans. Starting from the enrollment in FY2018, JASSO has expanded the system to exempt doctoral students with excellent performance from repaying their loans. The aim is to encourage continued education by reducing financial burden on students of doctoral programs.

To foster top level researchers who will play major roles in future scientific research, the Japan Society for the Promotion of Science (JSPS) offers the Research Fellowship for Young Scientists Program under which fellowships are granted to doctoral students (DC).

At the request of MEXT, the Science Council of Japan (SCJ) has been developing a Guideline for Curriculum Formation that focuses on the basic education given to all graduates for the quality assurance of university education in each academic field and compiled the reference standard for 33 academic fields by FY2020.

(4) Development for the next generation of STI professionals

MEXT supports deployment of assistants for science observations and experiments in order to develop a teaching system for further improvement of observations, experiments and teaching in science education. The ministry is also advancing plan-based improvement of facilities and equipment for science and mathematics education including equipment for scientific observations and experiments, pursuant to the Science Education Promotion Act (Act No. 186, 1953).

MEXT designates high schools that provide advanced science and mathematics education as Super Science High School (SSH). This initiative aims to help students develop scientific abilities and thereby develop human resources for science and technology who can play important roles globally in the future. Specifically, schools designated as SSH are promoting project studies in cooperation with universities, research institutes, etc., developing and using curricula focused on science and mathematics to foster highly creative talents. In FY2020, 217 SSHs throughout the country provided such advanced and specialized education.

Under the Global Science Campus (GSC) program, JST selects and supports universities that develop and implement programs to cultivate high-school students who have desire and talent into international human resources in science and technology. In FY2017, JST started the School to Cultivate Junior Doctors for elementary and junior-high school students with outstanding desire and ability in science and mathematics. In this initiative, universities, etc. provide special education programs to further develop their abilities.

The Science Intercollegiate is a venue for undergraduate students in natural sciences courses from across the country to present their own research in a friendly nationwide competition. They also have opportunities to meet with persons outside academia such as business people. The 10th Intercollegiate was held online from late January to late February 2021. Presentation was made by 40 teams who passed document screening.

In addition, the JST has sponsored preliminary domestic contests for international science and technology contents, such as the International Science Olympiads for mathematics, chemistry, biology, physics, informatics, earth science and geography, and the International Science and Engineering Fair (ISEF), as well as supporting Japanese students' participation in competitions abroad and international competitions held in Japan (Figure 2-4-4). The Japan Junior High School Science Championship is a nationwide competition of schools and teams, to determine comprehensive strengths based on paper tests and practical skills in science and mathematics. In FY2019, the 8th Championship was scheduled in Himeji City, Hyogo Prefecture, from December 4 to 6, 2020, but was suspended considering the spread of COVID-19 infection. Instead, the 2020 Japan Junior High School Science Exhibition was remotely held from December 5, 2020 to March 5, 2021 and the 5TKs team of Tokyo won first place (Figure 2-4-5). The Japan High School Science Championship was held from March 19 to 21, 2021 in Tsukuba City, Ibaraki Prefecture and a team representing Kyoto Prefecture won first place (Figure 2-4-6).

MEXT, the Japan Patent Office (JPO), the Japan Patent Attorneys Association, and the National Center for Industrial Property Information and Training (INPIT) jointly host the Patent Contests and Design Patent Contests for students at high schools, colleges of technology and universities. 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. MEXT honors the schools of the participating students, which made active efforts for these contests to enhance the Intellectual Property Mind of students or deepen their understanding of the IP system.

Children who will live in Society 5.0 need to effectively use state-of-the-art technologies based on ICT in education, but the ICT environment of schools is underdeveloped and there is a big gap among local governments. To address this issue, budgetary steps were made in FY2019 for realization of the GIGA School Program to integrally develop a system for "1 device for 1 student" with high-speed and high-volume networks while at the same time promoting the use of the cloud, establishing a system for procurement of ICT equipment, spreading best practice of utilization and ensuring the PDCA cycle of utilization.

■ Figure 2-4-4/Participants in the International Student Contests in Science and Technology (FY2020) ■

International Mathematical Olympiad (Online/Russia) Participants

From back row left
MASUGI Kazuki, 3rd grade, Rakunan High School (silver medalist)
SHUKUTA Ayato, 3rd grade, Kaisei High School (silver medalist)
WATANABE Naoki, 3rd grade, Hiroshima University High School (silver medalist)
ISHIDA Atsuya, 3rd grade, Rakunan High School (silver medalist)
KAMIO Yuhi, 2nd grade, Kaisei High School (silver medalist)
HIRAYAMA Fuma, 3rd grade, Nada Senior High School (silver medalist)

Source: The Mathematical Olympiad Foundation of Japan

International Biology Olympiad 2020 (Online/Japan) Participants

From left
SUEMATSU Mahiro, 3rd grade, Eiko Gakuen Senior High School (gold medalist)
KANEHISA Ren, 3rd grade, KOCHI GAKUGEI Senior High School (silver medalist)
MATSUFUSA Manami, 3rd grade, Oin Senior High School (silver medalist)
KAWAMOTO Seita, 3rd grade, Rakuhoku Senior High School (silver medalist)

Source: International Biology Olympiad Japan Committee

International Olympiad in informatics (Online/Singapore) Participants

From left
YONEDA Masataka, 3rd grade, Senior High School at Komaba, University of Tsukuba (gold medalist)
YONEDA Hirotaka, 3rd grade, Kaisei High School (silver medalist)
HOSHII Tomohito, 3rd grade, Senior High School at Komaba, University of Tsukuba (silver medalist)
MATSUO Rintaro, 2nd grade, Azabu Senior High School (gold medalist)

Source: International Olympiad in Informatics Japan Committee
* Note: The schools and grades are as of when the award was won.

■ Figure 2-4-5/ 2020 Junior High School Science Championships (Exhibition) ■

Winning team: 5Tks team (Tokyo)

From left
KITA Shunsuke, 1st grade, Junior High School at Komaba, University of Tsukuba
WATANABE Soma, 1st grade, Junior High School at Komaba, University of Tsukuba
TAKAHASHI Hiroto, 1st grade, Kaisei Junior High School
SEKIGUCHI Isane, 1st grade, Junior High School at Komaba, University of Tsukuba
IDONUMA Yusei, 1st grade, Junior High School at Komaba, University of Tsukuba

Source: Japan Science and Technology Agency
* Note: The grades are as of when the award was won.

■ Figure 2-4-6/The 10th Japan High School Science Championships ■

Winning team: Kyoto Prefectural team
From front row left
TANAKA Yuto, 2nd grade, Rakuhoku Senior High School
TAKAHATA Rintaro, 2nd grade, Rakuhoku Senior High School
TOKUDA Hinata, 2nd grade, Rakuhoku Senior High School
ODA Ryoichiro, 2nd grade, Rakuhoku Senior High School
TAKEGAMA Shintaro, 2nd grade, Rakuhoku Senior High School
SONO Masaki, 2nd grade, Rakuhoku Senior High School
IIDA Kenta, 2nd grade, Rakuhoku Senior High School
SEKI Shiryu, 2nd grade, Rakuhoku Senior High School

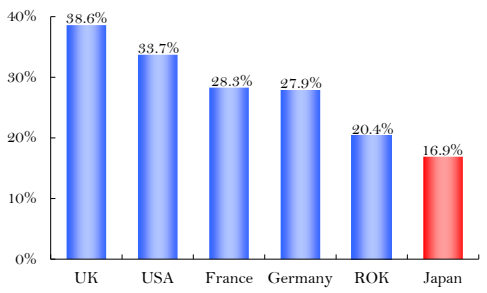
* Note: The grades are as of when the award was won.

❷ Promoting diversity and career mobility

(1) Improving women's career prospects in STI

Encouraging female researchers to fulfill their potential promotes economic and social revitalization and gender equality. In Japan, by supporting employment and increasing the roles of female researchers, the share of female researchers has been increasing every year. However, woman still accounted for only 16.9% of researchers as of March 31, 2020, which is lower than in other advanced countries (Figure 2-4-7). The 6th Basic Plan set the following goals for the ratio of women among researchers hired by universities by 2025: 20% in the physical sciences, 15% in engineering, 30% in agriculture, 30% in medicine, dentistry and pharmacology combined, 45% in humanities and 30% in social sciences.

■ Figure 2-4-7/Percentage of female researchers by country ■



Note: 1. The data are as of 2018 for the UK and Republic of Korea, 2017 for the U.S.A., France and Germany.
2. For the U.S.A. data on scientific professionals (i.e., bachelor's/ master's/ doctoral degree holders in science or engineering who engage in a science-related profession) are used instead of data on researchers. "Science" includes the social sciences.
Source: Adapted by MEXT based on Survey on Research and Development (MIC), Main Science and Technology Indicators (OECD) and Science and Engineering Indicators 2020 (NSF)

The Cabinet Office's website Science/Engineering Challenge [1] provides information on efforts by universities and companies to encourage such challenges and provides communications from female workers in science and technology. In August 2020, an online symposium "How will career choice change my life? - Science will expand my future 2020" was held on the website. Through the symposium, diverse

1 http://www.gender.go.jp/c-challenge/

role models in science and engineering fields sent messages to female junior-high/high school students across Japan, their guardians and teachers.

Measures to expand diversity including promotion of active participation by women are decided under the "Comprehensive Package to Strengthen Research Capacity and Support Young Researchers" (decision by The Meeting to Promote Comprehensive Innovation Strategy on January 25, 2020)

MEXT has implemented the Initiative for Realizing Diversity in the Research Environment, to support initiatives for diversity implemented by universities and other institutions. The initiative includes integrated promotion of leader training through support for researchers to allow them to balance their research with maternity, childcare and other life events and support for female researchers in improving their research capabilities. 121 institutions implemented the initiative in FY2020.

The JSPS has implemented the Restart Postdoctoral Fellowship (RPD)[1] Program to provide research incentives to male/female researchers who have temporarily discontinued their research due to maternity/childcare responsibilities.

The Japan Science and Technology Agency (JST) implements the "project to encourage female students of lower/upper secondary schools to follow scientific career paths." The project provides female junior-high/high school students with opportunities of exchange with female researchers, engineers, university students, and experimental workshops and lectures on demand to arouse the interest of students in science and support their science/engineering career choice.

The National Institute of Advanced Industrial Science and Technology (AIST) organized the Diversity Support Office (DSO), a consortium of 20 universities and research institutions nationwide. The DSO promotes information-sharing and exchanges of opinions on diversity promotion among member institutions. The DSO is also implementing the action plan based on the Act on Promotion of Women's Participation and Advancement in the Workplace in cooperation with universities and companies and working to promote diversity by further expanding the network, supporting work-life balance and career development of researchers and raising awareness.

(2) Enhancing the international research network structure

A. The development of international networks of researchers

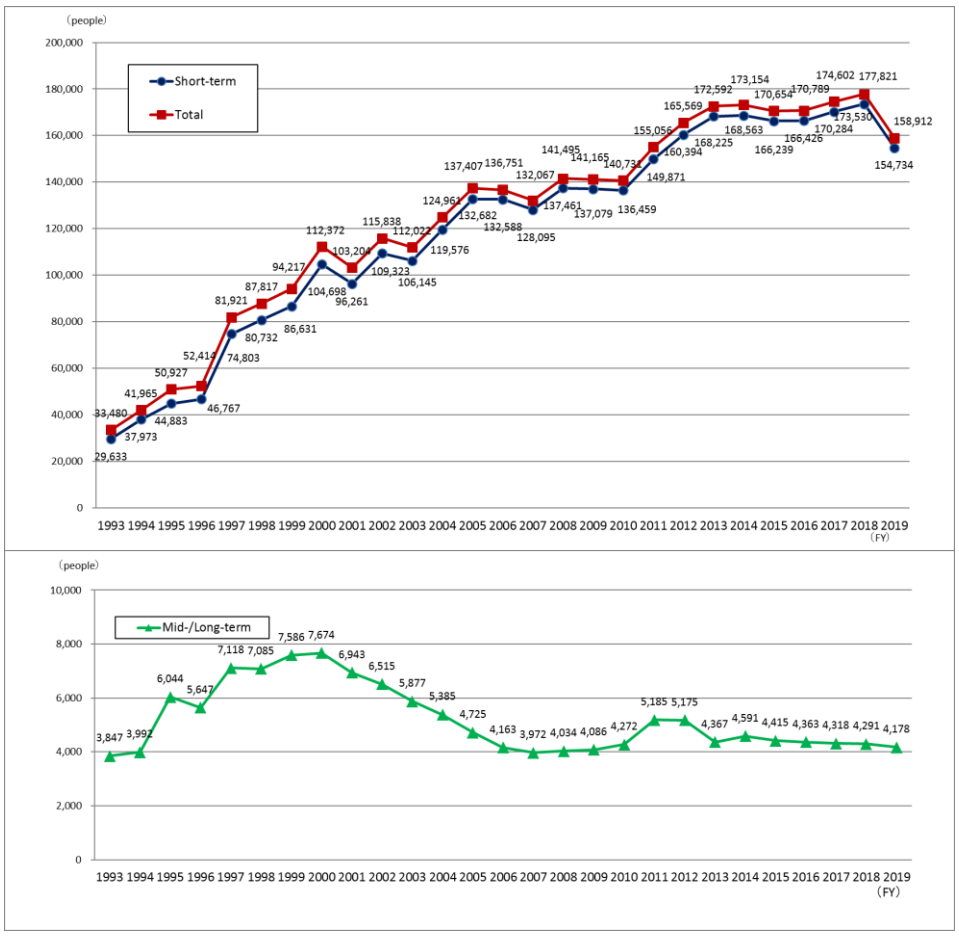
(A) International mobility of Japanese researchers

According to the Overview of International Research Exchanges published in FY2021, the number of Japanese researchers on overseas short stays had tended to grow since the start of the survey but significantly decreased in FY2019. The number of Japanese researchers on mid-length to long stays overseas varied between 4,000 and 5,000 every year since FY2008. The number slightly decreased in FY2019 from the previous year, but the decrease is small compared with short stays (Figure 2-4-8). The number of short-

1 Refers to postdoctoral researchers restarting research activities

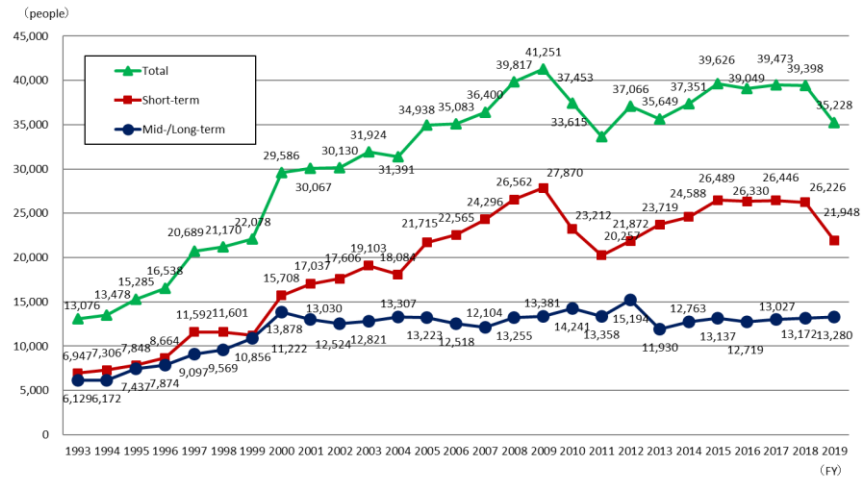
stay foreign researchers accepted by universities and Incorporated Administrative Agencies in Japan showed a tendency to grow until FY2009, while the number decreased in FY2011 as a result of the Great East Japan Earthquake and then rebounded in the following four years to the level before the disaster, but significantly decreased again due to the impact of the COVID19 pandemic in FY2019. The number of foreign researchers on mid-length to long stays varied between 12,000 and 15,000 every year since FY2000. Unlike short-stay researchers, the number did not decrease in FY2019 (Figure 2-4-9).

■ Figure 2-4-8/Changes in the number of Japanese researchers overseas (Short or mid-length to long stay) ■



Note: 1. "Short stay" means 30 days or fewer; "mid-length to long stay" means more than 30 days.
2. Postdocs and research fellows are included in the figures in and after FY2010.
Source: Overview of International Research Exchanges, MEXT (2021)

■ Figure 2-4-9/Changes in the number of foreign researchers in Japan (Short or mid-length to long stay) ■



Note: 1. "Short stay" means 30 days or fewer; "mid-length to long stay" means more than 30 days.
2. Postdocs and research fellows are included in the figures in and after FY2010.
3. The overlap caused by multiple counting of the same foreign researchers accepted at multiple institutions in Japan in the same fiscal year was eliminated from the FY2013 survey.
Source: Overview of International Research Exchanges, MEXT (2021)

(B) Efforts to promote international exchanges of researchers

In the midst of the globally accelerating brain circulation, Japan is making efforts to ensure that Japanese researchers and research teams can play a central role in networks of international research or researchers.

To foster young Japanese researchers who can play active roles internationally, the JSPS has provided various programs for the purpose of sending young researchers abroad and inviting excellent researchers from other countries to Japan. In the FY2019 Grants-in-Aid (KAKENHI) JSPS introduced a system to temporarily suspend research funds when the recipient is traveling overseas, and expanded "Fostering Joint International Research (B)" for acceleration of international joint research with the requirement of participation of young researchers.

In addition, JSPS offers the Overseas Research Fellowships, aiming at fostering and securing highly capable researchers who have broad international perspectives and who will forge future academic activities in Japan. This fellowship program provides excellent young Japanese researchers with an opportunity to conduct long-term research at a university or research institution overseas. The Overseas Challenge Program for Young Researchers is offered to support doctoral students and other travels abroad.

In addition, the Cross-border Postdoctoral Fellowship (CPD) program has been implemented since FY2019 to provide research grant to excellent young researchers who are working to form a network with famous researchers and others, while tackling ambitious research at a core university/research institution of the international community.

JSPS accepts overseas research fellows under the International Fellowships for Research in Japan to give outstanding foreign researchers opportunities to conduct research at universities or research institutions

in Japan, which will contribute to internationalization of the research environment of Japanese universities, etc. In addition, Bilateral Programs support forming a sustainable network between Japanese and foreign research teams.

To foster young scientists and build collegial networks in the Asia-Pacific and Africa regions, HOPE Meetings have been organized by JSPS to provide selected graduate students and young researchers from these regions with opportunities to engage in interdisciplinary discussions with Nobel laureates and other distinguished researchers.

The JST started the Japan-Asia Youth Exchange Program in Science (Sakura Science Plan) in FY2014 to invite excellent youths (high school, undergraduate and graduate students and researchers aged under 40) from 41 countries and regions predominantly located in Asia for a short-term visit (one to three weeks) to call in outstanding foreign human resources.

B. International research grant programs

The Human Frontier Science Program (HFSP) is an international research grant program first advocated by Japan at the summit in Venice in June 1987. This program aims at supporting international joint basic research on the complex mechanisms of living organisms and providing the research results for the general interest of mankind. Currently the International Human Frontier Science Program Organization (HFSPO; President: NAGATA Shigekazu) has 15 members (Japan, Australia, Canada, the EU, France, Germany, India, Israel. Italy, The Republic of Korea, New Zealand, Singapore, Switzerland, the UK and the U.S.A.). Japan has been actively supporting the program since its establishment and playing a key role in its operation.

This program provides grants for research expenses of international joint research teams (Research Grants), supports young researchers by covering the cost of overseas research travel and stays (Postdoctoral Fellowships), and holds HFSP awardees' meetings. During the 30 years since the program began in FY1990, HFSPO has given research grants for about 1,150 research tasks of over 4,000 researchers worldwide and provided fellowships to about 3,300 young researchers. Among past winners of the research grant, 28 researchers were awarded with the Nobel Prize, including HONJO Tasuku, Distinguished Professor, Kyoto University, who won the Nobel Prize in Physiology or Medicine in 2018. The international cooperation program that supports original, ambitious and inter-disciplinary research is highly regarded throughout the world.

(3) Promoting cross-field, cross-organization, and cross-sector mobility

MEXT and METI recognize the importance of promoting cross appointment to increase the mobility of human resources. In cross appointment, researchers can be employed based on an agreement on secondment between multiple organizations and engage in R&D and education in the organizations

according to their role in the respective organization under a certain activity management. The ministries published the "Basic Framework and Notes on Cross-Appointment System" compiling notes and recommended examples in December 2014 and have promoted introduction of the system The Guidelines for Fortifying Joint Research Through Industry-Academia-Government Collaboration formulated in November 2016 also encourages cross appointment. In addition, an addendum version of the "Basic Framework and Notes on Cross-Appointment System" was released in June 2020 for further promotion of cross appointment.

MEXT has been implementing the Building of Consortia for the Development of Human Resources in Science and Technology. In this program, consortium is formed in multiple universities to ensure the stable employment of researchers while encouraging mobility for their career progression in cooperation with companies.

Section 2 Promoting Excellence in Knowledge Creation

Continuous creation of innovations requires flexible thinking and novel ideas not bound by traditions or conventional rules. Through reforms and strengthening of such academic research[1] and basic research as well as development of an environment for researchers to settle down to study, we work to strengthen the foundation of knowledge both in quality and quantity.

❶ Promoting academic and basic research as a source of innovation

(1) Reform and enhancements to promote academic research

A. Reform and strengthening of Grant-in-Aid for Scientific Research

MEXT and the JSPS have been implementing the Grants-in-Aid for Scientific Research (KAKENHI). KAKENHI, which are available through MEXT and the JSPS, are the only competitive funds provided for all academic research in any field, from the humanities and social sciences to the natural sciences. KAKENHI grants have been supporting diverse, creative research, broadening the base of various research activities, continually advancing research, and generating profound knowledge. In FY2020, around 29,000 research applications were newly selected by peer review screening (assessment of the research proposals by reviewers selected from the research communities) from over 100,000 applications in major research categories. About 83,000 projects, including those continuing for the several fiscal years, were funded. (The KAKENHI budget for FY2020 is 237.4 billion yen).

The KAKENHI system has been reviewed continuously for improvements, and MEXT has carried out radical reforms including the introduction of a Multi-year Fund and a review of its screening system. In FY2020, MEXT expansively reviewed "Scientific Research on Innovative Areas" to establish "Grant-in-

[1] Academic research refers to research that is conducted based on the researcher's own motivation and its focus is on pursuit of truth, problem solution and discovery of new challenges.

Aid for Transformative Research Area (A and B)" and decided to accept double applications for "Grant-in-Aid for Early-Career Scientists" and "Grant-in-Aid for Scientific Research (S, A and B)" (the latter provides greater support) in an effort to encourage challenges by young researchers. The ministry will secure and improve KAKENHI for further promotion of academic research.

B. Promotion of shared use and joint research at universities and inter-university research institutes

The system for shared use and joint research has made a big contribution to the development of academic research in Japan. Under the system, researchers across the country can use leading edge large equipment and precious materials/data outside the framework of university. The system functions mainly through inter-university research institutes and joint usage / research centers of national, public and private universities certified by the minister of MEXT.[1] and shared use/joint research centers of national, public and private universities certified by the minister of MEXT.

Large-scale scientific research, in particular, leads the world's scientific research by tackling uncharted research subjects using large-scale state-of-the-art research equipment, and forms a global research center by gathering excellent researchers of Japan and other countries. For this reason, it is important to promote such projects under a shared use/research system. MEXT supports these projects under the "Large-Scale Scientific Frontier Promotion Projects" program. Representative examples are Super Kamiokande (SK) that produced research results leading to the awarding of the Nobel Prize in Physics to KAJITA Takaaki, Director of the University of Tokyo's Institute for Cosmic Ray Research in FY2015, and Hyper Kamiokande (HK) that is the next-generation of SK. HK has observation capacity that exponentially exceeds the capacity of SK and aims to discover new physical principles and unlock the mystery of elementary particles and space through proton decay search and neutrino research. Construction of HK started in FY2019.

○ Large-Scale Scientific Frontier Promotion Projects

https://www.mext.go.jp/a_menu/kyoten/20200826-mxt_gakkikan-1383666_001.pdf

(2) Reform and enhancements to promote strategic and on-demand basic research

The Strategic Basic Research Programs (Creating the Seeds for New Technology) operated by the JST and the Advanced Research and Development Programs for Medical Innovation launched by the Japan Agency for Medical Research and Development (AMED) invite applications from researchers at universities and other institutions. These programs are carried under the strategic objectives set by the national government. The research is conducted through a fixed-term consortium that is connected over

1 107 centers of 54 universities (including 7 centers of 5 universities in international joint usage / research centers) have been certified and are active as of April 2020

institutional boundaries. The important results generated by the research are being accelerated and deepened. In order to incite unique and bold ideas of researchers and encourage interdisciplinary research by researchers of diverse fields, the system is reformed by consolidating strategic targets, for example. MEXT set the following six targets for FY2020.

A. Strategic Basic Research Programs (Creating the Seeds for New Technology)

- Flexible sequences and functions
- Information carriers and new devices
- Trusted AI
- Innovative plant molecular design
- Dynamics and functions of intracellular configuration factors

B. Advanced Research and Development Programs for Medical Innovation

- Understanding of proteostasis and its application for to medical treatment

(3) Promotion of emergent research

Using the 50-billion yen fund for JST in the FY2019 supplementary budget, MEXT is implementing the Fusion Oriented REsearch for disruptive Science and Technology project. The project aims to encourage young researchers to break away from the short-term-performance-oriented approach and produce results that can bring about disruptive innovations by providing a long-term environment for researchers who are at the point just before or after becoming independent researchers so that they can concentrate on their ambitious visions. As 13.4 billion yen was added to the fund in the 3rd supplementary budget of FY2020, 252 research subjects in total were adopted through the 1st call for proposals.

(4) Promoting joint international research and forming world-class research centers

In order for Japan to be able to occupy an important position in global research networks and exert its presence on the global stage, it is important not only to take a strategic approach to the promotion of international joint research but also to build a research center that can become a hub of international brain circulation for the nation.

A. International joint research with other countries

(A) ITER project, etc.

The ITER project is managed under the international cooperation of seven parties for realization of fusion energy. The construction of ITER began in earnest in Cadarache, France, toward commencement

of operations in 2025. Japan is promoting the production of major equipment of ITER including superconductive coils (See Section 1, Chapter 3.) Japan and Europe are also promoting the Broader Approach (BA) that is an advanced fusion R&D supplementing and supporting the ITER project at Rokkasho Village of Aomori prefecture and Naka city of Ibaraki prefecture.

(B) International Space Station (ISS)

Japan participates in the ISS program by operation of the Japanese Experiment Module "KIBO" and the uncrewed cargo transfer spacecraft "KONOTORI" (HTV[1]) and long-term stay of Japanese astronauts in ISS. (See Section 4 2-(6), Chapter 3.)

(C) International Space Exploration

Japan decided to participate in the international space exploration Artemis Program at the Strategic Headquarters for National Space Policy in October 2019. In December 2020, the Japanese government and NASA signed a memorandum of understanding concerning the cooperation for Gateway, a manned space station orbiting the Moon, which will play the central role in the program. (See Chapter 3 Section 4-2(7))

(D) International Ocean Discovery Program (IODP)

The International Ocean Discovery Program (IODP) is a multilateral international cooperation project led by Japan, the United States and Europe with the aim of elucidating global environmental change, the inner structure of the Earth, and subseafloor biosphere, etc. The program has been implemented since October 2013. A Japanese deep drilling vessel, CHIKYU, which features the world's top level drilling capabilities among science drilling vessels, and a U.S. drilling vessel have been the principal vessels of the IODP. Mission-Specific Platforms are also provided by the European consortium. These drilling vessels are used to drill deep sea floors worldwide. In October 2020, 2050 IODP Science Framework (from 2023 to 2050) was formulated showing scientific goals for the next-term activities.

(E) Large Hadron Collider (LHC)

Currently, in the LHC project[2], the upgrade of LHC to increase its luminosity (HL-LHC[3] project) is underway.

(F) Other

An international researcher community is considering the International Linear Collider (ILC) project to

[1] H-II Transfer Vehicle
[2] In this experimental project, the large circular collider of CERN is used to reproduce extreme conditions similar to those of shortly after the Big Bang, with the aim of discovering unknown particles and the deep internal structure of matter.
[3] High Luminosity-Large Hadron Collider

investigate the properties of the Higgs Boson in more detail.

MEXT expressed "MEXT's view in regard to the ILC project" in March 2019. MEXT has been paying attention to the discussions in the researcher community.

B. Efforts toward Creation of world-leading international research centers

Through the World Premier International Research Center Initiative (WPI) MEXT has been improving and strengthening the "globally visible brain circulation centers" with highly global research environments and the world's top-level research standards. Specifically, about 700 million yen is provided to each center for 10 years under careful progress management by top scientists in Japan and abroad. Thirteen centers were active as of the end of FY2020 (https://www.jsps.go.jp/j-toplevel/04_saitaku_2018.html). In December 2020, new missions were formulated by advancing the past missions and adding "Values for the Future" toward regular and systematic center formation.

With the aim of increasing world-class universities and also enhancing universities' research capabilities, the government is implementing the Program for Promoting the Enhancement of Research Universities. Under this program it supports and promotes integrated efforts for securing/utilization of research management personnel, university reform and intensive reform of the research environment, so that the research capacity of the entire country will increase.

The Cabinet Office has been supporting activities for expansion of the Okinawa Institute of Science and Technology Graduate University (OIST) in order for OIST to conduct the world's leading education and research.

❷ Strategic enhancement of common-platform technology, facilities, equipment, and information infrastructure supporting research and development activity

(1) Strategic development and use of common-platform technology and research equipment

In line with the MEXT policies, the JST has been implementing the Development of Advanced Measurement and Analysis Systems program to promote the development of the most advanced, unique instruments for measurement and analysis that serve the needs of world-leading researchers and manufacturers. As of the end of March 2020, 69 prototypes had been developed and put into production.

(2) Maintenance, sharing, and networking of research facilities, equipment and intellectual infrastructure used by industry, academia, and government

A. Promotion of development/sharing of research facilities/equipment and their networking

As infrastructure to promote S&T, research facilities and equipment support a vast range of R&D; thus, they need to be further advanced and used more efficiently and effectively. The Act on Vitalizing the Creation of Science, Technology, and Innovation (Act No. 63, 2008) stipulates that the government shall

take necessary measures to promote the shared use of R&D infrastructure facilities and equipment as well as intellectual infrastructure owned by national universities and R&D agencies.

The government has been promoting the effective use of key general facilities and equipment by industrial, academic and government research institutions for diverse R&D on science and technology. The government is also working on networking of these facilities and equipment so that they will be available more conveniently in a mutually complementary manner and will be able to respond to emergencies.

(A) Specified Large-Scale High-Technology Research Facilities

The Act on the Promotion of Shared Use of Specified Large-Scale High-Technology Research Facilities (Act No. 78, 1994) (the Shared Use Act) defines large-scale research facilities of special importance as Specified Large-Scale High-Technology Research Facilities. This act stipulates the need for the systematic development and operation of these facilities, as well as for shared use in a fair, even manner.

(i) Super Photon ring-8 GeV (SPring-8)

SPring-8 is a research infrastructure facility that delivers the top performance in the world in the analysis of atomic or molecular structure/function by using synchrotron radiation, the extremely bright light that is produced when electrons accelerated to near the speed of light are forced to travel in a curved path. For 23 years since the service commencement in 1997, this facility has been contributing to innovative R&D in various fields of research from life science to environment/energy and new materials development which help boost Japan's economic growth.

Super Photon ring-8 GeV (SPring-8) and
an X-ray free-electron laser facility (SACLA)
Source: RIKEN

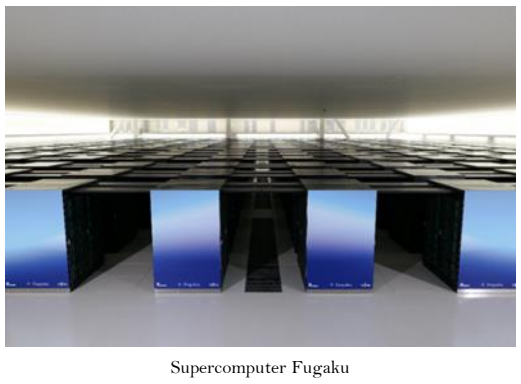
(ii) X-ray free-electron laser facility (SACLA[1])

SACLA is the most advanced research infrastructure facility in the world with respect to the generation of x-ray laser. The unprecedented light generated there has both laser and synchrotron radiation characteristics and allows instantaneous measurement and analysis of ultra-high-speed movements/changes in atomic-level hyperfine structures and chemical reactions. SACLA has been in use since March 2012. In FY2017 simultaneous operation of two hard x-ray free electron laser beam lines by switching the paths of the electric beams[2] started for the first time in the world. Its usage environment has

[1] SPring-8 Angstrom Compact Free Electron Laser
2 Multiple beam lines can be used simultaneously by switching the paths of the electric beam from the linear accelerator pulse-by-pulse.

been also steadily improved toward creation of further creation of high-impact results.

(iii) From the supercomputer "K" to "Fugaku"



Supercomputer Fugaku
Source: RIKEN Center for Computational Science

As a third approach to S&T, following the theoretical and experimental approaches, supercomputer simulations have been crucial for cutting-edge S&T and improvements in industrial competitiveness. The K computer that was operated by RIKEN from September 2012 to August 2019 underpinned breakthroughs in diverse fields, including upgrading of medical care and drug discovery, manufacturing innovations, mitigation of earthquake and tsunami damage, and elucidation of the origins of matter and the universe.

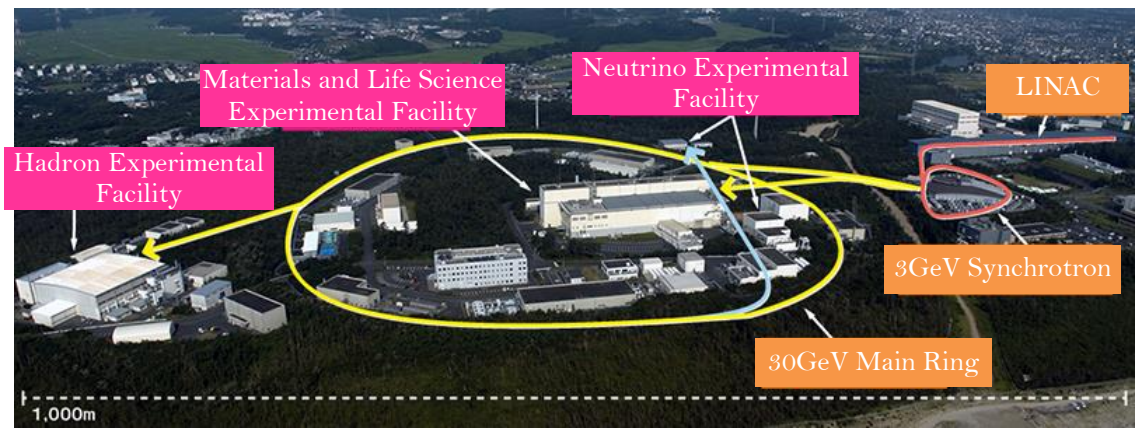
In order to contribute to solutions of Japan's social and science challenges, in 2014 MEXT started a project to develop the supercomputer "Fugaku" which succeeded the supercomputer "K". Through co-design of systems and applications, the ministry promoted the development of the supercomputer possessing the world's best computing performance and high versatility for diverse purposes and offered Fugaku for use in FY2014. Fugaku ranked No.1 in the world in four supercomputer rankings (TOP500, HPCG, HPL-AI and Graph500) two times in June and November 2020 for the first time in the world.

Furthermore, in April 2020 the ministry in cooperation with RIKEN decided to use a part of Fugaku that was under development for countermeasures against and study on COVID-19. Its results include simulations of the spread of droplets and exploration for remedy candidates.

(iv) Japan Proton Accelerator Research Complex (J-PARC)

All facilities of J-PARC started operation in FY2009. J-PARC has been contributing to a wide range of R&D including basic research and industrial applications, by using secondary particle beams of neutrons, muons and neutrinos[1] that are generated by its proton accelerator which possesses the highest beam intensity in the world. The Materials and Life Science Experimental Facility (Specified Neutron Facility) has been used for structural analyses which may spawn innovative materials and new drugs and numerous results have been achieved. The Shared-Use Act is not applicable to the Nuclear and Particle Experimental Facility (Hadron Experimental Facility) or the Neutrino Experimental Facility, but these facilities are used jointly by university researchers in Japan and abroad. At the Neutrino Experimental Facility, Tokai to Kamioka (T2K) experiments have been conducted with the aim of clarifying the characteristics of neutrino oscillations, following the research of neutrino oscillations that won the 2015 Nobel Prize.

[1] A neutrino is a neutrally charged, elementary subatomic particle. It is extremely difficult to detect neutrinos because they can penetrate ordinary matter without leaving any trace, and little is known about their characteristics or masses.



Japan Proton Accelerator Research Complex (J-PARC)
Source: J-PARC Center

(B) The next-generation synchrotron radiation facility (highly brilliant 3GeV-level radiation light source for soft X-ray)

The next-generation synchrotron radiation facility is a research platform that can visualize not only materials structure in the manner performed by existing facilities but also in the electronic state that influences materials function by using highly brilliant intense soft X-rays that can sensitively observe light elements. Beyond academic research, the facility is expected to be used in a broad range of fields including catalyst chemistry, life science and industrial use of magnetic/spintronics materials and high polymer materials.

Construction status of the next-generation synchrotron radiation facility
(As of March 25, 2021)
Source: Photon Science Innovation Center

MEXT will promote the facility in a public-private-regional partnership that designates the National Institutes for Quantum and Radiological Science and Technology (QST) as the government body responsible for the development and operation of the facility. Furthermore, the ministry selected five private/regional partners: Photon Science Innovation Center (representative,), Miyagi Prefecture, Sendai City, Tohoku University and Tohoku Economic Federation in July 2018. The next-generation synchrotron radiation facility is now under development toward completion in FY2023. Installation of accelerators and other equipment is scheduled around the end of 2021.

(C) Constructing a network of research facilities and equipment

(i) Platforms for shared use

MEXT has been working to maintain and advance the world's leading R&D infrastructure by forming platforms for shared use to construct a network of research facilities/equipment available for sharing by industry, academia and government.

○Project for the Introduction of New Systems for Advanced Research Infrastructure Sharing (Project to Support the Development of Platforms for Sharing)

https://www.jst.go.jp/shincho/program/pfkeisei.html

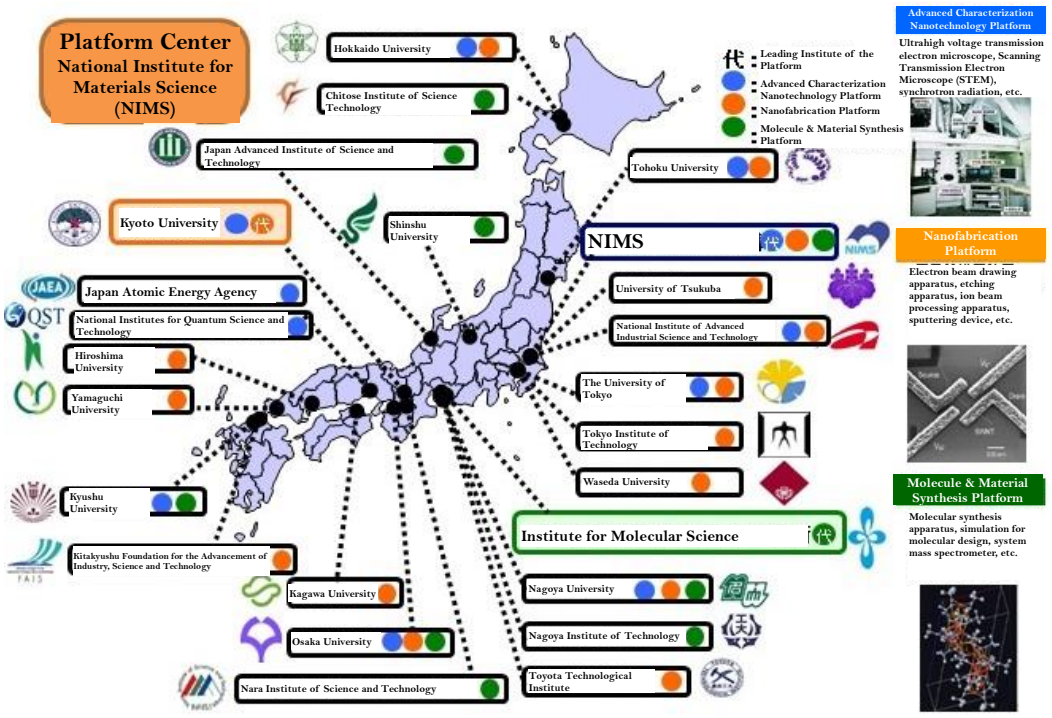
(ii) The development of Innovative, High Performance Computing Infrastructure (HPCI)

MEXT has built an innovative High Performance Computing Infrastructure (HPCI) in which supercomputers and storage sites at universities and research institutes are connected through the Science Information NETwork (SINET) to provide a computing environment meeting the needs of various users. MEXT is also promoting HCPI's use in various fields while working for its effective and efficient operation. In addition, the ministry with cooperation of HPCI universities and research institutes started special public invitation to promote its use for COVID-19 countermeasures and research in April 2020.

(iii) Nanotechnology Platform

MEXT is providing a nationwide system for the shared use of advanced equipment and technology. Under that platform, research institutions that have cutting-edge nanotechnological research facilities and knowledge work closely to provide opportunities for researchers from industry, academia and government around the nation to use their facilities.

■ Figure 2-4-10/ Nanotechnology Platform Promotion System ■



Source: MEXT

B. Introduction of new sharing system aligned with the competitive fund reform

MEXT is promoting introduction of a new sharing system to realize a virtuous cycle of R&D and sharing in conjunction with the reform of competitive research funds through early establishment of development and operation of research facilities/equipment integrated with the management of research organizations.

○Project for Promoting Public Utilization of Advanced Research Infrastructure (support for introduction of the new sharing system)

https://www.jst.go.jp/shincho/program/sinkyoyo.html

C. Introduction of a network for shared use of research equipment

MEXT is strengthening the functions of supervising departments that manage facilities of the entire research institution and is promoting enhancement of the mechanism to strategically introduce, renew and share research facilities/equipment that are increasingly managed by individual research units such as faculties, departments and graduate schools as research infrastructure of the entire research organization (establishment of core facilities). In order to contribute to the improvement of research productivity and regional research capabilities, MEXT conducted a demonstration experiment to build a network for shared use of research equipment among neighboring universities, enterprises and public experimental research institutions (PERI) and is promoting shared use of research facilities and equipment among universities and between universities and enterprises, for example.

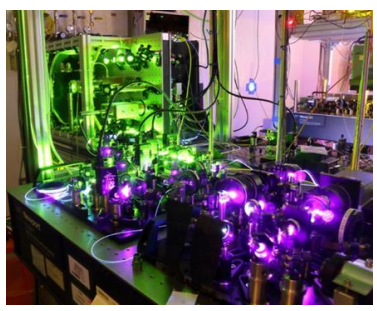
D. Promotion of development, sharing and networking of intellectual infrastructure

Under the National BioResource Project, through AMED, MEXT is improving the system so that biological resources, including animals and plants that may become the base of life science and that may be strategically important for the country, can be collected, preserved and distributed in a systematic manner. The ministry is also comprehensively promoting R&D on elucidation and control of the mechanism of aging and implementing "project for elucidation and control of the mechanism underlying aging" with the aim of forming centers of aging research.

In order to strengthen the country's R&D capabilities, METI presented the Third Intellectual Infrastructure Improvement Plan (draft) at the special subcommittee on intellectual infrastructure development of the Industrial Technology Environment Subcommittee, the Industrial Structure Council in February 2021. Progress of the second Intellectual Infrastructure Improvement Plan in individual fields is as follows:

Regarding measurement standards, AIST implemented various initiatives. As regards physical standards AIST developed calibration operation for high-precision force measuring devices in the infinitesimal force range under 10N based on the request from medical and food fields and industries

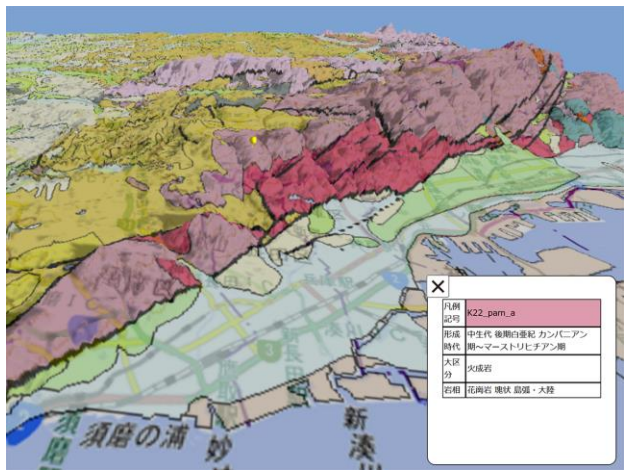
including semiconductor/electronic component manufacturing. Regarding reference materials, AIST developed a certified reference material of lanthanum solution, a type of rare earth widely used for catalysts, glass additives, electrode materials, etc. and a reference material of monoclonal antibody solution for quality control, to respond to the spread of industrial use of clinical tests and biomedicines. In addition, toward redefinition of the unit of a "second" of time in the future, AIST succeeded in operation of a cryogenic optical lattice clock at a high operation rate first in the world in order to contribute to the International Atomic Time. AIST also implemented activities related to COVID-19 control measures: an example is its participation in an international comparison on COVID-19 gene quantification implemented to improve the reliability of the PCR test for confirmation of COVID-19 infection, for which the International Bureau of Weights and Measures served as secretariat.



Optical lattice clock
Source: AIST

Regarding microorganism genetic resources, NITE has collected, preserved and distributed microorganism genetic resources and has also organized information on these resources in terms of their genes and genetic lineages so as to make the information accessible to the public, including researchers and industry (As of the end of January 2021, 8,812 strains of biological resources had been distributed.). NITE has also constructed cooperative relationships with Asian countries and regions by joining a network of 28 organizations from 15 countries and regions, which aims for the preservation and sustainable use of microbial resources (the ACM, founded in 2004) and has supported Asian countries in their efforts to use microorganism genetic resources through exchange programs according to the Convention on Biological Diversity (CBD) and the Nagoya Protocol.

■ Figure 2-4-11/ Releasing High-precision Altitude Tiles that can be used for 3D mapping ■



Source: AIST

As regards geological information, AIST published the geological maps 1:50,000 for two quadrangles (Rikuchu-seki and Ikeda), and the geological maps 1:200,000 for one block (NOHEJI (2nd edition)), and renewed the Seamless Digital Geological Map of Japan V2 (1:200,000). By these maps, AIST achieved its goal of the Second Intellectual Infrastructure Improvement Plan (published the geological maps 1:50,000 for 40 quadrangles). AIST also started provision of detailed 3D maps (Hyogo Prefecture Edition) using the High-Precision Elevation Tiles technique (Figure 2-4-11). This enables anyone to obtain any altitude tile,

easily leading to high-speed operation. on the internet such as 3D websites. The maps are also expected to be used for flooding and slope disaster prevention by connecting to other map data. In addition, AIST published the Water Environment Map providing information of groundwater for two quadrangles (Yamagata Basin (2nd edition), Kinokawa Plane) and revised this map for one quadrangle (Seisei district). AIST also published the geological map of the Mt. Esan volcano that is important site for disaster prevention and one of the constantly observed volcanoes.

(3) Development of university facilities and equipment, and enhancement of information infrastructure

A. Facilities and equipment at national universities

Facilities at national universities are places for development of human resources who will play important roles in the future. They are also important infrastructure for education and research activities by serving as centers for regional revitalization and creation of innovations. However, they have major safety and functional problems due to significant aging.

With this in mind, MEXT formulated the Five-Year Program for Facilities of National Universities and has promoted: improvement of infrastructure for safe and secure educational environments; response to changes which include the functional enhancement of national universities, and creation of sustainable campuses. (Figure 2-4-12).

As the 4th Five-Year Program will end in FY2020, MEXT held the "Committee of Research Partners Concerning the Future Development and Enhancement of. National University Facilities" eight times since FY2019. The committee studied measures to promote facility development in the future. The result was compiled as "Final Report toward Formulation of the Next Five-Year Program for Facilities of National Universities" in December 2020. The report found it is necessary for national universities not only to advance their education and research, but also to make their entire campuses "Innovation Commons[1] " to fulfill their role as centers of co-creation with the industry and communities based on the expectations for national universities (See Column 2-14). Based on the report, the 5th Five-Year Program for Facilities of National Universities for the period from FY2021 to FY2025 was formulated (decision by the Ministry of MEXT on March 31, 2021). Under the program, the ministry will promote systematic and focused facility improvement toward Innovation Commons with the function of co-creation centers., while at the same time ensuring safety by addressing aging of the facilities.

Toward systematic maintenance of national university facilities and based on the Basic Plan for Extending Service Life of Infrastructure (Liaison Conference of Ministries and Agencies Concerned with Promotion of Measures against Aging of Infrastructure in November 2013) and the "MEXT Plan for Extending Service Life of Infrastructure (Action Plan)" (March 2015) MEXT has been promoting

[1] Innovation Commons refers to a campus where various players including students, researchers, industry and local governments gather freely face-to-face or online to create new values in various fields including education, research, industry-academia collaboration and local collaboration.

formulation of action plans and individual facility plans by national universities, etc. Within FY2020 all national universities formulated their individual facility plans. In addition, the ministry is further promoting strategic facility management through effective utilization, appropriate maintenance and energy efficiency. MEXT is also promoting facility development using diverse funds.

Because facilities of national universities are infrastructure that supports cutting-edge research and high-quality education, they require plan-based maintenance, management and improvement. MEXT is improving facilities as education and research infrastructure for national universities and facilities contributing to enhancement of university functions, infection control, disaster management/response and other purposes. Furthermore, through its Large-Scale Scientific Frontier Promotion Projects MEXT has provided support for the world's most advanced research equipment developed based on the creative ideas of Japanese scientists, which include the "Hyper Kamiokande (HK) project".

■ Figure 2-4-12/ Examples of Facility Improvement for Securing Safe and Secure Education/Research Environment and Function Enhancement of National Universities, etc. ■

Earthquake resistance reinforcement and outer wall repair

Creating space for active learning

Creating space for multicultural exchange

Source: MEXT

<Related website>
Improvement of National University Facilities
https://www.mext.go.jp/a_menu/shisetu/kokuritu/index.htm

Colum 2-14 Transform National University Campuses to Centers of "Co-creation"

Facilities of national universities, etc. (including Inter-University Research Institute Corporations and the Institute of National Colleges of Technology, Japan) are infrastructure for national universities, etc. (including inter-university research institutes and national colleges of technologies) to fulfill their missions, which include education of creative students and promotion of ingenious and cutting-edge academic research. Since FY2001 the facilities have been improved based on the four Five-Year Programs for Facilities of National Universities ("Five Year Programs") formulated by MEXT in response to the Science and Technology Basic Plan of the government. As the 4th Five-Year Program will end in FY2020, MEXT formulated the 5th Five-Year Program for Facilities of National Universities (for the period from 2021 to 2025: "5th Five-Year Program") in March 2021 to continue to promote systematic and focused improvement of facilities of national universities, etc.

Under the past Five-Year Plans, safety measures including earthquake protection and elimination of overcrowding significantly progressed, but a large volume of facilities developed from 1965 to 1985 are becoming too old for use, and their improvement is not keeping up with their aging.

Under this condition, national universities are required to contribute to the communities, society and the world, while at the same time enhancing their education and research functions that are their essential roles. The enhancement involves the shift to learner-oriented education and promotion of cutting-edge research leading the world. For this purpose, they are expected to make the most of their characteristics as centers of knowledge and human resources to become centers of "co-creation" where creative activities are conducted in collaboration among various stakeholders of society including citizens, governments, education/research institutes, enterprises, financial institutions and NPOs.

The point of the 5th Five-Year Program is transformation of the entire campus to Innovation Commons so that national universities can fulfill their role as centers of "co-creation." Innovation Commons refers to a campus where various players including students, researchers, industry and local governments gather freely through an effective hybrid of face-to-face and online exchanges and co-create new values in various fields including education, research, industry-academia collaboration and local collaboration. Toward its realization, MEXT will further promote improvement of their ICT environment, initiatives for national resilience, carbon neutrality and facility management, utilization of diverse funds and other activities, while accelerating improvement to dilapidated facilities.

Images of Innovation Commons
Source: MEXT

Improvement of the facilities that are important bases of activities of national universities, etc. is "investment in the future." MEXT, national universities and other stakeholders will cooperate to implement the 5th Five-Year Program.

<Reference URL>
Five-Year Program for Facilities of National Universities
https://www.mext.go.jp/a_menu/shisetu/kokuritu/1318409.htm

B. Facilities and equipment at private universities

MEXT supports development of facilities/equipment forming the foundation of high-quality education and research activities of private universities based on their establishment principles and characteristics.

C. Enhancement of Research Information Infrastructure

The National Institute of Information and Communications Technology (NICT) has been promoting technical and social verifications of IoT and a next-generation communications network by using the NICT Comprehensive Test-bed which NICT has developed and has been operating.

The National Institute of Informatics (NII) has been improving and operating the Science Information Network (SINET) as a platform for supporting overall scientific research and education at universities and institutions. SINET is the 100 Gbps[1] network that covers all prefectures. The network was extended by 400 Gbps line between Tokyo and Osaka in December 2019 and measures have been taken to enhance its security in cooperation with national universities, etc. In order to ensure smooth international circulation of research information: which is required in international cutting-edge research projects, SINET is connected with many research networks in the United States, Europe and other countries. As of the end of FY2020, more than 950 domestic universities and research institutions connected to SINET, ensuring circulation of academic information for a large number of academic staffs and researchers. Since March 2020, to promote information sharing for remote classes by universities under the COVID-19 pandemic, NII has been holding a series of multiple online sessions of "Cyber-Symposium for Information Sharing on Remote Teaching Efforts at Universities since April" (renamed to "Symposium on DX at Educational Institutions -- Cyber-Symposium on Online Education and Digital Transformation at Universities and Other Institutions" in January 2021). By the end of FY2020, 29 sessions were held with about 37,000 participants in total.

Ministry of Agriculture, Forestry and Fisheries (MAFF) has been developing and operating MAFFIN[2] a research network that connects research institutions related to agriculture, forestry and fisheries. As of the end of Fiscal 2020, 73 institutions are connected in MAFFIN. MAFFIN, which is linked to an institution in the Philippines, is serving as part of a network for the distribution of research information overseas.

Ministry of Environment (MOE) runs the Network of Organizations for Research on Nature Conservation (NORNAC), in which 54 research institutions currently participate. The purpose of this organization is to contribute to the promotion of policymaking for nature conservation based on scientific information. National and local governments and research organizations related to nature conservation exchange and share information through this organization. MOE also serves as the secretariat for the Asia-

[1] Giga bit per second (bps) is a unit of data transmission rate and shows the number of bits of data sent in one second. 1Gbps stands for data transmission at the rate of 1 billion bit per second.
[2] Ministry of Agriculture, Forestry and Fisheries Research Network

Pacific Biodiversity Observation Network (AP-BON). AP-BON promotes collection and integration of observation data, including monitoring data, on biodiversity in the Asia Pacific region, towards strengthening the scientific infrastructure that is necessary for the conservation of global-scale biodiversity. Participants include not only many countries in the region but also the ASEAN Center for Biodiversity (ACB), Group on Earth Observations Biodiversity Observation Network (GEO-BON) and other international organizations.

D. Creation and provision of databases

The National Diet Library provides a database (NDL Search[1]) that enables integrated search not only for the materials that are collected by the library but also materials, digital contents and the like provided by libraries and academic research institutes nationwide.

To help enhance efficient and effective R&D activities, NII systematically collects scientific information necessary for creating innovations, organizes it into an easy-to-use format and posts it online. For example, NII constructed a database (CiNii[2]) on the whereabouts information regarding catalogs of academic books and journals kept by university libraries nationwide and on scientific papers including doctoral theses in Japan, to enable to search them at one time. NII jointly with the Japan Consortium for Open Access Repository is operating a service that provides a cloud-based institutional repository environment (JAIRO Cloud[3]) for universities, etc. to preserve and disseminate their research/educational results.

Japan Science and Technology agency (JST) collects and correlates basic information regarding literature, patents, researchers and research activities on science and technology in Japan and abroad, and organizes it as a database to offer an easy use public search service (J-GLOBAL). JST also creates a database for comprehensive Japanese-language search for bibliographies, abstracts, keywords, etc. of science and technology literature in Japan and abroad, and adds the function of analyzing and visualizing search sets to offer a bibliographic information service (JDream III) to support specialists. JST provides a researcher database (researchmap) that centrally accumulates researcher information in Japan to manage and provide information on research achievements and support universities in their development of comprehensive researcher lists. JST also provides a shared system environment for academic societies to publish their electronic journals (J-STAGE[4]) in order to ensure speedy distribution of academic journals, etc. published by various academic societies and strengthen global information dissemination (See 3 of this Section).

MAFF has been creating and providing databases on information regarding literature on agriculture, forestry and fisheries as well as on the whereabouts of literature, including the bibliographic database (Japanese Agricultural Sciences Index (JASI)) on papers published in Japanese science journals related to

1 https://iss.ndl.go.jp
2 Citation Information by NII
3 Japanese Institutional Repositories Online Cloud
4 Japan Science and Technology information Aggregator, Electronic

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. These cover topics related to agriculture, forestry and fisheries; and topics of ongoing research conducted at R&D institutions.

MOE is collecting, managing and providing information on natural environments and biodiversity throughout Japan by means of the Japan Integrated Biodiversity Information System (J-IBIS).

❸ Promotion of open science

(1) Development in Japan

The concept of Open Science which includes open access and open research data is rapidly spreading in the world as a new way of promoting scientific research. In the light of this trend, funding agencies, academic societies, industry, the government and other parties need to accelerate its promotion with appropriate international cooperation. The Integrated Innovation Strategy positions various data including research data as a "source of knowledge" that holds the key to science, technology and innovation, and requests the early establishment of a data policy and a data management plan considering open-and-closed strategy and the characteristics of individual research fields to preserve and manage research data securely.

The Committee on Promotion of Open Science Based on the International Trends" held by the Cabinet Office compiled "The 2nd Phase Report of Working Group on Research Data Infrastructure Development and International Deployment" in March 2021.

(2) Efforts concerning sharing and disclosure of research outcomes that use competitive funds

Japan Science and Technology Agency formulated its basic policy on handling of research results in April 2017 with the aim of creating a research environment for promotion of open science. This policy provides open access to all research papers created based on result of a research project in principle, and formulation of a data management plan specifying handling of research data. Disclosure of evidence data is recommended, while disclosure of other research data is desired.

AMED announced a data sharing policy for genomic medicine realization projects toward overcoming diseases and mandated data sharing in research projects in principle.

JSPS presented the direction of efforts pertaining to open access and is promoting open access to papers using KAKENHI etc.

(3) Initiatives for sharing and disclosure of research outcomes

RIKEN, National Institute for Materials Science (NIMS) and National Research Institute for Earth Science and Disaster Resilience (NIED) have been working to create new value by accumulating an enormous quantity of high-quality research data in a manner easy to use in the fields of life science,

materials and disaster prevention: areas where Japan can use its strength, and by sharing and analyzing the data in industry, academia and governments.

NII provides JAIRO Cloud while NII started the operation of a new infrastructure (NII-RDC[1]) in March 2021 that facilitates management, sharing, publication and discovery of research data and that is designed for easy employment as a common research environment in the cloud by universities and research institutions.

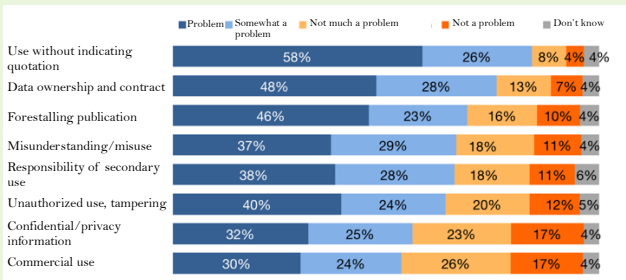
To ensure speedy distribution of journals published by various academic societies and strengthen global information dissemination, JST has been providing a shared system environment for academic societies to publish electronic journals (J-STAGE). As of the end of January 2021, a total of 3,228 electronic journals of 1,824 academic societies were on J-STAGE. In March 2020, JST started operation of a data repository (J-STAGE Data) to disclose evidence data of articles on J-STAGE. The JST Bio Science Database Center is promoting the Life Science Database Integration Program. Under the program, the center is promoting open science through expansion of a joint portal site for centralized reference of life-science data bases held by four ministries (MEXT, MHLW, MAFF and METI), cooperation with the Japan Agency for Medical Research and Development and other efforts.

[1] National Institute of Informatics - Research Data Cloud

Column 2-15 Difficulty of Research Data Sharing Exposed by COVID-19 and New Rule Making

As COVID-19, that was an unknown virus for humankind, had a great influence on society, many research results were shared in order to cope with this global crisis. For example, Japan Agency for Medical Research and Development and other research subsidizing organizations in the world, publishers, etc. adopted a "joint statement committing to rapidly and widely sharing research results and data related to the novel Coronavirus" to promote disclosure of papers and research data. COVID-19 Data Portal JAPAN collects research data on COVID-19 infection, which are scattered in Japan and abroad, to ensure speedy access by researchers.

This move appeared to spread to disclosure of vaccine information and other intellectual properties, but the secretary general of the World Intellectual Property Organization (WIPO[1]) said that limiting intellectual property rights with no basis will confuse the economy and delay its recovery. Disclosure of research data sometimes involves compensation as in the case of patents, but the rule is yet to be established.



Concerns about disclosure of research data
Provided by MEXT National Institute of Science and Technology Policy (NISTEP)

A survey of researchers in Japan showed a great concern about "data ownership and contracts" as obstacles of research data disclosure (Figure). Furthermore, in the recommendations on open science of the Science Council of Japan, which was issued in July 2020, "the need to create rules in an era when data plays a central role" was pointed out first.

The issue of research data sharing questions again how swiftly data can be disclosed and contribution of the disclosure can be recognized by balancing the contribution of open data to science and society on one hand and protection of intellectual property rights on the other. This calls for new rules, which will start from custom formation.

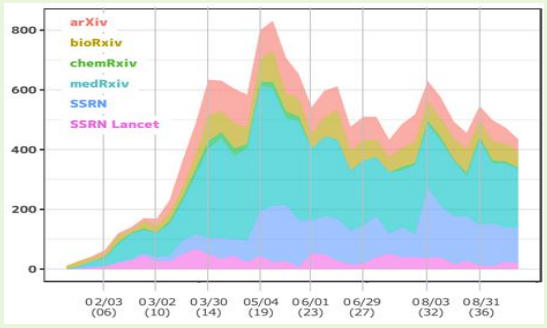
(Report of MEXT NISTEP
A Survey on Open Research Data and Open Access 2018, (RM289)
https://doi.org/10.15108/rm289
(Other base information)
Joint statement committing to rapidly and widely share research results and data related to the novel coronavirus
https://www.amed.go.jp/news/topics/20200203.html
COVID-19 Data Portal JAPAN
https://covid19dataportal.jp/
Initiatives concerning patent right restriction
https://tinyurl.com/GurryCorona (a letter to WIPO Director General
https://apps.who.int/gb/ebwha/pdf_files/WHA73/A73_R1-en.pdf
Resolution of the World Health Organization referring to restriction of rights
Concerns of WIPO Secretary General
https://www.wipo.int/about-wipo/en/dgo/news/2020/news_0025.html
SCJ Recommendation "Recommendations toward Promotion and Deepening of Open Science" (July 2020, Japanese version only)
http://www.scj.go.jp/ja/info/kohyo/kohyo-24-t291-1-abstract.html

[1] World Intellectual Property Organization

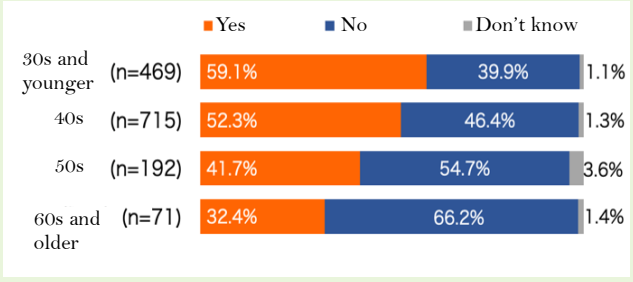
Column 2-16 Is it OK in Draft? COVID-19 Changes Research Papers and Preprints

Many of the results of scientific research are made public as a "paper." In most cases "paper" refers to the original paper appearing in a journal published by academic publishers and a certain level of quality is guaranteed by peer review. The numbers of original papers and their quotations (quotations in other papers) greatly influence the evaluation and career of the researchers, and is also used for evaluation of universities and other research institutes.

Many researchers have been also sharing draft papers for feedback before contributing to an academic journal (preprint). Since the early 1990s, a custom to widely share preprints via an internet server (arXiv) emerged in the high energy physics and other fields. In the latter half of the 2010s, sharing of preprints expanded in the field of life science mostly using bioRxiv. As COVID-19 infection increased the urgency to share related information, a large number of preprints related to COVID-19 have been registered mostly with a medical preprint server (medRxiv). COVID-19-related information has been swiftly shared in this way (Figure above).



Number of registered preprints related to COVID-19 (weekly)
Provided by MEXT NISTEP



Experience of obtaining a preprint (by age group)
Provided by MEXT NISTEP

However, because preprints are issued before peer review, careful assessment is required. Especially, we must be careful about easy use of preprints related to COVID-19 and other medical preprints by unprofessional readers and wide promulgation of the content to society. The process of peer review takes some time but today this is the most appropriate means to guarantee the reliability of science. It is unlikely that preprints would replace original papers that have gone through peer review.

Nevertheless, preprint is an effective means for swift sharing of research results. Preprints have been actively used for sharing information when peer review cannot keep up with the fast development of research in the field of high temperature superconduction in the past and deep learning in recent years. Although preprints and original papers are mutually complementary, a survey of Japanese researchers shows that use of preprints will increase and younger researchers have more experiences obtaining preprints. Changes in customs with change in generations is predicted (Figure above).

For the time being, role sharing between preprints and original papers will advance in publication of results. The key is how to achieve both swiftness of research result publication and reliability of the results. The issue raises a question: what is the desirable way to publish research results in the age of open science?

(Source)

1) "A Trial of early detection system for research trends through the preprints data — Research status around COVID-19/SARS-CoV-2". MEXT MISTEP 2020, NISTEP DISCUSSION PAPER No. 186
2) "Analysis of Preprints with Focus on arXiv" MEXT NISTEP, 2020, DISCUSSION PAPER No. 187
3) "Open Science Accelerated by COVID-19 – Transformation of Science Information Distribution Seen from Preprint Analysis", MEXT NISTEP, 2020, STI Horizon 2021 Spring issue.

Section 3 Strengthening Funding Reform

Research funds provided by the government are divided into basic research funds for stable and continued support for research and education by universities, etc. and competitive funds to promote excellent research and research contributing to specific purposes.

The government is advancing the reform of research funds considering the appropriate balance of the two types of funds and promoting the reform of research funds and the organizational reform of national universities in an integrated manner to strengthen the foundation of ST innovation activities.

1 Fundamental funds reform

(1) National universities

National university corporations as centers of knowledge and human resources have a role to lead knowledge and create innovations in the knowledge-intensive society. In addition, as regional education and research centers based on their strategic distribution across the country, they are a driving force of social changes by developing the potential of regions in order to contribute to regional revitalization.

Japan has many challenges including the paradigm shift to a knowledge intensive society, globalization of high education and formation of a geographically decentralized society. In this context, for national universities to fulfill their roles as the central core of human resource development and innovation creation, they need to develop an environment for solid implementation of university reform with due consideration to continuity and stability of education and research.

Operating support funds for national universities decreased 16.2 billion yen from the previous fiscal year to 1 trillion 80.7 billion yen in the 2020 budget, but the Cabinet Office separately allocated 26.4 billion yen for reduction/exemption of tuition fees under the new system for higher education support. As a result, the total funds increased 10 billion yen from the previous fiscal year to 1 trillion 107 billion yen.

As the budgetary allocation system during the period of the third medium-term objectives starting from FY2016, functional enhancement of national universities is promoted through focused support based on evaluation under the “three frameworks for focused support” in accordance with the direction of functional enhancement based on the strengths and unique characteristics of the universities. In FY2019 a new system “allocation based on records with focus on achievement” will be introduced to improve comprehensibility and transparency of evaluation, promote independent activities of universities and improve incentive for reform with due consideration to stability and continuity of education and research.

2 Reform of public funds

(1) Improvement and enhancement of the competitive research fund system

The competitive research fund system is a core research-fund system for the establishment of a competitive research environment and the consistent development of and ongoing commitment to

researchers in various creative R&D activities. Efforts have been made to reserve budgets and improve the system (722.6 billion yen for FY2020 initial budget).

Based on the Integrated Innovation Strategy 2020 (Cabinet Decision on July 17, 2020), and in order to strengthen the nation's research capability, since FY2020 the system has been gradually changed to allow payment of direct cost of the competitive research fund for taking care of non-research works and for labor cost paid to the principal investigator (PI) so that researchers can secure research hours.

In addition, the ministry is promoting appropriate payment of research assistant costs involving doctoral students from competitive research funds in order to improve treatment of doctoral students.

For the purpose of reducing office work burden on researchers to secure their time for research, the existing "competitive funds" and funds for open-type projects are integrated as "competitive research funds" to improve various office procedures under a unified rule.

In order to ensure the fair, transparent and high-quality examination and evaluation of research proposals, the government ensures diversity in the age, gender and affiliation of examiners. It also aims to eliminate stakeholders, to develop an examiner-evaluation system, to specify methods and criteria for examination and adoption and to disclose examination results.

For example, the examination of KAKENHI applications is conducted via a process of peer review by more than 7,000 examiners. JSPS selects examiners from the examiner candidate database (about 126,000 researchers as of FY2019) by taking into account the balance among research institutions and the aggressive promotion of young and female researchers. Disclosure of examination results to the applicants has been improved in order. In addition to numerical information such as a rough ranking of all unsuccessful research applications and the average score of each evaluation element, detailed items in each evaluation element that examiners have judged as being inadequate are disclosed through the Electronic Application System for KAKENHI to give the applicants a more detailed evaluation of the results.

Concerning measures to prevent the inappropriate use of competitive funds and other public research funds, guidelines have been formulated, which include the Measures to Prevent the Inappropriate Use of Research Funds (Council for Science and Technology Policy (CSTP), August 31, 2006) and the Guidelines for Management and Audit of Public Research Funds at Research Institutions (Implementation Standards) (Decision of the Minister of Education, Culture, Sports, Science and Technology on February 15, 2007: "The Guidelines"). While conducting thorough monitoring including investigation of the research institution's system for abuse prevention, MEXT has urged them to establish an adequate system for their management and auditing of public research funds by providing guidance and taking measures for improvement if necessary. In addition, MEXT revised the Guidelines in February 2021 and is working to prevent the abuse of public research funds by reinforcing more effective initiatives toward an organizational culture that prevents abuse based on the strengthening of governance, enlightenment activities and a system to prevent abuse.

<Reference URL>

Competitive Research Funds System (FY2019 initial and supplementary budget amount)
https://warp.da.ndl.go.jp/info:ndljp/pid/11616358/www8.cao.go.jp/cstp/compefund/kyoukin_r1-2.pdf

List of FY2019 Competitive Research Funds System (outline of the systems)
https://warp.da.ndl.go.jp/info:ndljp/pid/11616358/www8.cao.go.jp/cstp/compefund/kyoukin_r1.pdf

List of FY2020 Competitive Research Funds System (outline of the systems)
https://warp.da.ndl.go.jp/info:ndljp/pid/11616358/www8.cao.go.jp/cstp/compefund/kyoukin_r2.pdf

(2) Harmonization of efficiency improvement of execution rules

In order to secure research hours of researchers by reducing their office work and ensure effective and efficient use of research funds, the entire government is working on system improvement with the aim of improving usability of research funds. Harmonized and simplified rules for use of competitive funds will also be applied to other research funds. The government will unify application formats that were designated separately by individual programs and enable application using the unified format through the cross-ministerial R&D management system (e-Rad).

3 Integrated promotion of the national university reform and the research funds reform

Based on the Integrated Innovation Strategy 2019 decided by the Cabinet on June 21, 2019, and on the premise of establishment of a system for appropriate implementation by the research institutions, it was decided to allow payment of labor cost to the principal investigator (PI) from the direct cost of the competitive fund in proportion to his/her efforts for the research activities at the request of the principal investigator. In this way, based on appropriate cost allocation, research institutions can use secured funds to enhance research performance of principal investigators through environmental improvement for focused research and also to strengthen research capacity of the institutions by securing diverse and excellent talents including young researchers. The reform is expected to enhance research capabilities of both researchers and research institutions. Furthermore, in order to increase the hours researchers are able to concentrate on research projects, the buyout system was adopted to allow payment for taking care of non-research works for which principal investigators are responsible in their research institution.

In addition, based on the Comprehensive Package to Strengthen Research Capacity and Support Young

Researchers (the Council for Science, Technology and Innovation (CSTI) in January 2020) and "Guidelines for Employment and Fostering of Postdocs, etc." (CST Committee on Human Resources on December 3, 2020), active employment of doctoral students necessary for research execution as research assistant (RA) and payment of suitable compensation will be included in the FY2021 application guidelines of the competitive research fund system.

Through these efforts, MEXT will work for the continuing creation of research outcomes using competitive research funds, while at the same time encouraging strengthening of the university governance and human resource and payroll management that are the key to university reform.