Chapter 2 Science, Technology, and Innovation Policy Toward Realization of Society 5.0

Section 1 Transformation into a sustainable and resilient society which ensures the safety and security of the people

This chapter is on the government's initiatives to redesign Japanese society and transform it into a society that enables each individual to realize well-being by solving global issues ahead of the world and ensuring the safety and security of the people.

1 Creating New Value through the Fusion of Cyberspace and Physical Space

To realize Society 5.0, the goal of the 6th Basic Plan, our aim to is to create new value by merging cyberspace and physical space. Specifically, the goal is to create a high-quality digital twin using a wide variety of data in cyberspace, change physical space by actively using AI based on the digital twin, and reproduce the result in cyberspace, thereby transforming society into a society that creates a dynamic virtuous cycle that is constantly changing.

❶ Strategy and organization for building cyberspace

The Digital Agency will inspect and review the conformity of regulations and systems to digital principles and bring full-fledged structural transformation in Japanese society; concerning regulations that use analog methods, such as regulations that rely on the human eye, the Agency will first promote cross-sectional inspection and review of such regulations taking into account the possibility of using digital technology. In December 2022, the Agency finalized its review policy concerning approximately 10,000 provisions concerning analog regulations and its process schedule for the review. In parallel with these kinds of initiatives, it cooperates with the ministries and agencies with jurisdiction over the regulations and companies, etc. to develop "RegTech Map," which organizes model types that compile regulations with similar purposes and objectives as well as the correspondence relationships of technologies, and by generating a positive spiral of "reviews of regulations" and "progress of technologies" it aims to create new growth industries as a consequence of the rationalization of regulations and to realize economic growth.

Also, the "Act on Making Payments That Become Part of the National Revenue by the Method Using Information and Communications Technology" (Act No. 39 of May 9, 2022), which enables cashless payments of fees and other charges for administrative procedures, was enacted on April 27, 2022 and brought into effect on November 1 the same year. The Act was applied and cashless payments for automobile inspection and registration fees, passport issuance fees, etc. were introduced. Moreover, in order to utilize data for economic development and the solution of social problems, it is promoting the "National Data Strategy," and has formulated the common rules for handling data when building a platform, developed the public data infrastructure as a registry catalog, and released My System Navi, which enables search for support systems.

❷ Development of data platforms and provision of highly convenient data utilization services

In FY2022, the Digital Agency developed pilot

versions of the address database and public facilities as a base registry, and released the registry catalog site which is the data release site for the registries with these bases.

In addition, the Digital Agency formulated the "Basic Policy for Development and Management of Information Systems" (decided by the Minister for Digital Transformation on December 24, 2021), which is an important policy, particularly from the perspective of information systems, for the national government, local governments, incorporated administrative agencies, and other related parties to work in collaboration effectively. The Digital Agency also conducts reviews throughout the year in accordance with each phase of a project in the budgeting process at the budget request stage and execution stage, and the results of the reviews are appropriately reflected in the budget request and execution, thereby aiming to reduce the system modification expenses included in the operation and maintenance cost of government information systems, by 30% in FY2025, which amounted to a total of 540 billion yen as of FY2020.

Furthermore, to promote digitalization and data linkage in semi-public sectors such as health and medical care, education, and disaster prevention and provide personalized services to users, the Digital Agency is working on conducting research and demonstration in each field under cross-ministerial and cross-agency systems.

To enhance the industrial competitiveness of Japan and realize safe and secure data distribution, the Digital Architecture Design Center (DADC) established at the Information-technology Promotion Agency, Japan, has been working on the design of architecture, including standards for linking systems and data that have been individually developed among different businesses and sectors.

The Cabinet Office, Government of Japan, developed "Cross-Sectoral Data Linkage Infrastructure Technology" to realize data linkage across sectors under the Cross-ministerial Strategic Innovation Promotion Program (SIP[1]) "Big-data and AI-enabled Cyberspace Technologies." Introducing connectors, which are a part of Cross-Sectoral Data Linkage Infrastructure Technology, into the data infrastructure of each specific field enables easy data provision, searching, retrieval, and more. It utilized these technologies to demonstrate the linkages with the smart city data infrastructure and data infrastructure for each sector built in the SIPs, etc., and verify the Cross-Sectoral Data Linkage Infrastructure Technology.

❸ Building a reliable data distribution environment, including data governance rules

In the "Sub-working Group for Trust-Assured Digital Transformation (DX)" established under the "Data Strategy Promotion Working Group," the Digital Agency published a report in July 2022 and organized the "Key Principles of Trust Policy." Furthermore, for the implementation of the "Guidance for the Implementation of Data Handling Rules on the Platform ver. 1.0," it was implemented and referenced in some semi-public sectors, etc. and some of the promotion grants for the vision of a Digital Garden City Nation.

❹ Next-generation infrastructure for the digital society and development and R&D of data /AI utilization technologies

1. Next-generation infrastructure for the digital society

In order to respond to the rapid increase of network traffic, diversification of service requirements and complication of networks in Society 5.0, MIC conducted R&D aimed at

1 Cross-ministerial Strategic Innovation Promotion Program

practical use of an optical transmission system exceeding 5 Tbps per operation unit, and R&D for automation of communication network operation taking advantage of artificial intelligence. Furthermore, keeping in mind the further implementation in society of the 5th generation mobile communication system (5G), MIC is conducting R&D to realize further upgrades of the reliability and energy efficiency, etc. of 5G by FY2022, and in addition with the focus on the technologies required beyond 5G, it is conducting R&D concerning high frequency band communication devices over 100GHz. In addition, R&D on ultra-high-definition video interface technology, beam control technology, and wireless signal processing technology was conducted to develop applications for the wireless communication infrastructure technology that enables uncompressed transmission of ultra-high-definition video using terahertz waves.

National Institute of Information and Communications Technology (NICT) worked on R&D of device technologies and integration technologies aiming to realize a wireless communication system at the level of 100Gbps using terahertz waves, and fundamental technologies regarding signal source, detectors, etc. In order to respond to rapid increase in communications traffic and power consumption accompanying ICT use, NICT promoted R&D on all-optical network that realizes networks with ultra-high speed and low-power consumption.

Because 5G with further enhanced functions including ultra-low latency and multiple concurrent connections ("Post 5G") is expected to be used for diverse industrial applications including the smart factory and automated driving, METI is tackling the development of Post 5G-compatible information communication systems and related technologies such as the semiconductors used in the systems, and is tackling the development of the advanced semiconductor manufacturing technologies which will be necessary with Post 5G. In addition, as the IoT and electrification of industries progress and the importance of supporting semiconductor-related technologies increases, the government has tackled research and development for the advancement of new generation power semiconductors and semiconductor manufacturing equipment to realize electronic products with more efficient energy conservation by utilizing Japan's high-level elemental technologies, etc.

Moreover, for the realization of the Beyond 5G next-generation information communication infrastructure "Beyond 5G," which is anticipated to be the foundation of all industries and social activities in the 2030s, MIC has been supporting R&D of the elemental technologies for Beyond 5G using the R&D fund established in NICT in March 2021 to support R&D into the elemental technologies necessary to realize Beyond 5G. As the period of the fund was limited, in March 2023 MIC newly established in NICT a permanent fund in order to conduct R&D for the innovative information and communication technologies including such as Beyond 5G, etc. Going forward, it will utilize that fund to promote R&D in the field of ICT and its social implementation, implementation in society, and overseas expansion.

Column 2 Response to the 3D structure paradigm shift in advanced logic semiconductors Development of R&D bases

In communication using social media, on-line bank payments, and automated driving using AI, "value" which is not visible to the eye called "information" is gathered and computed and converted to "added value," and furthermore they are distributed throughout the world in real time using the Post 5G/6G communication method which realizes "high speed and capacity," "low latency" and "multiple concurrent connections," countless information links are formed. Logic semiconductors carry out ultra-high speed digital computation and digital communication processing, and they are one of the extremely important critical technologies in national security as well. With logic semiconductors, the most important technological factor is how many semiconductor transistors (switches) can be fabricated per unit area, and over the last 60 years or more, the miniaturization of circuit elements has been advanced vigorously. It is expected that from 2025 onward we will enter the era of one trillion semiconductor circuit elements, and there will be a paradigm shift to a 3D structure compatible with further high integration (Figure), and as a consequence of that transformative innovation in semiconductor operating principles and manufacturing process technologies is required.

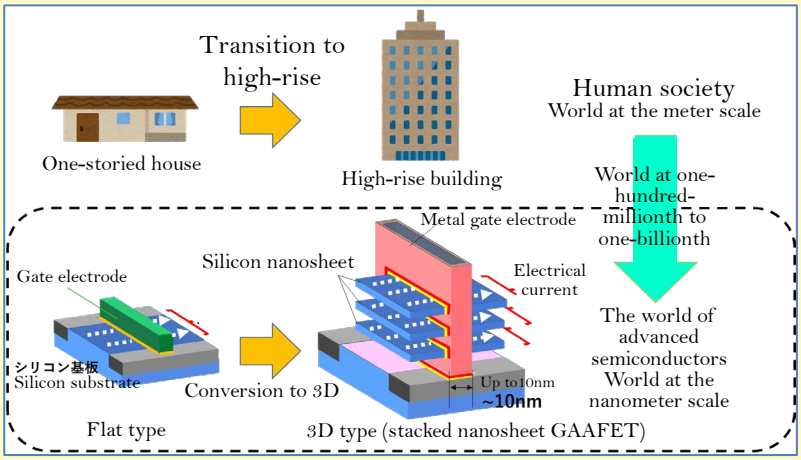


Figure: Paradigm shift for the structure of advanced semiconductors: from the flat type to the high rise type (conversion to 3D)

Provided by: AIST

As part of the "Development of manufacturing/process technologies and pilot line for advanced logic devices with 3D channel structures" adopted in the New Energy and Industrial Technology Development Organization (NEDO)'s "Research and Development Project of the Enhanced Infrastructures for Post-5G Information and Communication Systems, R&D Item 2. Development of manufacturing technologies for advanced semiconductors (a) Development of front-end technologies for advanced semiconductors (More Moore technologies)," the National Institute of Advanced Industrial Science and Technology (AIST) has completed most of the introduction of the necessary cutting-edge manufacturing equipment in FY2022 for its plan to develop a shared pilot line capable of prototyping logic semiconductor devices with a 3D structure (stacked nanosheet GAAFET) inside the super clean room installed in the AIST Tsukuba Center. AIST expects to commence operation of the pilot line at the end of FY2023, so it has formed the Advanced Semiconductor Manufacturing Technologies Consortium (https://unit.aist.go.jp/cpo-eleman2022/ASMA/) and will provide a mechanism which can be used by the members.

2. Development and R&D of AI utilization technologies

The government formulated the AI Strategy 2022 in April 2022 as the new national strategy concerning AI. This strategy focuses on the importance of taking action against large-scale disasters, etc., while keeping in mind implementation in society by companies in particular as it sets out new goals: improvement of the reliability of AI, enhancement of data, environmental improvements such as securing human resources, etc.

Looking at initiatives in the related ministries and agencies, MIC, at NICT, is developing a system for objective assessment of human emotions using brain activity analysis technology. Using this

system, the ministry is developing an efficient information processing process reflecting aspects such as the unconscious value judgments appearing in brain activities, and is making efforts concerning the ethical, legal, and social issues (ELSI[1]) which arise due to the spread of AI by utilizing brain information and communication technology, etc., toward its social implementation. In addition, intending to realize universal communication where everyone can understand each other, MIC is conducting research, development, and demonstration of multilingual translation, interactive systems, and behavioral support using advanced technologies such as deep learning technology that uses a vast amount of data including voice, text, and sensor data.

At the Center for Advanced Intelligence Project that was established at RIKEN, MEXT has been promoting (1) elucidation of the principle of deep learning and development of basic technologies for generic machine learning, (2) R&D on AI and other basic technologies for further development of the fields where Japan has its strengths and solutions to social challenges, and (3) research of ELSI arising from the spread of artificial intelligence technologies In FY2022, based on the "AI Strategy 2022," MEXT will advance R&D for construction of the theory of highly-reliable next-generation basic AI technologies which exceed conventional deep learning and the implementation in society of cutting-edge basic AI technologies in the medical care sector and the disaster prevention sector. Furthermore, JST has been providing integrated support for unique ideas of young researchers in artificial intelligence and other fields and for challenging research tasks in order to open the way for new innovations (AIP Network Lab[2]).

METI brought together excellent researchers and technologies at the Artificial Intelligence Research Center (AIRC) established at AIST in May 2015. As a hub for research by universities and industry, the center has been working to create an environment that produces an efficient cycle for commercializing the results of goal-oriented basic research. Specifically, it has been tackling (1) development of the basic technologies of AI systems that evolve together with humans, (2) establishment of AI evaluation methods which can be trusted in the real world, and (3) development of AI technologies which can be easily built and introduced. Furthermore, in the Information Technology and Human Factors domain of AIST, it is operating the "AI Bridging Cloud Infrastructure (ABCI 2.0[3])," a large-scale, power-saving computing system which possesses an artificial intelligence processing performance at the top level in the world. Moreover, based on METI's "Development of Next Generation Artificial Intelligence, Sensing and other Core Technologies for Realization of IoT Society," NEDO is implementing R&D into AI systems which realize cooperation with humans and reliability, R&D into the AI technologies necessary for remote systems, and development of sensing devices and systems, etc. for obtaining real data with high accuracy, guaranteeing reliability. In addition, as part of the "Development of Integrated Core Technologies for Next-Generation AI and Robots" project for the advancement of energy demand and supply structure, started in FY2018, METI is working on research and development to accelerate the implementation of AI technologies that contribute to the advancement of energy demand and supply, development of basic technologies to accelerate the introduction of AI dramatically, and development of AI technologies to support the transmission and efficient utilization of "skills and

1 Ethical, Legal and Social Issues
2 Advanced Integrated Intelligence Platform
3 AI Bridging Cloud Infrastructure

tacit knowledge (experience and intuition) of experienced professionals" accumulated at design and manufacturing sites in the manufacturing sector.

Also, for efficient use of the massive amount of information that has increased with the advent of IoT society, METI has been working on development of a computing technology pertaining to innovative ultra-low power consumption AI chips that operate on the edge side of the network, and a next-generation computing technology that combines high-speed and low power consumption based on a new principle (e.g., brain type computer, quantum computer, light dispersion computer, etc.). Under the "Innovation Promotion for Acceleration of AI Chip Development," the ministry has been supporting AI chip development by private companies by building an AI chip design center equipped with design tools and verification devices that were necessary for AI chip development.

❺ Fostering human resources who will play a vital role in the digital society

With rapid progress of innovations and bewildering evolution of technologies in recent years, there is an increased need for commercialization of technological innovations including AI, big data and IoT and at the same time development of human resources who can promote structural reform of industries by using the technologies toward realization of Society 5.0.

With the aim of achieving the goal of AI Strategy 2022: "all humanity and science students of universities and colleges of technology (KOSEN) (about 0.5 million graduates/year) master introductory-level skills" and "students of universities and colleges of technology (KOSEN) (about 250,000 graduates/year) master basic skills for application in their respective fields," MEXT developed and is using a model curriculum (literacy level and advanced literacy level) systematizing the basic concept of mathematics, data science and AI education, learning objectives/skill set, education methods, etc. The curriculum has been spread to universities, etc. across the country through development of teaching materials, and collection and compilation of actual social challenges and real data, which can be used for education. Based on the AI Strategy 2019, the government certifies excellent educational programs on mathematics, data science and AI education provided in universities and colleges of technology (KOSEN). As of FY2022, 217 educational programs had been given a certification of literacy level and 68 educational programs had been given a certification of advanced literacy level. This certification system aims to foster an environment where not only the government but the entire society including industry actively evaluate initiatives of individual universities, etc. to improve the quality of education.

Moreover, through the provision of 300.2 billion yen in the second supplementary budget of FY2022, the government established a new fund and will provide flexible and continuous support so that motivated universities and colleges of technology (KOSEN) can embark on reorganization, such as transitioning faculties to include growth fields, with foresight for the development of the highly professional human resources who drive growth fields such as digital, etc.

The "Doctoral program for Data-Related InnoVation Expert" has been implemented since FY2017 with the aim of developing training programs for top-class experts in various fields in order to cultivate abilities to play key roles using data science, etc. in academia and industry. In addition, MEXT has been working on the "Statistics Professors Training Programs" since FY2021, with the aims of fostering personnel with advanced statistics skills and building an ecosystem of human resource development on the

subject.

MIC has been implementing the INNO-vation Program since FY2014 to support people who take on far-fetched and ambitious technological challenges without fear of failure. Under this program, MIC has been promoting initiatives to take on the "challenge" of disruptive ICT innovation which creates new value and to support its global expansion.

METI through the Information-technology Promotion Agency has been implementing the "The MITOU program" to discover and train excellent individuals (IT creators) who have original ideas and skills to create innovations taking advantage of IT.

❻ Contribution to the international society on the ideal digital society

The Digital Agency has been implementing measures for solving issues that need to be addressed in promoting international data flow, such as data quality, privacy, security, mutual trust in infrastructure, rules, and standards to establish a global framework of data flow for the operationalization of Data Free Flow with Trust (DFFT [1]), based on the G7 Digital and Tech Ministers' Meeting in April 2023, which Japan hosted.

The Cabinet Office, Government of Japan is considering how to respond to international discussions on the ideal way of a digital society, etc., in cooperation with relevant ministries and agencies, while taking into account the technological outcomes obtained through the efforts to establish a data linkage infrastructure, etc.

In view of the Expo 2025 Osaka, Kansai, Japan, MIC are implementing R&D for realization of "simultaneous interpretation" by AI covering also business and international conference discussions by further advancing the multilingual translation technology of NICT under the "Global Communication Plan 2025" (March 2020).

The Ministry of Foreign Affairs (MOFA) and the Japan International Cooperation Agency (JICA) are working to promote cooperation that contributes to the building of a digital society in developing countries under their official development assistance projects, including the utilization of digital technologies in various fields of development, development of human resources and industries that will be responsible for digitalization as a foundation for such utilization, and strengthening of cybersecurity capabilities, etc.

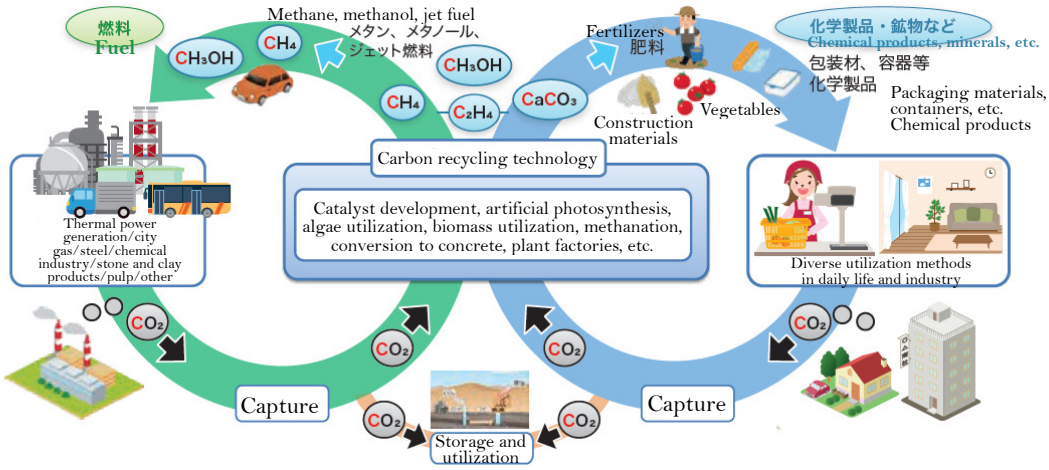
❼ New policy themes

The Cabinet Office is taking into account the tends in the discussions of the related ministries and agencies concerning the promotion of DFFT, etc. while advancing studies of measures to encourage data utilization across national borders, etc. through a range of initiatives based on the AI Strategy, National Data Strategy, etc.

2 Promoting Social Change and Discontinuous Innovation to Overcome Global Issues

The goal is to achieve carbon neutrality by 2050, which will reduce overall greenhouse gas emissions to zero by 2050 and create a society in which development of the green industry leads to economic growth and a virtuous cycle between the economy and the environment is created, by taking actions for realization of a circular economy through sound and efficient waste treatment and advanced recycling.

1 Data Free Flow with Trust



Concept of carbon recycling
Created by METI

❶ Promotion of R&D and cost reduction of innovative environmental technologies

1. Environment Innovation Strategy and Green Growth Strategy

Based on the "Environment Innovation Strategy" and other such strategies, the government is strengthening its research and development of innovative technologies related to promising areas. In addition, by formulating a "Green Growth Strategy Through Achieving Carbon Neutrality in 2050," the government is promoting research and development and demonstration of innovative technologies and their implementation in society, utilizing Green Innovation Fund projects that provide continuous support for the development of innovative technologies.

2. Promote research and development toward carbon neutrality

MEXT took budget measures in the FY2022 supplementary budget and created a fund in March 2023 for the "Green Technologies of Excellence (GteX) Program" which aims to create "innovate GX technologies" that bring about disruptive innovation for the realization of carbon neutrality by 2050 and future industrial growth.

To promote the development of carbon recycling technologies in which CO_2 is treated as a resource, separated and captured, and recycled into concrete through mineralization, into chemicals through artificial photosynthesis, and into fuels through methanation[1], etc. to reduce CO_2 emissions into the atmosphere, METI has formulated the "Roadmap for Carbon Recycling Technologies" in June 2019 and revised it in July 2021 in light of the latest trends. In line with this Roadmap, METI is implementing R&D into carbon dioxide separation and capture technologies, sustainable aviation fuel (SAF[2]), technologies for manufacturing concrete using carbon dioxide, bioproduction process technologies for producing biomass-derived chemical products, etc., and in the carbon recycling sector it is advancing the social implementation of technologies while utilizing the Green Innovation Fund. Moreover, it has developed the R&D and Demonstration Base for Carbon Recycling at Osaki-Kamijima, Hiroshima Prefecture, which is implementing concentrated technology development and demonstration tests.

Aiming at the practical use of CO_2 Capture,

1 Technology to synthesize methane, the main component of natural gas, by synthesizing carbon dioxide and hydrogen.
2 Sustainable Aviation Fuel

Utilization and Storage (CCUS[1]), METI is advancing R&D for the demonstration of an integrated system designed to separate, capture and transport CO_2 from large CO_2 emission sources and store it underground at depths of more than 1,000 m, and also developed technologies to drastically reduce costs and improve safety. In steel manufacturing, METI is aiming to improve energy efficiency in the steel manufacturing process, and it developed technologies to lower the temperature and increase the efficiency of iron ore reduction reactions using coke (ferro coke), which is produced by effectively utilizing low-grade raw materials. Furthermore, in light of the outcomes of the project for development of process technologies for hydrogen reduction, etc., CO_2 Ultimate Reduction System for Cool Earth 50 (COURSE 50[2]), and aiming for a significant reduction in carbon dioxide emissions, METI is carrying out the development of technologies using hydrogen to reduce iron ore in "Green Innovation Fund Project: Hydrogen Utilization in Iron and Steelmaking Processes."

MOE has been compiling (1) costs of separating and capturing most of the CO_2 from exhaust gas from thermal power plants, (2) design and construction of Japan's first full-scale CO_2 separation/capture equipment toward assessment of degradation in power generation efficiency and environmental impact, and (3) methods for smooth introduction of Carbon Capture and Storage (CCS[3]) suitable for Japan. METI and MOE have jointly conducted geological investigations, including elastic wave explorations, to determine areas suitable for CCS in Japan. Since FY2018 the ministries have been implementing demonstration of CO_2 Capture and Utilization (CCU[4]), artificial photosynthesis and methanation initiative as well as examination and evaluation of the CO_2 reduction effects over their lifecycle.

METI is conducting demonstration of HEFA[5] technologies, including ATJ[6] technology (producing SAF[7] from alcohol using catalyst technology), gasification FT[8] synthesis technology (reacting materials such as wood with water vapor and oxygen to produce hydrogen and carbon monoxide, and producing SAF by reacting the gas and catalyst), and microalgae culture technology utilizing carbon recycling, in order to commercialize sustainable aviation fuels (SAF) that will contribute to decarbonization initiatives in the aviation field.

In addition, through the Green Innovation Fund Project: Development of Technology for Producing Fuel Using CO_2, etc. Projects, METI plans to support technologies that will enable mass production of SAF (ATJ technology).

Regarding methanation, the establishment of large-scale and highly-efficient synthetic methane production technologies capable of large volume supply is necessary. For this reason, METI is implementing technology development and demonstration for scaling up methanation facilities using the Sabatier reaction. Moreover, through the Green Innovation Fund Project: Development of Technology for Producing Fuel Using CO_2, etc. Projects, METI has commenced the development of innovative methanation technologies which dramatically increase production efficiency.

JST is promoting research and development of innovative biotechnologies to produce chemical products from biomass that will replace petroleum

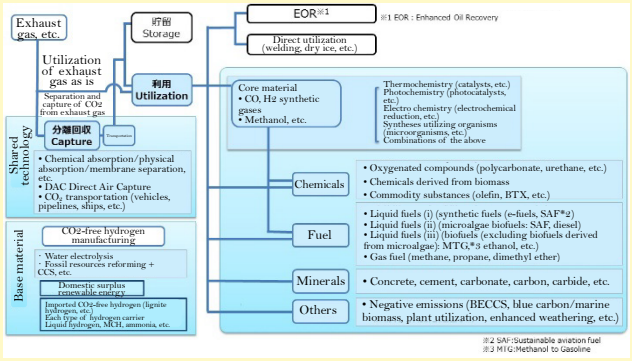
1 Carbon dioxide Capture, Utilization and Storage
2 CO2 Ultimate Reduction System for Cool Earth 50
3 Carbon Capture and Storage
4 Carbon dioxide Capture and Utilization
5 Hydroprocessed Esters and Fatty Acids
6 Alcohol To Jet
7 Sustainable Aviation Fuel
8 Fischer-Tropsch

products, under the "Strategic Basic Research Programs Advanced Low Carbon Technology Research and Development Program (ALCA [1])" and the JST MIRAI program: "Low Carbon Society" mission area.

RIKEN has been conducting leading studies on the cyclic use of carbon, which has been consumed in petrochemical products, through interdisciplinary studies on plant science, chemical biology, catalytic chemistry and biomass engineering. Another RIKEN endeavor is R&D on the establishment of innovative bioprocesses towards the discovery of new materials derived from biomass.

Column 3 Carbon recycling

"Carbon recycling" refers to initiatives which think of carbon dioxide as a resource, separate and capture it, reuse it as concrete, etc. through mineralization, or chemical products through artificial photosynthesis, etc., or fuel through methanation, etc., to curb carbon dioxide emissions in the atmosphere. Furthermore, it is a technology that could become a game changer for realizing both the stable supply of energy and carbon neutrality, and there is competitiveness in Japan. Concrete and polycarbonate used in the headlight covers of cars, etc. with carbon dioxide as the raw material have already been practically applied.



Carbon recycling
Created by METI

On the other hand, cost reduction is an issue for many carbon recycling technologies; in particular, carbon dioxide-free hydrogen is still very expensive, innovation is necessary in technologies using hydrogen. For that reason, in the short term, MEXT will target technologies which make hydrogen unnecessary, such as technologies which fix more carbon dioxide in concrete and the creation of biofuels using algae, etc. In the long term, use which replaces existing general-purpose products such as synthetic fuel, etc. is expected, and currently MEXT is utilizing the Green Innovation Fund while R&D is being advanced through industry-university-government collaboration.

Furthermore, the R&D and Demonstration Base for Carbon Recycling at Osaki-Kamijima in Hiroshima Prefecture commenced full-scale operation in September 2022 in order to accelerate the creation and practical application of innovation. It uses the carbon dioxide captured with the Integrated Coal Gasification Fuel-Cell Combined Cycle (IGFC) Demonstration Project on the adjacent site to implement concentrated technology development and demonstration tests. With this base as a "showcase" of diverse carbon recycling technologies, it aims to encourage collaboration with overseas researchers and to create and accelerate further innovation by promoting the most advanced technologies throughout the world.

R&D and Demonstration Base for Carbon Recycling at Osaki-Kamijima
Created by METI

3. Initiatives for Moonshot

The Moonshot R&D Program sets nine goals for science and technology to proactively take on the challenges facing Japan, such as an aging and declining population, extreme natural disasters and global warming, and to open up future growth areas (refer to Chapter 1, Section 2 2 ❹). The program sets "Realization of sustainable resource circulation to recover the global environment by 2050" as the target in goal #4, aiming to solve the

1 Advanced Low Carbon Technology Research and Development Program

global warming problem (the Cool Earth) and environmental pollution problem (the Clean Earth) through the realization of sustainable resource circulation for the regeneration of the global environment. The program sets "Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050" as the target in goal #5, which aims to satisfy both food production and global environmental conservation.

4. Global Zero Emission Research Center

AIST established the Global Zero Emission Research Center (GZR) on January 29, 2020. GZR conducts basic research on key technologies for the Environment Innovation Strategy, including in the fields of renewable energy, rechargeable batteries, hydrogen, separation and utilization of carbon dioxide, and artificial photosynthesis through international collaboration, and also promotes its activities as an innovation hub such as international conferences of leaders gathering national research institutes from G20 nations on clean energy technologies (RD20) and serves as the secretariat of the Tokyo Zero-emission Innovation Bay (Zero-emission Bay).

5. Initiatives for agriculture, forestry, and fisheries

As the global focus on the SDGs and environmental issues accelerates, it is necessary to take the initiative in establishing sustainable food systems. In May 2021, MAFF launched the "Strategy for Sustainable Food Systems, MIDORI" that aims to enhance productivity potential and ensure sustainability of agriculture, forestry, fisheries and food industries in Japan through innovation. In order to facilitate the implementation of the MIDORI strategy, the "Act Concerning Promotion of Low Environmental Impact Business Activities to Establish a Food System in Harmony with the Environment" (the "MIDORI Act") was established and brought into effect in 2022. Through the certification of producers and business operators under the MIDORI Act, etc., MAFF is encouraging the development and spread of new technologies which contribute to the reduction in environmental load, including an automatic irrigation and fertilization system which contributes to reducing the use of chemical fertilizers, a paddy field weeder which contributes to reducing the use of chemical pesticides, and expanded initiatives for organic farming, etc. Furthermore, this strategy has set out 14 numerical targets (KPIs[1]) by 2050, including realization of zero CO_2 emission from fossil fuel combustion in agriculture, forestry, and fisheries sectors, 50% reduction (risk-weighted) in use of chemical pesticides, 30% reduction in chemical fertilizer use, increase in organic farming to 25% of farmland, etc. In June 2022, the targets (KPIs) for 2050 were complemented by intermediate targets with a 2030 time horizon.

For the creation of innovation, MAFF is comprehensively promoting R&D for solving the issues faced by production sites and R&D to tackle global warming countermeasures, etc. from a medium- to long-term perspective. In FY2022, it implemented continuous improvement of technologies which operators of agriculture, forestry, and fisheries, etc. utilize on site and the development of basic technologies for decarbonization and sustainability, etc. It also promoted in an integrated manner technology development and demonstrations to accelerate the social implementation of smart agriculture technologies and technologies for the utilization of pellet compost, and environmental improvements such as soil cultivation, etc. based on data. Furthermore, as challenging R&D which should be

1 This stands for Key Performance Indicator, which refers to "important indicators for the evaluation of performance."

tackled in the medium- to long-term, MAFF promoted the development of a new pest control technology which contributes to reducing the amount of chemical pesticides used by irradiating flying pests with a laser beam to shoot them down, and the development of candidate materials for methane reduction from cattle by elucidating the microbial functions in the which relating methane production and increasing productivity of cattle.

Smart agriculture demonstration projects were conducted across Japan in 205 districts to develop smart agriculture technologies, such as automatic driving systems for agricultural machinery using satellite positioning information and image data and robotized harvesting of vegetables and fruit trees, and to clarify the economic benefits of introducing these technologies to production sites (as of March 2023). Moreover, in order to spread the demonstrated outcomes, MAFF published the results of management case analyses for two years in the adopted areas in FY2019, and a smart support team comprised of producers, private business operators, etc. which possess technologies and know-how cultivated in the demonstrations, commenced the expansion of smart agriculture technologies to new production regions.

In addition, to realize the "Fukushima Innovation Coast Framework," MAFF will develop advanced technologies in agriculture, forestry, and fisheries using ICT and robotics, promote on-site demonstrations, and social implementation initiatives for contributing to addressing the new issues faced by the field.

In light of the challenges experienced in the fields, the ministry revised the Smart Agriculture Promotion Comprehensive Package (formulated in October 2020) in June 2022 and is promoting acceleration of social implementation of smart agriculture.

Based on this package, the ministry pursued steady implementation of the demonstration and dissemination of the results, fostering of agriculture support services including farm work contracting and agricultural machinery sharing, and verification of the safety and studies of measures to ensure safety for robotics that requires solutions to safety issues before installation in the field.

Furthermore, in order to develop an open API[1] which aims for data linkage of agricultural machinery, etc. for the encouragement of data utilization in agricultural sites, the ministry has implemented the standardization of data formats, formulation of the rules for handling the data use authority, etc. regarding the data items which contribute to farm management in agricultural machinery such as tractors, combine harvesters, etc., grain dryers, facility horticultural equipment, etc.

ICT services are being developed for farmers using the "Agricultural Data Collaboration Platform (WAGRI)," a data platform that enables the linkage and provision of various data types. In addition, the building of a food chain platform enabling data sharing in agricultural production, distribution, processing, consumption, and export was advanced.

The Public Works Research Institute is implementing development of improvement and maintenance technologies for agricultural production bases in snowy cold regions contributing to converting agriculture into a growth industry and building its resilience, and R&D concerning the improvement and maintenance of fisheries bases in cold seas which contribute to enhancing the productivity of marine resources.

Since FY2020, MAFF has been working on the development of carbon sink technology using materials including biochar, blue carbon, and wood

1 Application Programming Interface

biomass as climate change reduction technologies in agriculture, forestry, and fisheries. The ministry is also developing implementation-scale climate change reduction technologies that can reduce GHG emissions and improve productivity in rice paddies, dry field crops, and horticultural facilities, and has newly started developing a technology to significantly reduce the breeding period for tree species with excellent carbon sequestration capabilities. Furthermore, the ministry is promoting the development of technologies to reduce methane emissions derived from fermentation in the cow's rumen and the development of comprehensive cultivation management technologies concerning the reduction of GHG emissions in the paddy fields of the Asia region.

Also, MAFF has been working on the development of driftwood disaster prevention and damage reduction technologies, as well as technologies for the management of pests and invasive alien species as part of climate change adaptive technologies.

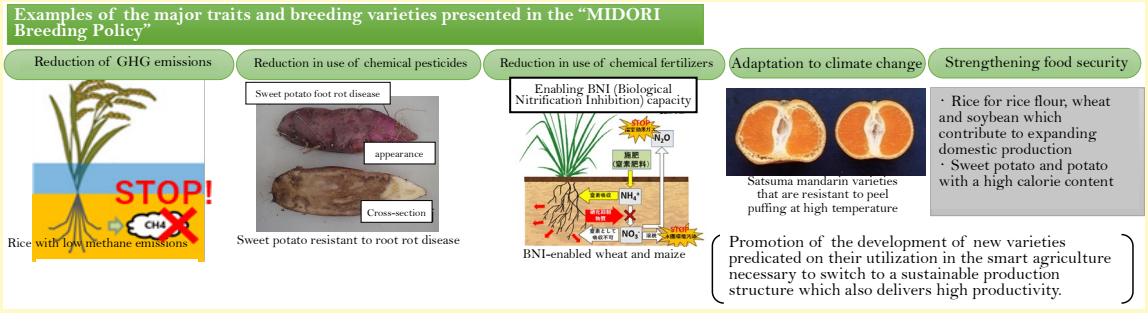
In order to support development of new cultivars by private companies and other breeders using plant genetic resources from foreign countries, MAFF has been promoting bilateral joint research with mainly other Asian countries and conducting surveys focusing on collection and evaluation of genetic resources. MAFF has also been building a database to efficiently supply that information. In the genebank project concerning genetic resources for agricultural purpose, NARO collects, preserves, evaluates, and provides genetic resources of rice and other crops.

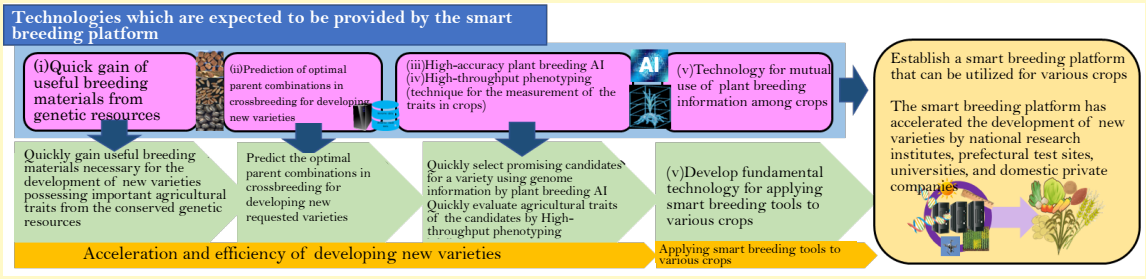
Column 4 Formulation of the "MIDORI Breeding Policy" for realization of the goals in the Strategy for Sustainable Food Systems, MIDORI

In order to build a sustainable food system, MAFF formulated the Strategy for Sustainable Food Systems, MIDORI in 2021 to realize both enhanced productivity potential and sustainability in agriculture, forestry, fisheries, and food industries. In this strategy, realization of zero CO_2 emissions from fossil fuel combustion in agriculture, forestry, and fisheries industries, 50% reduction in (risk-weighted) use of chemical pesticides, 30% reduction in chemical fertilizer use, and increase in organic farming to 25% of farmland (1,000,000 ha) were set out as the goals by 2050, and it is expected that breeding the varieties which have innovative characteristics will bear an important role in realizing the goals of this strategy. For that reason, in December 2022 MAFF formulated the "MIDORI Breeding Policy" which summarizes the policy direction for breeding the varieties which will be necessary going forward and described the establishment of a "smart breeding platform" to accelerate the breeding of these varieties.

Regarding the breeding of specific varieties, it presents policy directions for each of the five items of "reduction of greenhouse gas emissions," "reduction in use of chemical pesticides," "reduction in chemical fertilizer use," "adaptation to various climate changes," and in addition, "strengthening food security," which has become a problem due to the recent rapid changes in the global situation.

Furthermore, enormous efforts and a time period of more than ten years are generally necessary for developing a new variety. Therefore, in order to develop the required varieties quickly, MAFF decided to establish the "smart breeding platform" combining technologies which streamline the development of varieties, such as techniques which quickly gain useful breeding materials from genetic resources and which use AI to predict the optimal parent combinations in crossbreeding for developing new varieties, etc.





Provided by: Secretariat of Agriculture, Forestry and Fisheries Research Council

<Reference URL> Secretariat of Agriculture, Forestry and Fisheries Research Council website

https://www.affrc.maff.go.jp/docs/hinsyu/hinsyu_kaihatu.html

6. Initiatives to improve energy efficiency and zero emissions of social infrastructure facilities

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been supporting the technological development of next-generation ships (zero-emission ships, etc.) in order to consolidate and strengthen cooperation in the maritime industry centered around the top runners in technology. In collaboration with MOE, MLIT conducted a project to promote the introduction of LNG-fueled ships to spread advanced navigation systems that combine LNG fuel systems and the latest CO2-saving equipment.

The National Institute of Maritime, Port and Aviation Technology (MPAT) has been in charge of research on fundamental technologies to significantly reduce GHG emissions from ships, which contribute to achieving regulatory control aiming at zero emissions with social rationality, resulting in mitigating environmental impact.

MPAT is promoting onsite surveys and experiments in coastal areas for quantitatively measuring the atmosphere/seawater gas exchange rate and the carbon flow between the seawater and benthic ecosystems. The aim is to establish a method for measuring blue carbon, which has potential for both domestic and international applications.

The Public Works Research Institute is implementing the development of technologies for resources and materials utilization and environmental impact reduction adapted to changes in the social structure.

NILIM is carrying out research concerning sewage treatment technologies which curb greenhouse gas emissions and recover energy and resources and the development of rational evaluation methods for energy consumption performance in light of the improved performance of energy-saving houses.

MPAT is conducting R&D pertaining to submarine construction, transportation/communication between ocean base and sea floor, etc. MPAT is also conducting research on the development and improvement of techniques for safety evaluation of offshore structures and for reducing environmental impacts. These techniques are the basis of key technologies for the exploitation of ocean resources and energy.

7. Development of technologies for observation of the earth environment and continued observation

(1) The promotion of Earth observations

To understand current global warming trends, many countries and organizations worldwide have been observing the Earth from the outer space by satellite, as well as by ground-based and maritime observation systems. To enhance the effectiveness of global efforts for tackling climate change problems, a system that facilitates access to observational data and scientific knowledge to countries and institutions through international collaboration is important. The Group on Earth Observations (GEO [1]) was established as an international framework to promote the development of the Global Earth Observation System of Systems (GEOSS [2]). It had 258 countries and institutions as members as of March 2023. Japan has been playing a leading role on the GEO Executive Committee.

As one of the studies using the Environment Research and Technology Development Fund, MOE has been implementing the "Comprehensive Research on Projection of Climate Change Impacts and Evaluation of Adaptation (S-18)" aimed at creation of the latest scientific

1 Group on Earth Observations
2 Global Earth Observation System of Systems

information on projection of climate change and adaptation evaluation to support Japan's adaptation to climate change. The ministry is comprehensively promoting the strategic studies and other research on observation/monitoring, projection and assessment of climate change and its impacts as well as countermeasures using the Environment Research and Technology Development Fund.

(2) Satellite-based observation

To promote satellite observations of the earth, Japan Aerospace Exploration Agency (JAXA) has been operating the Global Change Observation Mission - Climate "SHIKISAI" (GCOM-C[1]), the Global Change Observation Mission - Water "SHIZUKU" (GCOM-W[2]) and the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2[3]) and so on, and has been conducting R&D for the Advanced Land Observing Satellite-4 (ALOS-4[4]) and for other satellites (See Chapter 2, Section 1 3 ❺).

In order to help clarify climate change and its effects, MOE, with related ministries and agencies as well as relevant organizations at home and abroad, has developed and is operating global CO_2 and methane, etc., observation technologies using the Greenhouse Gases Observing SATellite "IBUKI" (GOSAT[5]) and "IBUKI-2" (GOSAT-2). In addition, the ministry is conducting continuous monitoring by using airplanes and ships, and monitors on the ground. With the aim of further promotion of climate change countermeasures, GOSAT has been used for clarification of the global concentration distributions of CO_2 and methane, as well as estimation of absorptions and emissions by month and region. The project revealed a trend of rising concentration of CO_2 and methane through seasonal changes since 2009 when the observation started. The project also suggested a possibility of identifying the sources and amounts of greenhouse gasses emissions from human activities. The successor "GOSAT-2" improved the accuracy of observation of CO_2 and methane that have been observed by GOSAT and added CO to its observation targets. Carbon dioxide is emitted not only from human activities such as industrial activities and fuel consumption but also from forests and activities of other living things. On the other hand, carbon monoxide is emitted from human activities but not from forests and activities of other living things (excluding natural fires). Its aim is to estimate CO_2 emissions of "human origin" through observation and analysis of CO_2 emissions in combination with carbon monoxide emissions. GOSAT-2 was launched in October 2018. In addition to succeeding the mission of GOSAT, that is, to observe global greenhouse gas concentration, it aims to contribute to transparency increase of emissions reporting based on the Paris Agreement through new functions to identify sources of emissions of human origin and improve accuracy of emissions estimation. Furthermore, in order to continue the mission of water cycle and GHG observation and further enhance its observation capability, since FY2019 the ministry has been promoting development of the Global Observing SATellite for Greenhouse Gasses and Water Cycle (GOSAT-GW[6]) that mounts the successor sensor of GCOM-W (Advanced Microwave Scanning Radiometer 3: AMSR3[7]) and the successor sensor of GOSAT-2 (Total Anthropogenic and Natural

1 Global Change Observation Mission-Climate
2 Global Change Observation Mission-Water
3 Advanced Land Observing Satellite - 2
4 Advanced Land Observing Satellite - 4
5 Greenhouse gases Observing SATellite
6 Global Observing SATellite for Greenhouse gases and Water cycle
7 Advanced Microwave Scanning Radiometer 3

emissions mapping SpectrOmeter-3: TANSO-3)[1].

In addition, to contribute to increased transparency of climate change measures implemented by countries around the world under the Paris Agreement, MOE is promoting verification and overseas deployment of international standardization of emissions estimation technologies, etc., based on observation data of the GOSAT series. MOE, in collaboration with the Government of Mongolia, has been working on advancing these technologies since FY2018 and has succeeded in improving the technologies until the amount of CO_2 emissions estimated from GOSAT observation data roughly matched the volume of emissions calculated by Mongolia from statistical data. Moreover, since FY2021 MOE has been promoting expansion of these technologies to countries other than Mongolia, and in FY2022 it built cooperative relationships with two countries in Central Asia pertaining to the expansion of emissions estimation technologies.

(3) Terrestrial and ocean observations

The marine environment is rapidly changing in recent years: sea temperature is rising, ocean acidification is progressing worldwide and oceans are polluted by plastic wastes, for example. It is necessary to understand the changes in the marine environment for the preservation of oceans and marine resources and their sustainable use, and elucidation of global environmental changes. To this end, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been constructing an integrated ocean observation network by combining observations by drifting floats, moored buoys, vessels and other means.

JAMSTEC and Japan Meteorological Agency (JMA) in cooperation with MEXT and other relevant organizations are participating in an ocean observing system (the Argo program[2]) for a detailed understanding of changes in the ocean interior around the world to improve the accuracy of climate change prediction. The Argo program aims at the real-time monitoring and evaluation of oceans around the world based on Argo floats deployed in these oceans.

MEXT is promoting research and observation in various fields related to the Antarctic and the Arctic, where it is possible to accurately measure global environmental changes. In the "Japanese Antarctic Research Programs," MEXT has commenced the 10th Six-Year Antarctic Research Program (FY2022 to FY2027), under which it is implementing surveys, observations, etc. in the Antarctic, including surveys of the Antarctic ice sheet melting mechanism and material circulation fluctuations, etc.

The Arctic is known as the place where warming is most rapidly progressing due to various mechanisms. On the other hand, the melting of ice in summer presents the possibility of various uses for Japan and other countries. Both for correspondence to global climate change and contribution to sustainable use of the Arctic, it is essential to enhance scientific knowledge that is their basis.

For this reason, the "Arctic Challenge for Sustainability II (ArCS II[3])," which was commenced in FY2020, uses international collaboration bases and the Oceanographic Research Vessel "Mirai," etc. to implement initiatives for the sustainable use of the Arctic through collaboration between the arts and sciences, in order to ascertain the actual state of environmental changes in the Arctic, elucidate the

1 Total Anthropogenic and Natural emissions mapping SpectrOmeter-3
2 The Argo program is an international project in which over 30 countries, including Japan and the United States, and international organizations such as the World Meteorological Organization (WMO) and the UNESCO Intergovernmental Oceanographic Commission (IOC) participate to observe the oceans of the world constantly.
3 Arctic Challenge for Sustainability II

processes behind those changes, quantifiably predict their impact, and consider solutions, etc. Furthermore, under ArCS II, in FY2022 the 20th observations of the Pacific Ocean side of the Arctic Sea were implemented by the Oceanographic Research Vessel "Mirai" and ArCS II contributed internationally by continuously participating in the Synoptic Arctic Survey (SAS).

From FY2021, the ministry has been steadily advancing the construction of the Arctic research vessel into an international research platform capable of observing the sea ice areas for which data has not been sufficient, with the goal of putting the vessels into service in FY2026.

JMA has also been observing greenhouse gasses in the atmosphere in Japan and at the Showa Station in Antarctica in order to contribute to the monitoring of climate change, in particular global warming. In addition, JMA is observing greenhouse gasses in seawater and in the atmosphere near seawater by using an ocean weather observation ship and in the atmosphere at high elevations in the northwest Pacific Ocean by using an aircraft. Furthermore, it is also implementing observations and analyses of aerosols, solar radiation, the ozone layer and ultraviolet light, and is releasing this data, including about greenhouse gases. In addition to the data observed by JMA, it utilizes the data observed by ships, Argo floats, satellites, etc. gathered from around the world to analyze oceanic fluctuations related to the global environment, and compile and release the current situation and future prospects as the "Ocean Health Diagnostic Chart."

(4) Advancement of climate change projection/prediction technologies using super computers, etc.

In the MEXT-Program for the Advanced Studies of Climate Change Projection (SENTAN), MEXT has been promoting R&D towards the creation of scientific information that will be necessary to address climate change by advancing climate change models and increasing the sophistication of climate change projection, utilizing super computers such as the Earth Simulator. The outcomes of the climate change research promoted by MEXT to date are provided as projection information contributing to the climate change countermeasures of Japan. For example, they were summarized in 15 sets of climate change projection data along with its guidebook (MEXT and JMA) published in December 2022, etc. In addition, they are making international contributions. For example, they were cited many times in the Sixth Assessment Report of the "Intergovernmental Panel on Climate Change (IPCC[1])."

In the "MEXT-Program for Data Integration and Analysis System Program (DIAS[2])," which archives and integrates global environmental data for analysis, MEXT has been promoting R&D that contributes to solving global challenges such as climate change and disaster risk reduction utilizing global environmental big data.

The Meteorological Research Institute (MRI) under JMA has developed the MRI Earth System Model for global warming prediction. It can simulate the effects of aerosols on clouds, changes in the ozone layer and the carbon cycle. Using this model, the institute is making near-future climate change predictions (i.e., about 10-year lead time) and long-term predictions based on IPCC emissions scenarios. The institute has also

1 Intergovernmental Panel on Climate Change
2 Data Integration and Analysis System

developed a sophisticated cloud-resolving regional climate model that has sufficient resolution to simulate Japan's unique local climatic phenomena for regional climate warming prediction.

JAMSTEC has been making full use of its supercomputer systems to develop the most advanced predictive models and simulation techniques. These are used to elucidate the possible impacts of global environmental changes on Japan and to help solve climate change problems from the viewpoint of marine science.

❷ Promotion of R&D and demonstration for utilization of various energy sources

The Japan government approved the Strategic Energy Plan based on a cabinet decision in October 2021. It specifies the importance of technological development and innovation, stating that in order to achieve carbon neutrality by 2050, it is necessary to attempt and realize various innovations common to all economic activities in the industry, commercial, residential, transportation, and power sectors, and promote the implementation of new decarbonization technologies in society. Even as we aim to achieve carbon neutrality by 2050, it is important to ensure a stable and cost efficient energy supply on the basic premise of ensuring safety, and to this end, pursue all alternatives, including renewable energy, nuclear power, hydrogen, and CCUS[1].

1. Generation technologies pertaining to solar power generation systems

METI is conducting R&D on component technologies toward the commercial application of innovative technologies such as Perovskite solar cells[2] that are thin and lightweight to overcome restrictions on installation, the development of advanced peripherals, the maintenance technology toward improving the efficiency of the solar power generation system and developing low-cost recycling technology.

Under the JST MIRAI program: "Low Carbon Society" mission area, JST is promoting R&D on technologies pertaining to innovative sunlight utilization within a competitive environment. The targeted technologies are aimed at developments that have a high potential for greenhouse gas reduction and that are not merely extensions of conventional technologies.

2. Generation technologies pertaining to floating offshore wind power plant

METI carried out a demonstration project using multiple windmills off the coast of Fukushima Prefecture to evaluate the safety, reliability and economic efficiency of floating offshore wind power generation systems to expand their introduction and carried out verifications of all aspects of the power generation project from development to removal. Furthermore, it started offering assistance for the development of elemental technologies through the Green Innovation Fund, in order to reduce the cost of floating offshore wind power generation with expansion to the Asian market in mind.

MOE conducted a development and demonstration of Japan's first 2MW floating offshore wind power plant and established related technologies. Based on the technology development and demonstration, the commercial operation of offshore wind power started first in the country in 2016. Its secondary effects include new fishing places around the windmills. The ministry also implemented initiatives aimed at establishment of new methods for low-carbon and high-efficiency construction toward full-scale dissemination of floating offshore wind power

1 Carbon dioxide Capture, Utilization and Storage
2 Solar cell created in Japan using materials with a crystal structure called Perovskite. Because it can be used in simple processes including coating and printing, significant reduction in production costs is expected.

generation. In FY2022, MOE continued its initiatives from the previous year to promote decarbonization businesses by newly organizing information to contribute to the early dissemination of floating offshore wind power generation, conducting various surveys necessary to aim for local production for local consumption of energy from floating offshore wind power generation, and examining the business feasibility and carbon dioxide reduction effects in relevant regions.

Toward cost reduction of floating offshore wind power plants, since FY2018, MLIT has been studying design and safety evaluation methods, etc. aimed at simplification of the floatation structure and installation methods while ensuring safety. In FY2022, the ministry conducted a fact-finding survey and feasibility study on remote inspection and monitoring.

3. Technology development pertaining to geothermal power generation

In order to solve problems of geothermal power generation, which include high risk and cost of resource exploration, operation efficiency and output stability at the power generation stage, METI has been developing technologies to improve exploration accuracy and drilling speed, streamline development and operation and stabilize output. The ministry is also conducting examination of the resources quantity evaluation, etc. concerning the next generation geothermal power generation (supercritical geothermal system) with high generating capacity, which is a highly anticipated development.

4. Technology development for high-efficiency coal-fired thermal power generation and efficient capture and utilization of CO_2

METI has been developing technologies such as Integrated Gasification Fuel-Cell (IGFC [1]) Combined Cycle, a next-generation high-efficiency coal-fired thermal power generation technology, with an eye on decarbonization. The ministry is also developing technologies for efficient capture and utilization of CO_2 (Carbon dioxide Capture and Utilization (CCU)/Carbon Recycling [2]) emitted from thermal power generation.

5. Other technology development

METI has been developing an innovative oil refining technology toward greening of domestic refineries. The technology clarifies the composition of heavy oil at a molecular level and uses an oil refining technology that combines reaction simulation models, etc. to assess the components and reactivity of heavy oil in advance with the aim of reducing inefficient operation of refinery apparatuses through correct combination of operations of secondary devices, thereby contributing to the reduction of CO_2 emissions.

6. R&D related to nuclear power

In 2017, the Cabinet Office's Japan Atomic Energy Commission formulated the "Basic Policy for Nuclear Energy" (the "Basic Policy") which looks at nuclear energy use overall and serves as a compass showing the long-term direction of the government regarding nuclear energy policy going forward from a unique perspective taking into account expert viewpoints and international lessons, etc. The Basic Policy was revised in February 2023 taking into account the environmental changes, etc. surrounding nuclear energy. The Basic Policy presents the principles

1 Integrated Coal Gasification Fuel Cell Combined Cycle
2 Carbon dioxide Capture and Utilization/Carbon Recycling

and basic goals concerning not only nuclear energy use for energy but also a wide range of areas including reflection on and lessons learned from the Tokyo Electric Power Company Holdings, Inc. (TEPCO) Fukushima Daiichi Nuclear Power Station accident, international cooperation, ensuring nuclear non-proliferation and nuclear security, rebuilding public trust, coping with decommissioning and radioactive waste, use of radiation and radioisotopes, R&D, and human resource development. After the "Basic Policy" was revised by the Japan Atomic Energy Commission, the Cabinet made the decision to respect it.

(1) Technologies to improve safety and nuclear security pertaining to nuclear power utilization

METI has been developing technologies and infrastructure under the Technological Development Program Contributing to Improvement of Nuclear Safety to enhance safety measures including sophistication of comprehensive risk assessment of nuclear power plants. This is based on what has been learned since the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. Japan has been working with the International Atomic Energy Agency (IAEA[1]), the U.S. and other countries in a leadership role towards advancing international cooperation related to R&D on technologies for nuclear nonproliferation and nuclear security, as well as on those related to human resources development. Japan Atomic Energy Agency (JAEA) established the Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN). This center has provided training courses in nuclear nonproliferation and nuclear security. ISCN has been contributing to development training materials and exchanging lecturers and information regarding human resources development based on practical arrangement with the IAEA regarding the development of human resources for nuclear security. Efforts have also been made to develop technology for the following: 1) non-destructive assay of nuclear materials using the active neutron technique, and 2) nuclear forensics to identify the origin and history of nuclear and other radioactive materials out of regulatory control. ISCN has also been contributing to strengthening detection capability for nuclear tests through the observation at Horonobe town and Mutsu city based on the noble gas joint measurement project with the CTBTO[2].

(2) Basic and fundamental R&D for nuclear science

In the Nuclear R&D, Infrastructure and human resource Working Group, MEXT comprehensively studied the following subjects: (1) development of new technologies that drastically improve safety, reliability and efficiency of use of nuclear energy, and (2) R&D and infrastructure/human resource development toward strengthening of human resources, technologies and industrial infrastructure beyond the boundaries of industry, academia and government. Based on the study result, with the aim of acquiring new knowledge to create nuclear innovations and find solutions regarding challenges, under the "Nuclear System R&D Project," in cooperation with the METI, MEXT has been promoting strategic basic/fundamental research that will support the nation's nuclear technology by setting strategic themes to be tackled toward future social implementation. JAEA is conducting basic and fundamental research in such fields as nuclear engineering, reactor

1 International Atomic Energy Agency
2 The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization

engineering, fuel and material engineering, nuclear chemistry, environment and radiation science, partitioning and transmutation, computational science, advanced nuclear science and use of neutrons and radiated light.

Furthermore, the utilization of radioisotopes (radioactive isotopes: RIs) is proceeding in the medical care sector and the industry and agriculture sectors, etc. In particular regarding the medical care sector, in light of the fact that it is important to enhance Japan's medical care system and thereby contribute to enhancing the welfare of the citizens through the dissemination of diagnoses and treatments using RIs, there is a need to realize domestic production of the important radio isotopes, most of which currently depend on imports. For this reason, the Japan Atomic Energy Commission formulated the "Action Plan for Promotion of Production and Utilization of Medical Radioisotopes" in May 2022 to promote sequentially and in an integrated manner initiatives for R&D using a research and test reactor and accelerator, practical application, and dissemination.

(3) Development of revolutionary nuclear technologies

Because nuclear energy is a practical option for carbon-free society, it is important to promote innovation of nuclear technologies that meets diverse demands of society in addition to safety improvement. Under the "program to support innovative nuclear technology development that responds to demand of society" In FY2019 METI started to support development of nuclear technologies with excellent safety, economy and mobility possessed by private companies and others.

In addition, the JAEA made preparations for the resumption of operation of the experimental fast reactor Joyo and strived to maintain and develop the R&D infrastructure required to develop advanced nuclear technologies. Moreover, R&D on high-temperature gas-cooled reactors which have the possibility of a wide-range of industrial application including power generation and hydrogen production and inherent safety has been promoted in terms of the contribution to the enhancement of safety and to the diversification of nuclear use.

In addition, the Basic Policy for the Realization of GX (February 2023 Cabinet decision) stipulates that Japan will tackle the development and construction of next-generation advanced reactors with new built-in safety mechanisms in order to utilize nuclear energy based on the Strategic Energy Plan, and that the necessary initiatives will be promoted in the related ministries and agencies.

(4) Securing and developing human resources in the nuclear field

There is the need to foster and secure a wide range of skilled human resources, in order to support the nuclear technology, ensure greater safety, and secure the safety of nuclear facilities and the smooth decommissioning of reactors in older nuclear power plants.

MEXT is supporting development of human resources in an effective, efficient and strategic manner, in collaboration with the relevant sectors of industry, academia and government, based on the Global Nuclear-HRD Initiative (GN-HRD). The Advanced Nuclear Education Consortium for the Future Society (ANEC[1]) was established in FY2021 as an integrated system for human resource development in collaboration with multiple institutions, such as universities and research institutions, whereas in the past, each institution was supported individually. When the meeting of

1 Advanced Nuclear Education Consortium for the Future Society

relevant cabinet ministers on nuclear power held in December 2016 decided the government's policy to transition to the decommissioning of the fast-breeder-reactor Monju, it was also decided to install a new research and test reactor on the site of Monju in the future. In FY2017 the government studied the reactor type to be installed at a deliberation council, etc., and as a result the government narrowed it down to a research and test reactor for which the principal purpose is to use neutron beam, started examination of its conceptual design and appropriate method of operation from 2020 and transitioned to the detailed design stage in March 2022. Next it will steadily advance the initiatives necessary for installation of the new research and test reactor.

METI also has been supporting human resource development using funds provided by the Expenses for Commissioning Human Resource Development toward Improving Nuclear Safety, in order to educate field engineers involved in nuclear facility maintenance and in the nuclear safety industry. This undertaking is expected to contribute to the decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station and to the safety control of other existing nuclear power stations.

(5) Research and development of technologies, etc. for decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, Inc.

Toward the decommissioning of the Fukushima Daiichi Nuclear Power Station, METI, MEXT and other relevant ministries and agencies have been taking measures in coordination and cooperation based on the Medium-to-Long-Term Roadmap for the Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. (revised on December 27, 2019). In these measures, these ministries have been supporting R&D conducted by business operators on technologies that are technically difficult and that need the government to spearhead work on them. Such R&D includes a technology for extracting fuel debris and a technology for examining the inside of reactor containment vessels.

In order to bring together wisdom from inside and outside Japan to implement the decommissioning, etc. safely and steadily, MEXT is promoting initiatives for R&D and human resources development meeting the medium- to long-term needs of the reactor decommissioning site with the "JAEA Nuclear Energy S&T and Human Resource Development Project through Concentrating Wisdom" and the "JAEA Collaborative Laboratories for Advanced Decommissioning Science (CLADS)" (Tomioka, Futaba District, Fukushima Prefecture) at their core.

Development of facilities to establish the technical basis for decommissioning is also advancing. JAEA started full-scale operation of the Naraha Remote Technology Development Center (Naraha town, Futaba-gun, Fukushima), a facility for development and demonstration of remote operation equipment/devices (mock-up facility), in April 2016. In addition, with the aim of developing analysis methods, proper understanding and treatment/disposal of fuel debris and radioactive waste, Okuma Analysis and Research Center (Okuma town, Futaba gun, Fukushima) started operation of some facilities in March 2018. Furthermore, the 1st building and the 2nd building are under development toward establishment of an analysis implementation system using the center.

(6) Nuclear fuel cycle technology

The Strategic Energy Plan (Cabinet Decision on October 2021) states "In order to resolve the issues related to reprocessing and disposal of spent fuels and mitigate the risks for and the burden on future generations, the government will make efforts

towards a nuclear fuel cycle that contributes to the reduction of the volume and harmfulness of high-level radioactive waste and effective utilization of resources while adequately taking the past history into consideration and continuing to gain the understanding of relevant municipalities and the international community, and will promote reprocessing and plutonium use[1] in LWRs." The "Strategic Roadmap" pertaining to the development of fast reactors was revised in order to put into practice the development processes and systems (December 23, 2022 decision of the meeting of relevant cabinet ministers on nuclear power).

(7) Technology development toward radioactive waste disposal

The government is advancing basic/fundamental research of nuclear transmutation and group separation technologies using fast reactors or accelerators, which can contribute to the reduction of volume and hazardousness of high-level radioactive waste.

For disposal of low-level radioactive waste from research facilities and medical institutions, JAEA has been advancing necessary initiatives according to the "Plan on implementation of burial disposal" (approved in November 2009; changes to the plan were approved in November 2019)" that was formulated by JAEA in line with the "Basic policy for implementation of burial disposal" (decision by the Ministers of MEXT and METI in December 2008), and based on "Approach to the Treatment and Disposal of Low-Level Radioactive Waste (Opinion)" (December 2021, Japan Atomic Energy Commission).

(8) Decommissioning of facilities owned by JAEA

JAEA bears an important role as a comprehensive nuclear R&D organization. In order to fulfill this role, it is important for JAEA to steadily proceed with decommissioning of the facilities that will no longer be used for research while at the same time ensuring public understanding and giving the highest priority to safety. JAEA published the "Backend Roadmap" that is a long-term policy for decommissioning of the entire facilities of JAEA in December 2018. MEXT supports JAEA's efforts and encourages safe and steady decommissioning of the nuclear facilities owned by JAEA.

Regarding the fast-breeder-reactor Monju, decommissioning is being undertaken for approximately 30 years from 2018 based on the decommissioning plan. In the first phase of the decommissioning plan, the work of taking the fuel assemblies out of the reactor vessel and into the fuel pool was completed by October 2022. The decommissioning plan modification approval application received approval in February 2023, and in the second phase from FY2023 it was decided to start the dismantling work, etc. for power generation equipment such as water and steam systems, etc. Future decommissioning of Monju will be safely, steadily and systematically carried out while listening to opinions from the local area.

Concerning the prototype advanced thermal reactor Fugen, dismantling and removal of peripheral equipment of the reactor is underway based on the decommissioning plan, and a contract, etc. with a French company was implemented for completion of the transportation of spent fuel by the summer of 2026. Furthermore, in preparation for the dismantling and removal of the reactor core going forward, construction methods were reviewed, etc. using new technology development in order to further enhance the safety during the dismantling.

1 Plutonium separated from spent fuel by reprocessing is mixed with uranium, processed into mixed-oxide fuel and used

The top priority issue for the Tokai Reprocessing Plant is early risk reduction for the highly radioactive liquid waste held in the plant based on the decommissioning plan. Efforts are being taken for the vitrification of the highly radioactive liquid waste and securing the safety of the liquid waste storage site, while measures for the aging facility and improvement of safety are steadily progressing.

(9) Efforts for understanding and co-existence with the public

MEXT has been supporting projects to deepen the understanding of the facilities among people nationwide and in regions where those facilities are located, towards the sustainable development of the region and education on nuclear power and other energy sources.

(10) International nuclear cooperation

MOFA has been supporting the promotion of the peaceful use of nuclear science and technologies by the IAEA and member states' efforts to achieve the Sustainable Development Goals (SDGs[1]). Through technical cooperation based on the Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA[2])" in the Asia-Pacific region, financial support to the IAEA with contribution to the Peaceful Uses Initiative (PUI[3]) and strengthening of cooperation between the IAEA and Japanese universities, research institutions and companies with expert knowledge and technologies, the Ministry has been promoting capacity building in developing countries and supporting international deployment of Japan's excellent human resources and technologies. The IAEA, in cooperation with Japan, designated an IAEA Response and Assistance Network Capacity Building Centre (IAEA-RANET-CBC) in Fukushima Prefecture in 2013, and has been providing training for persons involved in Japan and abroad to enhance their ability to prepare for and respond to emergencies. Its activities for strengthening international nuclear security include an international symposium on transport security of nuclear and other radioactive materials held in collaboration with ISCN of JAEA in Tokyo in November 2019.

MEXT has been leading the way in peaceful use of peaceful of nuclear energy and nuclear non-proliferation by contributing to projects implemented by the IAEA and the Nuclear Energy Agency under the Organization for Economic Co-operation and Development (OECD/NEA[4]). Also, MEXT contributes to the Forum for Nuclear Cooperation in Asia (FNCA[5]), which is led by the Cabinet Office, and MEXT has been supporting FNCA member countries, Asian countries in particular, in their R&D and infrastructure development in the areas of, for example, radiation utilization and nuclear research reactors utilization.

METI has advanced R&D for the establishment of verification technology for fast reactors, which are expected to contribute to reductions in toxicity and in the volume of radioactive waste, by means of Japan-French cooperation, Japan-US cooperation and other international cooperation frameworks.

METI is also involved in wide-ranging cooperation in nuclear energy system R&D, etc. with the United States, France and other countries advanced in nuclear science through activities of the Generation IV International Forum (GIF[6]).

1 Sustainable Development Goals
2 Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology
3 Peaceful Uses Initiative
4 OECD Nuclear Energy Agency
5 Forum for Nuclear Cooperation in Asia
6 Generation IV International Forum

(11) Efforts pertaining to the peaceful use of nuclear energy

Japan concluded IAEA in 1977 and signed the Additional Protocol in 1999. Pursuant to the agreement and the protocol, Japan has been complying with IAEA safeguards whereby IAEA verifies that nuclear materials are used only for peaceful purposes and are not diverted or misused for nuclear weapons assembly. Thus, pursuant to the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No. 166 of 1957) (Nuclear Reactor Regulation Law), Japan has been implementing a system of accounting for and controlling nuclear material, providing reports to IAEA, and accepting IAEA inspections.

On May 18, 2022 the government reported the result of safeguard implementation activities in Japan during 2021 to the Nuclear Regulation Authority. The result is provided to IAEA as information for its evaluation of our safeguards implementation activities. The IAEA's safeguards implementation report derived the conclusion that all nuclear materials in Japan remained in peaceful activities in 2021 as well. Broader Conclusion has been reached since the implementation result in 2003.

7. Research and development of fusion energy technologies

Some key features of fusion energy include ample fuel resources, no greenhouse gas emissions during the power generation process, and the capability of large-scale power generation from a small amount of fuel. Therefore, it is expected to be an important source of clean energy in the future that will fundamentally solve energy and environmental issues and also contribute to ensuring energy security. Coupled with the technological advancements of the ITER Project[1] (discussed below), policy interest in this area has been growing in other countries in recent years.

Construction of ITER (International Thermonuclear Experimental Reactor) in October 2021
(Cadarache in Saint-Paul-Lès-Durance, France)
Source: ITER Organization

Japan is promoting the ITER Project to demonstrate the scientific and technological feasibility of fusion energy through the construction and operation of an experimental reactor, taking place with the cooperation of 35 countries in 7 regions around the world and based on international agreements. Construction of ITER is in full swing in France, the construction location, and superconducting toroidal magnetic field coils and other important equipment are arriving there one after another. Regarding superconducting toroidal magnetic field coils, the final unit, which Japan was in charge of producing, has been completed (except for the spare equipment) and the completion ceremony was held in February 2023. Design activities for the blanket, a device that is indispensable for fusion power generation and is used to extract energy as heat from the fusion reactor, are currently underway for carrying out tests in ITER. A ceremony was held in October 2022 to commence operation of the testing apparatus developed in the National Institutes for Quantum Science and Technology Blanket Engineering Test Building (Rokkasho Village, Aomori Prefecture). In addition, Japan is

1 An international joint project to demonstrate the scientific and technological feasibility of fusion energy through the construction and operation of an experimental fusion reactor, based on an international agreement between 35 nations in 7 regions including Japan, Europe and the United States

promoting Broader Approach (BA [1]) activities through Japan-Europe cooperation, which are advanced R&D activities to establish the technological infrastructure required for the DEMO reactor, complementing and supporting the ITER Project. R&D of the BA activities which include the move of JT-60SA[2] to the adjustment phase toward experimental operation, are also progressing smoothly in FY2022[3].

For the realization of fusion energy, Japan has been promoting the ITER Project and BA activities based on the Roadmap toward Fusion DEMO Reactor (first report), etc. formulated in July 2018 by the Science and Technology Committee on Fusion Energy of the Council for Science and Technology, as well as various academic research including helical devices (The National Institute for Fusion Science) and lasers (Institute of Laser Engineering, Osaka University), which have achieved world-leading results. In FY2022, studies were carried out regarding the timing of implementation of fusion power generation, etc. As a result, it was decided to continue carrying out studies regarding the timing of implementation while taking into account the results of the Second Intermediate Check and Review planned for 2025 onward[4].

Furthermore, the Cabinet Office formulated the "Fusion Energy Innovation Strategy" in April 2023 in order to accelerate energy innovation through industrialization[5].

8. Development of other long-term energy technologies

METI has been developing a panel that integrates electric power production and supply, which is necessary for space photovoltaic power generation, while at the same time conducting technology development for its weight reduction and efficiency improvement of the power transmitting unit in order to contribute to efficiency improvement of wireless power transmission using microwaves.

JAXA has been conducting R&D of elemental technologies toward practical use of space-based solar power.

❸ Promoting economic and social redesign

1. Initiatives for transitioning to a "decarbonized society"

MOE is supporting the improvement of energy-saving performance, such as the renovation of residences and buildings with higher thermal insulation, as well as the construction of net-zero

1 Broader Approach
2 The critical plasma testing apparatus JT-60 was shut down in August 2008, dismantled for repair, and reassembled in March 2020. Currently undergoing adjustments to commence operation
3 Fusion Energy - Connect to the Future
https://www.mext.go.jp/a_menu/shinkou/fusion/
4 The way to fusion energy - ITER
https://www.youtube.com/watch?v=QEohCE1famE (Source: ITER japan – QST)
5 Nuclear Fusion Strategy by the Cabinet Office (cao.go.jp)
https://www8.cao.go.jp/cstp/fusion/index.html

energy structures (ZEH[1]/ZEB[2]) and is promoting energy management of solar power generation and demand-side equipment such as home appliances through the introduction of HEMS[3] and BEMS[4], combined with the use of EVs[5] and PHEVs[6] through the introduction of charging and discharging equipment. In addition, the ministry is promoting "zero-carbon drives" by supporting local authorities and businesses that simultaneously introduce renewable energy equipment and EVs/PHEVs and offer them as a car-sharing service.

MOE formulated published the Assessment Report on Climate Change Impacts in Japan in December 2020, based on the provisions of the Climate Change Adaptation Act, and the government revised the Climate Change Adaptation Plan in October 2021 based on that report. Furthermore, the Ministry of the Environment confirmed the progress of the measures based on the Climate Change Adaptation Plan and the actual figures for the KPIs, and published those results in November 2022. Based on the Climate Change Adaptation Act and the Climate Change Adaptation Plan, the Center for Climate Change Adaptation at the NIES has been providing the latest information on adaptation in cooperation with relevant ministries and agencies as well as research institutions through the Climate Change Adaptation Information Platform (A-PLAT[7]) and supporting studies on the impact of and adaptation to climate change and adaptation efforts by local governments and other bodies in scientific aspects. To allow stakeholders in various regions to cooperate in promoting adaptation measures, the Regional Councils on Climate Change Adaptation based on the Climate Change Adaptation Act were set up in seven regional blocks across the country.

MEXT has built a network of universities and other institutions to accelerate the region's decarbonization and deploy this regional model to the world. Through A-PLAT of the Center for Climate Change Adaptation at the NIES, R&D results such as climate change projection information is being provided to local governments and other bodies based on their needs.

2. Research and development for global warming countermeasures

(1) Stable energy use using energy storage technologies including hydrogen/storage batteries

METI is conducting the technological development and demonstration of batteries and fuel cells. Specifically, to date the ministry has been promoting efforts for implementation of technological development for optimal control and management methods when introducing large batteries for power systems, which will become necessary with the expansion of renewable energy introduction. There are business operators who utilize the knowledge, etc. gained in these initiatives to enter into actual businesses, and the ministry provides assistance for their introduction in preparation for dissemination and expansion. Technological development was conducted also for the performance enhancement and cost reduction of lithium-ion and post lithium-ion batteries for next-generation vehicles[8], such as plug-in hybrids or fully electric cars. The main applications for fuel

1 net Zero Energy House
2 net Zero Energy Building
3 Home Energy Management Service
4 Building and Energy Management System
5 Electric Vehicle
6 Plug-in Hybrid Electric Vehicle
7 Climate Change Adaptation Information Platform
8 Innovative storage batteries with higher energy density than solid-state and lithium-ion batteries

cells are in fuel cell vehicles (FCVs[1]) and for stationary uses such as household use, etc. We have carried out technology development to enhance their durability and efficiency and reduce their cost, and we have carried out demonstrations aimed at expanding to new applications. Toward further spread of fuel-cell vehicles, the ministry has installed about 164 hydrogen stations as of the end of February 2023 (with 15 more stations being installed), mainly in four major cities.

With a view to a future society that will use a huge amount of renewable energy, MOE has been promoting initiatives under the "Construction of autonomous distributed energy system using hydrogen from renewable energy project," which aims to establish methods to introduce and use an autonomous hydrogen energy supply system by constructing a system that can supply renewable energy as power and heat without depending on a power system, but instead by using storage batteries and hydrogen based on regional conditions. In addition, the ministry is implementing the "Hydrogen Energy Supply Chain Demonstration Project," which aims to build hydrogen energy systems using local resources and utilize them locally and is moving forward to accommodate regional characteristics and diverse technologies.

MEXT is promoting R&D related to the next-generation storage battery with greatly higher performance compared with conventional ones in a technology area of special focus of the "Strategic Basic Research Programs - Advanced Low Carbon Technology Research and Development (ALCA)" of JST. Furthermore, the ministry is conducting R&D with industry-academia collaboration at the advanced storage battery R&D centers of The Program on "Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT)." The "JST-MIRAI program – Large-scale Type" is promoting R&D of a high-efficiency, low-cost, compact and long-life innovative hydrogen liquefaction technology that will contribute to expansion of hydrogen utilization, including hydrogen power generation, storage of surplus power and transportation means. Also, the JST MIRAI program: "Low Carbon Society" mission area promotes R&D of water electrolysis technology that enables sustainable hydrogen production from renewable energy.

(2) Improvement of energy utilization efficiency and consumption reduction using new technologies

The Cabinet Office through SIP has been working on the "Energy system of IoE society" since FY2018 toward realization of an IoE[2] society where various energy sources are connected to a network enabling supply and demand management of energy. In this SIP, studies were conducted to design a conceptual model and platform for an integrated energy management system for transportation and electric power infrastructure through sector coupling, aiming for the mass introduction of renewable energy. The project developed guidelines for local governments to design regional energy systems and established an energy supply and demand database by municipality. The project promoted R&D toward social implementation of the universal power module and wireless power transmission systems, which will enable optimum control of diverse input power sources including renewable energy by using gallium semiconductor devices.

METI has been conducting a demonstration of a virtual power plant that remotely integrates and controls consumer-side energy resources spread

1 Fuel Cell Vehicle
2 Internet of Energy

across the power grid including energy facilities such as renewable energy power facilities and storage batteries, and demand response, to make them function as one power plant and use them for adjustment of supply and demand.

In order to ensure advancement and social implementation of innovative technologies and promote necessary technology innovations toward prevention of global warming, MOE promoted not only the use of renewable energy and rational energy use, but also development, demonstration and dissemination of technologies leading to drastic reduction of energy consumption through use of innovative and highly CO_2 emission reducing members /materials such as gallium nitride (GaN) and cellulose nanofiber (CNF), fuel cells, hydrogen energy, storage battery, CCUS[1], for example.

MOE has been implementing projects to establish an advanced model for implementation of CO_2 emissions reduction measures with the overall highest cost performance in the various regions by introducing decentralized and self-reliant energy systems that use renewable energy and independent cables in public and other facilities, and by optimizing energy supply and demand to increase the ratio of renewable energy in the regions.

Under the "JST MIRAI Program – Large-scale Project" JST is promoting R&D on an innovative thermoelectric conversion technology that enables use of heat sources in the environment (e.g., waste heat, body heat) as independent power source for sensors.

RIKEN has been conducting R&D in the fields of condensed matter physics, supramolecular chemistry and quantum information electronics to pioneer new materials and new principles, creating entirely new materials science that enables innovation in energy utilization technologies, including electric power generation, transmission and storage, and to realize radical lower power consumption and significant improvement of energy conversion efficiency.

The Aviation Science and Technology Committee of MEXT outlined a vision for R&D on decarbonization technologies, including an electric hybrid propulsion system and fuel cell engine system that can be applied to hydrogen-powered aircraft, and is promoting the implementation of R&D plans reflecting this vision.

JAXA has been conducting R&D on reducing fuel consumption and the environmental load in the aviation field, such as low NOx and highly efficient aeroengine and aircraft electrification. With an eye on the social implementation of the research results in collaboration with the industry, JAXA is accelerating initiatives to strengthen international competitiveness.

NEDO has been implementing the "Program to Develop and Promote the Commercialization of Energy Conservation Technologies to Realize a Decarbonized Society" through open public invitations for proposals. The program focuses on key technologies listed in the Strategy for Energy Efficiency Technologies 2016 (revised in July 2019), for effective promotion of R&D and the spread of energy-efficient technologies.

The Building Research Institute has been conducting R&D for environmentally-sound and efficient use of resources/ energy in housing, construction and urban planning fields.

(3) Application of innovative materials, devices, etc. to a broad range of areas

In the "MEXT program Innovative Power Electronics Technologies (INNOPEL)," MEXT is promoting integrated R&D as a total system of circuit systems and passive circuit elements, etc. for R&D into next-generation power semiconductors

1 Carbon dioxide Capture, Utilization and Storage

using gallium nitride (GaN), etc., a sector in which Japan possesses strength, and the practical application of power electronic devices, etc. maximally utilizing the properties of the semiconductors. In addition, in the "Initiative to Establish Next-generation Novel Integrated Circuits Centers (X-NICS)," MEXT has promoted the formation of a core center in academia in order to promote R&D from a new perspective and the development of human resources to drive the future semiconductor industry toward the creation of the semiconductor integrated circuits that the society will require around 2035-2040.

Under the JST MIRAI program: "Low Carbon Society" mission area, JST is promoting R&D on innovative materials development/application and chemical processes.

NIMS has been promoting R&D for stable energy supply and efficient energy use. The R&D includes: high-efficiency batteries and solar cells for construction of network systems that promote use of diverse energy sources; energy conversion/storage materials for effective use of energy; R&D toward the breakthrough of high-output semiconductors for energy efficiency, high-luminance light materials, etc.; high-efficiency/performance transportation equipment materials and energy infrastructure materials contributing to a low environmental burden society.

METI has been developing technologies for: producing plastic materials and other major chemical products from carbon dioxide and water by using solar energy (artificial photosynthesis project); highly efficient production of organosilicon materials without using metallic silicon; replacement of the batch synthesis method of functional chemicals with the flow synthesis method, and accurate and speedy evaluation of performance and characteristics of all-solid-state lithium-ion cell materials. The ministry is also developing basic information necessary for development and safety assessment of compounding/processing technologies for cellulose nanofiber production according to the purpose of use, which promises cost reduction in the production process, optimization of the manufacturing process and a mass production effect.

(4) Basic research and development for accelerating regional decarbonization

MEXT has been promoting cross-sector R&D for tools to further advance regional carbon neutrality through collaboration between universities and local communities, utilizing a wide range of knowledge from the humanities and social sciences to the natural sciences with "MEXT-Program for Research and Development for Accelerating Local Climate Actions in Partnership of Universities" to achieve carbon neutrality. In addition, through the "University Coalition for Carbon Neutrality," MEXT is facilitating information sharing and project creation among universities and other research institutions.

3. Initiatives for transitioning to a "circular economy"

In April 2022, the "Act on Promotion of Resource Circulation for Plastics" (Act No. 60 of 2021) was enacted to accelerate plastic resource circulation for transitioning to a circular economy.

As a measure to promote plastic resource circulation, METI has been promoting R&D on the practical application of technologies to increase the resource efficiency and resource value of plastics and is also promoting R&D to develop new technologies and materials to meet future applications and demand and to propose international standardization of marine-degradable plastics through its "Advanced Plastics Utilization Project" for the development, introduction and spread of marine biodegradable plastics. Furthermore, based on the "Act on

Promotion of Resource Circulation for Plastics," METI is assisting capital investment, etc. for technologies which contribute to advanced resource circulation of plastics throughout their entire life cycle.

MOE is carrying out technological demonstrations on material substitution from fossil-based plastics to renewable resources such as biomass and recycling of composite plastics that are difficult to recycle.

The ministry also releases "Guidelines for the Introduction of Bioplastic Garbage Bags in Local Governments" to promote the conversion of plastics, such as designated collection bags for combustible garbage, which must be incinerated due to their primary use, to biomass.

Moreover, taking into account the Osaka Blue Ocean Vision proposed by Japan at the G20 Osaka Summit, and based on the resolution in the fifth session of the United Nations Environment Assembly, MOE has been actively working on measures against marine plastic litter in Japan and abroad by participating in the Intergovernmental Negotiating Committee for the formulation of an international legally binding instrument (treaty) on plastic pollution, providing assistance to developing countries mainly in Southeast Asia, intensifying the accumulation of scientific knowledge that forms the basis of marine plastic litter countermeasures, and considering measures to reduce the leakage of plastics into the environment.

4. Biodiversity that constitutes a "decentralized society"

Concerning biodiversity that constitutes a "decentralized society," MOE is promoting R&D of technologies related to the protection of endangered species and the control of invasive alien species, technologies for monitoring, maintaining and restoring ecosystems including secondary nature, technologies for evaluating the economic and social value of ecosystem services and natural capital including genetic resources, as well as the sustainable management and use of them. The ministry is also taking initiatives to realize "living in harmony with nature."

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES[1]) has been producing assessment reports with the aim of strengthening the coordination of science and policies regarding biodiversity and ecosystem services. In February 2019, the IPBES Technical Support Unit for the Assessment of Invasive Alien Species was established at the Institute for Global Environmental Strategies (IGES). In addition, in order to effectively reflect Japan's knowledge in the reports of the ongoing assessments, MOEJ organized the domestic liaison meetings in July 2022 and March 2023 bringing together Japanese experts involved in IPBES and relevant ministries and agencies. Moreover, MOEJ organized a symposium titled "Reexamining the Value of Nature and Our Values for a Sustainable Future" in February 2023 based on the IPBES Values Assessment Report published in 2022.

Japan provided biodiversity data to the Global Biodiversity Information Facility (GBIF[2]), which aims to collect data on biodiversity so that the data can be made available worldwide, in cooperation with the National Institute of Genetics, the NIES, and the National Museum of Nature and Science, which are all GBIF nodes (data providing centers). Data accumulated by GBIF are expected to serve as fundamental for evaluation at IPBES.

The National Institute of Technology and Evaluation (NITE) has collected, preserved and distributed biological resources and has also

1 Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services
2 Global Biodiversity Information Facility

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. NITE has also joined the network composed of 29 organizations from 14 countries and regions, which aims for the preservation and the sustainable use of microbial resources and has actively supported Asian countries in their efforts to use biological resources by constructing cooperative relationships with them according to the Convention on Biological Diversity (CBD). Furthermore, NITE has constructed and launched the Data and Biological Resource Platform (DBRP[1]) as a comprehensive database of information related to microorganisms, providing one-stop access to bioresources and related information.

Marine ecosystems, which are closely linked to human society in terms of food production and climate control, have been exposed to environmental stresses such as pollution, global warming and overfishing in recent years, and understanding, conserving, and utilizing marine ecosystems in light of these stresses has become an important subject. For this reason, MEXT has been carrying out R&D to understand these complex and diverse marine ecosystems and to develop conservation and utilization technologies for them by discovering new knowledge from big data based on existing data or data acquisition technologies under "Advancement of Technologies for Utilizing Big Data of Marine Life" of the Technology Development to Promote Utilization of Marine Resources Program.

❹ Encouraging changes of changes in public behavior

MOE is constructing and demonstrating behavior change models that encourage voluntary decarbonization actions in various daily life scenarios by combining behavioral insights such as nudges and advanced technologies such as AI/IoT (biotech). In FY2022, it implemented preliminary demonstrations for the sequential implementation from FY2023 of large-scale demonstrations to clarify the heterogeneity (regional differences and individual differences) and sustainability (maintaining behavior over multiple years and making it a habit) of the effect of nudges, etc.

The results are compiled and presented through keynote speeches and panel discussions at domestic and international conferences with nudge units from other countries. The ministry is sharing information and collaborating with a wide range of stakeholders, including the general public.

In FY2010, MOE started a large-scale, long-term birth cohort study, the Japan Environment and Children's Study (JECS[2]), by enrolling 100,000 pairs of parents/children across the country. In this study, biological samples such as cord blood, blood, urine, breast milk, and baby teeth have been collected and preserved for analyses. Also, follow-up surveys such as questionnaires have been conducted.

As of the end of December 2022, 325 scientific articles have been published, with research continuing on the influence of environmental factors, such as exposure to chemicals and the living environment, on abnormalities during pregnancy and delivery, as well as on children's health during their growth after birth. In addition, data from JECS have been used for the risk

1 Data and Biological Resource Platform
2 Japan Environment and Children's Study (JECS)
https://www.env.go.jp/chemi/ceh/en/index.html

assessment by the Cabinet Office, Food Safety Committee, as well as for the development of gestational weight gain growth charts for pregnant women and a developmental screening tool for children, etc.

Efforts are being made to disseminate the research findings to the public and to educate people to reduce health risks by holding symposiums and dialogue with stakeholders to promote behavioral changes among people.

3 Building a Resilient, Safe and Secure Society

The government of Japan aims to build a society that is resilient to natural disasters, which are becoming more frequent and severe. At the same time, the government will ensure the safety and security of people's lives, the economy and society from attacks in new areas such as cyberspace or new biological threats, promote R&D of advanced technologies, and implement appropriate measures against technology leaks.

❶ Responding to increasing frequency and severity of natural disasters

1. Improvement of prevention capabilities

As preparation for a large-scale earthquake disaster caused by an earthquake directly under Tokyo, a Nankai Trough earthquake, etc. which could occur in the future, National Research Institute for Earth Science and Disaster Resilience (NIED) is utilizing the 3-D Full-Scale Earthquake Testing Facility (E-Defense) to implement R&D concerning damage suppression and damage level evaluation technologies, including for non-structural members in addition to the structural frame, and development of information gathering technologies and determination technologies concerning the determination of the safety and continued use of the facilities.

MLIT has been developing and operating the Nationwide Ocean Wave Information Network for Ports and Harbors (NOWPHAS [1]) in mutual cooperation with MPAT and other research institutions. Data on waves and tidal levels observed across Japan are collected through this network, and details are published on MLIT's website in real time[2].

The Public Works Research Institute is implementing development of technologies to promote River Basin Disaster Resilience and Sustainability by All in response to intensifying water disasters, development of risk reduction technologies for emerging landslide disasters, and development of disaster prevention and disaster mitigation technologies to respond to increasingly extreme snow and ice disasters.

The Building Research Institute is conducting technology development to ensure the structural safety of buildings, thus contributing to prevention of damage/collapse due to natural disasters and ensuring continued use of buildings.

Towards early recovery and reconstruction after a major earthquake, MPAT is conducting research on forecasting earthquake- and tsunami-induced deformation and performance degradation for structures in coastal areas and the areas behind them, for the improvement of safety and reliability for facilities in coastal areas.

In order to accelerate research elucidating the mechanisms behind the occurrence of stationary linear mesoscale convective systems, etc., the Meteorological Research Institute (MRI) launched research to elucidate the mechanism of stationary

1 Nationwide Ocean Wave information network for Ports and HArbourS
2 http://www.mlit.go.jp/kowan/nowphas/

linear mesoscale convective systems in February 2022 and then collaborated with 14 institutions including universities, etc. from June to October 2022 to implement high-density intensive observations. Furthermore, MRI is addressing the development of real-time observation and monitoring technology for the detection of unusual meteorological phenomena, such as intense localized downpours, by means of dual polarization radar, phased array radar and global positioning system (GPS). MRI is also advancing the development of a numerical prediction model with high enough resolution to display intense localized downpours, in order to improve the accuracy of weather information and thereby to help reduce damage from local meteorological phenomena.

2. Improvement of predictive capability

Under the Headquarters for Earthquake Research Promotion (Director: the Minister of MEXT; Hereinafter: HERP), administrative agencies and universities are working in close cooperation on seismological investigations and research.

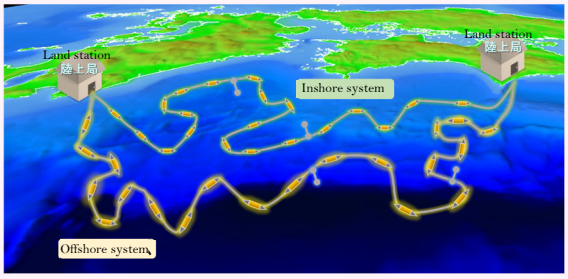
The HERP has been making long-term evaluations of the probabilities and magnitudes of earthquakes. The evaluation methods, as well as their publication methods, have been reviewed and revised, taking into account the 2011 off the Pacific coast of Tohoku Earthquake, which ruptured large area beyond the expected regions, and the Kumamoto Earthquake occurred on active faults. Moreover, the HERP is promoting evaluation of tsunamis caused by various earthquakes, considering the serious tsunami damage caused by the 2011 off the Pacific coast of Tohoku Earthquake.

MEXT launched the "Research Project for Disaster Prevention on the great Earthquakes along the Nankai Trough" which includes research and development on scientific evaluation of seismic activities when "Anomalous Phenomena" along the Nankai Trough are observed, and conducting surveys and research on appropriate disaster management for the areas where damage is anticipated.

After the Great Hanshin-Awaji Earthquake, comprehensive earthquake observation networks were built in land areas. Although several sea-area observation networks have been built, there are far fewer observation points in these networks than in land-based observation networks. Accordingly, National Research Institute for Earth Science and Disaster Resilience (NIED) is operating the Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET[1]) that is a dense submarine network equipped with seismometers and hydraulic gauges for real-time seismic observation in the seismic source region of the anticipated Nankai Earthquake. Furthermore, off the Pacific Coast of Tohoku where large aftershocks and tsunamis are likely to occur, the Seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net[2]) has been operated to directly detect earthquake and tsunami to contribute to accurate and prompt communication of disaster information. In addition, the construction of the Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net[3]) was advanced in the sea area extending from off the coast of Kochi Prefecture to Hyuganada, where the observation network is not yet installed in the anticipated seismic source region of the Nankai Trough Earthquake (Figure 2-2-1).

1 Dense Oceanfloor Network system for Earthquakes and Tsunamis
2 Seafloor observation network for earthquakes and tsunamis along the Japan Trench
3 Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis

■ Figure 2-2-1/The Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net)



Created by MEXT

In the field of volcanology, the Integrated Program for Next Generation Volcano Research and Human Resource Development was launched in FY2016 in response to the eruption of Mt. Ontake in 2014. The program is promoting integrated research of "observation, forecasting and countermeasures" in coordination and jointly with other fields in order to contribute to reduction of volcano disasters in addition to existing observation research. The project also fosters volcano researchers who have comprehensive knowledge and advanced technique. In addition, under the "Volcanic Observation Campaign Preliminary Research Project" started in FY2021, preliminary research is being conducted on establishing systems necessary for realizing quick and efficient volcanic observation campaign in the event of emergencies, such as the occurrence of volcanic eruptions and precursor phenomena.

NILIM has been implementing the "Response to Intensifying Disasters," including developing a calculation method for predicting the extent of sediment reach and sedimentation depth in the event of sediment and flood damage, with high accuracy.

NIED is observing various tremors ranging from feeble tremors imperceptible to the human body to strong tremors causing big damage by using about 1,900 high-performance and high-precision seismometers covering the entire land area of Japan evenly and densely. It operates about 200 seismometers and tsunami meters in sea area and has been operating Monitoring of Waves on Land and Seafloor (MOWLAS[1]) since November 2017. MOWLAS is an earthquake, tsunami and volcano observation network covering all land and sea areas of Japan, including the Fundamental Volcano Observation Network (V-net[2]) for 16 volcanoes in Japan. NIED is advancing research and implementation of real-time prediction of earthquakes and tsunamis as well as observation and prediction of volcanic activities by using MOWLAS and has provided observation data to JMA. NIED also promoted use of the observation data by research institutes, local governments and the private sector including railway companies.

In addition, NIED is also conducting research on storm, flood and landslide prediction based on multi-sensing and research contributing to reduction of damage caused by natural disasters including evolving snow/ice disasters and coastal disasters. For example, the creation of new information such as the identification of road conditions such as snow accumulation and flooding using AI, assessment of rainfall-triggered hazard area based on the return period, named as the "rarity" of heavy rainfall, and high-resolution area snowfall information using radar and numerical snowpack models, etc., and expansion of the provision area of snow load alert system; construction of an information website on snowdrifts in Niseko; social application of snow/ice disaster prevention information including provision of snowfall/snow-melting information to local governments by introduction of IoT to the existing snow-melting devices,

1 Monitoring of Waves on Land and Seafloor
2 The Fundamental Volcano Observation Network

development of early prediction technique for short-lived local heavy rainfall using cloud radars[1] and; participation in an innovation creation project in cooperation with private companies.

JMA, in cooperation with MEXT, collects, processes, and analyzes data from the fundamental earthquake survey and observation networks, and provides the results to the Earthquake Research Committee of the Headquarters for Earthquake Research Promotion (HERP) in addition to utilizing it in disaster prevention information, etc. Also, JMA has developed and introduced an Automatic Hypocenter Determination Method (PF Method[2]). For the Earthquake Early Warning System, JMA added the long-period ground motion class to the release standards and in addition introduced the IPF Method[3] and the PLUM Method[4]for earthquake alerts to cope with simultaneous earthquakes and massive earthquakes, which became an issue during the 2011 off the Pacific coast of Tohoku Earthquake. Technological development for further enhancement is underway in cooperation with the NIED. For tsunamis, JMA has introduced a method for accurately predicting the height of coastal tsunamis from offshore tsunami observation waveforms (tFISH[5]).

MRI researches the following topics: the development of real-time scale estimation of tsunami/earthquake to mitigate damage by tsunamis, and tsunami forecasting based on offshore tsunami monitoring data; research on a real-time understanding of the scale, rupture areas and slow slip events of earthquakes occurring in the Nankai Trough, and development of a monitoring method to advance volcanic activity assessment and prediction.

To collect geological information useful for disaster prevention/mitigation, AIST investigates geological surveys of active faults, tsunami deposits, and active volcanoes, and publishes the results of these surveys. Regarding major active faults in Japan, seven active faults (the eastern margin of Yokote Basin, the western margin of Nagano Basin, Minobu, Sakai Pass and Kamiya/Mt. Kirito to Narai, Yasaka, Futagawa, Miyako Island) for which the probability of earthquake occurrence and the latest active period are unknown were surveyed to obtain data necessary for calculating the probability and magnitude of earthquake occurrence. In addition, data updates and system improvements were steadily made to the active fault database. Regarding tsunami deposits, a geological survey was conducted to clarify the size of the tsunamis caused by past mega-earthquakes along the Chishima Trench and a fault model of the wave sources which could explain those results was studied. Moreover, a comprehensive groundwater observation site that contributed to the short-term prediction of the Nankai Trough Earthquake was operated and maintained. Groundwater levels (hydraulic pressure), groundwater temperature, crustal strain, and seismic waves were constantly observed.

Concerning volcanoes, field surveys and analyses of the pyroclastic material, etc. were carried out with respect to the eight volcanoes designated as active volcanos (Rausu and Shiretoko Io mountains, Mount Meakan Stratovolcano in Japan, Mount Iwaki, Akita-Yake-Yama, Mount Ontake, Mount Hakone, the Izu-Tobu volcanic cluster, Izu Oshima) and information contributing to elucidation of the scale and form, etc. of past eruptions and forecasts of activity trends going forward was obtained.

JAMSTEC in cooperation with universities and

1 Weather radar to observe cumulus clouds before developing into precipitation clouds
2 Phase combination Forward search
3 Integrated Particle Filter method: A method to accurately estimate hypocenters even during multiple simultaneous earthquakes. Developed jointly with the Disaster Prevention Research Institute, Kyoto University
4 Propagation of Local Undamped Motion method: A method to appropriately predict the seismic intensity of large earthquakes even over an extremely wide area of strong motion
5 tsunami Forecasting based on Inversion for initial sea-Surface Height

other relevant organizations, conducts surveys and observations of seafloor earthquakes and volcanoes using research vessels and various types of observation equipment in the sea area assumed to be the epicenter of the expected Nankai Trough mega earthquake, and the oceans surrounding Japan and the western Pacific Ocean . By advancing methods to analyze data from these observations, JAMSTEC predicts transition of seismic and volcanic activities through large-scale and high precision numerical simulations.

GSI is responsible for observation, analysis, and R&D on crustal deformation and plate motions through GNSS[1] CORS[2] network, Very Long Baseline Interferometry (VLBI[3]), and Interferometric Synthetic Aperture Radar (InSAR[4]). Detailed monitoring of crustal deformation in and around volcanoes has been implemented through integrated analysis of GNSS volcanic observation data, which have been collected by several institutes, such as JMA, NIED, the Hot Springs Research Institute of Kanagawa Prefecture, and the Disaster Prevention Research Institute, Kyoto University.

The Japan Coast Guard (JCG) has been operating GNSS-A seafloor geodetic observation and bathymetric survey. The data and results are regularly published.

JMA is strengthening and accelerating efforts to improve the prediction accuracy of stationary linear mesoscale convective systems. In June 2022, JMA began issuing weather information about heavy rain caused by stationary linear mesoscale convective systems around half a day in advance, and from June to October of the same year, it conducted real-time simulation experiments using the super computer "Fugaku" with a numerical weather prediction model under development.

1 Global Navigation Satellite System
2 About 1,300 sites nationwide, as of March 31, 2023
3 Very Long Baseline Interferometry : Technology that measures distances of thousands of kilometers with a margin of error of a few millimeters, using radio waves reaching the earth from billions of light years away
4 Interferometric Synthetic Aperture Radar: Technology to monitor changes in the earth's surface from space using satellites

3. Improvement of response capabilities

In the First Period of the SIP Program, "Enhancement of Societal Resiliency against Natural Disasters (FY2014-2018)," the "Shared Information Platform for Disaster Management (SIP4D[1])," which is a system to gather disaster information on digital maps and enable information sharing among relevant organizations, was developed. During the heavy rains that began from August 3, 2022, and Typhoons Nos. 14 and 15 of 2022, the Information Support Team (ISUT[2]), operated by the Cabinet Office, Government of Japan (disaster management), used the platform to provide information support to relevant government ministries and agencies, local governments, and designated public agencies for their response to the disasters. In the second period of the SIP Program "Enhancement of National Resilience against Natural Disasters" that started in FY2018, the Cabinet Office is promoting R&D and social implementation to construct an information system that makes the best of the latest science and technologies including satellites, IoT, and big data to support decision making by the central and municipal governments in the event of a natural disaster. During the development of the "One Stop System for natural disaster satellite observation" for the immediate centralization and sharing of satellite data, the evaluation, validation, and improvement of the system were implemented through the response to the heavy rains that began from August 3, 2022, in collaboration with the related government agencies. The office is also promoting R&D into disaster prevention chatbots, a system involving automatic talk with AI on social media for affected persons at the time of disaster, through field tests with local governments and other participants. This system was also actually utilized for Typhoon No. 14 of 2022.

Quasi-Zenith Satellite MICHIBIKI started service on November 1, 2018. The service consists of disaster crisis management reporting to provide disaster prevention weather information through Michibiki and collection of safety information of evacuees in shelters, etc.

MIC has been conducting R&D on ICT for improving the disaster-resistance of information and communications facilities, and for collecting data on damage at times of disaster. In addition, MIC has vigorously applied its research results, such as a communication system that can be carried in disaster-stricken areas for emergency restoration of communications (a movable and deployable ICT resource unit) in communities in Japan and worldwide.

NIED conducts research on the development of systems to share and utilize information of various natural disasters and has been conducting necessary demonstrations and providing information for public disaster response based on its role as a designated public institution. During the heavy rains that began from August 3, 2022, and Typhoons Nos. 14 and 15 of 2022, the information collected in "SIP4D" and the information collected in the disaster-affected areas were consolidated in a centralized manner and along with the past information and analysis results related to each disaster disseminated to disaster response agencies via a website that displays maps called "Disaster Prevention Crossview" (bosaiXview; open to the public) and ISUT-SITE (open only to disaster response agencies), assisting the unification of situational awareness, etc.

The National Research Institute of the Fire and Disaster Management Agency has established a new 5-year research plan on natural disaster response that started in FY2021 and is currently

1 Shared Information Platform for Disaster Management
2 Information SUpport Team

conducting research and development on (1) Improving firefighting capabilities during landslide disasters using drones, etc., (2) Research and development to control damage caused by fires in urban areas when an earthquake occurs and (3) Mitigating earthquake disasters at hazardous material facilities as a response to natural disasters.

NICT has been increasing the sophistication of an airborne Polarimetric and Interferometric Synthetic Aperture Radar system (Pi-SAR[1]) that can observe the ground surface in disaster-stricken areas as needed. Additionally, the system developed by NICT that allows the synchronization and provision of information in areas where telecommunications networks are interrupted is being introduced to local governments. NICT is also developing fundamental improvements to a portable communications device (Portable SIP4D) that will allow SIP4D to communicate in areas where telecommunications are interrupted. In addition, an information analysis technology that analyzes SNS postings in real time and extracts disaster-related information is being developed and is being field tested in disaster prevention training in cooperation with the local governments.

NILIM is conducting research on the following activities: (1) techniques to evaluate the performance of residences and buildings from the perspective of continued use during disasters, and; (2) research on design objectives of independent energy systems for continued daily living after a disaster.

The Public Works Research Institute is developing technology to ensure that infrastructure continues to function after a major earthquake.

JAXA has been contributing to various disasters monitoring and grasping of the state of disaster using the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2[2]) and other satellites.

In response to the global outbreak of COVID-19, METI will advance introduction of EdTech to schools and development of online contents that promote home schooling. The ministry will also enhance support for non-face-to-face/remote business activities. The support includes promotion of use of cross-border e-commerce[3], construction of digital business talk platforms and promotion of smart industrial safety.

4. Development of information platform integrating observation and projection/prediction data

Under the Program to Promote Development of Global Environmental Data Platform, MEXT has developed DIAS. It is an information platform that accumulates, integrates and analyzes big data of the global environment (observation information, projection/prediction information, etc.) to contribute to solving climate change and other global issues. The DIAS[4] has supported R&D in Japan and abroad and produced results including a system that predicts floods caused by a typhoon, etc. MEXT is working to establish a management structure to ensure its long-term stable use by a large number of users including researchers and enterprises in Japan and abroad, and is also promoting development of common fundamental technologies contributing to solution of social challenges in various fields including, energy, weather, disaster prevention and agriculture.

By analyzing the data from the Superconducting Submillimeter-wave Limb-Emission Sounder (SMILES

1 Polarimetric and Interferometric Airborne Synthetic Aperture Radar
2 Advanced Land Observing Satellite-2
3 Electronic Commerce
4 Data Integration and Analysis System

[1]) that NICT developed in cooperation with JAXA, NICT issues warning on global environmental changes based on the new knowledge and has been releasing observation data for free use since FY2020. NICT is also promoting unique mathematical algorism analysis of the global environment observation data from GOSAT, etc. The institute is also distributing monitoring/forecast and alarms regarding solar activities and the electromagnetic environment around the earth, which influences how radio waves are transmitted, while conducting integrated collection, management, analysis and release of space environment observation data. In addition, NICT is advancing the development of space environment measurement/prediction technologies to further advance these observation technologies and prediction technologies using logical models and AI.

Furthermore, JMA observes tropical cyclones and sea surface temperature, etc. by using Himawari-8 and Himawari-9, to contribute to prevention of natural disasters and monitoring of climate change, not only in Japan but also in the entire Asia Pacific region.

❷ Efficient infrastructure management through digitalization, etc.

Under PRISM[2] "innovative construction and infrastructure maintenance and innovative disaster prevention/mitigation technologies field," the Cabinet Office promotes "change through innovation" by allocating additional budget to and accelerating promotion of i-Construction and other measures of relevant ministries and agencies. In order to realize steady and efficient infrastructure maintenance while accelerating open innovation brought about by effective use of data, the ministry in cooperation with MLIT is promoting construction of an infrastructure data platform that coordinates data of the national and local governments and the private sector. To realize Society 5.0 in the field of infrastructure, the investigative commission for data linkage in this field and the investigative TF for "Smart Infrastructure Management System," the proposed topic of the next SIP (the 3rd SIP), have conducted examinations covering the improvement of the productivity and efficiency of infrastructure and maintenance management, among other issues. MLIT has promoted the development and introduction of robots to maintain social infrastructure and implement anti-disaster measures more effectively and efficiently.

MLIT is promoting i-Construction where ICT is used in all construction production processes from investigation/survey to design, installation, inspection, maintenance and renewal. The aim is 20% improvement of productivity in construction sites by FY2025. In addition, MLIT is leveraging the opportunity created by the countermeasures taken in response to the outbreak of COVID-19 to promote a DX (Digital Transformation) in the infrastructure field to shift conventions by using digital technology to enable smarter infrastructure peripherals, including the working practices of managers and the services they provide to users and the related procedures. Examples include providing real-world risk information using 3D hazard maps, remote inspections that allow management without having to be on site, labor-saving rebar placement inspections using digital data, and autonomous and remote construction. By the end of FY2021, MLIT formulated the "DX Action Plan for Infrastructure," which outlines specific processes per measure, etc. As the next stage to evolving and accelerating efforts further,

1 Superconducting Submillimeter-Wave Limb-Emission Sounder: SMILES performs observations of the atmospheric limb by using an offset Cassegrain antenna. The high-sensitivity, low-noise superconducting receivers of SMILES receives submillimeter waves emitted by atmospheric trace species in order to measure the concentrations of ozone and other molecules. The frequency range from 300 GHz to 3,000. GHz is the submillimeter-wave range. GHz is the submillimeter-wave range. SMILES uses sub-millimeter waves ranging from 624 GHz through 650 GHz.

2 Public/Private R&D Investment Strategic Expansion PrograM

MLIT will promote initiatives that are comprehensive and cross-organizational in the future. MLIT will continue its activities to mark 2023 as a breakthrough year to further accelerate innovation through DX.

In order to promote i-Construction and accelerate DX in the infrastructure field, the Geospatial Information Authority of Japan (GSI) is developing "National Geodetic Datum," which is a common rule for positional information used in individual processes of: investigation, survey, design, construction, inspection, maintenance and renewal. GSI is implementing technology development on novel survey techniques contributing to improvement of the accuracy, efficiency and reliability of 3D surveys.

NILIM is conducting "Research on Fundamental Labor Productivity Improvement through DX in Each Phase of Construction Projects," which examines systems for utilizing digital data such as BIM/CIM[1] models. It develops technologies linked to improved labor productivity and safety by improving the work of construction engineers based on the use of new technologies and analysis of construction site data. In cooperation with other MLIT departments and agencies, NILIM has been developing technologies for the utilization of existing buildings in order to ensure continued safe use of existing housing and social capital stock through more efficient and advanced inspection, repair and renewal, techniques and technologies for utilization of existing buildings and building lots, and conformity evaluation criteria for new digital technology to improve the efficiency of existing housing inspections and the equivalent for RC homes.

The Public Works Research Institute conducts research and development on renovation and new construction aimed at extending the service lives and reliability of social infrastructure, developing technologies that contribute to preventive maintenance of structures, developing efficient maintenance and management technologies for infrastructure in snowy and cold environments, and improving productivity in the areas of execution and management.

MPAT conducts research to develop technologies for the inspection and monitoring of coastal infrastructure that supports Japan's economic and social activities and to contribute to improving the efficiency of maintenance and management and reducing life cycle costs.

NIMS has comprehensively conducted R&D in the materials field, in which Japan excels, for technologies to inspect, diagnose, repair and upgrade infrastructure and evaluate reliability of materials as well as for development of new structural materials with the aim of extending the service life and enhancing the earthquake resistance of the social infrastructure.

METI is promoting smart industrial safety, which realizes improved safety and efficiency through the use of technology in the industrial safety field.

❸ Ensuring security in cyberspace, where attacks are becoming increasingly diverse and sophisticated

For the purpose of comprehensively and effectively advancing measures for Cybersecurity pursuant to the Basic Act on Cybersecurity (Act No. 104, 2014), the Cybersecurity Strategy was decided by the Cabinet on September 28, 2021 after deliberations by the Cybersecurity Strategic Headquarters led by the government. The government has been promoting R&D on technologies related to cybersecurity based on the strategy.

Through the SIP "Cyber-Physical Security for

1 Building Information Modeling/Construction Information Modeling/Management

the IoT Society" from FY2008 to FY2022, the Cabinet Office of the Government of Japan developed and demonstrated its Cyber-Physical Security Framework infrastructure technology for the realization of a secure Society 5.0. The technology enables the protection of IoT systems and services, as well as the entire large-scale supply chain, including small and medium enterprises. It will lead to applications in various social infrastructures and services, and in manufacturing, distribution, construction, and other industrial sectors with diverse supply chains in the future.

MIC promotes research and development of cyber-attack observation, analysis, visualization, and countermeasure technologies through NICT that respond to increasingly diverse cyber-attacks, cross-analysis technologies for large-scale aggregated information on various cyber-attacks, and verification technologies to improve security in new network environments. MIC aims to use its technical knowledge obtained through the R&D to train security human resources who have the practical ability to handle increasingly sophisticated and complex cyber-attacks. To this end, MIC has been implementing the practical cyber defense exercise (CYDER[1]) for government agencies, local governments, and others, and SecHack365 to train young security personnel at the National Cyber Training Center organized in NICT. In addition, NICT has established the "Integrated intellectual and human resource development infrastructure of cybersecurity (CYNEX[2])," which will serve as a node between industry and academia in the collection and analysis of cybersecurity information in Japan and the development of capable cyber security personnel, with the technologies, know-how, and information possessed by the organization at its core, and is working toward starting full-scale operations within FY2023.

METI formulated the "Cyber-Physical Security Framework (CPSF)" in April 2019, organizing the overall framework of measures required of industries to ensure cyber security of the entire supply chain in Society 5.0 realized by IoT and AI, and guidelines for each industry sector (buildings, factories, electric power, space, etc.) are being developed based on CPSF. In addition, as a concept linked to the CPSF, a framework for handling data in cyberspace and IoT device security was developed. The "Cyber Physical Security Research Center," established by AIST in November 2008, promotes and conducts research and development of technologies to analyze increasingly sophisticated and complex threats and strengthen security against threats as cyber space and physical space converge. In addition, to strengthen protection against cyber-attacks in industries that support critical infrastructure and the foundation of Japan's economy and society, the Industrial Cyber Security Center of Excellence (ICSCoE) established in the Information-technology Promotion Agency, Japan, is promoting joint initiatives by the public and private sectors to develop human resources to play a central role in cyber security measures.

METI will support construction of cyber security validation technology as the basis of non-face-to-face and remote activities as well as SME's measures in this area. The ministry also intends to encourage capital investment to promote digitization by SME.

❹ Response to new biological threats

Concerning research and development for novel coronavirus infection, the government supports research and development related to treatment methods, diagnostic methods, vaccines, etc.

1 CYber Defense Exercise with Recurrence
2 Cybersecurity Nexus

Universities, etc., have been conducting research and development regarding therapeutic methods, since the first cases of COVID-19 infections in Japan were confirmed. From the perspective of promptly creating a therapeutic drug, the government has been supporting research and development through the Japan Agency for Medical Research (AMED) and Development, focusing initially on the redevelopment of existing drugs, in which the efficacy and safety of existing therapeutic drugs are examined. In addition, from the viewpoint of new drug discovery, the government supports basic research and clinical research that have achieved results, such as finding genes associated with an increased risk of COVID-19 infections becoming severe.

Regarding diagnostic methods, through AMED, basic research on rapid diagnostic kits for gene amplification tests, rapid antigen diagnostic kits, test reagents, etc., is being supported and these have been put into practical use in the medical treatment guideline for the COVID-19 prepared by the research project funded by the MHLW subsidy for administrative promotion research project. The project for the development and demonstration of technologies for measures against viruses and other infectious diseases supports research and development that leads to solutions to infectious disease issues and the development and demonstration of equipment and systems to meet the needs of the field for measures for the novel coronavirus disease (COVID-19 pandemic).

In response to the demand to accelerate the development of vaccines and strengthen the supply system in Japan, the implementation of basic, non-clinical, and clinical research by domestic companies and universities is being supported through AMED.

The pandemic has provided an opportunity to identify the factors that have stalled vaccine development in Japan, and the government has worked together to rebuild the necessary systems to solve the problems. The "Strategy for Strengthening Vaccine Development and Production System" (Cabinet decision on June 1, 2021) was formulated as a national strategy for long-term, continuous efforts. As part of this strategy, an advanced center for research and development strategy (SCARDA[1]) was established in AMED to strengthen the research and development and manufacturing frameworks in normal times in preparation for future infectious disease crises. Led by competent personnel with expertise in various fields, including medicine and immunology, research and development, practical application of biopharmaceuticals, and management, SCARDA has established a system to collect and analyze a broad range of information on infectious diseases and vaccines in Japan and abroad, and promotes R&D support with a comprehensive outlook on vaccine research, development, and practical application. Under the new structure, SCARDA will engage in projects such as intensive support for practical application research by industry-academia-government collaboration using new drug discovery methods, the establishment of world-class R&D centers, and fostering drug discovery ventures. In addition to the initiatives by AMED, other necessary initiatives are being taken to establish a system that will enable the rapid development and supply of vaccines, such as the establishment of dual-use vaccine production sites.

The novel coronavirus pandemic has once again shown that a global response system is needed, and the ("Research Program on Emerging/ Re-Emerging Infectious Diseases" (under the jurisdiction of MEXT)) supports strengthening the research infrastructure for infectious diseases in Japan and overseas and promotes basic research

1 SCARDA: Strategic Center of Biomedical Advanced Vaccine Research and Development for Preparedness and Response

through AMED, and the ("Research Program on Development and Promotion of Innovative Drugs for Emerging and Re-emerging Infectious Diseases" (under the jurisdiction of MHLW)) is consistently promoting development and research for practical application of infectious disease crisis-response drugs, etc., as part of a fundamental enhancement of infectious disease contingency planning. In addition, (the "Project to Create a Clinical Research and Trial Network in the Asian Region" (under the jurisdiction of the MHLW)) is in the process of establishing a foundation to promote clinical research and clinical trials in the Asian region led by Japan.

In addition, in order to balance the prevention of COVID-19 infections with economic activities, the government solicited research themes from academia and companies to create new daily routines that contribute to the prevention of the spread of infection, including droplet simulation using the supercomputer Fugaku, and conducted simulations of the infection situation, such as the number of new positive cases and the number of severely ill cases.

❺ Responding to threats to the safety and security of space, marine, and other fields

1. Promotion of R&D in space science

Today, positioning, communication, and observation space systems are supporting the security and economic/social activities of Japan and are also increasing in importance as infrastructure for the realization of Society 5.0. In this context, space activities embark on an age of public-private co-creation and there are efforts to vitalize industries through space use in a wide range of fields. As the progress of space exploration expanded human activities beyond terrestrial orbit to the moon and deeper space, the success of HAYABUSA2 in conducting sample collection from an asteroid demonstrated the high level of the nation's S&T and raised the expectations of the public. Space is further increasing its importance as a S&T frontier and driving force of economic growth. It can be a big driving force in innovation creation in Japan.

With this understanding, the government based on the Basic Plan on Space Policy (Cabinet Decision on June 30, 2020) is promoting the nation's space development and use comprehensively, systematically and powerfully as a national strategy.

In FY2022, the launch of Epsilon rocket No. 6 and H3 Test Flight No. 1 failed, and the satellites they carried, including (ALOS-3 [1]), were lost. MEXT has established a task force that is conducting investigations based on technical observations to determine the cause of the failures at its expert meetings.

(1) Space transportation systems

Space transportation systems that have a role to launch satellites are a key pillar for the development and utilization of space. Technologies for sending satellites to their designated altitudes whenever needed are vital for the autonomy of Japan's space activities. MEXT is progressing the development and advancement of the flagship rockets such as the H3 and Epsilon rockets to expand Japan's autonomous space activities and ensure its international competitiveness. Looking ahead to 2040, in order for Japan to meet the large demand to utilize space expected in the future, MEXT formulated the "Innovative Space Transportation Roadmap" in July 2022, which is to promote the development of two types of rockets as the two pillars of a space transportation system, the upgraded flagship rockets to correspond to government missions and the high frequency outbound flight space

1 Advanced Land Observing Satellite - 3

transportation system. At the same time, the public and private sectors are working together to develop the basic technologies and environmental improvements required for the system through the "Innovative Space Transportation Programs," which have been underway since FY2022.

Launch of H-IIA F43
Source: JAXA

(2) Global positioning satellite systems

The Cabinet Office started a high-precision positioning service based on a 4-satellite constellation of Quasi-Zenith Satellites MICHIBIKI on November 2018. Toward the 7-satellite constellation to be established in FY2023 and its function and performance improvement, the office is promoting the development of MICHIBIKI-5, 6 and 7. Toward further utilization of MICHIBIKI, relevant ministries and agencies are working together on various demonstration experiments including automated driving of automobiles and farm machines, physical distribution and disaster prevention.

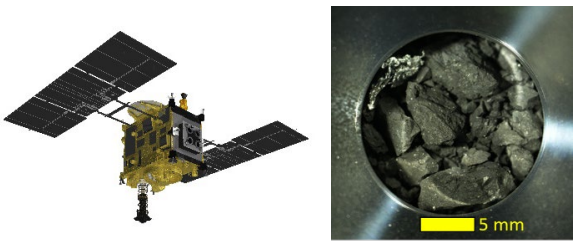
(3) Satellite communication and broadcasting systems

In order to realize internationally competitive next generation geostationary communication satellites in the 2020s, MIC and MEXT have been jointly developing the Engineering Test Satellite 9 since FY2016. This satellite will be developed for the purpose of demonstrating technologies of electric propulsion, high-power generation, and flexible payload.

(4) Earth observing system

Through GOSAT launched in FY 2008 and GOSAT-2 launched in FY2018, MOE has demonstrated that global CO2 and methane concentrations have been rising year by year. In order to aggressively expand this mission and grasp the effects of the measures toward the decarbonized society, the ministry is promoting the development of its successor, GOSAT-GW for the launch scheduled in FY2024.

The JAXA is operating SHIZUKU (GCOM-W), launched in May 2012, and SHIKISAI (GCOM-C), launched in December 2017, to elucidate the mechanisms of the hydrological cycle and climate change on a global scale. Data from SHIZUKU together with the data from the Global Precipitation Measurement (GPM [1]) core satellite launched in February 2014 under the international cooperation project with the National Aeronautics and Space Administration (NASA [2]) are used by JMA to improve the accuracy of precipitation estimates and for various other purposes, including weather forecasting and fishing ground detection. SHIKISAI is also used to ascertain the state of



Asteroid explorer "HAYABUSA2" (left) and collected samples (right)
Source: JAXA

1 Global Precipitation Measurement
2 National Aeronautics and Space Administration

massive forest fires overseas. In order to continue the mission to observe the water cycle and GHG and further strengthen observation capability, JAXA is developing the GOSAT-GW.

In addition, DAICHI-2 (ALOS-2) launched in May 2014 is contributing to disaster prevention and management, and solutions to global issues such as global warming through monitoring of various disasters, grasping of damage situations and the observation of forests and ice of Polar Regions, etc. Currently JAXA is developing ALOS-4, capable of wide-area and high-resolution imaging. JAXA launched optical data relay satellites in November 2020 and is working for demonstration of optical communication between these satellites, which will enable instantaneous relaying of satellite data of affected areas to the ground when a natural disaster strikes. This is expected to help speedy disaster countermeasures in the future.

Optical data relay satellite
Source: JAXA

Toward stable operation of Japan's satellites, MEXT and JAXA have established and have been operating the SSA [1] system since FY2002 to observe space debris, etc. from the ground. It will contribute to the stable usage of space by providing observation data to the system operated by the Ministry of Defense from the end of FY2022.

(5) Space science and exploration

Regarding R&D in space science, JAXA has been playing a pivotal role. JAXA has achieved globally unrivaled results in X-ray and infrared astronomical observation, such as by developing and operating the world's first satellite for simultaneous X-ray photography and X-ray spectrography and by using the HAYABUSA probe to collect samples from the asteroid Itokawa. Venus Prove AKATSUKI put into Venus orbit in December 2015 produced results leading to the elucidation of the mechanism of "super rotation" in the Venus atmosphere. HAYABUSA2, launched in December 2014, achieved an array of the world's first brilliant feats after arriving at the Ryugu asteroid, including formation of an artificial crater on the surface of the asteroid and twice-repeated touch downs to the same asteroid. HAYABUSA2 returned to the vicinity of the Earth in December 2020 and separated the mounted capsule toward the earth. Later the capsule was collected in a desert in Australia. Samples from the Ryugu asteroid inside the capsule have been verified and are currently being analyzed in detail by research institutions in Japan and abroad. In 2022, research findings have been published one after another, including those amino acids associated with the origin of life were detected on the Ryugu asteroid. The "Hayabusa 2" exploration unit is currently heading toward another asteroid. (It is expected to arrive in 2031.)

In addition, the Mercury Magnetospheric Orbiter of the BepiColombo international collaborative mission to Mercury (launched in October 2018) in cooperation with the European Space Agency (ESA) is now navigating toward Mercury. JAXA is also developing the Smart Lander for Investigating Moon (SLIM [2]), the

1 Space Situational Awareness
2 Smart Lander for Investigating Moon

satellite XRISM[1] (both SLIM and XRISM are scheduled for launch in FY2023) and the Martian Moons eXploration (MMX[2]) program for sample return from the Martian Sphere. In this way JAXA has been active in establishing a leading position in the world as well as in promoting R&D on space science that helps broaden the frontiers of space for humankind.

In addition, based on Japan's decision to participate in the international space exploration project (Artemis Program) described below, MIC started the research and development of a Lunar Terahertz SUrveyor for KIlometer-scale MappIng (TSUKIMI) on the lunar surface in FY2021 to realize surface exploration of water resources, which are expected to be used as energy resources in lunar activities.

(6) Human space activities

The International Space Station (ISS[3]) program[4] is an international cooperative project between five partners (15 countries): Japan, U.S., Europe, Canada, and Russia. Japan has been participating in the ISS program through development and operation of the Japanese Experiment Module "KIBO" and the uncrewed cargo transfer spacecraft "KOUNOTORI" (HTV[5]) and long-term stay of Japanese astronauts on ISS. NASA announced in January 2022 that the U.S. would extend the ISS operation period until 2030. Japan became the second country, following the U.S., to announce its participation in this extension in November 2022.

The Japanese team has made various achievements: establishing crewed and uncrewed space technologies, establishing an international presence for Japan, promoting the space industry, and contributing to society through social benefits accruing from the use of space (e.g., generating high-quality protein crystals leading to drug discovery, acquiring medical knowledge, creating materials useful for next-generation semiconductors and deploying small satellites), and educating young people. All KOUNOTORI from the 1st (2009) to the 9th (2020) successfully completed their missions. With the functions unique to KOUNOTORI, including one of the world's best supply capacities (up to 6 tons) and the capacity to mount multiple units of large test equipment, the spacecraft supported the use and operation of the ISS. Taking advantage of the experience through KOUNOTORI, Japan is developing its successor, a new space station resupply vehicle (HTV-X) targeting better carrying capacity with reduced development and operation costs.

As for Japanese astronauts aboard the ISS, Mr. WAKATA Koichi began a six-month stay on the ISS in October 2022 for his fifth spaceflight, the most by a Japanese astronaut, and returned to Earth in March 2023. Furthermore, JAXA began recruiting and selecting new Japanese astronauts from 2021, and two astronaut candidates were selected in February 2023.

(7) International space exploration

"Artemis Program" is an international space exploration program led by the United States to construct the "Gateway," a manned space station orbiting the Moon, and to conduct technology demonstration for the future manned exploration on Mars and continued manned activities on the Moon, with participation of private enterprises. The Government of Japan decided to participate in

1 X-Ray Imaging and Spectroscopy Mission
2 Martian Moons eXploration
3 International Space Station
4 An international cooperative project to construct, operate and utilize a manned space station in low Earth orbit (about 400 km) based on an intergovernmental agreement between Japan, U.S., Europe, Canada and Russia
5 H-II Transfer Vehicle

the Artemis Program in 2019 while Europe and Canada also expressed their intention to participate. Based on the decision, MEXT and NASA signed a joint exploration declaration of intent for lunar cooperation in July 2020. Later in December, the Government of Japan and NASA signed a memorandum of understanding concerning cooperation on the civil lunar Gateway. The memorandum provides a legal framework to enable the cooperation confirmed in the joint declaration, which include Japan providing equipment to the Gateway, and NASA providing flight opportunities for Japanese astronauts to the Gateway. In November 2022, MEXT and NASA signed an implementing arrangement concerning cooperation on the civil lunar Gateway based on the memorandum of understanding to specify the details of the cooperation. Under the implementing arrangement, Japan is to provide equipment and supplies for the Gateway habitat, while NASA is to provide a flight opportunity for Japanese astronauts to the Gateway. In addition, in order to further facilitate a smooth partnership between Japan and the U.S. on the exploration and use of space, both governments signed a new legal framework, the Framework Agreement between Japan and the United States of America for Cooperation in the Exploration and Use of Outer Space in January 2023.

(8) Initiatives to promote the utilization of space

Concerning the use of space, MEXT established a system for increasing the utilization of expertise possessed by government, industry and academia. Under this system, entrustment expense fees for the promotion of aerospace science and technology is used for the purpose of expanding the base of space users by discovering potential users of satellites and developing new utilization methods. Using this system MEXT continues R&D on space utilization technologies with a view to their practical use in human resource development, disaster prevention, the environment and other aerospace fields.

METI developed the Hyperspectral Imager Suite (HISUI[1]) that enhances remote detection capacity for oil resources. After installing HISUI on the Japanese experiment module "Kibo" of the ISS in December 2019, the analysis and use verification of the acquired data were conducted in FY2022. Support for developing low-cost, high-performance space parts and components that utilize technologies from the consumer sector and provide opportunities for in-orbit demonstrations, as well as developing and demonstrating low-cost, high-performance small satellite general-purpose buses for mass production and constellation. In addition, in order to increase the use of space data that has been becoming big data, the ministry provides the government's satellite data for open and free use and is also developing a user-friendly satellite data platform (Tellus).

2. The promotion of oceanographic R&D

Surrounded by seas on all sides and having one of the world's most extensive sea areas under its jurisdiction, Japan must regard marine science and technology as important for a national strategy and continue to strengthen its efforts in the field from a long-term perspective while taking into account the multifarious nature of science and technology. It is important to accumulate and utilize scientific knowledge related to oceans in order to conserve marine biological resources and ecosystems, secure energy and mineral resources, respond to global issues such as global warming and marine plastic litter, set up countermeasures for threats such as earthquakes, tsunamis and volcanoes, sustainably utilize the Arctic polar region, and strengthen the competitiveness of

1 Hyperspectral Imager SUIte

marine industries.

The Cabinet Office is promoting efforts to solve technology development challenges related to oceans in close cooperation with the Headquarters for Ocean Policy and ensuring consistency with the Third Basic Plan on Ocean Policy (Cabinet Decision on May 15, 2018).

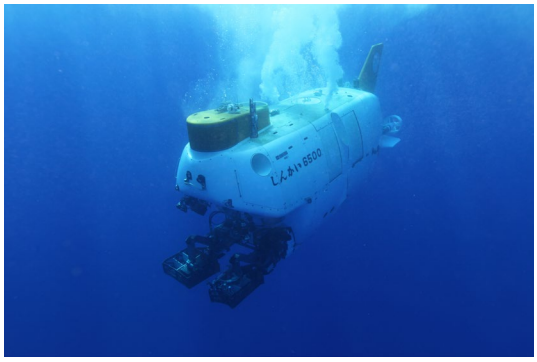
In light of the formulation of the 3rd Basic Plan on Ocean Policy, in January 2019 MEXT revised the R&D plan pertaining to ocean science and technology (formulated at the CST's Subdivision on Ocean Development in 2016) and has been promoting R&D in the marine S&T fields contributing to innovations toward creation of future industries.

Using vessels, probes, observation equipment and other means, JAMSTEC has been conducting surveys and research in the ocean including the deep sea bottom and ice-infested waters that are difficult to access, as well as simulations using obtained data and archiving and dissemination of data. Using these technologies JAMSTEC is promoting basic research to elucidate the actual state of the areas that need further elucidation.

(1) Ocean survey and observation technologies

For the purpose of understanding the subseafloor microbiosphere, the mechanisms of subduction-zone earthquakes and tsunamis, and the genesis as well as the possible existence of marine resources, JAMSTEC has been advancing the development of technologies for drilling by using the deep-sea scientific drilling vessel Chikyu and technologies for real-time observations by using DONET. These technologies are also utilized for surveys, research and the development of other technologies. The ministry has also been conducting research and surveys that focus on the seas around the Japanese archipelago and the entire Pacific Ocean. Specifically, crustal structures are explored by using research vessels, the manned

Deep-sea scientific drilling vessel Chikyu
Source: JAMSTEC



Manned research submersible SHINKAI 6500
Source: JAMSTEC

research submersible SHINKAI 6500 and unmanned submersibles, towards deepening our understanding of phenomena related to the deep ocean floor, such as tsunamis and huge earthquakes that can cause devastating damages.

(2) Technologies contributing to sustainable ocean development, use, etc.

MEXT has been implementing R&D of observation/measurement technologies for efficient and highly accurate understanding of marine ecosystems, marine environment and other marine information using a wide range of advanced technologies and knowledge held by universities, etc. under the "Technology Development for Understanding of Marine Information" within the framework of the program for developing technologies for promoting the use of marine resources.

In order to contribute to the promotion of industrial use of the ocean in Japan, JAMSTEC is

promoting understanding of material cycles and formation of useful resources in the oceans from both biological and non-biological perspectives, and providing related industries with obtained scientific knowledge, data, technologies and samples.

Based on the results of "Next-generation Technology for Ocean Resources Exploration" implemented during the 1st Period of the SIP Program, the Cabinet Office has been promoting "Development of Innovative Technologies for Exploration of Deep-Sea Resources" during the 2nd Period of the SIP Program since FY2018 and proceeding with the development of technologies for efficiently investigating mineral resources such as REY-rich mud that exist on the seabed at depths of 2,000 m or more and recovering them offshore. By improving the accuracy of the preliminary rare earth resource estimate in the Minamitorishima survey area, a promising development site was selected in FY2022. Furthermore, technological development to produce rare earth elements in the future is steadily making progress, such as a mud cutting and lifting test being successful at sea at a depth of 3,000 meters.

(3) Technologies contributing to the securing of safety and security on the Oceans and preservation of ocean environment

Marine ecosystems, which are closely linked to human society in terms of food production and climate control, have been exposed to environmental stresses such as pollution, global warming and overfishing in recent years, and understanding, conserving, and utilizing marine ecosystems in light of these stresses has become an important subject. For this reason, MEXT has been carrying out R&D to understand these complex and diverse marine ecosystems and to develop conservation and utilization technologies for them by discovering new knowledge from big data based on existing data or data acquisition technologies under "Advancement of Technologies for Utilizing Big Data of Marine Life" of the Technology Development to Promote Utilization of Marine Resources Program.

MPAT is conducting research on the development and improvement of techniques for safety evaluation of offshore structures and for reducing environmental impacts. These techniques are the basis of key technologies for the exploitation of ocean resources and energy. JCG is gathering information of ship movements for the purpose of ensuring safe marine transportation and improving operational efficiency. JCG is developing a system to predict the risk of maritime traffic accidents based on the analysis of these big data.

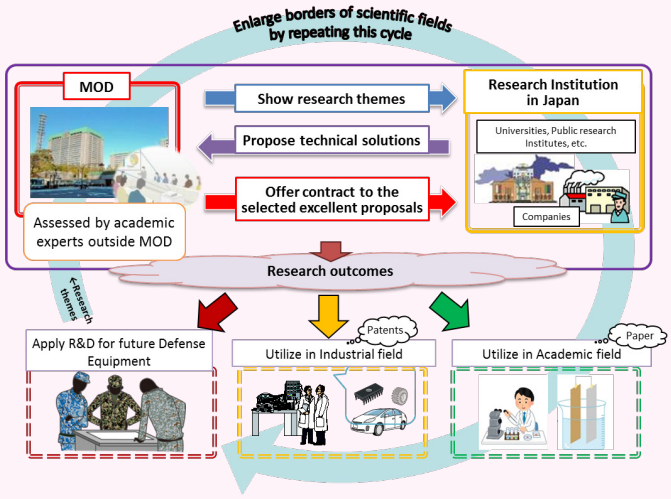
3. Promoting R&D in the field of defense

The National Security Strategy (National Security Council/Cabinet Decision of December 16, 2022) calls for enhancing public-private partnerships to improve technological capabilities and actively capitalize on outcomes of R&D in the security field. In order to widely and actively utilize Japan's advanced technological capabilities in the public and private sectors for security purposes, a whole-of-government mechanism will be established to match R&D needs based on the views of the MOD, with the appropriate technological seeds possessed by the relevant ministries and agencies, in addition to implementing these projects.

Expecting future contribution to R&D in the defense field, MOD launched the "Innovative Science & Technology Initiative for Security" to publicly seek and commission basic research on advanced technologies (Figure 2-2-2) in FY2015. In FY2021, the ministry established a technology think-tank function to study advanced civilian technologies that will be important for Japan's

national security in the future and to conduct analyses that will contribute to the consideration of technology development policies for application in the defense field.

■Figure 2-2-2/Innovative Science & Technology Initiative for Security



Source: Acquisition, Technology & Logistics Agency (ATLA)

In addition, Advanced Technology Bridging Research, in which promising advanced technologies can be discovered and nurtured at an early stage and quickly and flexibly applied to equipment R&D by raising the level of maturity of the technologies, has been greatly expanded. Furthermore, for the early commercialization of defense equipment that could be a game changer, MOD is making efforts to outsource research on relevant important component technologies to private companies, etc., in parallel with its research on the core technologies of such equipment, starting from FY2022.

Column 5: Efficient R&D through collaboration with other defense research institutions

Advanced commercial technologies related to uncrewed devices, such as drones, have made significant progress in recent years and are impacting a variety of fields. In the defense sector, it is imperative to bolster capabilities related to unmanned assets, which could be an innovative game changer.

Japan is surrounded by the sea in all directions, so it is vital for its defense to gain control of the highly concealed underwater region. Significant contributions are anticipated by actively utilizing unmanned assets such as unmanned underwater vehicles (UUVs) to gain an advantage in the underwater region. Consequently, MOD is actively conducting research and development on UUVs while actively incorporating advanced civil technologies.

One example of the adoption of commercial technologies is a joint research project between ATLA and JAMSTEC on underwater mobile communications that was conducted for three years from 2019, through an agreement signed in 2014. Future cooperation is envisioned with UUVs integrated into the network. Acoustic communication is the primary form of communication underwater. However, sound is greatly affected by movement and cannot reach the target properly relative to radio communication over the air. Therefore, ATLA's Naval Systems Research Center and JAMSTEC have been jointly researching mobile underwater communications technology, and the results were combined and tested for underwater mobile communications, which validated the technology's applications for stable communications with UUVs moving underwater. Going forward, MOD will continue to advance research aimed at the realization of a maritime communication network by developing the maritime communication technology implemented at MOD and research institutions while taking advantage of the collaborative relationship.

MOD is also cultivating fundamental underwater technologies, such as the following research topics applied for and accepted by JAMSTEC through the "Innovative Science & Technology Initiative for Security" of ATLA: "Research for Long-Range Acoustic MIMO Communications by Time Reversal (FY2018–FY2022)" and "Research for underwater hybrid sensing applying laser reflection (FY2020–2024)."

Furthermore, in Advanced Technology Bridging Research, a hybrid opto-acoustic underwater wireless communication device was produced under the Innovative Science & Technology Initiative for Security that incorporates the results of underwater optical and acoustic communications. Since FY2022, the "Study on underwater communication for UUV" has been conducted to validate its performance.

The development of unmanned vehicle technologies, etc. will be further promoted in cooperation with other research institutions and private companies with the aim of their early implementation

Tank testing of hybrid opto-acoustic underwater wireless communication
Provided by: ATLA

4. Promoting R&D for anti-terrorism measures in the police

The National Research Institute of Police Science is developing detectors for on-site detection of nuclear materials. It is expected that this device will be significantly lower-cost than conventional devices. The enhanced portability resulting from the smaller size is also projected to enable more mobile field operations in the future. The institute also evaluates the power and

sensitivity of homemade bombs made of commercially available materials and used for international terrorist attacks, conducts their demonstration tests and implements research that will contribute to measures for sales entities who sell chemical substances that can become explosives.

❻ Initiatives to "Know," "Develop," "Utilize," and "Protect" for ensuring safety and security

The Cabinet Office, Government of Japan, had conducted the pilot projects since the fall of 2021 through FY2022 for think-tank functions to conduct surveys and research on STI from various perspectives such as technology and socioeconomic trends at home and abroad and national security. The government will continue preparatory work for the establishment of a think tank in FY2023. The "Key and Advanced Technology R&D through Cross Community Collaboration Program" (the K Program[1]) aims to promote R&D of cutting-edge critical technologies in the fields of AI, quantum, space, ocean and others for a wide range of civil and public applications. In September 2022, the research and development vision for the K Program was decided in cooperation with the Cabinet Secretariat of Japan, MEXT, and METI, from the perspective of ensuring and strengthening economic security, and the invitation for funding applications started in December. Furthermore, efforts are being made to autonomously ensure the soundness and fairness of research (research integrity[2]) at universities and other research institutions in response to new risks associated with the internationalization and openness of research activities[3].

In FY2021, METI, in collaboration with MEXT and relevant ministries and agencies, held a briefing session on security trade control for universities and research institutions to promote initiatives to strengthen internal control systems and prevent the outflow of sensitive technologies by explaining and clarifying the control of "deemed exports" under the Foreign Exchange and Foreign Trade Act which was enforced on May 1, 2022, and revising the guidance on sensitive technology control related to security trade.

In addition, the Cabinet Office, Government of Japan and METI collaborated to promote efforts to make security trade control a requirement in contracts for government R&D projects, which requires the establishment of a security trade control system and appealed to funding agencies and relevant ministries and agencies.

Discussions on how to carry out export control of sensitive technologies are underway among the countries concerned, including international export control regimes.

The Cabinet Intelligence and Research Office (CIRO), the National Police Agency (NPA), the Public Security Intelligence Agency (PSIA), MOFA, and MOD are working closely together to gather information, including in the field of economic security, as well as strengthening their capabilities.

4 Formation of an innovation ecosystem that will serve as the foundation for creating new industries for value co-creation

The goal is to create a society in which a new

1 This program is a collaboration between the Cabinet Secretariat, Cabinet Office of the Government of Japan, MEXT, METI and related government agencies, and carried out with funding set up by the Japan Science and Technology Agency (JST) and NEDO. In October 2022, this program was designated as a fund based on the Act on the Promotion of Ensuring National Security through Integrated Implementation of Economic Measures (Act No. 43 of 2022).

2 Research integrity refers to the soundness and fairness of research, which must be newly secured against any new risks associated with the internationalization and openness of research.

3 Further details are described in Chapter 2 Part 1 6 ❺ 1 (6) Autonomously ensuring the soundness and fairness of research (research integrity) associated with the internationalization and openness of research activities.

industrial base is built where companies, universities, public research institutions, etc., collaborate with each other to co-create value while ensuring diversity by creating a succession of startups that take on the challenge of solving issues driven by the needs of society.

❶ Support for startup creation and growth based on social needs

1. Support by the Small Business Innovation Research System (SBIR system)

Under the SBIR[1] system, the ground rules were transferred from the Small and Medium-sized Enterprises Business Enhancement Act (Act No. 18 of 1999) to the Act on Vitalizing the Creation of Science, Technology, and Innovation (Act No. 63 of 2008) to strengthen cross-agency efforts as an innovation policy, and the previous specific subsidies, etc., were changed to designated subsidies, etc. and subsidies for specific new technologies, etc. In June 2022, the Cabinet made a decision update an expenditure target for subsidies made available to startups (target amount for FY2022: approximately 5.46 billion yen) and to revise policies to improve the operation of the subsidy system.

Additionally, a demonstration phase in the field of leading-edge technology will be added to the SBIR program to promote the societal application of the achievements of technological demonstrations through startups and others in the field of leading-edge technology. MAFF, through the Bio-oriented Technology Research Advancement Institution (BRAIN), conducts the "Comprehensive Support for Startups" to provide integrated support for the creation of new businesses in the fields of agriculture, forestry, fisheries and food, including the creation of technology seeds and the commercialization of developed technologies.

2. Support for university-launched startups

The number of university-launched startups was on the decrease for a period of time, but has been increasing in recent years, reaching 244 in FY2021.

JST has been implementing the "Program for Creating STart-ups from Advanced Research and Technology (START[2])," which combines public funding and private-sector commercialization knowhow from the pre-startup stage. The program provides support for initiatives to create university-launched startups with novelty and social impact that will lead to social transformation and solutions for social issues in the post-COVID era and support for initiatives to build ecosystems in cities for startup ecosystems that gather resources from universities, local governments, and industry to create world-class startups. With the target of creating startups that will grow rapidly by capturing international markets, the government has adopted the "the Startup Development Five-year Plan," through which startups have been actively developed and established a fund to support the preparation of startup programs, such as a gap financing program combined with internationalization support for university research results and a startup creation system centered on core regional universities, etc. The "SUpport program of Capital Contribution to Early-Stage companieS (SUCCESS[3])" invests in startup companies that attempt to translate the outputs from JST-funded R&D into practical applications.

Through the "Intensive Support for Young Promising Researchers" of the NEDO, which was started in FY2020, METI has been providing matching support for young researchers from universities and other research institutions aiming for commercialization with companies, as well as funding joint research with companies. Additionally, in FY2022, through the "Intensive

1 Small Business Innovation Research
2 Program for Creating STart-ups from Advanced Research and Technology
3 SUpport Program of Capital Contribution to Early-Stage CompanieS

Support Program for Young Promising Researchers with startups," METI has supported joint research, etc. with young researchers from universities, etc. to work on solving challenges faced by startups.

3. Technology-Based Startup Support Program

METI, in collaboration with NEDO, has been implementing the "Technology-Based Startup Support Program," which provides seamless support for the growth of technology-based startups, including support for entrepreneurs before starting a business, early-stage R&D support after starting a business in collaboration with private venture capitalists, and commercialization support in collaboration with business enterprises, in order to provide integrated support from the discovery to the commercialization of technology seeds possessed by Japan.

In July 2020, the Platform for Unified Support for Startups (PLUS) set up by nine government-affiliated organizations [1] provided information, consulting services, etc., to startups through "Plus One," a centralized service for startups. With the addition of seven new institutions[2] in November 2022, it is expected that the knowledge and networks of all 16 institutions will be shared and the support programs of Plus One will be expanded.

❷ Promoting innovation activities in business

METI has been considering measures taking into account the trends of the ISO56000 series and domestic and international trends related to innovation management.

To promote an understanding of the managerial importance of open-source software (OSS), which is essential for the creation of open and agile innovation, and to raise awareness of OSS utilization, the Cabinet Office, Government of Japan held a panel discussion at a workshop organized by the Japan Intellectual Property Association (JIPA), attended by a number of business persons.

❸ Promoting new value co-creation through industry-academia-government collaboration

1. Current status of domestic and international industry-academia collaborative activities

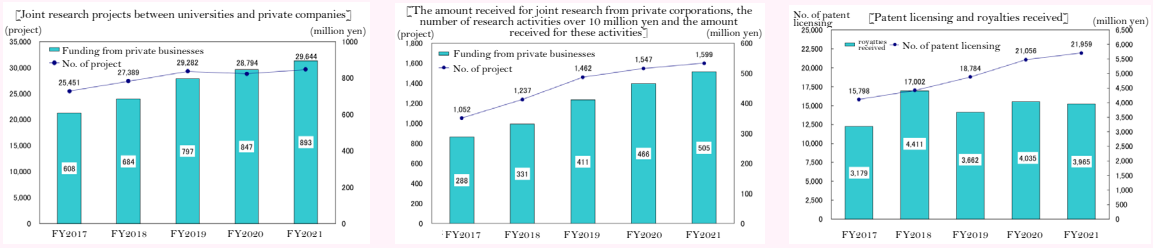
(1) Status of industry-academia-government collaboration at universities

Since the corporatization of national universities in April 2004, industry-academia-government collaboration activities have been increasing. In FY2021, the research funds received by universities through joint research with private companies were about 89.3 billion yen (up 5.4% from the previous year), of which the research funds received by universities through joint research over 10 million yen per project were about 50.5 billion yen (up 8.4% from the previous year). Also, the number of patents licensed was 21,959 (up 4.3% from the previous year), showing a steady increase from the previous year (Figure 2-2-3).

1 Nine organizations currently participating in Plus: New Energy and Industrial Technology Development Organization (NEDO), AMED, Japan International Cooperation Agency (JICA), Japan Science and Technology Agency (JST), National Agriculture and Food Research Organization (NARO), Japan External Trade Organization (JETRO), Information-technology Promotion Agency (IPA), National Institute of Advanced Industrial Science and Technology (AIST), Organization for Small & Medium Enterprises and Regional Innovation, Japan (SME SUPPORT JAPAN)

2 The Seven institutions newly participating in Plus: National Center for Industrial Property Information and Training (INPIT), Development Bank of Japan, Nippon Export and Investment Insurance, Japan Finance Corporation, Development Bank of Japan, Regional Economy Vitalization Corporation of Japan, and Japan Investment Corporation

■ Figure 2-2-3/Transition in achievements of joint research at universities



Note: 1. Subjects: national, public and private universities
2. The term "Universities" indicates universities, junior colleges, colleges of technology (KOSEN), and inter-university research institutes
3. The number of patent licensing denotes the number of patents that have been licensed or transferred (including patents pending)
Source: Implementation Status of Industry-Academia-Government Collaborations at Universities (2021), MEXT (as of February 10, 2023)

(2) Current state of Technology Licensing Organization (TLO)

As of January 1, 2023, 32 TLOs [1] had been approved by MEXT and METI under the Act on the Promotion of Technology Transfer from Universities to Private Business Operators (Act No. 52 of 1998).

2. Development of industry-academia-government collaboration systems at universities

With regard to industry-academia-government collaboration systems for joint research by Japanese universities and National R&D Agencies with foreign enterprises, the government commenced studies on guidelines for collaboration with foreign enterprises while considering security trade control.

In November 2016, MEXT and METI formulated the "Guideline for Enhancing Industry-Academia-Government Collaboration Activities," which compiles the issues and solutions for universities and the National Research and Development Agency for strengthening their industry-academia-government collaboration functions from the perspective of industry, based on the government's target of tripling corporate investment in universities and National Research and Development Agency over the next decade. In addition, solutions to alleviate bottlenecks at universities, etc., and a new systemization of problems and regulations in the industry/business sectors were combined into a supplement (June 2020) to improve the effectiveness of the above guideline. Specific approaches were then outlined in an FAQ (March 2022). Approaches to the evaluation and calculation of the value of "knowledge" have been organized into a practical standard, "Handbook for the Evaluation and Calculation of the Value of 'Knowledge' at Universities, etc., for the Enhancement of Industry-Academia Collaboration" (March 2023); both documents have been published, and efforts are being made to disseminate them. In FY2018 the ministry started "the development of the Open Innovation System [2]" to encourage private investment by promoting large-scale joint research through the development of a system for

1 Technology Licensing Organization
2 Development of the Open Innovation System
https://www.mext.go.jp/a_menu/kagaku/openinnovation/index.htm

centralized management of large-scale research that is deeply involved with corporate business strategies (with focus on competing areas).

Further in July 2019, the ministry jointly with MEXT, Japan Business Federation and METI published the "University Fact Book 2019" to advance "visualization of universities' efforts for industry-academia-government collaboration. In March 2023, "University Fact Book 2023" was compiled with updated contents based on the latest data.

Under the Industry-Academia Collaborative Support Project, MAFF has allocated industry-academia collaboration coordinators (experts in agriculture, forestry and fisheries and in the food industry) around the country to capture needs, collect and provide research seeds, support industry-academia-government matching, introduce and support R&D funding, and support commercialization.

3. Enhancement of R&D through industry-academia-government collaboration

In order to promote the practical application of research results from universities and other research institutions, JST has been implementing the "Adaptable and Seamless Technology Transfer Program through Target-driven R&D (A-STEP[1])," which provides hands-on support from the discovery of various technology seeds and the business exploration stage for researchers with cutting-edge basic research results to the transfer of technologies to companies through establishment of core technologies and promotion of practical development, and the "Newly extended Technology Transfer Program (NexTEP)," which supports the large-scale commercial development of technologies using research results from universities and other research institutions, with development risks implemented by companies and funding from the government of Japan.

Through the "Intensive Support for Young Promising Researchers" of the NEDO, which was started in FY2020, METI has been providing matching support for young researchers from universities and other research institutions aiming for commercialization with companies, as well as funding joint research with companies, while subsidizing joint research with enterprises with the aim of tripling the support for young researchers and private investments in universities. Additionally, in FY2022, through the "Intensive Support Program for Young Promising Researchers with startups," METI has supported joint research, etc. with young researchers from universities, etc. to work on solving challenges faced by startups.

MIC is promoting technological and social demonstrations of IoT and a new generation network in industry-academia-government partnership using the NICT[2] comprehensive test bed that has been developed and managed by NICT.

MAFF has set up and operates the Ministry of Agriculture, Forestry and Fisheries Research Network (MAFFIN[3]) to connect research institutions related to agriculture, forestry and fisheries. As of FY2022, 71 organizations are a part of this network. MAFFIN also has an international line with the Philippines and plays a role in the global distribution of research information.

4. Developing platforms

To promote STI promptly and effectively, it is necessary to develop platforms for industry-academia-government collaboration. Since FY2019 JST has been promoting the projects (1)

1 Adaptable and Seamless TEchnology transfer Program through target-driven R&D
2 National Institute of Information and Communications Technology
3 Ministry of Agriculture, Forestry and Fisheries Research Network

and (2) below integrally under a framework: "Open Innovation Platform for Industry-Academia Co-creation."

(1) Formation of an innovation ecosystem where knowledge and human resources are collected

JST has been implementing the "Program on Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT [1])" since FY2020 to support the formation of open innovation platforms for backcasting R&D in industry-academia-government co-creation toward realization of a desirable future society based on the United Nation's Sustainable Development Goals (SDGs[2]), with an eye on the with/post-COVID era, and is promoting R&D at 48 centers as of FY2022.

(2) Forming Open Innovation Platform with Enterprises, Research Institute and Academia

JST has been implementing the Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA[3]) since FY2016. Using funds for matching with private companies, the program aims to realize full-scale industry-academia partnership at the organization level toward full-fledged open innovation in Japan. The activities under the program include: integrated promotion of large-scale joint research in noncompetitive fields in consortiums of multiple companies, human resource development of graduate students and reform of industry-academia partnership of universities.

(3) Exploration of technology seeds and promotion of R&D projects by AIST

AIST has been exploring technological seeds and promoting R&D projects while capturing the various technological needs of industry and society. Specifically, AIST plays a role in promoting activities of TIA (see 5. (1)) as an open innovation hub, while participating in its 17 Technology Research Associations as part of the effort to form a place of co-creation (as of March 31, 2022.)

5. Developing open innovation centers

(1) Tsukuba Science City

Tsukuba Science City has been developed as a center of R&D and education of the highest level in Japan, away from the congestion of Tokyo. The city has research institutes and corporations, including 29 national experimental research and education institutes, and has been promoting many governmental plans, such as those for research exchanges and the functional improvement of international research exchanges.

TIA is a center of open innovation founded under the leadership of four public organizations in the city (NIMS, AIST, Tsukuba University and the High Energy Accelerator Research Organization) in 2009 and subsequently joined by the University of Tokyo and Tohoku University. In FY2021, which was the second year of the third term, the TIA Collaborative Research Program "Kakehashi" strengthened its initiatives to enhance research activities through collaboration with companies and carried out initiatives such as SDGs

1 The Program on Open Innovation Platform for Industry-Academia Co-Creation (COI- NEXT) https://www.jst.go.jp/pf/platform/index.html

2 Sustainable Development Goals

3 Program on Open Innovation Platform with Enterprises, Research Institute and Academia https://www.jst.go.jp/opera/index.html

and pre-venture activities. Also, the TIA Graduate School Summer Open Festival, a human resource development project of TIA, was held virtually. "Nanotech CUPAL[1]," which aims to foster young researchers, held the "Summary Report Meeting for the Human Resource Development Project CUPAL" in the final year of the project.

(2) Kansai Science City

Kansai Science City is promoting the construction of towns that will play a role as bases for developing the world's culture, science and research and the nation's economy. As of the end of FY2022, it had over 150 facilities at which various research activities were under way.

6. Promoting Open Innovation Platform for industry academia partnership in diverse fields

MAFF has been promoting development of the Field for Knowledge Integration and Innovation (FKII) to promote research in industry-academia-government collaboration that introduces technologies of various fields into agriculture, forestry, fisheries and foods.

In April 2016, the ministry established "The Council of Industry-Academia-Government Collaboration, Field for knowledge Integration and Innovation (FKII)." As of March 2022, it has 4,597 members, including researchers, producers, and companies from various fields. As of March 2022, 178 R&D platforms are active, creating research strategies and business models for specific purposes. Furthermore, research consortiums have been formed within the R&D platforms to carry out R&D and commercialize their results.

7. Creating an environment that facilitates matching of technology seeds and needs

In cooperation with the relevant ministries and institutions, MAFF holds the Agribusiness Creation Fair every year. The objective is to exhibit technology seeds from private companies, universities, public experimental research institutions and independent administrative institutions, and to promote collaboration with institutions which are in need of technology. In FY2022, 130 institutions from across Japan gathered at Tokyo Big Sight to present information on their latest findings and industrial applications, and nearly 20,000 people attended the three-day event.

MEXT, through its "Program for Building Regional Innovation Ecosystems[2]," supports commercialization projects that can be developed globally by incorporating human resources and technologies from within and outside the region, with the source of the region's competitiveness (core technologies, etc.) at the core and having a high social impact despite high risks. A total of 21 regions have been selected for the program to date.

The research institutes of universities, national research and development agencies, business enterprises, and local governments are invited by MIC to apply for funding for new and innovative R&D projects in the field of ICT. Through the Strategic Information and Communications R&D Promotion Programme (SCOPE[3]), which is entrusted with research and development, MEXT is promoting the generation of new value for the society of the future, the development of young ICT researchers, the discovery of novel technologies by small and medium-sized

1 Nanotech Career-up Alliance
2 Program for Building Regional Innovation Ecosystems
https://www.mext.go.jp/a_menu/kagaku/chiiki/program/1367366.htm
3 Strategic Information and Communications R&D Promotion Programme

enterprises, regional revitalization through the utilization of ICT, and the attainment of international standards.

In its "Project for Creating Hub for Industry-Academia Fusion" initiated in FY2020, METI is supporting a hub for industry-academia collaboration that will be the base for a model hub actively working on cutting-edge interdisciplinary industry-academia initiatives and a university-based corporate network, and working toward promoting open innovation and new developments in industry-academia partnerships. In addition, METI is supporting the development of incubation facilities and industry-academia fusion centers at universities, etc. to encourage the creation of startups and the promotion of industry-academia collaboration in FY2022's "Project for the Development of Incubation and Industry-Academia Fusion Centers at Core Universities in the Region."

MAFF operates the Research program on development of innovative technology through BRAIN. This program contributes to the fostering of innovation in the fields of agriculture, forestry, fisheries, and food, and to the resolution of regional issues in an invitation for funding applications by supporting research and development that brings together diversified knowledge and technologies from a variety of fields. In addition, MAFF has assigned industry-academia-collaboration coordinators nationwide who are experts in agriculture, forestry and fishery and on food industries. They promote R&D in these fields through collection/identification of needs and collection/provision of seeds while supporting industry-academia-government matching, introducing and supporting R&D funding and supporting commercialization. In addition, MAFF is promoting initiatives such as holding new technology promotion forums to support the promotion of research and development and the dissemination of new technologies tailored to local conditions.

AIST is working in close coordination with public experimental research institutions (PERIs) through human exchange to discover needs of local companies and provide them technical support using technology seeds of AIST. Specifically, AIST commissions or employs 137 PERI personnel and former senior officials as AIST Innovation Coordinators who coordinate "bridging" to local companies, and has been strengthening the cooperation system among PERIs as well as their cooperation with AIST through the Industrial Technology Liaison Council and also supporting improvement of technical abilities of personnel and human resource development at PERIs. Furthermore, AIST is actively promoting cooperation with local authorities by signing a comprehensive agreement, and cooperation in the technical field suitable for the characteristics of the regional industry by using the subsidy program of local authorities. This way, by transferring its technical seeds to business activities at the local and national levels to contribute to technical competitive power of local companies, AIST is working on regional revitalization.

❹ Creation of a world-class startup ecosystem

Toward the solution of social challenges through the creation of a startup ecosystem and innovations, the Cabinet Office, MEXT, and METI formulated "Beyond Limits. Unlock Our Potential - Strategies for creation of a startup ecosystem to compete with the world top ecosystems-" in June 2019. In FY2020, four global base cities and four promotion base cities were selected. The Global Startup Acceleration Program (GSAP) is being implemented to encourage startups in the hub cities to enter the global market and attract

investment from foreign investors, with intensive support being provided by the government, government-related organizations and private supporters to promote the formation of a world-class startup ecosystem.

While cooperating with top overseas universities and other organizations, the government promotes the specification of the concept of creating "Global Startup Campus" deep-tech research and incubation functions. This initiative aims to generate startups that are ready to compete globally by forming an ecosystem of startups meeting global standards based on private funding and flexible management.

❺ Developing human resources capable of taking on challenges

As part of the "Program for Creating STartups from Advanced Research and Technology (START)," JST is supporting cities that are hubs for startup ecosystems, in addition to supporting the establishment of entrepreneurship support systems such as universities, including entrepreneurship training. In the second supplementary budget for FY2022, JST is implementing the "EDGE-PRIME Initiative" to support the expansion of entrepreneurship training to gifted children and high school students, who are the gateway to realizing future plans, mainly in the startup ecosystem cities. MEXT appointed ten entrepreneurs "Education Ambassadors for Entrepreneurship[1]" to enhance this momentum.

To further promote the fostering of entrepreneurship throughout Japan, MEXT has implemented the "Nationwide Entrepreneurship Promotion Project " since FY2022. As part of it, MEXT has conducted the "National Entrepreneurship Human Resources Development Program" online to expand educational opportunities for university students nationwide.

MEXT is also implementing the "Building of Consortia for the Development of Human Resources in Science and Technology" program, in which consortiums are formed by several universities, etc., in collaboration with companies to increase the mobility of researchers and advance their careers while securing stable employment.

In December 2014, MEXT and METI published the "Basic Framework of the Cross-appointment System and Points to Note," which is based on recognizing the importance of promoting a cross-appointment system that allows researchers to engage in R&D and education according to their roles at each institution and under a certain level of effort management, while being employed at each institution based on an agreement on secondment between multiple institutions, outlining the points to note when implementing the system and providing examples of implementation. A supplemental version of the report was published in June 2020 to promote the introduction of the cross-appointment system.

❻ Continuation and technological succession of R&D for important technologies that are highly necessary to be retained in Japan

In the event it becomes difficult for companies, etc. to continue research on important technologies that are highly necessary to be retained in Japan, AIST will, to the extent possible, utilize various acceptance systems and provide support such as

1 Education Ambassadors for Entrepreneurship
https://www.mext.go.jp/a_menu/shinkou/sangaku/mext_00009.html

temporary employment of the relevant researchers and taking over or continuing the research for a certain period of time, on the assumption that the relevant technologies will be handed over to Japanese companies in the future.

5 Urban and regional development that will serve as infrastructure to pass on to the next generation (development of smart cities)

The government of Japan aims to create a society with sustainable living infrastructure that maximizes human vitality for all stakeholders through the creation of diverse and sustainable cities and regions nationwide that can solve urban and regional issues and continue to create new value while demonstrating regional potential.

❶ Development of infrastructure to facilitate data utilization and development of city OS[1] that enables data linkage

The Cabinet Office, Government of Japan, has been conducting a survey to organize the issues that need revision in "Smart City Reference Architecture," a common design framework for building smart cities (prepared as part of the 2nd Period of the SIP program. Big Data and AI-Enabled Cyberspace Technologies, published in March 2020).

❷ Development of smart city creation examples throughout Japan with collaboration centered around super cities

Based on the Act Partially Amending the Act on National Strategic Special Zones (Act No. 34 of 2020), the government is promoting discussions and initiatives that will lead the world toward the realization of a future way of life by 2030.

In April 2022, Tsukuba City in Ibaraki Prefecture and Osaka City in Osaka Prefecture were designated as Super City National Strategic Special Zones, while Kaga City in Ishikawa Prefecture, Chino City in Nagano Prefecture, and Kibichūō Town in Okayama Prefecture were designated as Digital Garden Health Special Zones, following deliberations at the Council on National Strategic Special Zones, etc. In March 2023, the Council on National Strategic Special Zones was established for Super City National Strategic Special Zones and Digital Garden Health Special Zones. In accordance with the zone policy, which defines the goals and project orientation of each special zone, the first zone plan was prepared and approved by the Prime Minister, which included initiatives to support business startups. Super cities are aimed at advancing DX and realizing a future society in a wide range of fields through regional digitalization and regulatory reform. In addition, the Digital Garden Health Special Zones aims to be a pioneering model for solving regional issues by focusing on issues that are particularly problematic in rural areas, such as declining population, falling birthrate and aging population, through the use of digital technology. In these special zones, efforts are being made to link data and realize cutting-edge services, accompanied by bold regulatory reforms. The government will continue to work on bedrock regulatory reform throughout the National Strategic Special Zones to accelerate the deployment of results from zones that have no exceptional adverse effects.

The Comprehensive Special Zone System consists of an "International Strategic Comprehensive Special Zone," which aims to create a focal point of industries and functions that will serve as the engine for Japan's economic growth, and "Comprehensive Special Zones for Regional Revitalization," which aim to enhance regional

1 Abbreviation for city operating system. A generic term for an IT system that facilitates the introduction of services in various fields to be introduced in smart cities by integrating functions commonly utilized by regions that are wanting to realize smart cities

competitiveness through regional revitalization efforts that make the most of regional resources. The government provides comprehensive support through special regulatory measures, taxation (only for International Strategic Comprehensive Special Zones), and fiscal and financial support measures.

Additionally, related ministries and agencies are promoting local and private-sector-led initiatives to implement advanced services by providing support for matching local governments and private companies through the Smart City Public-Private Partnership Platform and through the horizontal deployment and dissemination of leading examples using the Smart City Guidebook (published in April 2021).

The Cabinet Office, the Government of Japan and related ministries and agencies are working together toward the implementation and spread of smart cities, such as jointly selecting areas for smart city-related projects at the Joint Council on Smart City-Related Projects.

The Cabinet Office of the Government of Japan, together with relevant ministries and agencies, will study Smart City evaluation indicators. The results were compiled into a "Policy for the Establishment of Smart City KPIs (published in April 2022)" to contribute to the establishment of KPIs in the region, and efforts were made to improve the KPIs.

❸ International expansion

Under Japan's concept of "free and open smart cities," the government is utilizing the "Smart City Catalog" to disseminate information at international activities such as the Global Smart City Alliance (GSCA) and various international conferences.

Related ministries and agencies are also promoting initiatives for developing smart cities through the framework of the ASEAN-Japan[1] Smart Cities Network, such as by conducting project formulation surveys and holding the ASEAN-Japan Smart Cities Network High Level Meeting (4th meeting held in October 2022) with the participation of relevant countries and cities.

Moreover, the relevant ministries and agencies have examined proposals for international standards and the establishment of Japanese and international frameworks in cooperation with foreign standards experts from Japan and overseas to promote the overseas development of Smart Cities by utilizing international standards.

❹ Developing next-generation human resources for sustainable activities

Related ministries and agencies have worked to spread and permeate the Smart City Guidebook, which includes tackling cases of leading initiatives on issues such as capable personnel development necessary for the realization of smart cities, and have been considering initiatives to solve such operational issues.

6 Promoting R&D and social implementation to resolve various social issues and utilizing Convergence Knowledge (So-Go-Chi)

While utilizing "Convergence Knowledge (So-Go-Chi)" based on the fusion of humanities, social sciences, and natural sciences and in collaboration with countries, regions, and international organizations that share values with our country, the government aims to create a society where future industry creation and economic growth are compatible with the resolution of social issues and challenges by working on R&D and social implementation of the results.

1 Association of South East Asian Nations

❶ Formulation and promotion of national strategies based on a vision of future society and evidence utilizing the Convergence Knowledge (So-Go-Chi)

1. "Convergence Knowledge (So-Go-Chi)" that contributes to comprehensive understanding and problem solving of humans and society

The Cabinet Office, the Government of Japan, has studied the basic concept of "Convergence Knowledge (So-Go-Chi)" that contributes to a comprehensive understanding of human beings and society and to the solution of problems based on the social background in which "Convergence Knowledge (So-Go-Chi)" is required, as well as strategic promotion measures, and compiled them in a mid-term report.

2. Sectoral strategies

For areas that should be promoted across ministries and agencies, such as AI (see Chapter 2, Section 1, Subsection 1 ❹); biotechnology, quantum technology, materials and space (see Chapter 2, Section 1, Subsection 3 ❺); marine (see Chapter 2, Section 1, Subsection 3 ❺); environment and energy (see Chapter 2, Section 1, Subsection 2); health and medical care, food, agriculture, forestry and fisheries (see Chapter 2, Section 1, Subsection 2 ❶); fusion energy (see Chapter 2, Section 1, Subsection 2 ❼); research and development, etc., are being promoted based on national strategies. Among the sectoral strategies not described elsewhere in this white paper, those for biotechnology, quantum technology, materials, health and healthcare, and fusion energy are described below.

(1) Biotechnology

Given the growing worldwide interest in bioeconomy, the government formulated the "Bio-Economy Strategy 2019" in FY2019 with the overall goal of "achieving the world's state-of-the-art bioeconomy society by 2030," and the policy is being promoted while revising the strategy. Following the outbreak of the COVID-19 pandemic at the beginning of 2020, the "Bio-Economy Strategy 2020 (cross-sectional policy)" and "Bio- Economy Strategy 2020 (market areas policy)" were both formulated as separate volumes in FY2020, with a view to responding to the immediate need for R&D to contain the spread of infectious diseases in line with the Bio-Economy Strategy 2019 and to achieving a rapid economic recovery after their containment. After the subsequent dizzying developments in response to COVID-19 infections and the international response to climate change, etc. The volumes were integrated in FY2021 into the "Integrated Innovation Strategy" in consideration of these trends. Essentially making the Integrated Innovation Strategy the Bio-Economy Strategy of today.

There are three pillars that comprise the Bio-Economy Strategy: expanding bio-related markets, building the biocommunities, and developing data infrastructure. For the expansion of bio-related markets, the government aims to generate bio-related markets totaling 92 trillion yen by 2030 and has established nine market areas to expand these markets. The nine market areas are grouped into three areas: bio-manufacturing, primary production, etc., and health and healthcare. METI is responsible for bio-manufacturing, MAFF for primary production, and the Cabinet Office of the Government of Japan for health and healthcare. Each has developed market area roadmaps and is promoting their respective initiatives. Moreover, the Cabinet Office of the Government of Japan is also working on building the biocommunities. Building the biocommunities is an initiative to expand bio-related markets by creating diverse and unique communities across Japan and building value chains in each market area by continuously

supporting their growth. Reflecting on past measures related to the formation of biotechnology hubs, the Cabinet Office believes there was insufficient discussion on what the centers should be and what issues they face with limited resources (such as capable personnel and financial resources). On the basis of the above, the Cabinet Office stresses the establishment of a system to clarify this vision and attract capable personnel and investment from outside these entities. There are two tiers of promotional activities to build the biocommunities: building global biocommunities to lead the world in the field of biotechnology, and building regional biocommunities that realize ecosystems based on distinctive initiatives that capitalize on the strengths of local communities. In April 2022, two centers of the global biocommunity were accredited: the Greater Tokyo Biocommunity in the Tokyo metropolitan area and Biocommunity Kansai (BiocK) in the Kansai area. Two new regional biocommunities were accredited in December 2022, the Hiroshima Bio-DX Community and the Okinawa Bio-Community, bringing the total number of accredited regional biocommunities to six in Japan. Furthermore, to promote and encourage activities among the biocommunities, a "Public-Private Partnership Platform" meeting was held to bring together these communities, relevant ministries, related organizations, staff of overseas diplomatic missions, etc., to make a "Support Package for Bio-Community Development" and to discuss the status of each biocommunity. The establishment of a website to provide one-stop access to information on the status of each biocommunity and reference information is also underway. In regard to the preparation of a data platform, the integration of bio- and digital technology is vital for future research and development and commercialization in the field of biotechnology. Consequently, initiatives are underway to create an environment that enables a wide range of flexible data linkages.

(2) Quantum technologies

Quantum science and technologies (optical and quantum technologies) are generic technologies that can become the core for the creation of values, which include ultra-high-speed processing of data that have been increasing explosively in recent years. In recent years, worldwide research and development on quantum science and technology has intensified, and overseas, in the US, Europe and China, in particular, governments have formulated R&D strategies and increased R&D investments. Leading IT companies in the world are also making rigorous investments while venture companies have been established and raising funds.

In light of the advanced nature of such quantum science and technology and their fundamental nature to support all sciences and technologies and international trends, the government formulated the "Quantum Technology and Innovation Strategy" in January 2020. Based on this strategy, it has been engaged in strategic R&D focused on "Quantum Technology Innovation Centers," consisting of eight domestic hubs established in February 2021. In April 2022, "Vision of Quantum Future Society" was launched in order to realize the social application of quantum technology and the strengthening of the quantum industry in the face of changing external conditions, such as intense international competition in the quantum industry. It sets forth the conditions that should be achieved by 2030, including a goal of reaching 10 million users of quantum technology in Japan. To achieve this goal, the Center is promoting the hybridization of quantum and classical technological systems, the development of a test bed for quantum computers and communications, the promotion of R&D for and utilization of

quantum technology, and the creation and stimulation of new industries and startup companies. The government is being called on to respond flexibly to efforts to achieve a sustainable society and economy in the practical application and industrialization of quantum technology. With the goal of realizing the "Vision of a Quantum Future Society," the government is focusing on the practical application and industrialization of quantum technology through industry-university-government partnerships. The Cabinet Office of the Government of Japan has held a working group on promoting the practical application of quantum technology to discuss the direction of specific efforts that should be emphasized and prioritized in order to formulate a new strategy.

Under the 2nd Period of the SIP Program that has been implemented since FY 2018, the Cabinet Office has been promoting R&D and social implementation of (1) laser processing, (2) optical/quantum communication, (3) optical electronical information processing and a network-type production system that will integrate them. In R&D on the Photonic Crystal Surface Emitting Laser (PCSEL[1]) of (1), in particular, succeeded in developing the most miniature LiDAR[2] system in its class, which is 1/3 the volume of previous systems and is also working on increasing brightness and performance for ultra-compact laser processing systems. Furthermore, the office set up the "Quantum Technology Domain" in the PRISM Program in June 2020 to support R&D contributing to the expansion of public and private R&D investments. Furthermore, in January FY2020, under the Moonshot Research and Development Program, the Moonshot Goals, "Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050," was set to promote challenging research and development.

MIC and NICT have been working on R&D of quantum encryption that is impossible for computers to decode and quantum communication technologies based on quantum signal processing that extracts information from a single photon. MIC also supports R&D on elementary technologies for the realization of a quantum Internet, an anticipated future social infrastructure, and R&D on technologies for long-distance quantum key distribution in terrestrial systems (long-distance link and relay technologies). Furthermore, in order to introduce quantum cryptography that has been developed for terrestrial fields to satellite communication, the Institute has been working on R&D for construction of a system that is operable under the restrictive environment of outer space, technology for earth stations to accurately receive light from rapidly moving satellites and technologies mountable on microsatellites. Since FY2021, research and development are being conducted for the Building a Global Quantum Cryptography Communication Network that integrates terrestrial and satellite networks. In conjunction with the above, with a view to the advancement of 5G and other technologies, MIC is conducting research and development of technologies to add functions to common key cryptosystems and post-quantum cryptography (PQC) that support ultra-high speeds and large capacities to prevent decryption by large-scale quantum computers, etc.

MEXT has been implementing the "Quantum Leap Flagship Program (Q-LEAP)" program since FY2008 targeting (1) Quantum information technology (Quantum simulator, Quantum computer), (2) Quantum metrology & sensing, and (3) Next generation laser and is promoting the

1 Photonic Crystal Surface Emitting Lasers
2 Light Detection And Ranging

Flagship Project, basic fundamental research, and are promoting the Flagship Project, which conducts research and development aimed at demonstrating prototypes, basic research and development of human resource development programs. The project has developed a Japanese quantum computer (superconducting method) since FY2018, and RIKEN released the first unit on its Cloud on March 27, 2023. The Ministry will foster R&D efforts toward the release of the next-generation machine (100 qubits) in FY2025.

As a center for quantum technology innovation, the National Institutes for Quantum Science and Technology (QST) is working on R&D in quantum life sciences, a fusion of quantum-related technologies such as quantum measurement and sensing, and life sciences and medicine at its center for quantum life sciences (established in February 2021). At the same time, its Center for Quantum Materials and Applications (established in May 2022) is engaged in R&D for quantum materials with advanced properties. Moreover, QST is also engaged in research on the miniaturization and refinement of a charged particle radiotherapy device.

METI through the "Project for Innovative AI Chip and Next-Generation Computing Technology Development," which began in FY2018, has been developing a quantum computer specialized (quantum annealing machine) for "combinatorial optimization problems" that exist extensively in society. Integrated development of quantum annealing machines, from hardware to software to applications, is underway, and in FY2019, the development of interface integrated circuits to connect common software and hardware was started. From FY2021, these three topics of quantum annealing, hardware, software, and interface were consolidated into "Comprehensive R&D for Quantum and I-Sing Computing Systems," enabling R&D for practical applications to be conducted in a more integrated manner.

A second supplementary budget for FY2022 was allocated to establish a global industrialization center at AIST with facilities for R&D and performance evaluation of quantum computers, devices, and materials for quantum computers to accelerate the industrial use of quantum technology.

(3) Materials

The materials area is highly competitive in Japan's industry and academia, supports a wide range of diverse research areas and applications, and, due to its transversal nature, contributes to solving a wide range of social problems as a key to bringing about discontinuous innovation through the fusion of different fields and technologies, and is a fundamental technology that will be the core for creation of values in future society.

In light of the importance of this field and with its vision for society and industry for the year 2030, the government of Japan announced the "Materials Innovation Strategy" at the Council for Integrated Innovation Strategy in April 2021 to enhance "the ability to create materials innovations" or the "materials innovation capacity," which will play an important role in realizing Society 5.0, achieving the SDGs, overcoming resource and environmental constraints, and building a strong society and industry. The strategy promotes the (1) Development and swift social implementation of innovative materials; (2) Use materials data and manufacturing technology to promote data-driven research and development; and (3) More sustainable international competitiveness under the common vision of the industry, academia, and government, leveraging the strengths of Japan, which has a large number of diverse researchers and companies and a world-class research and development infrastructure.

MEXT strategically promotes basic and

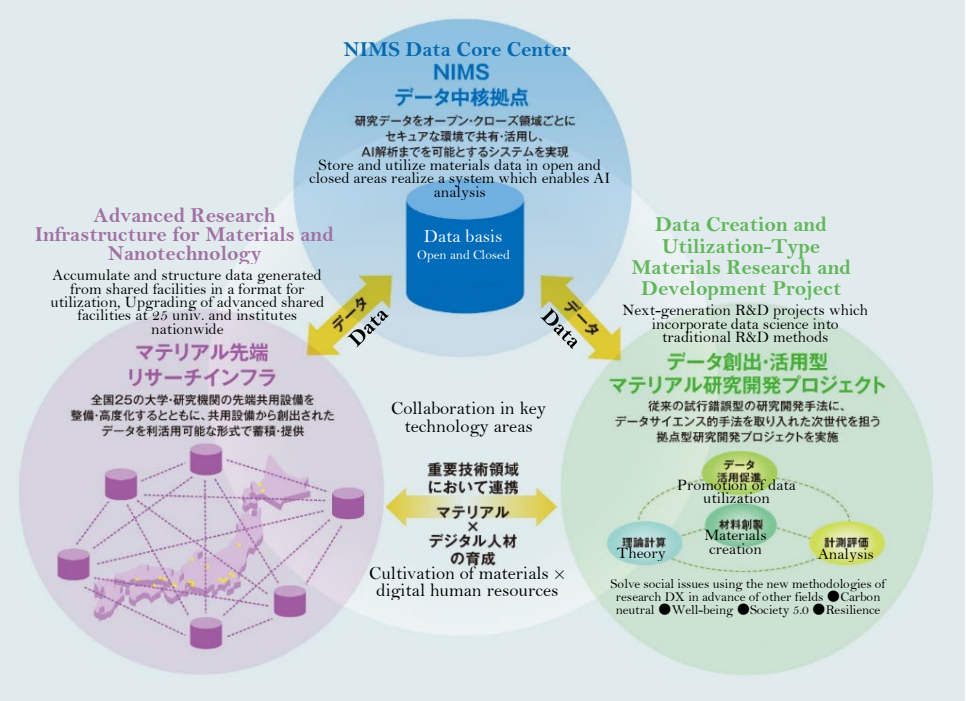
pioneering research in this field to technological development from the perspective of practical application and supports the formation of research and development centers. Specifically, "Materials Processing Science project" (Materealize) aims to establish a system of cooperation between industry, academia, and government at universities, etc., and to build an academic and scientific infrastructure to solve process issues to lead to the social implementation of innovative materials that have innovative functions but require the establishment of process technology.

In light of the stated need to develop a data-centric R&D platform and promote the utilization of materials data, under the "Materials Innovation Strategy," MEXT established a new hub-and-spoke system consisting of a hub with diverse research facilities and spokes with distinctive technologies and equipment using the advanced equipment sharing system of the "Nanotechnology Platform" as a base and launched the "Advanced Research Infrastructure for Materials and Nanotechnology (ARIM)" from FY2021 to establish a nationwide infrastructure for shared use of state-of-the-art facilities capable of generating high-quality data. This project is proceeding with the establishment of a platform for strategically collecting, accumulating, structuring and nationwide utilization of materials data from industry-academia materials data through a Data Core Center installed by NIMS. Additionally, the "Data Creation and Utilization-Type Materials Research and Development Project, "DxMT," aims to pioneer ultra-fast and innovative materials research methods using data, and to develop and deploy them throughout Japan. Full-scale research began in FY2022, based on the feasibility study conducted in FY2021, and the government is promoting R&D that handles everything from the creation, integration, and sharing of research data to its utilization seamlessly.

NIMS conducts basic research and R&D on materials science and technology, aiming for breakthroughs toward the creation of new substances and materials. In addition to promoting research and development of innovative materials that contribute to the government's priority fields, such as quantum, carbon neutral, and biotechnology, the program also establishes a place for the creation of innovative materials by integrating basic research with the needs of the industrial sector and a global center where researchers from around the world can gather, to vigorously promote innovation creation in the materials field, and the "Program for Strengthening Innovative Materials Development-M3 (M-cube)" is being implemented as a project to develop a research infrastructure to maximize these activities. From FY2020, NIMS carried out the development of a system as a core database that enables the use of materials data created from cutting-edge shared facilities across Japan, including strategic collection, accumulation and AI analysis, and NIMS has developed facilities for starting trial operations in FY2023, which is also listed in the Material Innovation Strategy.

To accelerate the development of process technologies using data in order to further promote manufacturing process technologies in fields where Japan has advantages, METI has established material process innovation platforms at three AIST bases, Tsukuba Center, Chubu Center, and Chugoku Center and began full-scale operation in FY2022.

The Cabinet Office of the Government of Japan chose the "Development of Fundamental Technologies for Innovative Materials Processes" as a candidate for the 3rd SIP theme starting in FY2023 and initiated a feasibility study in FY2022. This process revealed cases where the government's investment in data-driven



Overview illustration of a material DX platform
Source: ARIM pamphlet

development in the materials field significantly shortened the speed of development: Japan has a large number of promising markets where materials are central to long-term macro-trends, and it has many decentralized data and evaluation analysis platforms for a wide variety of materials that are not available in other countries. Based on these findings, a network platform was created in the 3rd SIP theme, "Creation of an Ecosystem for Innovation and Fostering of Materials Commercialization." The project will be used as a starting point for the creation of applications necessary for venture companies to establish innovative businesses. This will result in the formation of an ecosystem conducive to the creation of a succession of unicorns.

METI is working together to overcome restrictions on the procurement of rare elements such as rare earth and rare metals, which are essential raw materials for next-generation vehicles and wind power generation, and to save energy.

In addition, the "Project to Develop New Structural Materials to Radically Reduce the Weight of Transportation Equipment" aims to reduce energy consumption by transportation equipment through weight reduction. It also involves the development of thin, light steel plates and steel plates with improved strength, workability, and other functions using economical carbons that minimize the use of rare metals, aluminum, magnesium, titanium, carbon fiber, and carbon fiber composites, with the aim of energy saving in transportation equipment through weight reduction. The project is also developing multi-material technology to use multiple materials according to their strengths. In addition, to promote the effective utilization of urban mines in Japan, realize the stable supply of resources and resource saving and energy saving with the "Resource Circulation System Advancement Promotion Project," automatic sorting technology of waste products and waste parts, high-efficiency smelting technology, and arteriovenous information cooperation system are being developed. Furthermore, to strengthen the supply

chain of rare earth, which have a high risk of supply disruption, through "technology development and demonstration project that contributes to supply chain resilience," the organization is working to reduce the use of rare earth as much as possible, develop high-performance magnets that do not use rare earth and develop technologies to use low-grade rare earth that are difficult to use due to many impurities.

(4) Healthcare

Led by the Headquarters for Healthcare Policy, the government has promoted activities based on its new, 2nd "Healthcare Policy" since FY2020. The healthcare sector should comprehensively and systematically promote medical R&D that contributes to the provision of world-class medical care, and the creation of new industrial activities that contribute to the formation of such a society where all citizens can enjoy healthy lives and longevity (Approved by Cabinet decision on March 27, 2020. Partially amended on April 9, 2021.) and the "Plan for Promotion of Medical Research and Development" (Approved by the Headquarters for Healthcare Policy on March 27, 2020. Partially amended on April 6, 2021.)[1]

Previously managed by each of the relevant ministries and agencies, the budget for R&D in the medical sector has been consolidated under AMED and organized into six integrated projects described in A (1) through (6). Doing so with AMED as the core will promote consistent R&D from basic research to practical application. It is working to prepare an environment in which certified providers will be able to operate smoothly by requesting medical institutions, local governments, etc., to cooperate in providing medical information to certified providers based on the "Act on Anonymized Medical Data That Are Meant to Contribute to Research and Development in the Medical Field" (Act No. 28 of 2017).

A. Six Integrated Projects

❶ Pharmaceutical Product Project

From targeted drug discovery to clinical research, R&D is being conducted in consideration of the characteristics and properties of the modality to promote the practical application of drugs that meet the needs of medical professionals and patients.

Some examples from FY2022 include the promotion of drug delivery research through medicine-engineering collaborations, which is a challenge in the development of new modalities; the development of manufacturing technologies for internationally competitive next-generation antibody drugs; and the strengthening of infrastructure to support drug discovery by promoting the automation and remote operation of cryo-EM experiments. As an effort to accelerate the pace of practical applications, the Frank Conference between Academia and Industry for Leading united Translational Research on Academia Seeds (AMED-FLuX) since FY2021 has been a forum for the exchange of opinions between researchers in academia and experts from companies.

❷ Medical Devices and Health Care Project

The project aims to conduct R&D on medical devices and healthcare that will contribute to advanced diagnosis and treatment, prevention, and improved quality of life by fusing AI and IoT

1 Headquarters for Healthcare Policy
https://www.kantei.go.jp/jp/singi/kenkouiryou/senryaku/index.html

technologies, measurement technologies, robotics technologies, etc. With AMED as the core, this project is supported by METI, MEXT, MHLW, and MIC.

During FY2022, it enhanced the development of innovative medical devices, etc., utilizing technologies such as AI and robotics, and also advanced the development of medical devices, etc., for early diagnosis and prevention and minimally invasive treatment, etc., according to the characteristics of diseases, based on the future needs of the medical and welfare sectors.

❸ Regenerative and Cellular Medicine and Gene Therapy Project

For the practical application of regenerative and cellular medicine, the project has conducted R&D on gene transfer and gene editing technologies in relation to gene therapies, as well as basic research on cell cultures and differentiation induction, etc.; non-clinical and clinical research by disease/tissue and basic manufacturing technology; drug discovery research to elucidate the pathogenesis of incurable diseases and other diseases using disease-specific iPS Cells, etc.; and built the necessary infrastructure. The project is also fostering R&D in these interdisciplinary areas.

R&D from basic research on practical applications was promoted in a unified manner in FY2022: In addition to engaging in basic research toward practical application of regenerative and cellular medicine using iPS cells and somatic stem cells, integrated research with gene therapy and drug discovery research based on the understanding of pathological mechanisms using iPS cells and other cell types, the Research Center Network for Realization of Regenerative Medicine of MEXT has partnered in promoting clinical research and clinical trials for MHLW's research project on the practical application of tissue engineering and developing manufacturing technology in METI's project to develop basic technology geared toward the industrialization of regenerative medicine and gene therapy.

❹ Genome Data Infrastructure Project

The Genome Data Infrastructure Project aims to realize individualized prevention and medical care by promoting the development and utilization of the genome data infrastructure and promoting research and development that contributes to the prevention, diagnosis, and treatment of disease onset and severity with an overview of the life stage.

A project to build a platform for integrated utilization of R&D healthcare data was initiated in FY2022, and multiple databases generated by all AMED projects were linked as a platform for data linkage in the healthcare sector. The first step was to develop a way to link previously collected genomic data to provide a widely used visiting environment with cross-sectional searchability and guaranteed security that allows users to import and handle data for R&D that includes the industrial sectors. As for the MHLW's practical application research projects, etc. on innovative cancer treatments, the building of basic information and systems that contribute to the identification of novel genetic factors explaining the diversification of the images of hereditary tumors has been promoted based on the "Action Plan for Whole Genome Analysis 2022." It promoted the construction of basic information and systems for data utilization. In addition, MEXT and Tohoku Medical Mega-Bank Project are further enhancing the genome database, including launching a general public and private joint genome analysis of 10 million people.

❺ Basic Research Project on Disease

The project aims to expand the applications of research and development in the medical field and

is engaged in basic R&D to clarify the functions of the brain, the immune system, aging, and other biological phenomena, as well as to elucidate the mechanisms of a variety of disorders.

For example, in light of the impact of COVID-19, the foundation for infectious disease research in Japan and abroad was strengthened, and basic research was promoted in the field of infectious diseases in FY2022. In relation to oncology, MIC developed effective therapeutic methods and supported research to discover and develop promising seeds. Furthermore, in the field of brain function research, we elucidated the entire neural circuitry responsible for higher functions in non-human primates at the neuron level and created a brain structure-function map to elucidate the working principles of the human brain.

❻ Platform Project on Seed Develop and Research

In addition to establishing a research system that transcends the organizational and disciplinary boundaries of academic institutions and implementing basic research, such as the creation and cultivation of groundbreaking seeds for the creation of new modalities and conduct of international joint research, the project is developing systems and mechanisms to discover and transfer seeds and conduct high-quality clinical research and clinical trials, and it is promoting reverse translational research and the establishment of an infrastructure for empirical research in transitional research support centers and core clinical research hospitals.

In FY2022, MEXT's Advanced Research and Development Programs for Medical Innovation continued to promote cutting-edge basic research, and MEXT and MHLW worked together to build a research infrastructure. The ministries strengthened support for seed research at transitional research support centers and developed a framework for conducting and supporting safe and high-quality clinical trials and clinical research at core clinical research hospitals. Additionally, a new program has been launched to support top international joint research as a funded project.

B. Research and Development According to Disease Categories

As part of the above six integrated projects, R&D related to diseases will also be carried out. In doing so, this project promotes the capability to flexibly manage R&D for each specific disease within a unified project since it is necessary to respond to a wide range of diseases and to respond dynamically through measures to combat infectious diseases, etc. Major efforts in each disease field in FY2022, especially for infectious diseases in response to the spread of COVID-19, include the promotion of support for the development of therapeutic methods, diagnostic methods, and vaccines. At the same time, based on the "Action Plan for Whole Genome Analysis 2022," the government is also promoting cutting-edge analyses of cancer and incurable diseases to advance better medical care for patients affected by them, including the development of medical care for cancer and intractable diseases, and to promote personalized medicine. In the field of geriatrics and dementia, the Dementia Research and Development Grants supported research that contributes to the differentiation of dementia-related diseases and the elucidation of their pathological mechanisms using retrospective cohort data.

C. Moonshot R&D Program

The program looks ahead to the future that we should aim for, including the creation of a society where people can enjoy their lives without health concerns until they are 100 years old. In order to

contribute to the healthcare field, the program is to be carried out in cooperation with the relevant ministries and agencies to take on social issues that are daunting but are anticipated to have a major impact if resolved by sufficiently partnering with the strategic promotion council and the goals set by the Council for Science, Technology and Innovation (CSTI) based on the ambitious goals of moonshot R&D.

To further strengthen the efforts in FY2022, the program newly adopted and initiated research on inflammation control, intestinal bacteria control, and two Cancer Moonshot initiative projects based on a Japan-U.S. Joint Statement, in addition to continuing to promote the five research projects adopted so far.

D. In-house R&D

With respect to in-house R&D in the medical category conducted by in-house research institutions under the jurisdiction of the relevant ministries and agencies, a regular mechanism to ensure information sharing and collaboration between the Headquarters for Healthcare Policy Secretariat, relevant ministries and agencies, in-house research institutions, and AMED is being established based on the traits of each institution, and overall strategic and systematic R&D as a whole is being appropriately promoted while partnering with and sharing roles with AMED's R&D support.

In FY2022, liaison and coordination meetings were held between in-house research institutions to share information, and collaborative research was conducted, including the implementation of a drug discovery support network (building a robust collaborative system and supporting research on practical applications aimed at creating innovative new drugs from the findings of universities and public research institutions). Specific examples of the efforts of in-house research institutions include RIKEN's development of basic technologies to realize longevity with good health by understanding human biology, as well as strategic promotion of R&D in the life science field. The National Institutes of Biomedical Innovation, Health and Nutrition (NIBIO) undertook research on basic technologies related to AI drug discovery, etc., and supported drug discovery, etc. AIST has been involved in the development of cell isolation technologies to support the screening of candidate drug compounds in the drug discovery support network. In order to generate new innovations aiming to achieve world-class R&D and medical care at other in-house research institutions, AIST actively worked on R&D that responded to new needs and fields in which effective R&D was expected.

(5) Fusion Energy

Fusion energy has the following advantages:

① Carbon neutrality
② Abundant fuel
③ Inherently safe
④ Environmental preservation

As such, fusion energy is expected to be the next-generation energy source that can solve both energy problems and global environmental problems at the same time. Any countries can produce the fuel as long as they have technology, and energy hegemony will shift from those countries possessing energy resources to those possessing the technology. It will become vital to ensure energy security through the acquisition of technology.

In December 2022, researchers at the Lawrence Livermore National Laboratory succeeded for the first time in history in generating more energy from a fusion reaction using the deuterium-tritium fuel than was necessary to produce it. Such government-led scientific and technological breakthroughs are being made, and private-sector

investment in this area is also increasing in many countries. The US and the UK governments formulated their national strategies targeting the commercialization of fusion energy and have started confining relevant technologies to their own countries. The race to commercialization has already begun without waiting for the actual realization of fusion power generation.

Japan is a strong partner candidate for other countries, because Japan possesses technological advantages cultivated through its research and development, reliability in its manufacturing industries, and the basic research infrastructure and human resources development frameworks for supporting those industries. The synergistic effects from cooperation with other countries allow the utilization of partner countries' technologies for domestic development and provide opportunities for the acquisition of overseas markets. At the same time, considering the accelerating pace in other countries, Japan is facing the risk of lagging behind in commercialization though it provides technology and losing market competitiveness as a result.

Based on the background described above, the government labeled its fusion strategy "Towards the practical realization of fusion energy, the world's next-generation energy source — The commercialization of fusion energy: Seizing the winning market edge by leveraging Japan's technological advantage" in April 2023. It suggests leveraging technological advantages to win over markets and industrializing fusion energy for its practical application. Achieving this vision will require vigorous promotion of (1) developing the fusion industry, (2) developing the fusion technology, and (3) a framework for promoting the Fusion Energy Innovation strategy, etc.

Column 6: Japan Medical Research and Development Grand Prize

Since FY2017, the Japan Medical Research and Development Grand Prize has been awarded by the Prime Minister, Minister of Healthcare Policy, Minister of Education, Culture, Sports, Science and Technology, Minister of Health, Labour and Welfare, Minister of Economy, Trade and Industry, and President of AMED, in order to recognize the achievements of examples of significant contributions to the promotion of research and development in the field of medicine for the development of medicine in Japan and around the world.

Previous prizes have been conferred for exemplary projects in the life sciences that have contributed to the identification of disease causes and drug discovery, and for the development of innovative drugs and medical devices that are widely used in medical settings.

In December 2021, the fifth Prime Minister's prize was awarded to Terumo Corporation and Shiniro Takeda, Chairman of Japan ECMOnet, for their efforts to improve the durability of ECMO, a medical device that assists cardiopulmonary functions, to ensure that it could be used over a long period of time through R&D. At the same time, the recipients supported capable personnel in the medical field, and improved the resuscitation rate of severe COVID-19 patients.

From the sixth awards, the scope of qualifying projects was expanded, a new startup category was introduced to honor startups, etc., with promising future prospects in medical R&D, and then a wide range of applications for funding were invited. Winners will be selected, and awards will be presented around the summer of 2023, following a selection process by prominent experts.

Fifth Award Ceremony for the Japan Medical Research and Development Grand Prize

Source: Website of the Prime Minister's Office of Japan
https://www.kantei.go.jp/jp/singi/kenkouiryou/suisin/amed/dai5/index.html

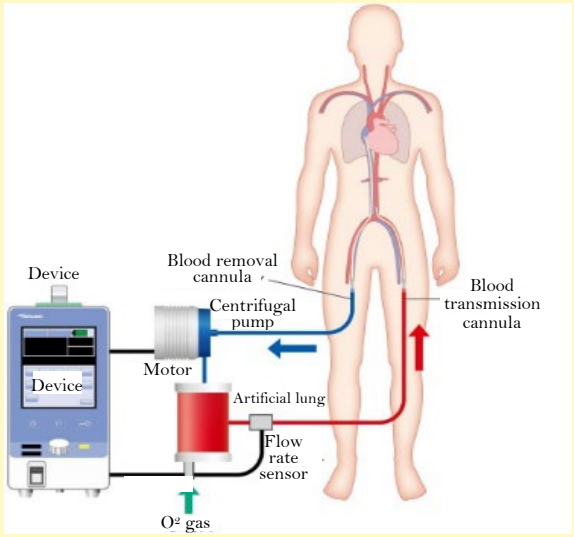


Diagram of ECMO-assisted cardiopulmonary bypass

Provided by: Terumo Corporation
https://www.kantei.go.jp/jp/singi/kenkouiryou/suisin/amed/dai5/pdf/prime_minister_award.pdf

The government is committed to promoting the Japan Medical Research and Development Grand Prize with the aim of encouraging the societal application of the findings of outstanding medical research and achievements produced by startup companies and their feedback to the public.

Column 7: Aiming for More Extensive Utilization of Medical Information—Next-Generation Medical Infrastructure Act

The environment encompassing the medical field has drastically shifted in recent years in conjunction with the spread of COVID-19 and the advancement of digitalization, which makes it even more important for medical information, including electronic medical records, to be utilized.

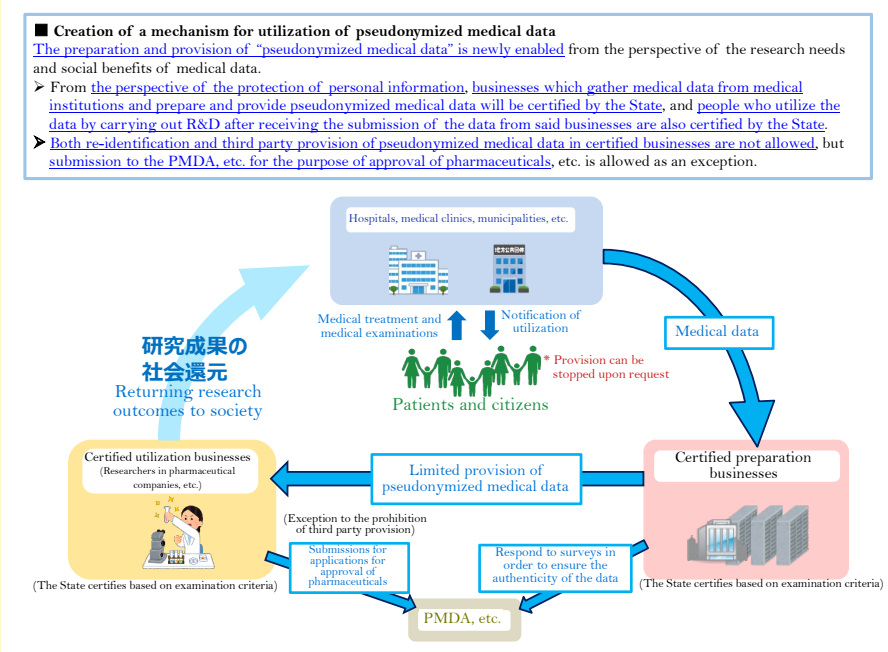
On the other hand, in Japan, medical billing statement (receipts) are the fundamental data available for utilization on a national scale, yet the utilization of data related to the results of medical treatment (outcomes) has not sufficiently progressed. Private medical institutions are the main source of medical information in Japan, so this information is decentralized due to the segmented nature of the insurance system.

Considering the above situation, the "Next-Generation Medical Infrastructure Act" (official name: Act on Anonymized Medical Data That Are Meant to Contribute to Research and Development in the Medical Field) (Act No. 28 of 2017) is an act for promoting the utilization of high-quality medical information and its application to research and development.

To accomplish the aim of the Act (which is to promote cutting-edge research and development in healthcare and to create a new industry that contributes to longevity in a healthy society), three government-authorized operators have collected the medical information of a total of some 2.6 million people from 108 medical institutions across Japan (as of the end of FY2022), based on notifications to patients. After this medical information is anonymized by authorized operators to prevent the identification of individuals, it is provided to pharmaceutical companies, university researchers, and other organizations. The use of the scheme is gradually progressing, evidenced by 21 organizations utilizing it.

On the other hand, it has been pointed out that restrictions unique to anonymized processing, in which a specific individual's information is processed so as to prevent identification, are that data on singular numerical values and rare cases will be processed, it is not possible to respond to continuous and evolving data provision, and it is challenging to validate the data by going back to the original data. Another ongoing issue is how to facilitate the collection of a wide variety of medical information in cooperation with medical institutions.

With these issues under consideration, discussions were held between a variety of experts. The discussions revolved around the establishment of a new framework for the utilization of pseudonymized medical information (see figure) and the enabling of consolidated analysis of information in public databases, such as NDB[1], and anonymized medical information. Afterward, a bill to amend this act was submitted to the Japanese Diet. Thereafter, it was adopted and enacted on May 17, 2023.



Establishing a framework for the utilization of pseudonymized medical information
Source: Cabinet Office, Government of Japan

The amendment is expected to enable the provision of high-utility data, including utilization in applications for pharmaceutical approval, materialize the consolidated analysis of anonymized medical information and other public databases, and further advance research and development in the medical field. The government will thoroughly safeguard the rights and interests of individuals as it promotes the further utilization of medical information to address the needs of drug discovery and other research areas.

1 A database that manages information on specified health examinations, specified health guidance information, and receipt information of the public based on the Act on Assurance of Medical Care for Elderly People.

3. Formulation of evidence-based strategies, planning and promotion of policies that embody the future society

As part of its exploration and analysis of long-term changes in examining the visions of future societies, the National Institute of Science and Technology Policy (NISTEP) of MEXT conducts the science and technology foresight survey every five years (initially conducted in 1971 by the Science and Technology Agency). For the next twelfth survey, a wide range of expert knowledge is being collected and accumulated through annual questionnaires to experts on science and technology that attract their attention as horizon scanning to capture early signs of science and technology and society, beginning in FY2020. As part of the twelfth survey, a visioning survey has been conducted since FY2022 to identify and analyze future changes in individual and societal values and the visions of "preferred" futures.

To contribute to the exploration and identification of important science and technology areas, the Cabinet Office, Government of Japan, has developed tools to identify global research trends and Japan's strengths and weaknesses in technologies of interest based on information from academic papers, and is promoting their use in policy deliberations. In addition, various data necessary for analysis are collected through the Cross-ministerial R&D Management System (e-Rad). These data are utilized in the evidence system (e-CSTI[1]) to analyze research expenses and research outputs, to analyze how many research facilities and equipment are shared, and how much external funds are obtained, and to analyze the human resource development needs of the industry and the status of subjects/courses taken by students.

NISTEP of MEXT established a data and information infrastructure to systematically and continuously develop and accumulate data and other resources for use in formulating policies and surveys, analysis, and research on science, technology and innovation. The results of surveys and research using this platform are provided to and utilized by various policy councils of MEXT and the Cabinet Office, the Government of Japan, including the consideration of the Science, Technology and Innovation Basic Plan.

In addition, the Center for Research and Development Strategy of JST grasps, overviews, and analyzes domestic and international trends in science, technology, innovation, and related societies, examines R&D strategies to maximize R&D results, and makes proposals that contribute to innovation policy planning.

As the importance of technological innovation is increasing with the advancement and sophistication of technologies, there is an increasing need for strategic investment of limited resources. From this perspective, the Technology Strategy Center of the NEDO, as an important player in providing evidence and knowledge necessary for formulating industrial technology policies, grasps and analyzes technological, industrial and policy trends from global and

1 Evidence data platform constructed by Council for Science, Technology and Innovation

diverse perspectives, and works together with policy authorities in the formulation of technological strategies in the fields of industrial technology and energy and environmental technology, and in the conceptualization of important projects based on these strategies.

MEXT publishes the Japanese Standard Tables of Food Composition, which lists the composition of the Japanese diet. In addition to considering how the Japanese Standard Tables of Food Composition should be improved and utilized, MEXT conducted a survey of food composition analysis, etc., based on the demand for the accumulation of high-quality information corresponding to modern dietary habits.

4. Initiatives to secure technological superiority and a stable supply of semiconductors

Semiconductors are a key technology that supports digitalization, decarbonization, and economic security, and initiatives are necessary as a national policy to secure technological superiority and establish a stable supply system comparable to those of other countries. METI held a semiconductor and digital industry strategy investigative commission meeting and launched its semiconductor and digital industry strategy in June 2021. Then, in November 2021, the strategy was further expanded upon with the "Basic strategies for revitalizing the Japanese semiconductor industry." The basic strategy outlines a 3-step approach, Step 1: Establishment of a domestic semiconductor manufacturing base, Step 2: Development of manufacturing technologies for next-generation semiconductors that are expected to be put to practical use in 2025 or later through international collaboration and Step 3: Develop future technologies, such as photoelectric fusion, which could be a game changer for 2030 and beyond.

Based on this strategy, the second supplementary budget for FY2022 allocated a total of 1.3 trillion yen, including approximately 800 billion yen for strengthening the semiconductor supply chain from advanced semiconductors to component materials, and approximately 500 billion yen for developing manufacturing technologies for next-generation semiconductors. In addition, with regard to developing and securing talented personnel for the semiconductor industry, which is essential for the realization of this strategy, industry-university-government collaborative efforts are underway at the regional and national levels, starting with the Kyushu region, and will be expanded to the rest of Japan. Necessary measures will be continued based on the strategy.

5. Initiatives for Robot Development, etc.

Based on the "Plan for Promoting Social Change Taking Advantage of Robots" compiled by the Council for the Promotion of Social Transformation through Robots in July 2019, METI has been promoting initiatives for (1) "Creating a Robot-Friendly Environment", (2) "Establishing a framework for the development of human resources", (3) "Building a R&D system that responds to mid- to long-term issues", and (4) "Open innovation that accelerates social application." Regarding "Creating a Robot-Friendly Environment," R&D is being performed in the fields of facility management, retail, food manufacturing, and logistics warehousing, and METI is promoting the development of robots from the user's perspective and the creation of standards related to data linkage, communication, and facility design, etc. Regarding "Establishing a framework for the development of human resources," the Council for the Training of Future Robotics Engineers (CHERSI [1]), established in

1 The Consortium of Human Education for Future Robot System Integration

June 2020 with the participation of educational institutions and industries such as robot manufacturers and system integrators, provides support for on-site training of teachers and students and for the formulation of educational curricula. Regarding "Building an R&D system that responds to mid- to long-term issues," basic and applied research is being conducted to realize next-generation industrial robots from a medium- to long-term perspective while incorporating technological seeds from other fields. Regarding "Open innovation that accelerates social application," the World Robot Summit 2020 was held in FY2021 as a competition to gather the wisdom of the world's robots (Aichi in September and Fukushima in October).

6. Development of geospatial information

Based on the Fourth Basic Plan for the Advancement of Utilizing Geospatial Information, the Office for the Advancement of Utilizing Geospatial Information, Cabinet Secretariat, decided on the "G-Spatial Action Plan 2022" in June 2022 in order to promote the implementation in society of technologies that maximize the potential of geospatial information with the aim of creating and providing diverse services through collaboration among industry, academia, government, and the private sector.

❷ Promotion of mission oriented research and development for solving social issues

1. SIP

In preparation for of SIP phase 3, based on the 6th Science, Technology and Innovation Basic Plan (Cabinet decision made on March 26, 2021), the government decided at the end of the 2021 on 15 candidate issues related to achieving Japan's future vision (Society 5.0), and set up a task force (TF) for deliberating on the issues. This task force, consisting of experts on various sub-issues, related ministries and agencies, research promotion corporations, and others, and chaired by a publicly recruited PD candidate, conducted a feasibility study (FS).

Based on the results of the FS, the government conducted a preliminary evaluation, decided on 14 issues at the meeting of the Council for Science, Technology and Innovation (CSTI) governing board on January 26, 2023, and formulated a Social Implementation Strategy and Research and Development Plan (Strategy and Plan) (tentative) for each issue. The formulated Strategy and Plan (tentative) was released for public comments in February 2023 and program directors (PD) were openly recruited at the same time, and both were finalized in March 2023.[1]

2. Moonshot Research and Development Program

The Moonshot Research and Development Program promotes challenging R&D under which the government sets ambitious goals that fascinate people (Moonshot Goals) to address important social challenges, including super-aging society and global warming. In FY2022, research and development were launched in relation to the two new Moonshot Goals decided on in FY2021 (Goal #8 and Goal #9). In addition, in accordance with the operation and evaluation guidelines, an external evaluation was conducted on Goal #4 and Goal #5 three years since the start of research, and

1 The decision on program directors (PD) for SIP phase 3
https://www8.cao.go.jp/cstp/stmain/20230317sip_pd.html

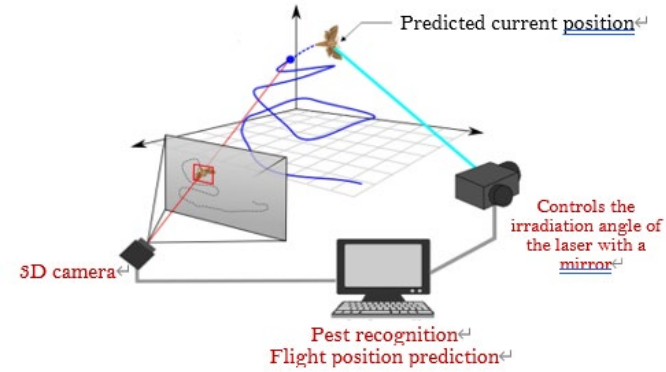
the portfolio was reviewed.

Column 8: Development of Technology to Zap Pests with Laser Beams

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has formulated the Strategy for Sustainable Food Systems "MIDORI" (May 2021), which aims to enhance both productivity and sustainability of Japan's agriculture, forestry, fisheries, and food industries through innovation, and has set the goal of achieving a 50% reduction in risk-weighted use of chemical pesticides by 2050, among other goals.

More than 40% of the world's crop production is lost due to harmful organisms such as damage-causing insects, plant diseases, and weeds. Considering the emergence of pesticide-resistant pests and the heavy labor involved in applying pesticides, there is a need to shift to innovative technologies that do not rely on chemical pesticides.

Therefore, as one of the R&D projects in the Moonshot Research and Development Program for Agriculture, Forestry and Fisheries, the research program is underway to develop a sustainable pest control technology that does not rely on chemical pesticides, but instead leverages advanced physical methods and unused biological resources.



System configuration to zap pests with laser beams
Provided by: National Agriculture and Food Research Organization (NARO)

So far, the project has developed a physical pest control technology that makes image detection and tracking and shoots down by irradiation with laser beams the *Spodoptera litura*, a type of moth that causes extensive damage to vegetables, fruit trees, and other crops.

Looking ahead to 2030, the researchers plan to develop and demonstrate prototypes of new pest control technologies that utilize physical methods, such as laser-based insect pest control technology, and biological methods, such as breeding new predatory natural enemies that prey on large numbers of pests.

3. Research Institute of Science and Technology for Society (RISTEX)

The RISTEX of JST conducts research and development through co-creation with a diverse range of stakeholders utilizing knowledge from natural sciences, humanities and social sciences to solve various social problems, including SDGs, such as the declining birthrate and aging population, environment and energy, safety and security, and disaster prevention and mitigation, and to address ethical, legal and social implications/issues (ELSI) that arise in the social implementation of emerging science and technology. In FY2022, 28 new projects were adopted in addition to the 66 projects that had been adopted up to FY2021, promoting research and development on topics such as solving regional issues to contribute to the achievement of the SDGs; preventing social isolation and loneliness; responding to ELSI in the life sciences, information technology, and other sectors; preventing and reducing problems that occur in private spaces and relationships, such as abuse and domestic violence; and formulating evidence-based science, technology and innovation policies. The program for preventing social isolation and loneliness was included as one of the measures in the Priority Plan on Measures for Loneliness and Isolation, which was revised in December 2022 by the Council for the Promotion of Measures for Loneliness and Isolation.

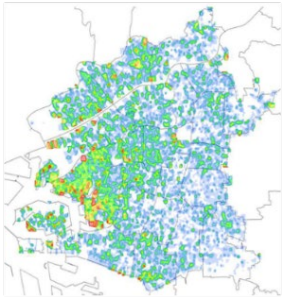
Column 9: Protecting Japan's Social Infrastructure through Deterioration Prediction Using Data Science Technology and Evidence-based Policy Formulation

Even as the aging of infrastructure such as roads, bridges, tunnels, and water supply and sewerage systems becomes an increasingly evident issue in society, management policies for the repair and renewal of infrastructure remain heavily dependent on veteran engineers' long years of experience, intuition, and knowledge. Given Japan's limited financial resources and personnel, there are major challenges for allocating resources for repair and renewal. Thus, it is important to establish a methodology for formulating policies based on scientific evidence and pursue economic efficiency while ensuring the safety and security of infrastructure users.

In the "Research on scientific evidence based policy making process for infrastructure management" project (principal investigator: KAITO Kiyoyuki, Associate Professor, Graduate School of Engineering, Osaka University), which was conducted from FY2019 to FY2022 under the Science of Science, Technology and Innovation Policy of the Research Institute of Science and Technology for Society (JST-RISTEX), researchers developed a methodology for predicting the timing of repair and renewal of aging infrastructure such as bridges, pavement, sewers, and slopes with data science technology using big data on inspections accumulated by veteran engineers. In addition, the team designed a process for formulating management policies for deteriorated infrastructure by utilizing the results of deterioration predictions and lifecycle cost assessments based on those predictions.

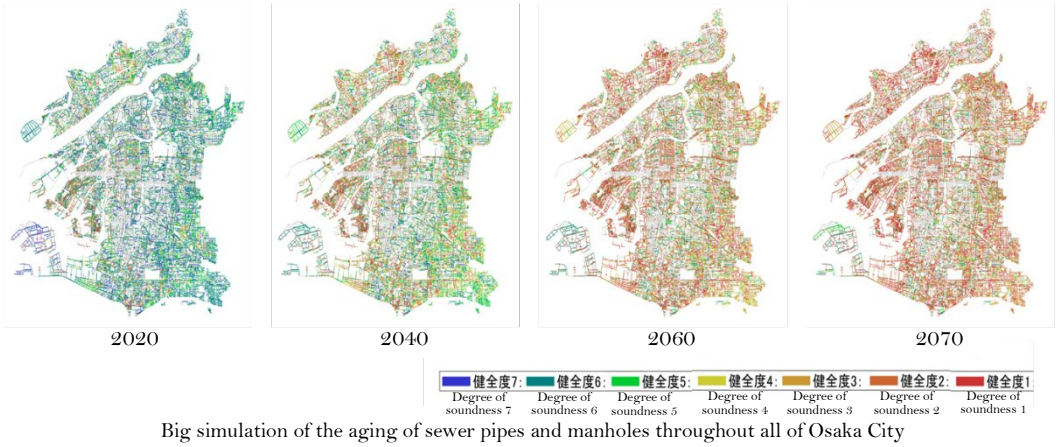
For example, in preparing a plan for the renewal of concrete sewer pipes in cooperation with Osaka City, the team statistically predicted the deterioration of all 115,050 concrete pipes in Osaka City based on big data from visual inspections at about 50,000 locations. This revealed that the expected life of concrete pipes is approximately 82.2 years, and that there is significant variation in the life of each pipe. Deterioration is progressing from areas closest to the sea, indicating that current functionality can be maintained if repairs are made starting with those areas. Furthermore, the team developed a mapping technology to predict changes over time in the condition of deteriorating concrete pipes throughout Osaka City, providing an objective basis for making policy decisions in Osaka City. This has contributed to the formulation of policies based on scientific evidence.

Distribution of the degree of soundness of sewer pipes and manholes



Dual kernel density estimation results

The administrative side evaluated that identifying and visualizing the areas for sewer pipe and manhole renewal "made it easier to prioritize repair plans by area"

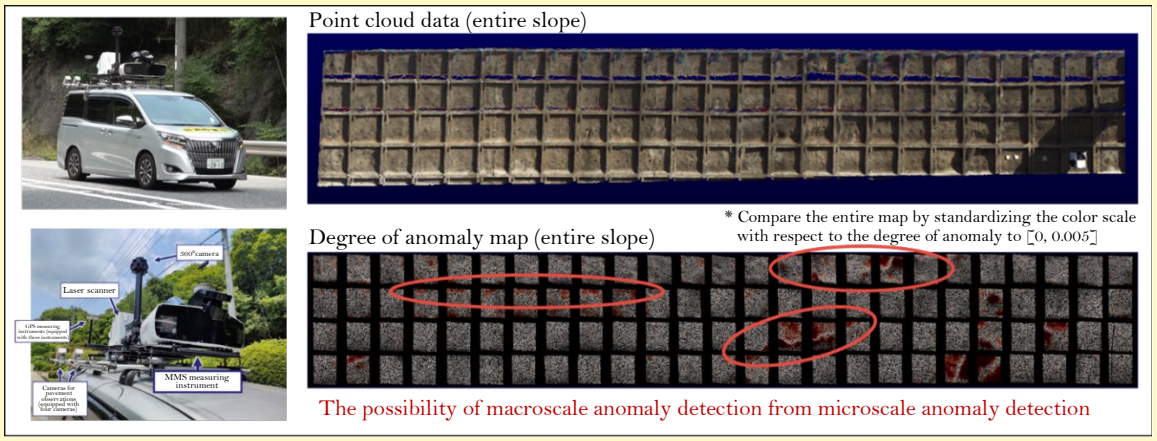


Big simulation of the aging of sewer pipes and manholes throughout all of Osaka City

Using deterioration prediction technology based on the inspection data, it is possible to map the changes over time in the state of deterioration of the concrete pipes and manholes throughout all of Osaka City

Provided by: KAITO Kiyoyuki Project

Next, the team addressed inspections of slopes along roadsides in mountainous areas, which have led to many accidents in the past, such as collapses in unexpected places, because deterioration could not be predicted even by veteran eyes. In cooperation with the Kinki Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), they developed and verified the effectiveness of a method to detect localized abnormalities on slopes by collecting point cloud data using a vehicle-mounted laser scanner instead of visual inspection data, and conducting big data analysis using AI technology. To apply this method in society, a "Manual for the Utilization of 3D Point Cloud Data for the Maintenance and Management of Road Earthwork Structures" is being prepared, and it is scheduled to be released in the first half of 2023.



Provided by: KAITO Kiyoyuki Project

In cooperation with the Japan International Cooperation Agency (JICA), these R&D results are being used to predict the deterioration of simple, low-cost paved roads in a project to develop infrastructure for daily life to correct regional poverty gaps in Myanmar. The results are also being considered for use in Ethiopia, Nepal, and other countries in Africa and Southeast Asia. In addition, the project is helping to advance cross-sectoral efforts for further social deployment of research results, including the establishment in FY2022 of a platform to discuss the integrated management of underground infrastructure, which currently falls under the jurisdiction of different ministries: sewage (MLIT), water supply (MHLW), industrial water, electricity, and gas (METI), and telecommunications (MIC).

MEXT / Science for RE-designing Science, Technology and Innovation Policy (SciREX)
https://scirex.grips.ac.jp/en/

JST-RISTEX "Science of Science, Technology and Innovation Policy R&D Program"
https://www.jst.go.jp/ristex/funding/stipolicy/index.html

"Research on scientific evidence based policy making process for infrastructure management"
(Principal investigator: KAITO Kiyoyuki, Associate Professor, Graduate School of Engineering, Osaka University)
https://www.jst.go.jp/ristex/output/example/needs/02/stipolicy_kaito.html

4. Fukushima Institute for Research, Education and Innovation (F-REI)

In May 2022, the Act Partially Amending the Act on Special Measures for the Reconstruction and Revitalization of Fukushima (Act No. 54 of May 27, 2022) was enacted to establish new provisions for the establishment of F-REI, aiming to make it a world-class "core center for creative reconstruction" that will strengthen Japan's scientific and technological capabilities and industrial competitiveness, while representing hopes and dreams for realizing the reconstruction of Fukushima and the entire Tohoku region. Based on this act, the Basic Plan for Research and Development for the Creation of New Industries was formulated in August 2022. Then, in September 2022, the Reconstruction Promotion Council decided to select Namie Town as the location for F-REI, and to promote efforts to spread the effects of establishing F-REI over a wide area. Furthermore, in December 2022, the Reconstruction Promotion Council decided to hold a "Relevant Ministers' Meeting on F-REI" in order to coordinate measures necessary for F-REI's stable, long-term operation, and efforts were made toward its establishment in April 2023.

❸ Social implementation of advanced science and technology for solving social problems

1. Initiatives in the next phase of SIP

In the third phase of SIP starting in FY2023, plans and systems will be established leading not only to the development of technologies, but also to the social application of those technologies, including related social system reforms. To this end, the "R&D plan" in the Basic Policy for Expenditure on Science, Technology, and Innovation Promotion was changed to "strategy to achieve social implementation and R&D plan," and under the leadership of the program directors (PD), necessary initiatives were promoted from five perspectives (technology, governance, business, social acceptability, and human resources) through collaboration among government ministries and agencies and industry-university-government collaboration. As indicators to measure efforts from these five perspectives, BRL (Business Readiness Level), GRL (Governance Readiness Level), SRL (Social Readiness Level), and HRL (Human Resources Readiness Level) were newly introduced, in addition to TRL (Technology Readiness Level).

2. Promotion of the Public/Private R&D Investment Strategic Expansion PrograM (PRISM) and Social Application via the Program for Bridging the Gap Between Research & Development and Society 5.0 (BRIDGE[1])

PRISM is a program established in FY2018 with the aim of directing the policies of various government ministries and agencies to areas[2] that are highly effective in inducing private investment and areas where government spending is expected to be more efficient through the utilization of R&D results. According to the various strategies decided by the Council for Science, Technology and Innovation (CSTI), the funds are being allocated focusing on the fields of AI technologies, innovative technologies for construction/infrastructure maintenance and disaster prevention/mitigation, biotechnologies, and quantum technologies, and additional allocations were made to 33 policies in these four

1 Biomedical Research Innovation Data Governing Enterprise
2 In the first year of FY2021, AI technology, construction/infrastructure maintenance/fire prevention/mitigation technology, and biotechnology were added. Quantum technology was added in 2020.

fields in FY2022. In FY2022, the existing PRISM framework was utilized to conduct a review aimed at not only developing technologies but also strengthening the policies of ministries and agencies aimed at achieving social application, and—given that the purpose of this was to create a bridge linking to social application—the name was also changed to "BRIDGE." The plan is to continue to use BRIDGE to expand public/private investment in research and development, such as by resolving social issues related to innovative technologies, creating new technologies, and promoting innovation related to ministries and agencies, including not only various strategies formulated or revised by the CSTI but also important issues set by the council every year, such as improving the business environment and creating startups (see Chapter 1, Section 2 2).

3. Introduction of advanced technology into government projects

In order to accelerate the social implementation of the results of science, technology and innovation, it is important for the government to take the lead in promoting innovation by introducing advanced technology in government projects. To this end, the Cabinet Office, Government of Japan, in cooperation with related ministries and agencies, promote innovation in a wide range of government projects, including public works projects.

❹ Promoting the resolution of social issues and acquisition of international markets through the international and strategic use of intellectual property and standards

1. Promoting an intellectual property strategy and an international standardization strategy

With the progress of economic globalization, the importance of various intellectual activities that are sources of economic growth has been increasing. To enhance the competitiveness of Japanese industries and improve the lives of the citizens, it has become important for Japan to create advanced technologies and rich culture, and to link these to the creation and expansion of businesses. The Intellectual Property Strategy serves as the foundation for such activities.

In June 2022 the Intellectual Property Strategy Headquarters decided the "Intellectual Property Promotion Plan 2022." For Japan to respond to and win the digital and green competition, the plan summarizes the situation in Japan that should be taken into account when considering intellectual property (IP) strategy in the "Basic Understanding" section at the beginning of the plan, then identifies eight priority policies: "Strengthening the IP ecosystem for startups and universities," "Strengthening mechanisms to promote investment and utilization of IP and intangible assets," "Promoting the strategic use of standards," "Development of a data distribution and utilization environment for the realization of a digital society," "Content strategy for the digital age," "Bolstering the use of IP among SMES, local regions, and in agriculture, forestry and fisheries sectors," "Enhancing institutional, operational, and human resource infrastructure to support the use of IP," and "Rebooting Cool Japan for the post-pandemic period." In line with this plan, the IP Strategy is being promoted under the leadership of the Intellectual Property Strategy Headquarters, together with related ministries and agencies.

2. Proactive response to strategic use of international standards

In order to strengthen the international competitiveness of Japanese industry in the global marketplace, promoting the strategic use of international standards by the Japanese public and private sectors is necessary. For this reason, the government as a whole first developed a control

tower function and system and is promoting measures that should be prioritized in cooperation with related ministries and agencies under the "Standard Utilization Promotion Task Force" established in the "Integrated Innovation Strategy Promotion Council." Specifically, to further advance important measures by related ministries and agencies, support is provided by allocating additional budget through support projects for accelerating the use of standards utilizing the framework of PRISM. In addition, the strategic use of international standards in important fields such as smart cities, smart agriculture, etc. in terms of solving social issues and acquisition of international markets, is being promoted based on overseas government and corporate trends and the international market environment, and at the same time, a mechanism is being developed to comprehensively identify, organize and respond to necessary areas.

In addition, in government-supported R&D projects, private business operators have introduced project management and follow-up mechanisms that call for a clear social application strategy, international competition strategy, and international standard strategy, as well as the commitment of corporate management to efforts achieve these strategies. This has promoted the penetration of mechanisms to ensure the strategic use of international standards by companies.

In addition, METI has established an international standard for "Data container format for wearable sensor" as one of the systems for commissioning projects to acquire and disseminate international standards related to energy conservation (Development of International Standards for Energy Conservation (International Electrotechnical Standards Field)). Hiroshima City University plays a central role in the promotion of international standardization, with the participation of several private companies and the cooperation of the Japan Electronics and Information Technology Industries Association (JEITA). International standardization activities on strategically important research and development themes and cross-industrial themes are also being promoted in collaboration with national research and development agencies and private companies. In addition, when METI revised the "Standard Endpoints and Evaluation Criteria based on the METI Guidelines for Evaluating R&D" (December 2022) in its technology evaluation system, it enhanced endpoints and evaluation criteria such as "formulation of an open-close strategy" and "plan for the development of standards" so that appropriate evaluations can be conducted from the perspective of "IP and standardization strategy" with a view to social application. For human resource development, training courses are provided to develop young human resources who will lead international standardization based on the "three action plans to develop human resources for standardization (made public in FY2016)." METI also supported human resource development through the release of education materials for university teachers, and sending METI personnel for lectures on standardization at universities. Furthermore, the Ministry has established standardization qualification schemes through the Japanese Standard Association (JSA). METI serves as the secretariat of Japanese Industrial Standards Committee (JISC), Japan's national standardization body (NSB).

JISC is undertaking standardization cooperation with foreign countries such as European and Asian countries and conducting technical cooperation aiming for encouraging standardization experts in Asian countries to actively participate in international standardization activities. In FY2022, in order to discuss specific areas for cooperation and further cooperation in international

standardization, JISC participated in conferences convened with attendees from NSBs of 25 countries/regions in the Asia-Pacific region, a forum attended by standardization experts and NSBs from 3 countries in the Northeast Asia region, i.e. Japan, China, and South Korea, and bilateral meeting with NSBs of Asian countries. In addition, JISC held a capacity-building partnership project for African countries in collaboration with the International Organization for Standardization (ISO [1]), and a human resource development seminar for the Asia region in collaboration with the International Electrotechnical Commission (IEC [2]). Furthermore, JISC is engaged in strengthening collaboration with the Asia-Pacific region in international standardization activities by advancing projects for the harmonization of international standards and development and dissemination of standards under the framework of the Asia-Pacific Economic Cooperation (APEC [3]) Sub-Committee on Standards and Conformance.

MIC, based on the recommendations of the Telecommunications Council, has been promoting standardization activities in the International Telecommunication Union (ITU [4]) and other de jure standardization institutions and forum standardization organizations while also conducting research and development, aiming to reflect Japan's information and communication technology (ICT) in international standards. Under the "Beyond 5G New Business Strategy Center" (established on December 18, 2020) based on the "Beyond 5G Promotion Strategy" (formulated in June 2020, which brings together key players from industry, academia, and government, MIC is working to promote strategic IP acquisition and standardization activities from the early R&D stage.

MLIT and MHLW are promoting strategic international standardization with the aim of creating an international market in which Japanese companies aiming to expand internationally in the fields of water supply and sewerage systems can demonstrate a high degree of competitiveness.

As of FY2022, the ministries are proactive and taking the lead in working on "Drinking water, wastewater and storm water systems and services" (ISO/TC [5] 224), "Sludge recovery, recycling, treatment and disposal" (ISO/TC275), and "Water reuse" (ISO /TC 282).

3. Promotion of the Global IP Initiative

It is important to improve global IP infrastructure so that Japanese companies can smoothly engage in business internationally. Currently, the Japan Patent Office (JPO) is implementing the "patent prosecution highway" (PPH[6]) with 44 countries/regions (as of January 2023). This will allow patent applicants whose applications have been deemed patentable to apply for accelerated examination in other countries/regions. The JPO and the U.S. Patent and Trademark Office (USPTO) have conducted the JP-US Collaborative Search Pilot Program since August 1, 2015. Under this program, the patent examiners of both Offices conduct their own prior art searches and share the search results and opinions before providing the initial examination results to the applicants. For Patent Cooperation Treaty (PCT [7]) international application, the Patent Cooperation Treaty Collaborative Search and Examination (PCT CS&E) pilot project was implemented up to June

1 International Organization for Standardization
2 International Electrotechnical Commission
3 Asia Pacific Economic Cooperation
4 International Telecommunication Union
5 Technical Committee
6 Patent Prosecution Highway
7 Patent Cooperation Treaty

30, 2020. Under the PCT CS&E pilot project, five offices in Japan, the U.S., EU, China, and South Korea collaborated to produce international search reports. During the FY2022 evaluation period, evaluations were conducted on applications in the international phase and on applications that entered the national phase.

4. Intellectual property (intellectual property rights and R&D data) management for national R&D projects

(1) Initiatives concerning patent rights and other intellectual property rights

In order to commercialize national R&D results as much as possible, METI ensures appropriate IP management for each R&D project commissioned by the government based on the "Guidelines for IP management in commissioned R&D" (May 2015).

In national R&D pertaining to agriculture, forestry and fisheries, MAFF is working on IP management assuming commercialization of research outcomes from the initiation stage of research based on the "Intellectual Property Policy for Agriculture, Forestry and Fisheries" (formulated in February 2016, revised in December 2022).

(2) Initiatives concerning R&D data

METI has been publishing the National Project Data Catalog[1], which includes R&D data that can be utilized, since March 2018 based on the "Operational Guidelines for Data Management in Contract R&D" (December 2017) to create new businesses and strengthen competitiveness through the promotion of the utilization of R&D data.

5. Development and provision of patent information

The JPO through Patent Information Platform (J-PlatPat[2]) operated by the National Center for Industrial Property Information and Training (INPIT) and the Foreign Patent Information Service (FOPISER[3]) provides patent information of Japan and patent information of foreign countries, which is highly needed by users in Japan.

Furthermore, the INPIT provides a database service covering information of licensable patents and research tool patents which companies, universities, public experiments and research institutions, etc. intend to license or transfer.

6. Acceleration examinations

To meet the need among patent applicants for expedited patent rights acquisition, the JPO conducts accelerated examinations under certain conditions.

7. Maintaining and strengthening the patent examination system

In order to maintain and enhance its examination capacity, the JPO continued to maintain and strengthen the patent examination system in FY2022 with various measures, including re-employing some of the fixed-term examiners after termination of their term.

1 https://www.meti.go.jp/policy/innovation_policy/datamanagement.html

2 https://www.j-platpat.inpit.go.jp/

3 Foreign Patent Information Service https://www.foreignsearch2.jpo.go.jp/

8. Collective Examination for IP portfolio (CEIP)

To meet the needs of patent applications based on the intellectual property strategy, the JPO is implementing "Collective Examination for IP portfolio" (CEIP) under which it examines applications and grants rights in an interdisciplinary manner according to the timing of the applicant's business development, in order to support applications for comprehensive intellectual property. The new initiative applies to groups of intellectual rights (i.e., patents, design rights, and trademarks) that are associated with domestic and overseas projects.

In July 2022, the JPO reviewed the operation of CEIP and revised the guidelines to make it easier for users to use the system.

9. Implementation and publication of trend surveys on patent application technology

The JPO conducts surveys of patent application trends, etc., and publishes the results in order to contribute to the development of R&D strategies, especially in fields that are expected to generate new markets and technological fields that should be promoted as a part of national policy, as well as to assist companies in developing patent and business strategies by referring to these survey results in conjunction with their own management information.

In June 2022, the JPO published the Green Transformation Technologies Inventory (GXTI[1]) to provide a bird's-eye view of Green Transformation (GX) technologies, together with a method for searching for patent documents included in each technology category.

10. Experts' support for IP utilization

JPO implements the "Project for Dispatching IP Strategy Designers to Universities" to help universities identify research results whose IP rights are not yet acquired. Through INPIT, the office also implements the "Project for Dispatching IP Producers" and the "Startup Advisors for Industry-Academia Collaboration Project." The former supports universities, R&D consortiums, etc. promoting competitive, publicly-funded R&D projects. The latter supports the rapid social application of university research results. In FY2022, 16 IP Strategy Designers were dispatched to 22 universities, 23 IP producers were dispatched to 53 projects, and 9 Startup Advisors for Industry-Academia Collaboration were dispatched to 20 projects.

Through its "Industry-Academia Collaborative Support Project," MAFF has assigned approx. 140 coordinators throughout the country who are specialized in the agriculture, forestry, fisheries and food industries and can provide advice from a management of technology (MOT[2]) perspective, including on the strategic use of intellectual property. These coordinators support the preparation of research plans when universities, national research and development agencies, and public research institutes work together on research and development. In addition, the Japan Association for Techno-innovation in Agriculture, Forestry and Fisheries (JATAFF[3]) holds study sessions on agricultural intellectual property and other topics.

11. Efforts for management of technical information

Based on the Act on Strengthening Industrial Competitiveness, a "technical information management assessment system" was implemented, under which business operators can receive certification for their technical information

1 Green Transformation Technologies Inventory
2 Management of Technology
3 Japan Association for Techno-innovation in Agriculture, Forestry and Fisheries

management systems from a certification body authorized by the government (as of the end March 2023, eight certification bodies were authorized). In FY2022, the process of obtaining the certification was simplified, and a self-checklist was developed for business operators who have begun efforts to prevent the leakage of technical information. In addition, experts were dispatched (97 times) to provide support for the establishment of technical information management systems, and meetings of experts were held to improve the system (3 investigative commission and 3 working group meetings).

12. Support for acquiring IP rights of research results and promotion of their utilization

In order to support the discovery and patenting of outstanding research results, under the "Promotion of the Use of Intellectual Property," the Japan Science and Technology Agency (JST) supports comprehensive utilization of IP rights at universities, etc. by supporting the strategic acquisition of foreign patents for their research results and promoting utilization through collecting and packaging patents scattered across different universities, etc.

❺ Strategic promotion of science and technology diplomacy

1. Strategic promotion of science and technology diplomacy

As R&D activities become increasingly globalized, it is important for Japan to promote science, technology, and innovation and utilize its results to increase Japan's international presence and credibility. Therefore, Japan needs to promote comprehensive S&T diplomacy including promoting science, technology, and innovation internationally and as well as through efforts of the Ministry of Foreign Affairs (via the Science and Technology Advisor to the Minister for Foreign Affairs).

(1) Utilization of international frameworks

A. Activities related to The Group of Eight Summit

In 2008, the G8 Science and Technology Ministers' Meeting was held under the auspices of the Minister of State for Science and Innovation Policy KISHIDA Fumio, according to a proposal made by Japan, which held the G8 presidency at the time. Through these meetings, Japan intends to actively facilitate international S&T policy discussions between the Japanese Minister of State for Science and Technology Policy and officials from other countries to cooperatively solve global issues using S&T. In June 2022, the eighth Science and Technology Ministers' Meeting was held in person, hosted by G7 President Germany. At the meeting, ministers discussed freedom in science and research, the promotion and protection of research security and integrity, research on climate change, and research on long-term impacts of COVID-19, and confirmed that they would work together to address these pressing challenges. Japan took over the G7 Presidency in 2023, and the G7 Science and Technology Ministers' Meeting in Sendai was held in the Akiu area, Sendai City, from May 12 to 14, 2023, as a ministerial meeting associated with the G7 Hiroshima Summit. The Ministers' Meeting was chaired by Minister of State for Science and Technology Policy TAKAICHI. Under the main theme of "Realization of an open and evolutional research ecosystem based on trust," G7 members mainly discussed 1) respect for freedom and inclusiveness in scientific research and promotion of open science, 2) promotion of trustworthy scientific research through research security and research integrity measures, and 3) international cooperation in science and technology to solve global issues, resulting in the adoption of the G7 Science and

Technology Ministers' Communique. In addition, on May 12, G7 Science and Technology Ministers and delegates saw exhibits on science and technology in the six prefectures of the Tohoku region, including Sendai City, and demonstrations of cutting-edge robots, etc., in the same facility as the Ministers' Meeting venue. On May 13, they went on an excursion to the afflicted regions to visit the Ruins of the Great East Japan Earthquake: Sendai Arahama Elementary School and the International Research Institute of Disaster Science, Tohoku University. On May 14, they also visited the Next Generation Synchrotron Radiation Facility "NanoTerasu" and attended a high-level meeting titled "Quantum Innovation for a Better Future."

Currently, four working groups have been established under the G7 Science and Technology Ministers' Meeting: the Group of Senior Officials on Global Research Infrastructures (GSO[1]), the Future of the Seas and Oceans Initiative Working Group, the Open Science Working Group, and the Security and Integrity of the Global Research Ecosystem Working Group. In 2022, Germany proposed the establishment of a new Working Group on Science Communication, which was approved at the G7 Science and Technology Ministers' Meeting in Sendai in 2023. The Strategic Research Network for Achieving Climate Neutrality (renamed from the International Research Network for Low Carbon Societies in 2021) held its annual meeting in December 2021 under the theme "Accelerating Actions for Leveraging a Climate-Neutral, Sustainable Society." The 2021 annual meeting featured two keynote speeches and four thematic sessions on industrial decarbonization, employment, international cooperation and finance, with a total of 140 experts and researchers from 23 countries and regions participating in the 2-day event. As of 2023, 17 research institutions from seven countries, including Japan, are part of the network.

B. Asia-Pacific Economic Cooperation (APEC)

Meetings of the APEC Policy Partnership on Science, Technology and Innovation (PPSTI[2]) are held to promote scientific and technological innovation in the APEC region through joint projects and workshops. The 20th meeting in August 2022 and the 21st meeting in February 2023 were held in a hybrid format to discuss PPSTI activity plans, project implementation, and other matters.

C. Association of Southeast Asian Nations (ASEAN)

As the cooperation framework for Japan and the ASEAN Committee on Science, Technology and Innovation (COSTI[3]), the ASEAN-Japan Cooperation Committee on Science and Technology (AJCCST[4]) has been held roughly every year. MEXT is taking a leadership role in Japan's contribution to AJCCST. Under the Japan-ASEAN STI for SDGs Bridging Initiative agreed at AJCCST-9 in 2018, the ministry continues the cooperation to strengthen social implementation of ASEAN-Japan joint research results.

D. Others

i) Asia-Pacific Regional Space Agency Forum (APRSAF[5])

Since 1993, Japan has been hosting the annual APRSAF as a forum for exchanging information about space activities and utilization in the Asia-Pacific region and for promoting multilateral cooperation. The first meeting was attended by 60

1 The meeting of the Group of Senior Officials
2 Policy Partnership on Science, Technology and Innovation
3 Cooperation on Science, Technology and Innovation
4 ASEAN-Japan Cooperation Committee on Science and Technology
5 Asia-Pacific Regional Space Agency Forum

participants from 13 countries. It has since become one of the largest space-related forums in the region, with 380 participants from 36 countries and regions registered for the 28th meeting (2022). The 28th APRSAF meeting was held in Hanoi, Vietnam, under the theme of "Bridging Space Innovations Opportunities for Sustainable and Prosperous Future." Each working group session and workshop featured public-private, international, and cross-industry exchanges, and active discussions took place from a variety of perspectives on the creation of opportunities for space innovation.

ii) The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES[1])

The IPBES is an intergovernmental organization established in April 2012 as an intergovernmental platform to scientifically assess trends related to biodiversity and ecosystem services and to strengthen the science-policy interface. The ninth session of the Plenary of the IPBES was held in Bonn, Germany, in July 2022 with the participation of member states.

iii) Group on Earth Observations (GEO[2])

The GEO is an international framework pursuing the development of the Global Earth Observation System of Systems (GEOSS[3]) in accordance with the "GEO Strategic Plan 2016-2025" approved at the ministerial-level meeting in November 2015. A total of 258 countries, international organizations and entities participate in the GEO as of March 2023. In September 2022, the 15th AOGEO[4] symposium targeting the Asia-Oceania region was held under the auspices of Japan. Researchers and practitioners exchanged information on their views and achievements. The symposium concluded with the "2022 AOGEO Statement," which reflects the common understanding of the AOGEO's future direction for solving social issues unique to the Asia-Oceania region.

iv) Intergovernmental Panel on Climate Change (IPCC)

The IPCC was established in 1988 by the World Meteorological Organization (WMO[5]) and the United Nations Environment Programme (UNEP[6]) with the aim of preparing a report summarizing the latest scientific findings on climate change and providing scientific basis for national policies regarding climate change. The IPCC published the first working group contribution (The Physical Science Basis) to the Sixth Assessment Report (AR6) in August 2021, the second working group contribution to AR6 (Impacts, Adaption and Vulnerability) in February 2022, and the third working group contribution to AR6 (Mitigation of Climate Change) in April 2022, and integrated these findings in the Synthesis Report in March 2023.

v) Innovation for Cool Earth Forum (ICEF)

ICEF is an international conference that has been held annually since 2014 as a knowledge platform for discussions among industry, academia, and government leaders from around the world to promote "innovation," which is the key to solving the problems of global warming. The 9th Annual Meeting, held in a hybrid format on October 5 and 6, 2022, adopted "Low-Carbon Innovation in a Time of Crises" as its main theme and focused on actions to accelerate the creation of innovations in

1 The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
2 Group on Earth Observations
3 Global Earth Observation System of System
4 Asia-Oceania Group on Earth Observations
5 World Meteorological Organization
6 United Nations Environment Programme

order to achieve carbon neutrality by 2050. There were 1,600 participants from 87 countries and regions, including government agencies, industry, academia, and international organizations, in the 2-day meeting.

vi) Research and Development 20 for Clean Energy Technologies (RD20)

RD20 is an international conference that brings together leaders from research institutions of G20 nations and regions to create noncontiguous innovation aimed at drastically reducing CO2 emissions. At the 4th RD20 Conference held in a hybrid format in October 2022, discussions were held on task force activities aimed at creating joint projects to achieve carbon neutrality and summer schools for fostering advanced research personnel, among other topics. The outcome of the discussions was summarized in "Leaders Recommendations."

vii) Global Research Council (GRC[1])

The 10th Annual Meeting of the GRC, an international conference of heads of major academic-promotion organizations from around the world, was held from May 31 to June 2, 2022, in a hybrid format including online and face-to-face sessions in Panama City, Panama. The meeting was co-hosted by the National Secretariat of Science, Technology and Innovation of the Republic of Panama (SENACYT) and the U.S. National Science Foundation (NSF). Issues concerning research support and the role that academic-promotion organizations should play were discussed.

(2) Cooperation with international organizations

A. United Nations system (UN system)

i) Science, Technology and Innovation for Sustainable Development Goals (STI for SDGs)

As a partner country of the "Global Pilot Programme" launched in 2019 by the United Nations Inter-Agency Task Team (UN-IATT[2]) to promote the formulation of STI for SDGs roadmaps in countries around the world, Japan has provided support to promote the provision of digital financial services (DFS[3]) to Kenyan farmers through contributions to the World Bank since FY2020. In FY2022, Japan provided technical assistance to a startup company that provides financial services to farmers.

In addition, through contributions to the United Nations Development Program (UNDP[4]), which implements initiatives to understand social problems and needs in developing countries, since 2020, the "Japan SDGs Innovation Challenge for UNDP Accelerator Labs" has been implemented, in which Japanese companies consider commercialization based on local needs. To date, Japanese companies have been matched with UNDP Accelerator Labs in a total of eight countries, where they discussed and tested solutions to development issues. In FY2022, Japanese stakeholders began to discuss solutions for two new countries' issues and their feasibility.

ii) United Nations Educational, Scientific and Cultural Organization (UNESCO[5])

Japan has been participating and actively cooperating in various science and technology projects and activities of UNESCO, a specialized agency of the U.N. In UNESCO bodies, such as the Intergovernmental Oceanographic Commission

1 Global Research Council
2 UN Interagenecy Task Team on STI for SDGs
3 Digital Financial Services
4 United Nations Development Programme
5 United Nations Educational, Scientific and Cultural Organization

(IOC [1]), the Intergovernmental Hydrological Programme (IHP [2]), the Man and the Biosphere (MAB[3]) Programme, UNESCO Global Geoparks, the International Bioethics Committee (IBC[4]) and the Intergovernmental Bioethics Committee (IGBC[5]), international rules are formulated and projects are implemented towards solving global challenges. Japan is implementing support programs including the science human resource program in the Asia-Pacific region and the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) through contribution to UNESCO/Japanese-Funds-in-Trust, etc. Japan also promotes UNESCO activities by sending experts to contribute to discussions of committees/commissions. In November 2021, Japan made various contributions to the Recommendation on Open Science and the Recommendation on the Ethics of AI, which are adopted at the 41st session of the UNESCO General Conferences, including sending Japanese experts to advisory committees, regional consultations, and intergovernmental committees for the formulation of recommendations. In addition, a report was made to the Diet following a Cabinet decision in November 2022.

iii) The United Nations Decade of Ocean Science for Sustainable Development (2021–2030)

The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) is an international framework for concentrated initiatives for the ten years from 2021 to 2030 in order to attain the United Nations Sustainable Development goals including SDG14 through promotion of ocean science. The framework began in January 2021.

As societal outcomes to be achieved through the initiatives over the 10 years, the plan presents: (1) A clean ocean, (2) A healthy and resilient ocean, (3) A productive ocean, (4) A predicted ocean, (5) A safe ocean, (6) An accessible ocean, (7) An inspiring and engaging ocean. To this end, 10 challenges will be addressed, which include reduction in marine pollution, preservation of the marine ecosystem, improvement of marine literacy and change in human behavior. Aiming to contribute to these social achievements, Japan is promoting various initiatives at the national, interregional, and international levels by promoting collaboration among industry, government, academia, and the private sector, including relevant ministries, agencies, and organizations through the framework of the national committee established in February 2021.

B. Organisation for Economic Co-operation and Development (OECD[6])

The OECD engages in activities related to science and technology by developing statistical data and fostering exchanges of views, experiences, information and human resources among the member countries at the following OECD bodies: the OECD Ministerial Council, the Committee for Scientific and Technological Policy (CSTP[7]), the Committee on Digital Economy Policy (CDEP[8]), the Committee on Industry, Innovation and Entrepreneurship (CIIE[9]), the Nuclear Energy Agency (NEA[10]), and the International Energy Agency (IEA[11]), etc.

In the CSTP, information and views concerning

1 Intergovernmental Oceanographic Commission
2 Intergovernmental Hydrological Programme
3 Man and the Biosphere
4 International Bioethics Committee
5 Intergovernmental Bioethics Committee
6 Organisation for Economic Co-operation and Development
7 Committee for Scientific and Technological Policy
8 Committee on Digital Economy Policy
9 Committee on Industry, Innovation and Entrepreneurship
10 Nuclear Energy Agency
11 International Energy Agency

science and technology policies have been exchanged and the role of STI in economic growth, enhancements of research systems, and the roles of government and the private sector in R&D and international collaborations in R&D have been studied. The CSTP has four subgroups: the OECD Global Science Forum (GSF[1]), the Working Party on Innovation and Technology Policy (TIP[2]), the Working Party on Bio-, Nano- and Converging Technologies (BNCT[3]), and the National Experts on Science and Technology Indicators (NESTI[4]).

i) Global Science Forum (GSF)

The GSF discusses ways to facilitate international cooperation for solving global issues. In 2022, the following projects from 2021 continued to be implemented: "Science Mobilization in Times of Crisis", "Large Research Infrastructures (VLRIs)", "Integrity and Security in the Global Research Ecosystem" and "Future Research Talent".

ii) Working Party on Innovation and Technology Policy (TIP)

TIP studies how STI can contribute to economic growth through policies. In 2022, TIP continued to implement the project "Supporting co-creation in collaborative transitions" from 2021.

iii) Working Party on Biotechnology, Nanotechnology and Converging Technologies (BNCT)

Guided by the theme of "Technology in and for society," BNCT promotes projects aimed at, for example, realizing an international cooperation platform for the development of medical technologies, promoting implementation of the Council's recommendations on neuroscience, and realizing the bioeconomy and carbon-neutral society.

iv) Working Party of National Experts on Science and Technology Indicators (NESTI)

NESTI supervises, directs and coordinates OECD statistical work and contributes to the development of indicators and quantitative analyses, which are helpful for the promotion of STI policies. Specifically, with regard to science, technology and innovation indicators related to R&D expenditures, science and technology human resources and other factors, NESTI has been discussing and examining the development of survey methodologies and indicators as well as frameworks for international comparisons of indicators.

C. International Science and Technology Center (ISTC[5])

The ISTC is an international organization established in March 1994 with the aim of providing former weapons scientists from Russia and the CIS who had engaged in the development of weapons of mass destruction with opportunities to redirect their talents to R&D conducted for peaceful purposes. Today, the ISTC supports research activities of scientists for peaceful purposes with a focus on chemical, biological, radiological, and nuclear (CBRN) fields, in a broad area beyond Russia and the CIS, with contribution from Japan, the United States, the EU, the ROK, Norway, and Kazakhstan.

1 OECD Global Science Forum
2 Working Party on Innovation and Technology Policy
3 Working Party on Biotechnology, Nanotechnology and Converging Technologies
4 Working Party of National Experts on Science and Technology Indicators
5 International Science and Technology Center

(3) Utilization of research institutions

A. Economic Research Institute for ASEAN and East Asia (ERIA[1])

ERIA is an institution that provides policy analyses and recommendations towards promoting East Asian economic integration. Under the three pillars of deepening economic integration, narrowing development gaps and achieving sustainable economic development, ERIA implements research, symposiums and human resources development in a wide range of areas, including innovation policies. This year, ERIA will establish the Digital Innovation and Sustainable Economy Centre to contribute to sustainable development in East Asia through the use of digital technology.

(4) Promotion of Strategic International Activities Related to Science Technology Innovation

For Japan to assume a leading role in solving global issues and to maintain a strong position in the world, the nation needs to strategically promote STI policies from the perspective of international cooperation.

In FY2022, MEXT created a fund from the supplementary budget to promote the Adopting Sustainable Partnerships for Innovative Research Ecosystem (ASPIRE) Program. This program will strategically support international joint research in advanced fields initiated by national governments of the United States, EU, and other advanced countries, with the aim of promoting the entry of Japanese researchers into leading international scientific networks, strengthening exchanges and connections among young researchers of those countries.

In addition, MEXT and the Ministry of Foreign Affairs have been promoting international joint research with developing countries which contributes to finding solutions to global issues in the fields of the environment, energy, bioresources, natural disaster prevention and mitigation, and infectious diseases control by combining advanced science and technologies with the Official Development Assistance (ODA) of Japan through the Science and Technology Research Partnership for Sustainable Development (SATREPS[2]) since FY2008. Since FY2009, the ministry has been implementing the Strategic International Collaborative Research Program (SICORP[3]) to promote diverse international collaborative research according to the potential of the partner country/region, the field and the cooperation phase in equal partnership based on agreement among ministries and agencies toward the creation of innovations through strategic international cooperation. Furthermore, since FY2014, the International Youth Exchange Program in Science (Sakura Science Exchange Program) has been implemented to improve interest in Japan's cutting-edge science and technology among young people countries and regions around the world, and to promote youth exchanges in the field of science and technology with foreign countries in order to contribute to the future acquisition of excellent human resources from overseas (see Chapter 2, Section 2, 1 ❺).

MOE has been supporting the Asia-Pacific Network for Global Change Research (APN[4]) which was established to improve researchers' capabilities and to solve issues common to the nations in the Asia-Pacific region. In February 2021, the 24th intergovernmental meeting was held, and the 5th Strategic Plan was adopted toward further development of its activities. The ninth annual

1 Economic Research Institute for ASEAN and East Asia
2 Science and Technology Research Partnership for Sustainable Development
3 Strategic International Collaborative Research Program
4 Asia-Pacific Network for Global Change Research

LoCARNet[1] (Low Carbon Asia Research Network) meeting was held online in March 2021 with the aim of sharing the latest research outcomes and knowledge toward low-carbon growth of Asia.

(5) Cooperation with Other Countries

A. Cooperation with the United States and European Countries

Japan has been advancing science and technology cooperation with the United States and European countries in advanced research areas such as life sciences, nanotechnology, materials science, environmental sciences, nuclear energy and space exploration. Specifically, Japan has held joint committees' meetings on science and technology cooperation based on bilateral science and technology cooperation agreements, has been exchanging information and researchers with the above-mentioned countries and has been supporting the implementation of joint research.

Based on the Agreement between the Government of Japan and the Government of the United States of America on Cooperation in Research and Development in Science and Technology signed in June 1988, the Joint High-Level Committee Meeting and Japan-U.S. Joint Working-Level Committee on Science and Technology Cooperation were established with the United States. In June 2021, the 16th Japan-U.S. Joint Working-Level Committee Meeting on Science and Technology Cooperation was held to exchange views on science and technology policy, current collaboration, and new areas of collaboration, and a project arrangement on quantum information science was signed between MEXT and the U.S. Department of Energy. In addition, at the Japan-U.S. Summit Meeting in May 2022, the leaders concurred to continue to work together, under the Japan-U.S. Competitiveness and Resilience (CoRe) Partnership, in such areas as cancer research and the space domain, and concurred to strengthen cooperation in ensuring economic security, including the development of cutting-edge semiconductors.

Also, since 2021, SICORP has been conducting research in the field of digital science that contributes to new lifestyles required in the aftermath of COVID-19. Furthermore, as a new SICORP initiative, the Researcher New-mode Mobility Accelerator Program (ReNewMAP) was launched to conduct research in advanced fields related to digital science, AI, and quantum technology with the United States and other countries.

In cooperation with the EU, a document on the Japan-EU Digital Partnership was published at the 28th Japan-EU Summit held in May 2022. In addition, MIC and the European Commission have been soliciting for R&D projects in the e-Health field as the 5th Japan-EU Joint Call for Proposals since November 2019, with one project adopted in October 2020 and R&D continuing in 2021. The Joint Committee Meeting on Cooperation in Science and Technology was held with France in July 2022, Sweden in November 2022, Italy and Switzerland in January 2023, Germany and Hungary in February 2023, and the Netherlands in March 2023 to discuss further promotion of science and technology cooperation between Japan and those respective countries.

Through SICORP, research is also being conducted by Japan and European countries under EIG CONCERT-Japan[2], which is the successor to CONCERT-Japan, a project platform for international research cooperation activities under the EU's Seventh Framework Programme for Research and Technological Development (FP7), established in 2015.

1 Low Carbon Asia Research Network
2 The European Interest Group Connecting and Coordinating European Research and Technology Development with Japan

B. Cooperation with China and the Rep. of Korea

Based on a Memorandum of Cooperation signed between MEXT and the Ministry of Science and Technology of the People's Republic of China in August 2018, the SICORP "Collaboration Hubs for International Research Program" (environment and energy) is being implemented with China.

The Japan-China-Korea Trilateral Science and Technology Policy Seminar was jointly held by NISTEP of MEXT and Chinese and Korean S&T policy research institutions within the framework of the three countries.

C. Cooperation with ASEAN countries and India

In Asia, Japan can make use of its science and technology for the solution of problems in many fields including environment, energy, food, water, natural disaster prevention, and infectious diseases. It is necessary to play an active role in solving Asia's common issues and build relationships of mutual trust and benefits in the region.

In June 2012, MEXT in cooperation with JST launched the e-ASIA Joint Research Program for multilateral joint research. The program aims to strengthen R&D capabilities and solve common issues facing Asian countries. Institutions of countries in Asia-Pacific, including ASEAN countries, participate in the program, which covers seven fields: materials (nanotechnology), agriculture (food), alternative energy, health research (infectious diseases and cancer), disaster risk reduction and management, environment (climate change and marine science) and advanced interdisciplinary research towards innovation. The health research field has been supported by AMED since April 2015. In FY2020, urgent public invitation was made for joint research projects on COVID-19 infection.

As for Collaboration Hubs for International Research Program (CHIRP) in the SICORP, Phase II of support started in ASEAN (environment/energy, bioresources, biodiversity and disaster prevention fields) in 2020 and in India (ICT field) in 2022. With an eye to creating innovation, improving Japan's science and technology capabilities, and strengthening the foundation of research cooperation with partner countries and regions, JST has promoted continuous joint research and cooperation programs, aiming to promote Japan's identifiable and sustainable contribution, while also building research networks and fostering young researchers.

D. Cooperation with other countries

Japan is promoting science and technology cooperation with other countries as well, including information exchanges, researcher exchanges, and joint research. The Joint Committee Meeting on Cooperation in Science and Technology was held with Brazil in September 2022, South Africa in October 2022, Australia in November 2022, and New Zealand in March 2023 to discuss further promotion of science and technology cooperation between Japan and those respective countries.

As for science and technology cooperation with developing countries in Asia, Africa, and Latin America, etc., MEXT, the JST, and AMED, as well as MOFA and JICA, have been collaboratively implementing the SATREPS program which combines Japan's advanced science and technologies and ODA[1] with the aim to promote international joint research for solutions to global issues and its future implementation in society based on the needs of these countries. From FY 2008 through FY 2022, 179 SATREPS[2] projects in 53 countries (including 97projects in Asia, 44 projects in Africa, and 27 projects in Latin America) were adopted for implementation.

1 Official Development Assistance
2 Science and Technology Research Partnership for Sustainable Development

MEXT has been implementing a program that combines international joint research with government scholarships for international students. Specifically, the government provides scholarships for international students who wish to study at Japanese universities that participate in the SATREPS program. This program makes it possible for young researchers from countries participating in international joint research projects to earn degrees in Japan. Thus, MEXT is cooperating with other countries in developing their human resources. In addition, MEXT convened the "Africa-Japan Ministerial Dialogue Meeting on STI for SDGs" as an official side event of the 7th Tokyo International Conference on African Development (TICAD7[1]) in 2019. Based on the discussions at the meeting, AJ-CORE[2], a Japan-Africa multilateral joint research program led by Japan and South Africa, was launched. Under AJ-CORE, eight projects in the field of environmental science have been adopted through 2022.

(6) Autonomously ensuring the soundness and fairness of research (research integrity) associated with the internationalization and openness of research activities

In April 2021, the Integrated Innovation Strategy Promotion Council decided on the "Government policy for ensuring research integrity in response to new risks associated with the internationalization and openness of research activities" in order to appropriately respond to new risks associated with the internationalization and openness of research activities, and to promote essential international joint research. Based on this policy, in FY2022, the council held briefing sessions for universities and research institutions, conducted a survey of international trends, and ascertained and disclosed the status of efforts to strengthen training programs, etc., at universities and research institutions, the status of regulations and organizations concerning conflicts of interest and responsibilities, and the status of efforts at research funding bodies.

2. Ensuring Research Integrity

Securing of the integrity of research is essential for researchers to build trusting relationships with various stakeholders of society. Researchers and research institutions including universities need to bear firmly in mind that tirelessly addressing research misconduct is the way to respond to society's trust in STI and increase STI's driving force.

For promotion of fair research activities, MEXT works to ensure system development and other efforts by research institutes based on the Guidelines for Responding to Misconduct in Research (decision by the Minister of MEXT on August 26, 2014.) In addition, the ministry has been supporting research ethics education provided by research institutes in cooperation with JSPS, JST and AMED.

In order to prevent inappropriate use of research funds, MEXT urges appropriate management of public research funds at research institutions based on the Guidelines for Management and Audit of Public Research Funds at Research Institutions (Implementation Standards) ("the Guidelines": Decision of the MEXT Minister on February 15, 2007), while at the same time providing guidance and advice to support efforts by research institutions. The guidelines were amended in February 2021 to enhance measures to prevent misuse of research funds. In addition, METI is addressing this issue based on the Guidelines for Responding to Misconduct in Research (revised on January 15, 2015), and the Guidelines for

1 Tokyo International Conference on African Development
2 Africa-Japan Collaborative Research

Responding to Misuse of Public Research Funds (revised on January 15, 2015). Other relevant ministries and agencies are also addressing the issue based on their respective guidelines, etc.

In addition, information on persons involved in misconduct is shared among relevant ministries and agencies, and their eligibility to apply for competitive research funds at all relevant ministries and agencies is restricted in accordance with the "Guidelines for Appropriate Execution of Competitive Research Funds" (Revised on December 17, 2021, based on the agreement of the Inter-Ministry Liaison Conference).

Section 2 Expanding the frontier of knowledge and strengthening research capabilities as a source of value creation

Research based on the intrinsic motivation of researchers has pioneered the field of human knowledge, and the accumulation of such knowledge has supported the prosperity of humans. This white paper describes the government's measures to develop human resources, research infrastructure and research environments that foster "knowledge" through the realization of a culture that allows researchers to take on diverse research challenges.

1 Reconstruction of the environment that generates diverse and outstanding research

To produce diverse and excellent research results that open up new frontiers of knowledge, the government aims to realize research environments in which researchers can demonstrate their abilities to the fullest and continue to take on the challenge of solving issues based on the diverse awareness of issues inherent in each of them.

❶ Improving the treatment of doctoral students and expanding their career paths

MEXT launched the "Establishment of University Fellowships towards the Creation of Science Technology Innovation" in FY 2021 to support universities that have the ability and motivation to provide financial support for outstanding and ambitious doctoral students to devote themselves to research and to develop career paths for doctoral human resources to work in a wide range of fields, including industry. MEXT is also working on the new program called "Support for Pioneering Research Initiated by the Next Generation (SPRING[1])," in which JST is playing the lead role.

To foster top level researchers who will play major roles in future scientific research, the JSPS offers the Research Fellowship for Young Scientists Program under which fellowships are granted to doctoral students (DC[2]).

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. Students with interest-free scholarship loans 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.

It is expected that through such programs, the government's target of providing financial support to approximately 15,000 doctoral students, as indicated in the "Comprehensive Package to Strengthen Research Capacity and Support Young Researchers (Council for Science, Technology and Innovation, January 23, 2020)" will be realized. In the future, the government will aim to provide financial support to 22,500 doctoral students, which is the goal of the Sixth Basic Plan.

Furthermore, to improve the treatment of doctoral students, the government is promoting the active participation of doctoral students as research assistants (RA) and payment of

1 Support for Pioneering Research Initiated by the Next Generation
2 Doctoral course

reasonable compensation for RA expenditures resulting from such participation under the competitive research funding system established based on the Sixth Basic Plan and the "Guidelines for Employment and Training of Post-doctoral Fellows" (December 3, 2020, Human Resources Committee, CST).

MEXT has started a long-term and paid cooperative education through research internships as a preliminary and trial initiative from FY 2021 for doctoral students in graduate schools, where industry and universities will collaborate to provide graduate school education and foster practical skills backed by research capacity in the doctoral course, and has been working on initiatives to realize various career paths.

Additionally, for the improvement of the treatment of doctoral degree holders in ministries, the National Personnel Authority amended its rules in November 2022, putting a system in place conducive to adequately evaluating the specialization of individuals who have completed doctoral programs to determine higher initial salaries for them (effective April 1, 2023). In addition, in January 2023, the Cabinet Bureau of Personnel Affairs, the Secretariat of Science, Technology and Innovation Policy under the Cabinet Office of the Government of Japan, and MEXT jointly disclosed investigative results aimed at considering further utilization of doctoral degree holders in Japanese ministries and agencies. Through these endeavors, the government will examine further utilization of doctoral degree holders in ministries. In addition, MEXT implemented "investigative research on the status of the employment and utilization of doctorate degree holders at public institutions" to search for the current hiring situations of doctoral degree holders, the expectations for them, and the good examples for the job assignments where their high expertise and versatile skills are effectively utilized in public organizations in and outside of Japan.

❷ Development of an environment in which young researchers can play an active role at universities, etc.

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[1]) from the direct cost of the competitive research 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.

MEXT has prepared a guideline on personnel salary management reform (supplement) for national university corporations, which includes good examples of organization-wide efforts to secure positions for young researchers, provide support for the promotion of their fostering and participation, and build a sustainable research system through initiatives to allocate internal financial resources generated by the use of external funds (competitive research funds, joint research funds, donations, etc.) for employment funding to increase the number of positions for young researchers and to establish the research support system, utilization of annual salary

1 Principal Investigator

schemes and cross-appointment system, and promotion of the conversion to fixed-term employment for senior researchers with external funds. The guideline was officially announced on December 21, 2021.

Promotion of fostering and participation of research management personnel such as research administrators (URA) is important to develop the research environment for researchers. In order to strengthen URAs at universities further, as a means of contributing to the improvement of URAs' knowledge and skill and the visualization of their practical ability, in FY2021, a quality assurance (authorization) system for URAs was implemented under the project "Implementation of a Quality Assurance System for Management Personnel such as Research Administrators." In FY2022, operational aid continued to be rendered to facilities implementing quality assurance systems.

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 URAs 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 (refer to Chapter 2, Section 2 ❻).

The "Strategic Development Program for Young Researchers" has been implemented since FY2019 and has been supporting five organizations in FY2022. 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.

In addition, MEXT has been implementing the Leading Initiative for Excellent Young Researchers (LEADER) program since FY 2016 to support researchers and research institutions so that excellent young researchers can obtain a stable and independent research environment to devote themselves to voluntary and independent research at research institutions of industry, academia or government. By FY2022, at least 480 young researchers (as of February 1, 2023) found a stable and independent research environment at positions created under the program.

In addition, 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 was provided to 10 organizations in FY2022.

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.

NISTEP of MEXT conducted a survey for prospective master's degree recipients, which is the preliminary stage of the doctoral course, regarding

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

their plans to enter a doctoral course, their financial situation, career awareness, etc., and the report for those who completed the course in FY2021 was released in January 2023 (JM-Pro). Additionally, with regard to the Japan Graduates Database (JGRAD[1]), a doctoral human resource database serving as an information platform for grasping the career status of such personnel, in FY2022, NISTEP modified its operation so that individual doctoral program students could directly register with JGRAD in an effort to increase the number of database registrants.

Column10 Active Doctoral Human Resources: Researchers at Private Companies

According to the Science and Technology Indicators 2022, there were 6,000 working adult enrollees at graduate schools (in doctoral programs) in FY2021, accounting for as much as 41.7% of all doctoral personnel in Japan. We asked Dr. EGAWA Mariko, one of those working adult enrollees that accounts for nearly one in two doctoral personnel members in Japan, about her impetus for becoming one, among other questions.

EGAWA Mariko
Shiseido Co., Ltd., MIRAI Technology Institute, Senior Researcher
Ph.D. (Engineering) Specialty: Spectroscopic and biospectroscopic measurement

Through research on human skin component distribution analysis using near-infrared and Raman spectroscopy, Dr. EGAWA was recognized for making it possible to non-invasively evaluate the distribution of components of the skin in a "living state" and the changes in that distribution, which had been difficult to observe using conventional technology. She was granted the Science and Technology Award (Research Category), The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for FY2022.

When she was still a student, Dr. EGAWA apparently was unable to take in interest in academic research. However, in the course of working at her current company after graduating from university, she took a renewed interest in research. While continuing her life as a working adult, she enrolled in a doctoral program at Niigata University at her own expense to engage in research. In doing so, she earned a Ph.D. in engineering after a period of three years. Later on, thinking that she wanted to obtain a doctorate at her alma matter Tsukuba University as well, she earned another Ph.D. in engineering. As a researcher at a corporation, she has to be mindful of the outcomes of her research tying into profit. Still, because Dr. EGAWA's company takes an accepting view of research activities and values researchers' ideas, she conducts her research in cooperation with universities and other entities as well while simultaneously belonging to an academic society as a doctor.

While Dr. EGAWA advanced to a doctoral program as a working adult, balancing her studies and work was not easy. However, by writing numerous papers through her research activities, she was able to nurture her ability to see things to completion and her approach to the fundamentals, a must for any researcher. Looking back on her experience, she sees this as a positive she gained by advancing to a doctoral program.

When asking her to give a piece of advice to working adults considering advancing to a doctoral program. she answered:

"There are cases where you cannot discover something you like even after wrapping up your undergraduate and graduate studies. If, however, you do discover something after becoming a working adult and feel the new desire to pursue a doctorate, but find yourself unable to take the step forward you need because you are a working adult, I implore you to take on the challenge of a doctoral program. A positive future is bound to await you."

❸ Promoting the active participation of female researchers

Creating an environment in which female researchers can demonstrate their abilities and play an active role will contribute to the vitalization of science, technology, and innovation in Japan and

1 Japan Graduates Database

the promotion of 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, women still accounted for only 17.8% of researchers as of March 31, 2022, which is lower than in other advanced countries (Figure 2-2-4). The Sixth 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.

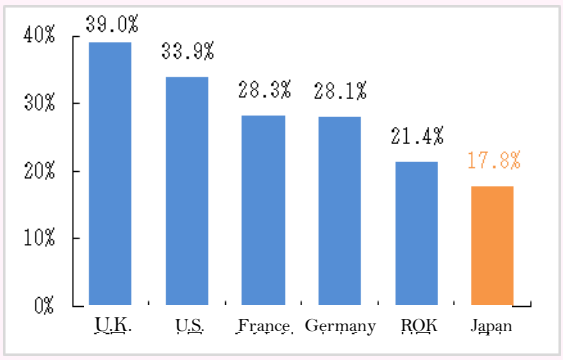
The Cabinet Office provides information, such as information on initiatives and events of universities and companies that promote women's participation in the field of science and engineering on the website "Science and Engineering Challenge (Riko Challenge) [1]." In 2022, an online symposium was held on the website. Through the symposium, diverse role models in science and engineering fields sent messages to female junior-high/high school students across Japan, their guardians and teachers. Furthermore, the Cabinet Office also conducted a STEM Girls Ambassadors initiative, where the ambassadors serve as role models to inspire more girls to choose STEM careers.

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 the 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. In total, MEXT has given support to 139 institutions by FY2022.

The JSPS has implemented the Restart Postdoctoral Fellowship (RPD) [2] Program to provide research incentives to male/female researchers who have temporarily discontinued their research due to maternity/childcare responsibilities.

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.

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



Note: 1. Data as of 2020 for South Korea, as of 2019 for the U.K., U.S., and Germany, and as of 2017 for France
2. For the U.S. 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 2022 Survey on Research and Development (MIC), Main Science and Technology Indicators (OECD) and Science and Engineering Indicators (NSF)

1 https://www.gender.go.jp/english_contents/index.html

2 Restart Postdoctoral Fellowship: Postdoctoral researchers restarting research activities

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

Column11 Active Doctoral Human Resources: Humanities and Social Sciences Researchers

According to the Science and Technology Indicators 2022, there were 1,629 enrollees in doctoral programs in the human and social science fields in FY2021, accounting for approximately 11% of all students enrolled in doctor's courses. We asked researchers in the human and social science fields, who constitute highly valuable and important high-talent personnel, about their impetus for aiming to become researchers, among other questions.

KOMIYA Michiko
The University of Tokyo Graduate School of Humanities and Sociology, Assistant Professor
Ph.D. (Literature) Specialty: 20th-century Russian literature

For the painstaking organization and analysis of the extensive drafts of Yury Olesha's leading work "Envy," a task said to have been left almost entirely untouched in Russian literature research, and the meticulous, high-level research she performed to elucidate on the writing process of that work, Dr. KOMIYA was awarded the 19th JSPS PRIZE in FY2022.

Dr. KOMIYA's impetus for researching Russian literature was "reading." She loved to read since she was a child. When she was in elementary school, the genres of books she read extended to world literature. Finding herself wholly enthralled with Russian literature after encountering it in junior high school, she became more curious about the genre. She would spend her youth with the determination to eventually research Russian literature. After researching that field through a doctoral program, Dr. KOMIYA proceeded to Moscow State University with a scholarship from Japan Student Services Organization (JASSO). There, she earned her doctorate after three years of study. She says the most enjoyable aspect of that program was the opportunities she had to interact with numerous overseas researchers who are active on the frontlines. Dr. KOMIYA, who submits her research results to journals and collections both within and outside Japan, has also been considerably lauded in Russia for her research. Russian-language versions of her works are also slated to be published. She claims that research is fun, and that she spends her time off going through scores of rare literature at the library.

MURAKAMI Yuko
Professor, Graduate School of Artificial Intelligence and Science, Rikkyo University
Ph.D. in Philosophy at Indiana University, United States

Dr. MURAKAMI currently researches philosophy of artificial intelligence (AI). In addition to applying existing philosophical theories of person and responsibility to the issues of AI, she also works on history and philosophy of logic and information education. Additionally, in 2019, she was granted the Best Paper Prize, which is awarded to papers bestowed with the highest evaluation, at the XXVIII International Conference of the European Academy of Management and Business Economics.

While Dr. MURAKAMI entered university on a humanities track, due in part to a newfound desire to study mathematics, she advanced to the Department of History and Philosophy of Science, where she began research in interdisciplinary fields in the form of using mathematical models to address problems with human reasoning. After earning her master's degree in Japan, she studied abroad with a Fulbright Scholarship from the United States and continued her research on moral reasoning. After coming back to Japan, she worked in National Institute of Informatics and Tohoku University before she found the current tenure job. Because of the interdisciplinary nature of her research topics, she has been affiliated in the departments from mathematics to international education.

When asked about the difficulty with research in interdisciplinary fields and her impression of doctoral program students, Dr. MURAKAMI gave the following answer: "In order to broaden research perspectives, it is very important to have frank discussions with researchers in differing fields. Also, highly motivated working adult students stimulate both to young master's students who just graduated from undergraduate and to faculty members."

While striking a balance between her busy research endeavors and home life, Dr. MURAKAMI tries to find time to enjoy various activities from exercising, reading books to joining music events.

❹ Promotion of Basic and Academic Research

1. Reform and Strengthening of Grants-in-Aid for Scientific Research

MEXT and the JSPS have been implementing the Grants-in-Aid for Scientific Research (KAKENHI). KAKENHI is a competitive research fund that covers scientific research in all fields ranging from the humanities and the social sciences to the natural sciences. By supporting creative research activities while ensuring research diversity, KAKENHI plays a role in expanding the base of research activities contributing to the sustainable development of research and forming a massive intellectual pool. In FY2022, around 26,000 research applications were newly selected by peer review screening (assessment of the research proposals by reviewers selected from the research communities) from about 90,000 applications in major research categories. About 83,000 projects, including those continuing for the several fiscal years, were funded. (The initial KAKENHI budget for FY2022 was 237.7 billion yen.)

The KAKENHI system has been reviewed continuously for improvements, and MEXT has carried out radical reforms including the introduction of Multi-year Funds, a review of its screening system, and enhancement of supports for young researchers. In FY2022, MEXT started providing support through "International Leading Research" and also gave assistance to early-career researchers through the introduction of Multi-year Funds for "Grants-in-Aid for JSPS Fellows" in order to encourage challenges by young researchers and formidably promote joint international research by talented research teams led by top-level researchers. To further promote scientific research in the future, the government will continue to review the KAKENHI system and enhance its support.

2. Strategic Basic Research Programs

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 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 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 setting broader strategic targets, for example. MEXT set the following six targets for FY2022.

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

- Innovation in measurement and analysis processes aimed at solving social issues
- Creation of innovative quantum control technology through integrating quantum information and quantum materials
- Creation of fundamental technologies to analyze humans and society for Society 5.0
- Recycling technology using a material conversion system pioneered through "Convergence Knowledge (So-Go-Chi)"
- Elucidation of the mechanisms relating to changes in biological robustness associated with aging and control of age-related diseases*

(2) Advanced Research and Development Programs for Medical Innovation

- Immunological memory: Understanding,

regulation and medical innovation

- Elucidation of the mechanisms relating to changes in biological robustness associated with aging and control of age-related diseases*

*Common goals of the JST Strategic Basic Research Programs (Creating the Seeds for New Technology) and AMED Advanced Research and Development Programs for Medical Innovation

3. Promotion of Fusion Oriented REsearch for disruptive Science and Technology (FOREST)

FOREST, which aims to create results that could lead to disruptive innovation, is implemented with a fund established by JST. This program provides an environment on a long-term basis in which researchers just before and after independence, especially young researchers, can devote themselves to working on their ambitious ideas. In FY2022, efforts were made to enhance and reinforce support, including the holding of a "forum for fusion" to promote network-forming among researchers and the fusion of their knowledge and other initiatives. Applications for funding were also invited for the third time, resulting in the selection of 263 new research subjects. In the second supplementary budget for FY2022, a budget enabling a fourth and further invitations of applications for funding was posted in an effort to enhance support.

4. Promotion of joint usage/research at universities and inter-university research institutes

The system for joint usage/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].

Large-scale scientific projects[2] lead the world's scientific research by tackling uncharted research subjects using large-scale state-of-the-art research equipment, forms a global research center by gathering excellent researchers of Japan and other countries, and provides common foundations of research activities for research institutes in Japan and other countries. For example, in neutrino research as represented by the Nobel Prize-winning efforts of Drs. KOSHIBA Masatoshi and KAJITA Takaaki, a next-generation "Hyper-Kamiokande Project" (Institute for Cosmic Ray Research (ICRR), The University of Tokyo, etc.), an endeavor in which Japan leads the world, is currently underway. The aim of this project is to discover new laws of physics and unravel the mysteries of space largely by elucidating on the nature of neutrinos in full and exploring proton decay.

Additionally, out of large-scale scientific research projects, projects that have considerable foundational properties and require long-term management are provided support as "scientific

1 108 centers of 59 universities (including 7 centers of 5 universities in international joint usage/research centers) have been certified and are active as of April 2023.

2 Large-scale scientific research projects
https://www.mext.go.jp/a_menu/kyoten/20230209-mxt_kouhou02-1.pdf

research foundation projects." Of particular note is the "academic research platform" by the National Institute of Informatics (NII). By maintaining the cutting-edge "SINET [1]" network infrastructure and "NII RDC[2]" research data infrastructure, this platform supports academic research by universities and other institutions and general educational activities as a core network while simultaneously contributing to the realization of data-driven research.

❺ Promotion of international joint research and international talent mobility and circulation

1. The development of international networks of researchers

(1) International mobility of Japanese researchers

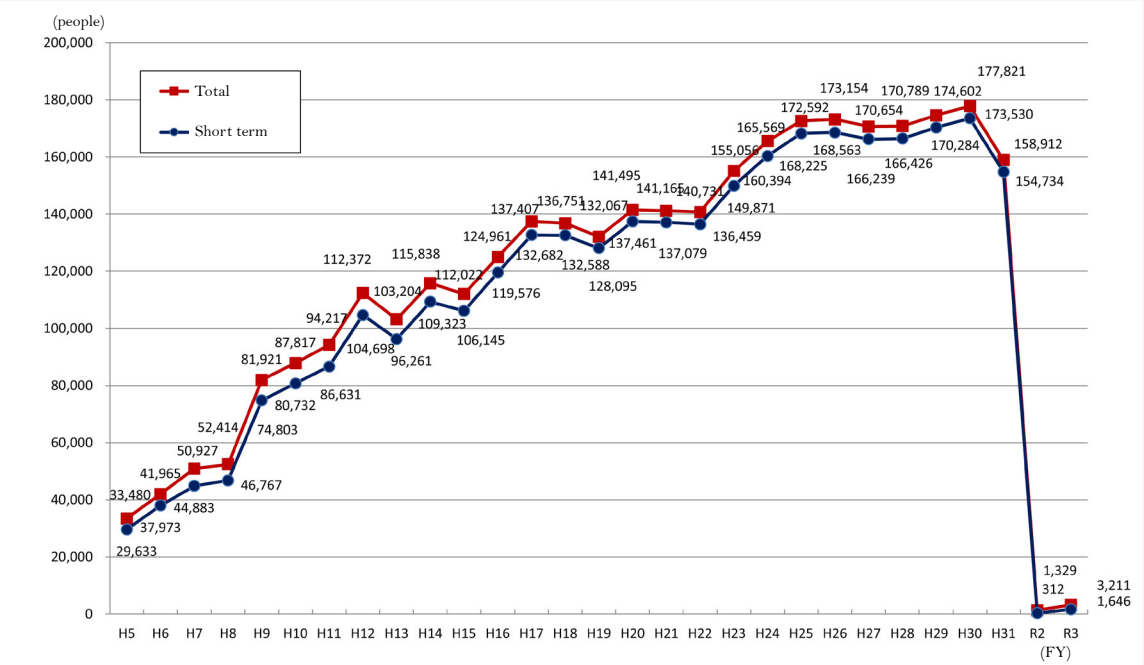
According to the Overview of International Research Exchanges published in FY2023, the number of short-term researchers dispatched had grown since the start of the survey. However, this number saw a significant drop in FY2020, and continued to be at a low level in FY2021 as well. The number mid-to-long-term researchers dispatched has generally remained between 4,000 and 5,000 since FY2008 with a considerable decrease in FY2020 and a slight increase in FY2021 (Figure 2-2-5).

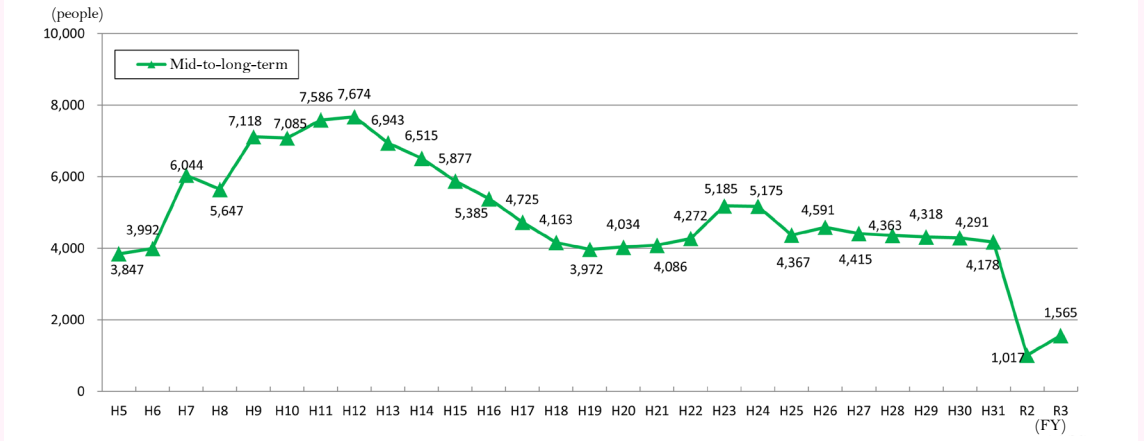
The number of short-term foreign researchers accepted by Japanese universities and Incorporated Administrative Agencies had been on the increase until FY2009, then decreased until FY2011 due to the impact of the Great East Japan Earthquake and other factors, and then recovered. It decreased considerably in FY2020 and remained below standards in FY2021. The number of mid- to long-term foreign researchers has generally remained between 12,000 and 15,000 since FY2000 and the number decreased significantly in FY2020, remaining below standards in FY2021 (Figure 2-2-6).

The low level of these indices is believed to be due to the impact of the novel coronavirus (COVID-19).

1 Science Information NETwork
2 NII Research Data Cloud: the GakuNin RDM data management platform, the JAIRO Cloud data disclosure platform and the CiNii Research data search platform.

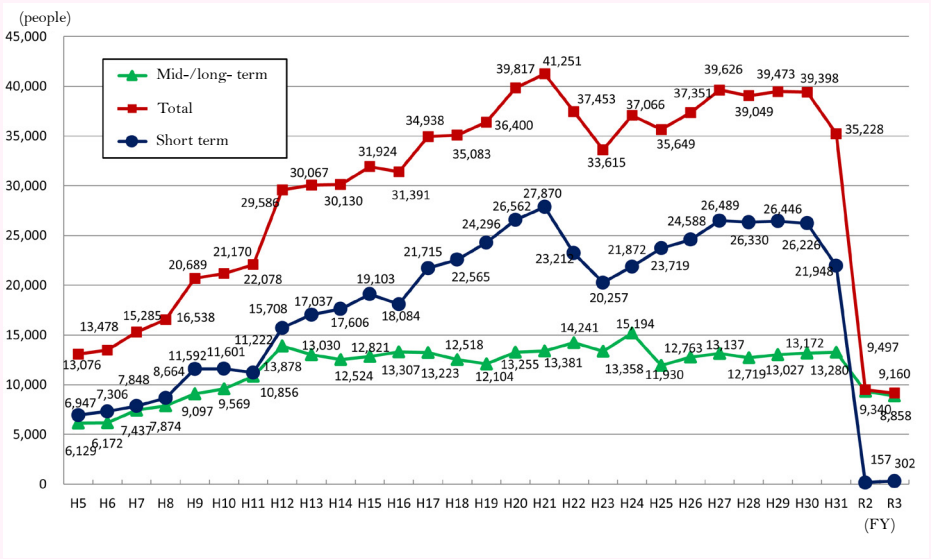
■Figure 2-2-5/Changes in the number of researchers dispatched abroad (short-term and mid-to-long-term)





Note: 1. "Short-term" refers to a maximum period of dispatch and acceptance of 30 days, and "Mid-to-long-term" refers to a period exceeding 30 days.
2. Postdocs and research fellows are included in the figures in and after FY2010.
Source: Overview of International Research Exchanges, MEXT (2023)

■Figure 2-2-6/Changes in the number of foreign researchers from overseas (short-term and mid-to-long-term)



Note: 1. "Short-term" refers to a maximum period of dispatch and acceptance of 30 days, and "Mid-to-long-term" refers to a period exceeding 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 (2023)

(2) Efforts to promote international exchanges of researchers

In the midst of the globally accelerating international talent mobility and 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 provides various programs which send young researchers abroad and invites excellent researchers from other countries to Japan. In the "International Leading Research" program that it established under the KAKENHI system in FY2021, JSPS is promoting the development of excellent young researchers who can compete on the global stage by sending young researchers (post-doctoral fellows and graduate students) abroad for long-term exchanges and providing independent support through joint international research, with the requirement that they participate in excellent research teams led by top-level researchers possessing solid research achievements and an international network.

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 universities or research institutions overseas. The Overseas Challenge Program for Young Researchers offers to support doctoral students traveling abroad.

In addition, the Cross-border Postdoctoral Fellowship (CPD [1]) program has been implemented since FY2019 to provide research grant to excellent young researchers who are

1 Cross-border Postdoctoral Fellow

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.

JST started the Sakura Science Exchange Program in FY2014 to invite excellent youths from countries and regions around the world for a short-term visit to call in outstanding foreign human resources.

Column12 Active Doctoral Human Resources: Researchers Active Overseas Doctoral Personnel Active in Various Locations: Doctors Currently Studying Abroad

After receiving his doctorate and serving as a research assistant professor in Japan, Dr. TAKAKU relocated his professional activities overseas. We asked him about his experience and if he has any advice for individuals looking to pursue opportunities abroad, among other questions.

TAKAKU Motoki
University of North Dakota, Assistant Professor
Ph.D. (Biochemistry)

With the aim of diagnosing breast and other cancers early based on etiology and discovering new therapeutic methods, Dr. TAKAKU studies molecular mechanisms behind cellular changes, including genetic and epigenetic mutations as well as environmental stress. After earning his doctorate in Japan, he moved to the U.S. as a special overseas researcher of the Japan Society for the Promotion of Science (JSPS), and accumulated six years of postdoc experience at the National Institute of Environmental Health Sciences (NIH/NIEHS). Since 2019, he has been continuing his research in his current role as principal investigator.

When he was a master's degree student, Dr. Takaku was not sure about his career path. His mentor, sharing experiences in the U.S., told him that a PhD degree is like a 'free ticket' to work in the U.S. This advice from his mentor inspired Dr. Takaku to focus on an academic career and motivated him to pursue his PhD. Dr. Takaku reflects that his doctoral program not only enhanced his experimental skills and knowledge, but also honed his abilities in logical discussion, problem-solving, and critical thinking. Regarding the experience of adjusting to a different culture, he admitted that communicating in English was particularly challenging. However, he said that his family played a crucial role in helping him overcome many of the difficulties.

When asked about the differences between Japan and the U.S., Dr. Takaku shared his insights: "In the U.S., the game really begins once you are in college. You have the opportunity to take a genuinely positive approach to your studies, meaning you are encouraged to explore subjects that genuinely interest you and are supported in pursuing your academic passions with enthusiasm and optimism. Additionally, graduate students in the U.S. often find themselves in a position where they have to constantly think about their future and seek ways to differentiate themselves from their peers. Americans who hold doctorates generally take great pride in their academic achievements. Possessing a doctorate often facilitates finding a job. Interestingly, Americans in general tend to enjoy scientific discussion and often have a wide range of knowledge."

According to the Science and Technology Indicators 2022, the number of Japanese individuals studying abroad at the higher education level (ISCED 2011 Level 5-8) in 2019 was 32,501. Likewise, Japanese individuals studying abroad in a doctoral program are also few in number. Here, we interviewed Mr. TSUKAMOTO, who is currently enrolled in a doctoral program overseas.

TSUKAMOTO Shingo
University of California, Berkeley, Mechanical Engineering Ph.D.
Master's (Mechanical Systems) Specialty: Mechanical engineering

After earning his master's degree in the mechanical system engineering field, Mr. TSUKAMOTO took advantage of the overseas study-abroad support program offered by Japan Student Services Organization (JASSO) to research the mechanisms through which the mechanical force in cells regulates DNA structure and gene expression at the University of California, Berkeley. He aims to understand cell responses, elucidate on the causes of cancer and autoimmune disorders, and establish associated therapeutic methods.

When he was junior at college, Mr. TSUKAMOTO was diagnosed as having "eosinophilic gastroenteritis," which is designated by the Japanese government as an incurable disease. This inspired him to want to work for the benefit of people suffering from the same disorder.
Thus, starting from his graduate curriculum, he set out to leverage mechanical systems engineering in medicine. While

Mr. TSUKAMOTO was diagnosed as having been cured due to his incurable disease showing no symptoms, he was all too familiar with the pain and despair that comes from being diagnosed with such a disease. For that reason, he continues to pour himself into his research without losing sight of his original intentions.

According to Mr. TSUKAMOTO, his impetus for advancing to an overseas doctoral program can be traced back to the time he studied abroad for his master's degree, when he was highly impressed by the overwhelming research facilities and situations in which researchers from around the world gathered together and joint research efforts came into existence one after the other.

"Berkeley is full of highly motivated students. Proactive discussions take place in the classroom there. Moreover, when I listen to lectures given by famous researchers in various fields and take part in discussions with them, I have a genuine sense that the center of the world is here. It is free in the sense that no one will say anything even if you do nothing, nor will they help you. At the same time, if you are motivated, you will find that things progress with great rapidity. At this stage, I am always working on my research whenever I feel like. Whether it is during my time off is irrelevant."

At the University of California, Berkeley, pursuing a career in a startup after completing a doctoral program is quite a common choice. Mr. TSUKAMOTO engages in his activities while considering all kinds of options, including academia, industry, and entrepreneurship.

2. 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, Specially Appointed Professor, Osaka University) has 17 members (Japan, Australia, Canada, the EU, France, Germany, India, Israel, Italy, the Republic of Korea, New Zealand, Norway, Singapore, South Africa, Switzerland, the U.K., and the U.S.). 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 expenses such as travel and stays (Postdoctoral Fellowships), and holds HFSP awardees' meetings. More than 30 years since the program began in FY1990, HFSPO has given research grants for about 1,200 research projects of about 4,400 researchers worldwide and provided fellowships to about 3,400 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 international joint research and creating world-class research centers

For Japan to establish a strong presence and position itself as a significant part of the global research network, it is important to strategically promote international joint research and form nationwide research centers that will serve as the core of international talent mobility and circulation.

(1) International joint research with other countries

A. ITER project, etc.

The ITER project is managed under the international cooperation of 35 countries, seven parties to realize fusion energy. The construction of ITER began in earnest in Saint-Paul-lès-Durance, France, toward the commencement of

operations in the near future. Japan is promoting the production of major equipment of ITER including superconducting coils (See Chapter 2, Section 1, 2 ❷). Japan and Europe are also promoting the Broader Approach (BA[1]) that is an advanced fusion R&D for supplementing and supporting the ITER project and establishing the necessary technical infrastructure for prototype reactors at Rokkasho Village in Aomori Prefecture and Naka City in 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 "KOUNOTORI" (HTV[2]) and long-term stay of Japanese astronauts in ISS[3]. The National Aeronautics and Space Administration (NASA) announced that the U.S. would extend ISS operations until 2030 in January 2022. Japan became the first country other than the U.S. to announce its participation in the extension of the ISS operation period in November of the same year (See Chapter 2, Section 1, 3 ❺).

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 Government of Japan and NASA jointly signed a memorandum of understanding concerning cooperation on the civil lunar Gateway. In November 2022, MEXT and NASA jointly signed an implementing arrangement concerning cooperation on the civil lunar Gateway based on that MOU. Additionally, in January 2023, the Japanese Minister for Foreign Affairs and U.S. Secretary of State jointly signed the Framework Agreement for Cooperation in the Exploration and Use of Outer Space (See Chapter 2, Section 1, 3 ❺).

D. International Ocean Discovery Program (IODP)

The IODP[4] 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, the 2050 Science Framework (until 2050) was formulated showing scientific goals for future activities.

E. Large Hadron Collider (LHC)

Currently, in the LHC project[5], the upgrade of LHC to increase its luminosity (HL-LHC[6] project) is underway.

F. Other

An international researcher community is considering the International Linear Collider

1 Broader Approach
2 H-II Transfer Vehicle
3 International Space Station
4 International Ocean Discovery Program
5 Large Hadron Collider: An experimental project that uses the gigantic circular particle accelerator of the European Organization for Nuclear Research (CERN) to reproduce the conditions of the early universe (immediately after the Big Bang) to discover unknown particles and explore the ultimate internal structure of matter. It is being implemented under international cooperation between CERN Member States and other countries such as Japan and the U.S.
6 High Luminosity-Large Hadron Collider

(ILC[1]) project to investigate the properties of the Higgs Boson in more detail.

(2) Initiations for formulation of world-leading international research centers

MEXT is enhancing and strengthening the centers that serve as "hubs for international talent mobility and circulation," through "World Premier International Research Center Initiative (WPI[2])," boasting highly internationalized research environments and world-class research levels. Specifically, about 700 million yen is provided to each center for ten years under detailed progress management by top scientists in Japan and abroad. Seventeen centers were active as of the end of FY2022 (https://www.jsps.go.jp/english/e-toplevel/04_centers.html). In 2020, a new mission, "Values for the Future" was added, and the existing missions were upgraded. Under this new mission, WPI research centers will be promoted in a step-by-step manner.

(3) Other initiatives related to research universities

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 the development for expansion of the Okinawa Institute of Science and Technology Graduate University (OIST[3]) in order for OIST to conduct the world's leading education and research. In FY2022, OIST Professor Svante Pääbo was awarded the Nobel Prize in Physiology or Medicine.

Column13 Active Doctoral Human Resources: Natural Science Overseas (Regional Universities)

In S&E-related fields, numerous researchers engage in various research activities while belonging to academia as their post-doctoral career path. Here, we asked early-career researchers in those fields about the nature of their research at universities and interdisciplinary appeal.

MINAMIKAWA Takeo
Tokushima University, Institute of Post-LED Photonics, Associate Professor
Ph.D. (Engineering) (Osaka University)
Ph.D. (Medicine) (Kyoto Prefectural University of Medicine)

For his "research on microscopic measurement making full use of light" in which he wielded light to observe molecules in the body and search disease diagnoses and therapeutic methods, Dr. MINAMIKAWA was awarded The Young Scientists Award, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for FY2022.

He has also earned his doctorate in medicine after becoming a working adult. According to Dr. MINAMIKAWA,

1 International Linear Collider
2 World Premier International Research Center Initiative
https://www.jsps.go.jp/english/e-toplevel/04_centers.html
3 Okinawa Institute of Science and Technology Graduate University

during his time at a college of technology (KOSEN), while he enjoyed making things, he wanted to try seeing a world of nature that surpassed humans. That is what compelled him to begin research in the medical field at a graduate school. Medical specialists are able to conceive the inconceivable. Furthermore, with engineering, successes are borne from mistakes. In medicine, such mistakes are not allowed. While this may sound obvious, experience that difference firsthand is a considerable advantage for a researcher.

Dr. MINAMIKAWA has experience conducting research at universities both in the countryside and city areas. On the differences between the two, he says that at large-scale universities, there are numerous opportunities to casually talk with researchers in differing fields, which serves as a reference in research. Conversely, such opportunities are few at regional universities. However, those universities are conducive to focusing on research due to the lack of excessive interference. It would seem, therefore, that both types have their own distinctive qualities.

Dr. MINAMIKAWA shares: "Becoming a doctor makes it possible to realize the concept of 'independence and self-respect' as famously described by Yukichi Fukuzawa. Through the research in my doctoral program, I developed basic lines of thinking and the ability to understand the flow of all kinds of things. Now, even if someone told me to tackle a different kind of science outside my specialty or to become a science writer, I am confidence that I could handle it."

TODA Satoshi
Kanazawa University, NanoLSI, Assistant Professor
Ph.D. (Medical Science) Specialty: Synthetic biology

To understand how cells communicate with each other to develop and maintain our bodies, Dr. TODA created cells embedded with synthetic receptors (artificial sensors) and tested the rules with which cell collectives spontaneously form multicellular tissue structures. Through his research, he was granted The Young Scientists Award, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for FY2022.

Dr. TODA had studied mechanical engineering in college. In the course of lectures on biological science as a general education subject, he started to question why people can create machines but not cells and how the mechanisms within living things are controlled so precisely. He visited a teacher who gave biological science lectures to ask questions. Then, from around his third year as an undergraduate, he spent his time during vacation at the biology-related labs. Subsequently, he majored in life sciences at graduate school and earned his doctorate, after which he went to the U.S. to study abroad and commenced his current research.

Dr. TODA said, "I made a change in my major starting with graduate school, but the doctoral program allowed me to learn ways of carrying out research and develop a sense of biochemistry. Additionally, the approach of mechanical engineering such as theoretical modeling of mechanical changes in microdomains has also benefitted me in considering biological phenomena. If there is something I want to do, I can always change what I am doing." Also, in his research pursuits, Dr. TODA holds dear the words, "What I cannot create, I do not understand," said by Richard Feynman, noted American recipient of the Nobel Prize in Physics.

He tells us that he intends on keeping up his current research while engaging in joint research with experts in various fields.

❻ Securing research hours

1. Utilization of URAs

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 (URA) 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.

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 URAs, 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. In addition, to further enhance URAs at universities, the utilization of a quality assurance (accreditation) system for URAs was implemented in FY2021 under the project "Implementation of a Quality Assurance System for Management Personnel such as Research Administrators." Operational aid for agencies that implement this quality assurance system will continue to be administered in FY2022. (see Chapter 2, Section 2 1 ❷).

Column14 Research Support Personnel Who Prop up Research at Universities

Research and development at universities is conducted by large numbers of researchers. However, that does not mean that all research work can be performed solely by researchers. Technical staff apply their deep level of expertise and skill towards supporting the foundation of research at universities. In conducting cutting-edge research and development, their presence is indispensable. In this column, we interviewed technical staff who are unsung heroes of university research.

Tohoku University Division of Engineering and Technical Staff, Technical Specialists
NAKANO Yoko and TAKAHASHI Shinji

Ms. NAKANO and Mr. TAKAHASHI field analysis requests from within and outside Tohoku University by conducting inorganic element analysis using inductively coupled plasma mass spectrometry (ICP-MS). In addition to performing inorganic element analysis for diverse analytical samples in wide-ranging fields of specialization, they carry out technology development for ICP-MS using Grants-in-Aid for Scientific Research (Promoted Research) and the Tohoku University School of Engineering Technology Subsidy Program, and have made technological contributions to numerous research and development endeavors up to this point. These outcomes have been recognized with the Research Support Award, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for FY2023.

Q. What inspired you to become technical specialists?
NAKANO: After graduating college, I found work in a job category that was different from research support duties. However, because I had an interest in duties that involved pursuing technology, I felt the desire to have involvement in a job category in which I would contribute to researcher endeavors and society as technical staff. That led me to my current job.
TAKAHASHI: I went directly from earning my master's degree to becoming technical staff. When I was a graduate student, I developed an interest in chemical analysis in the course of conducting research activities, and wanted to be a part of research through analysis even after becoming a staff member. That is why I am doing my current job.

Q. What aspects of being technical specialists do you find interesting or satisfying?
NAKANO: Because technical staff duties are not limited to specific research themes, I study daily so that I can handle analysis requests in various fields of specialization, including semiconductors, metals, and environmental samples. Additionally, I feel a sense of novelty and satisfaction at being able to handle a diverse array of research samples while my duties tie into my personal skill development.
TAKAHASHI: Being able to be a part of research results while having involvement in cutting-edge research support efforts for various laboratories is both fascinating and rewarding. We were recently recognized with a Commendation by the Minister of Education, Culture, Sports, Science and Technology. In FY2021, we both received the President's Research Support Technical Award at Tohoku University as well. Because we belong to a department that manages shared equipment, it is hard for results tied to specific themes to be generated. Still, it gives us great joy for research support duties such as ours to have been recognized, and translates into our sense of job satisfaction.

Q. Do you have a word for individuals considering becoming a technical specialist as an option?
NAKANO: It is possible to tackle research and development themes on your own and input your findings in your duties while concurrently providing research support to researchers. I highly recommend that you try taking on that challenge.
TAKAHASHI: The draw of being technical staff is that you have the opportunity to come into contact with numerous on- and off-campus researchers and research themes and be involved in large research projects. Moreover, I believe helping with research provides avenues for elevating your own skills in a wide range of ways. By all means, please consider becoming a technical staff member as a potential career path.

2. Accreditation of Partnership on Research Assistance Service (A-PRAS)

In October 2019, MEXT established "A-PRAS [1]" to certify research assistance services provided by private enterprises that meet specific requirements as "research assistance service partnerships." Through the accreditation of research assistance services, MEXT aims to improve research environments, including securing research hours of researchers, accelerating the promotion of science and technology and innovation creation in Japan, and supporting the development of various initiatives related to research assistance services. Nine services have been accredited as of FY 2020. In FY2022, in addition to services that have already been certified, MEXT investigated the status of utilization of other research support services with different outstanding features in order to cultivate those services.

3. Simplification and digitalization of university administrative procedures

MEXT has required universities, colleges of technology (KOSEN), and inter-university research institutes to adopt flexible measures to simplify and digitalize administrative procedures, such as permitting electronic procedures in accordance with the wishes of teachers, etc., who apply under open recruitment. In June 2021, MEXT began encouraging universities, etc. to consider flexible measures from the perspective of reducing the burden on applicants in preparing documents for job openings, such as permitting applicants the use of documents like resumes and achievements list prepared in formats other than those designated by each institution as applications. Since then, it has repeatedly been disseminating such measures at meetings for academic affairs staff at each research institution.

4. Unification and simplification of rules related to administrative procedures for competitive research funds

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. Projects that use existing "competitive funds" and other projects that use open-type funds were integrated under "competitive research funds," and the rules on the use of competitive funds that have been unified and simplified were expanded to cover other research funds in addition to competitive funds. Furthermore, entry forms that had been individually stipulated under each project were unified, and actions are being taken through the ministry-shared research and development management system (e-Rad) to enable applications using the unified form.

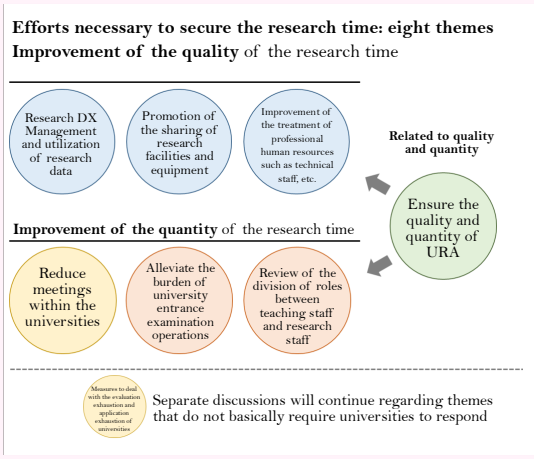
5. Guidelines on improving quality and quantity of research time

The Cabinet Office is following up on progress and future policy for initiatives indicated in the "Comprehensive Package to Strengthen Research Capacity and Support Young Researchers." In FY2022, the "securing of time to focus on research" was covered, and eight related themes were examined. Among them, the Cabinet Office classified the seven themes that universities should address into those with "quantitative" properties in that they increase time to focus on research and those with "qualitative" properties in the form of

1 Accreditation of Partnership on Research Assistance Service https://www.mext.go.jp/a_menu/kagaku/kihon/1422215_00001.htm

making research more efficient, sophisticated and so forth, and discussed those themes. These discussions were then compiled into guidelines for encouraging behavioral changes for members of management at universities and other institutions. Said guidelines also serve as those for research environments and management systems at each university in conjunction with the revised "Package for Comprehensive Promotion of Research Universities with a Regional Core and Distinctive Characteristics" (See Chapter 2, Section 2 3 ❸).

■ Figure 2-2-7/Diagram of necessary initiatives for securing research time



Source: Cabinet Office, Government of Japan

❼ Promotion of Humanities and Social sciences and Creation of the Convergence Knowledge (So-Go-Chi)

The Grants-in-Aid for Scientific Research (KAKENHI) is competitive research funds that cover scientific research in all fields ranging from the humanities and the social sciences to the natural sciences. By supporting creative research activities while ensuring research diversity, the Grants-in-Aid for Scientific Research plays a role in expanding the base of research activities contributing to the sustainable development of research and forming a massive intellectual pool.

In 2020, MEXT launched the "Project for the Co-Creation of Academic Knowledge centered on the Humanities and Social Science" through which initiatives are being implemented to build an environment in which researchers in the human and social science fields play a central role to create research subjects and research teams under the various issues that will be faced by future society ((1) Society and humanity in the face of future demographics, (2) Overcoming Divided Society, and (3) Creation of values that will shape a new human society), pooling their knowledge and expertise with various stakeholders that include industry and civil society in addition to researchers in the natural science fields.

In addition, under the "Topic-Setting Program to Advance Cutting-Edge Humanities and Social Sciences Research," JSPS began the "Academic Knowledge Co-Creation Program" in FY2021 through which it pursues essential and fundamental questions unique to the humanities and social sciences based on the summary of the deliberations of the Special Committee on Humanities and Social Sciences of the Subdivision on Science, CST.

MEXT has been implementing the Program for Promoting 'Science for Policy' in Science, Technology and Innovation Policy (SciREX Program), with the aim of realizing STI policymaking through a reasonable process based on objective grounds (evidence). This project provides support to centers (universities) that foster researchers for the scientific advancement of STI policies and human resources to support the making of these policies, and is building a mechanism to link these centers via a network, enabling systematic human resource development throughout Japan. Centered around these centers, MEXT is promoting research projects in which administrative officials and researchers collaborate

on policy research and analysis from the topic-setting stage.

The Graduate School Subcommittee under the Central Council for Education's University Committee compiled and disclosed its "Direction of Graduate School Education Reforms in Humanities and Social Sciences" (interim summary) (August 3, 2022).

The Cabinet Office, the Government of Japan, has studied the basic concept of "Convergence Knowledge (So-Go-Chi)" that contributes to a comprehensive understanding of human beings and society and to the solution of problems as well as strategic promotion measures, compiled them in a mid-term report in March 2022, and is currently opening a Convergence Knowledge (So-Go-Chi) portal site as well as implementing a caravan and other efforts to generate public awareness of the concept (see Chapter 2, Section 1, 6 ❶).

Since FY2021, the first year of the Sixth Basic Plan, NISTEP of MEXT has been including questions related to Convergence Knowledge (So-Go-Chi) to monitor awareness of it in the NISTEP TEITEN Survey, which is implemented annually in conjunction with the Basic Plan.

❽ Comprehensive reform of the competitive research funds system

The competitive research funds system [1] 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 (647.1 billion yen for FY2021 initial budget).

To strengthen Japan's research capacities and based on the "Integrated Innovation Strategy 2019" (Cabinet decision on June 21, 2019) and "Integrated Innovation Strategy 2020" (Cabinet decision on July 17, 2020), from FY 2020 onward, the direct expenses of competitive research funds can be used to pay for expenses related to outsourcing of non-research work to secure research hours of researchers. The financial resources secured by paying personnel expenses to research representatives from the direct expenses of competitive research funds can be utilized by research institutions to improve their research capacities.

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 (See Chapter 2, Section 2, 1 ❶).

Also, in order to promote the further activity of female researchers, gender equality and so forth, based on the Sixth Basic Plan as well as the "Basic Plan for Gender Equality" (decided by the Cabinet on December 25, 2020) and the "Policy Package regarding Education and Human Resource Development toward the Realization of Society 5.0" (decided by the Council for Science, Technology and Innovation on June 2, 2022), under the Competitive Research Funds System, a policy was adopted to apply as standardized rules the promotion of research based on the perspectives of gender equality and gender disparity, the promotion of the development of research environments that enable both male and female researchers to easily keep working even if childbirth, childcare, long-term care or another life event arises, the promotion of initiatives for researchers, etc. to conduct outreach activities to

1 Competitive Research Funds System
https://www8.cao.go.jp/cstp/compefund/

children while also leveraging the results of their research activities digitally with a view to promoting the development of human resources in S&E-related fields who will uphold the next generation, and so forth starting in FY2023 while taking into consideration the nature and other aspect of each project.

To reduce office work on researchers to secure their time for research, the existing "competitive funds" and funds for open-type projects are integrated as "competitive research funds," and initiatives are being taken to improve, simplify, digitalize and speed up various office administrative procedures under a unified rule (See Chapter 2, Section 2, 1 ❻). At the same time, the treatment of indirect expenses in competitive research funds, including the ratio to direct expenses, etc., shall be unified, and simplification of use reports and documentary evidence has been implemented from FY2022. 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 8,000 examiners. JSPS selects examiners from the examiner candidate database (which stored information on about 148,000 researchers as of the end of FY2022) while 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 research funds and other public research funds, guidelines have been formulated, which include the Measures to Prevent the Inappropriate Use of Research Funds CSTP), August 31, 2006 and the Guidelines for Management and Audit of Public Research Funds at Research Institutions (Implementation Standards) (Decision of the MEXT 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. Furthermore, MEXT is communicating information on specific cases tackled by research institutions based on the guidelines amended in February 2021, and is working towards preventing the inappropriate use of public research funds.

2 Construction of a new research system (promotion of open science and data-driven research, etc.)

These days, data-driven research methods utilizing simulations and AI are expanding as it becomes easier to collect and analyze various data, such as big data. This can be attributed to the digitalization of the whole society and the global trend toward open science, which requires the digital transformation of research itself (Research DX). Furthermore, the progress of Research DX is accelerating worldwide in the wake of the COVID-19 pandemic. In Japan, the government is

working to build a research system toward the realization of a new society brought about by Research DX, such as promoting the management and utilization of research data, which is an important keyword, and developing infrastructure to support Research DX.

❶ Developing an environment to promote appropriate management and utilization of reliable research data

Research data generated through various research activities are considered to be important intellectual assets not only for Japan but also for the world. On the other hand, since some data contains important information, securing industrial competitiveness or scientific and technological superiority, it is crucial to implement management and utilization of research data based on open-and-close strategies to consider both international contributions and national interests. Based on the above, the "Basic Concept on Management and Utilization of Research Data with Public Funds" (decided by the Integrated Innovation Strategy Promotion Council on April 27, 2021) was established as a national policy of Japan, and improvements to the research environment are underway, including the building of research data infrastructure that will enable meta data searches to facilitate the management and utilization of research data.

The National Institute of Informatics (NII[1]) provides various services to users and appropriately manages and stores academic information necessary for innovation creation. To promote the management and utilization of research data, NII continues to operate its system that encourages the management, sharing, disclosure and search of research data that universities and other institutions can share the use of over a cloud platform (NII RDC). In FY2022, alongside RIKEN, The University of Tokyo, Nagoya University and Osaka University, NII commenced the "Research Data Ecosystem-Building Project to Promote the Utilization of A.I., Etc." that will promote the sophistication of functions, the preparation of guidelines and other initiatives with the use of NII RDC.

Under the "JST Basic Policy on the Handling of Research Results Aimed at Promoting Open Science," by adopting the open licensing of research results papers based on research project results, the storage and management of research data based on data management plans and so forth as basic principles, the Japan Science and Technology Agency (JST) is endeavoring to make environmental improvements aimed at promoting open science. In April 2022, JST revised said policy in order to further promote open science. Additionally, by making environmental improvements to science and technology information platforms through its service that connects ten categories of science and technology information, including that on literature and patents, and provides information that can be utilized in a wide range of sectors and business categories (J-GLOBAL); its science and technology literature database search service that enables the comprehensive search and analysis of data on Japanese and overseas literature related to science and technology (JDream III); its researcher overview database through which researchers themselves can manage and communicate performance results (researchmap); its electronic journal platform that assists with the publication of published material on science and technology by domestic academic societies and other entities (J-STAGE[2]); Japan's first full-fledged preprint server for publicly releasing unannounced papers prior to

1 National Institute of Informatics
2 Japan Science and Technology information Aggregator, Electronic

peer review through open access (Jxiv); and so forth, JST supports the gathering, storage and disclosure of science and technology information in cooperation with public institutions and private companies and other research and development activities. Furthermore, the NBDC Project Promotion Department under JST has been contributing to the promotion of open science by implementing the "Life Science Database Integration Coordination Program" and maintaining information platforms for comprehensively utilizing a life sciences-related database through supporting the building of an integrated database, developing technology for that integration, and cooperating with MEXT, MHLW, MAFF and METI.

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[1])) on papers published in Japanese science journals related to agriculture, forestry and fisheries. MAFF is also creating and offering databases on digitized full-text information regarding research papers published by independent administrative institutions specializing in R&D, national/public R&D institutions and universities. 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[2]).

RIKEN, NIMS and 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.

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

❷ Developing infrastructure to spur Research DX for research outcome with high impacts

The government has been working on acceleration of Research DX by setting up and maintaining the world's best research infrastructure: networks, data infrastructure and computation resources. In addition to this, for the research to be carried out beyond the constraints of time and distance, the spread of smart laboratories that enable remote research and automation of experiments. It also promotes the implementation of cutting-edge research that is data-driven and AI-driven and research based on information science and technology to support these new research methods.

1. Development and operation of SINET

NII has developed and operates the Science Information NETwork (SINET) as the primary network to support all academic research and educational activities of universities and research institutions. From FY2022, the network started operating across all prefectures at 400 Gbps[3] (200 Gbps in Okinawa). Also, to facilitate the global exchange of research information required for international advanced research projects, NII has

1 Japanese Agricultural Sciences Index
2 Japan Integrated Biodiversity Information System
3 Giga bit per second：Bit per second (bps) is a unit of data transmission speed and indicates how many bits of data can be transmitted per second. 1 Gbps is capable of transmitting 1 billion bits (1 gigabit) of data per second.

been promoting collaboration with several overseas research networks in the U.S., Europe, etc., and is continuing to take measures to strengthen security in cooperation with national universities and other organizations.

2. 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.

(1) 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.

A. Super Photon ring-8 GeV (SPring-8)

SPring-8[1] 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. 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.

In recent years, the research and development support system at this facility has been reinforced by promoting the automation of measurement apparatus

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

and enabling automatic measurement and remote experiments that do not require facility visitation, among other efforts. Additionally, starting in FY2022, efforts have also been made to improve data infrastructure in order to effectively utilize high volumes of high-precision measurement data.

B. X-ray free-electron laser facility (SACLA)

SACLA[2] is the most advanced research infrastructure facility in the world with respect to

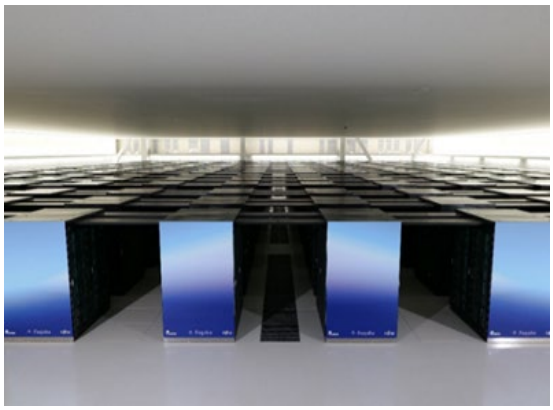
1 Super Photon ring-8 GeV
2 SPring-8 Angstrom Compact free electron LAser

the generation of x-ray laser. The unprecedented light generated there has both laser and synchrotron radiation characteristics and allows for the analysis of atomic-level hyperfine structures and the observation of ultra-high-speed movements/changes in 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[1] started for the first time in the world. Its usage environment has also been improved toward creation of further creation of high-impact results. Since FY2020, SACLA has also been utilized for injectors that supply electric beams to SPring-8. In addition to achieving energy-saving, this also contributes to the provision of higher-quality, more stable synchrotron radiation at SPring-8. Additionally, in FY2022, a remote system being developed to promote the digital transformation (DX) of the usage environment was used in the conducting of a user experiment for certain experimental infrastructure.

C. Supercomputer Fugaku

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. Development of the supercomputer Fugaku began in FY2014 as the successor to the K computer (September 2012 - August 2019) to contribute to solving the social and scientific issues facing Japan. The supercomputer was developed with the world's highest level of computational performance and versatility through cooperative development (co-design) of systems and applications, and its shared use began in March 2021.

Since FY2022, the utilization of the Fugaku supercomputer has spread across a wide range of sectors, including disaster protection and mitigation, manufacturing, life sciences, the environment and energy. Examples of application include real-time simulations in advanced research on linear precipitation zone forecasts by the Japan Meteorological Agency and the commencement of new drug discovery research using A.I. in cooperation with corporate consortiums. As a shared computation infrastructure, the government is connecting supercomputers and data storage facilities at universities and research institutions in Japan, including Fugaku, via SINET to build an Innovative High-performance Computing Infrastructure (HPCI) that meets the needs of diverse users and promoting the use of supercomputers in diverse fields. In addition, a subcommittee established under the Information Committee of CST studied the ideal state of Japan's computational infrastructure with a view to a post "Fugaku." "Investigative research pertaining to next-generation computing platforms" commenced in August 2022. To strategically develop such platforms in a post-Fugaku era on a national level, specific performance, functions and other aspects are currently being examined while technologies that Japan should independently develop and maintain are identified.

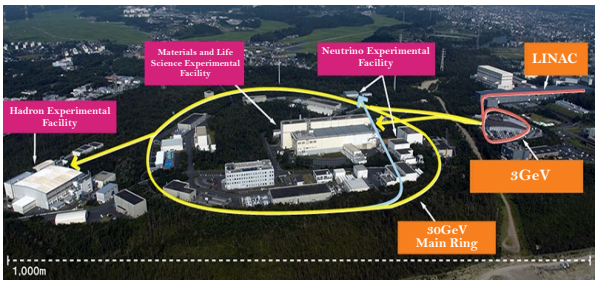


Supercomputer Fugaku

Source: RIKEN

1 Multiple beam lines can be used simultaneously by switching the paths of the electric beam from the linear accelerator pulse-by-pulse.

D. Japan Proton Accelerator Research Complex (J-PARC)



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

All facilities of J-PARC[1] 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, neutrinos[2] and so on that are generated by its proton accelerator, which possesses the highest beam intensity in the world. The Materials and Life Science Experimental Facility (Specific Neutron Beam Facility) has been used for structural analyses which may create innovative materials and new drugs and numerous results have been achieved. In FY2022, budgetary measures for improving the efficiency of results creation with the use of digital transformation (DX) were taken. Since December, efforts such as the maintenance of data centers aimed at enhancing experiment efficiency through the likes of online data analysis have been underway. 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.

(2) 3GeV Synchrotron Radiation Facility (NanoTerasu)

NanoTerasu 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.

3GeV Synchrotron Radiation Facility
(NanoTerasu)
(Under maintenance)
Source: Photon Science Innovation Center

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. MEXT will promote the facility in a public-private-regional partnership that designates the National Institutes for Quantum 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. Installation of the particle accelerator and other main equipment finished in FY2022, and the

1 Japan Proton Accelerator Research Complex
2 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.

construction of the facility is steadily progressing with the aim of producing synchrotron radiation in FY2023 and starting operation in FY2024.

Additionally, with regard to the ideal state of utilization of this facility, a meeting of experts on the ideal nature of utilization of a next-generation synchrotron radiation facility (NanoTerasu) convened seven times starting in August 2022, and summarized the results of its study in February 2023.

Furthermore, in February 2023, the Cabinet decided on the "Bill for Partial Revision of the Act on Promotion of Shared Use of Specified Large-scale High Technology Research Facilities," which newly adds NanoTerasu to "Specified Large-Scale High Technology Research Facilities" as well as lays down measures such as having QST conduct operations relating to common use of the facility.

(3) Constructing a network of research facilities and equipment

Project for promoting public utilization of advanced research infrastructure (Program for advanced research equipment platforms)

With the aim of remote use and automation of the most advanced research facilities and equipment in Japan, MEXT has been advancing initiatives to build a network among research facilities and equipment, which includes their maintenance and operation, to improve convenience through one-stop services and form nationwide platforms with an advanced utilization support system for all researchers.

(4) Strengthening the system for strategically introducing, upgrading and sharing research facilities and equipment as research infrastructure across research institutions

MEXT is promoting initiatives to strengthen the functions of the supervising departments that are responsible for the management of equipment across research institutions. The ministry is also strengthening the system for strategically introducing, upgrading and sharing research facilities and equipment that are being managed by research organizations such as faculties, departments and graduate schools, as research infrastructure for entire research institutions (building core facilities).

In March 2022, the "Guidelines for the Promotion of Shared Use of Research Facilities and Equipment[1]" were formulated to promote the strategic maintenance and operation of research facilities and equipment at universities and other research institutions, and awareness campaigns for universities are being conducted.

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

MEXT has been conducting the "National BioResource Project" that is to establish a system for systematically collecting, preserving, and providing bioresources such as animals and plants for research that are the basis of life sciences and important for the strategic development by the national government.

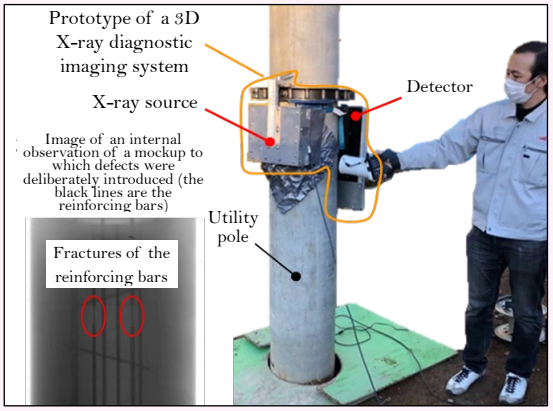
To strengthen Japan's research and development capacity, in May 2021, METI compiled and published a draft of the Third Intellectual Infrastructure Development Plan deliberated at a joint meeting of the Special Subcommittee on Measurement Standards, the Intellectual

1 Guidelines for the Promotion of Shared Use of Research Facilities and Equipment
https://www.mext.go.jp/content/20220329-mxt_kibanken01-000021605_2.pdf

Infrastructure of the Industrial Structure Council and the Intellectual Infrastructure Development Special Committee under Japanese Industrial Standards Committee (JISC)'s Basic Policy Subcommittee. The progress of each field in the Third Intellectual Infrastructure Development Plan is as follows.

For measurement standards and measurement, the National Institute of Advanced Industrial Science and Technology (AIST) implemented various initiatives. With the aim of revising the future definition of seconds, by considerably mitigating the uncertainty of optical lattice clocks and introducing remote control mechanisms, AIST implemented continuous, on-time corrections of international atomic time with even higher precision, achieving full-year utilization of 75%. In order to do its part to realize a green society, based on the results of demonstrative experiments for measurement precision inspection devices conducted using the master meter method for the purpose of evaluating hydrogen dispensers used at hydrogen stations, AIST submitted a final draft for the amendment of JIS B 8576, the industrial standard for hydrogen fuel measurement systems used to refill automobiles, as well as improved large hydrogen flow testing rooms in order to further enhance their precision. For the sake of speedy and accurate integrity diagnoses of dilapidated infrastructure, with the aim of establishing a three-dimensional X-ray image diagnostic system, AIST developed technology that constructs three-dimensional images using A.I. and demonstrated that it is capable of easily observing the state of fractures in inner reinforced concrete upon inspections of telephone poles (Figure 2-2-8). Additionally, AIST developed a reference material for amyloid beta, which has been designated as a diagnostic biomarker for Alzheimer's disease, with the intention of improving the precision of clinical medicine examinations, as well as carbon dioxide-standard gas with an atmosphere composition needed to measure carbon dioxide for the purpose of preserving the global environment and addressing the issue of climate change. Furthermore, AIST moved forward with the establishment of a system for issuing digital correction certificates based on trends in the international promotion of DX in measurement standards. AIST also tackled the likes of the effective and efficient generation of public awareness and cultivation of human resources as well as the communication of information by means such as the holding of hybrid lectures and other endeavors combining online and face-to-face exchanges and the utilization of websites and social media in order to cultivate familiarity with measurement standards among common wide-ranging age groups.

■Figure 2-2-8/Inspection of telephone poles using AIST-developed three-dimensional image diagnostic system



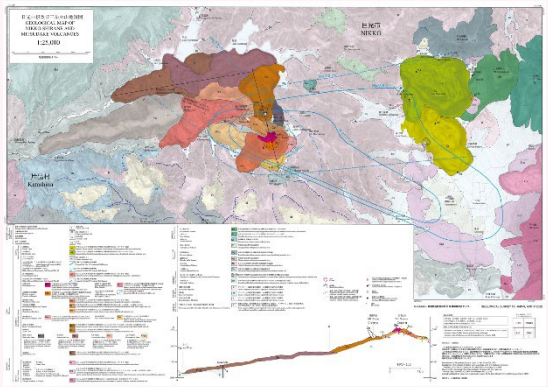
Provided by: AIST

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 (from April to the end of

December 2022, 5,894 strains of biological resources had been distributed). NITE has also constructed cooperative relationships with Asian countries and regions by joining a network of 29 organizations from 14 countries and regions, which aims for the preservation and sustainable use of microbial genetic 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.

Regarding geological information, AIST has published 1:50,000 geological maps for two quadrangles ("Urabandai" and "Kawagoe"), one 1:200,000 geological map for one quadrangle ("Miyazu (2nd Ed.)) and three marine geological maps ("Geological map of the vicinity of Kumejima Island," "Sedimentological map of the vicinity of Kumejima Island" and "Geological map offshore of Cape Noma Misaki"), and is updating the 1:200,000 Seamless Digital Geological Map of Japan. For coastal geology, AIST conducted the Web release of its "Alluvium atlas for the Tama River lowlands" as a special geological map that clarifies the alluvial distribution and formation of those lowlands. For volcanic geology, AIST published the "Geological map of Nikko-Shirane and Mitsudake volcanoes" (Figure 2-2-9). AIST also published a large-scale pyroclastic flow distribution map corresponding to low-frequency large-scale eruption disasters, "Distribution map of Ito Ignimbrite and associated deposits, Shikotsu Caldera." In addition, for the purpose of data integration, the digitization of geoscientific maps has been accelerated, and an API[1] for the linked use of some existing databases has been steadily developed and released on "GeoMapNavi," a comprehensive portal system.

■ Figure-2-2-9/Geological map of Nikko-Shirane and Mitsudake volcanoes



Provided by: AIST

The Genome Data Infrastructure Project aims to realize individualized prevention and medical care by promoting the development and utilization of the genome data infrastructure and promoting research and development that contributes to the prevention, diagnosis, and treatment of disease onset and severity with an overview of the life stage. In FY2022, further data registration and disclosure were made to the database (MGeND[2]) that accumulates and integrates clinical information and genomic information, etc., in MHLW's support project for the clinical genome information database. Additionally, in the likes of MHLW's research project for the practical application of innovative cancer medicine, based on the "Whole Genome Analysis Action Plan 2022" formulated in September 2022, efforts such as whole genome analysis for approximately 4,500 cases in the cancer and incurable disease field were conducted and the provision of medical care with the use of the analysis result was promoted. Simultaneously, the ministry worked on establishing an information platform to link together whole genome analysis results and other information with clinical information and feature it as well as on making environmental improvements

1 Application Programming Interface
2 Medical genomics Japan Variant Database

pertaining to the utilization of that platform. In addition, MEXT and Tohoku Medical Mega-Bank Project are further enhancing the genome database, including launching a general public and private joint genome analysis of 10 million people.

4. Research on mathematical and information science and technology

In its expansion of mathematical sciences aimed at realizing Society 5.0, MEXT sorted out five key issues (including interdisciplinary cooperation and cooperation with society) and formulated initiatives geared towards those key issues in the form of "Expansion of Mathematical Sciences with a View to the Year 2030: Expectations for Mathematical Sciences and Key Issues" in July 2022. The ministry is aiming for the establishment of a function expansion model in which the value of mathematics and mathematical sciences as human's intellectual assets is correctly evaluated after industry-university-government sectors share what the ideal form of mathematical sciences entails, innovation accompanying new industry and social transformation is created through the acceleration of joint research and other endeavors with various science and industrial sectors, and the results obtained are reinvested into academia.

In addition, RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program (iTHEMS [1]) aims to comprehensively elucidate various sciences centered on mathematics, theoretical science, and computational science, discover and solve problems in society and create innovation through collaboration with RIKEN SUURI CORPORATION, which was established through a joint investment with the private sector.

To build a new platform using information science and technology and realize the leading cases of Society 5.0, since FY2018, universities and other institutions with a high level of knowledge, information, technology and human resources have implemented the "MEXT Society 5.0 Realization Research Support Project" aimed at social implementation in cooperation with industry, public entities, and other research institutions while integrating various research results with information science and technology as the core.

5. Analysis of changes in research activities by DX

NISTEP of MEXT, as a part of the development of new analytical methods and indicators using DX related to changes in research activities, conducted a field survey on open science, including the disclosure and sharing of research data and the use of preprint, and conducted a comparison over time. Also, survey on the content of preprint servers by field, and a survey on the public status of various research results based on competitive funding in the U.K., were conducted.

❸ Creation of a new research community and environment pioneered by research DX

The government will promote research activities such as the creation and fusion of knowledge by co-creating with various entities such as local governments, NPOs and NGOs, small and medium-sized enterprises and start-ups, freelance researchers, and citizen participation. In addition, the government will implement the development of an environment that encourages the participation of various entities as a new science, technology, and innovation policy formulation process as a bottom-up approach by industry, academia, and government, such as the launch of citizen science research projects that expect the participation of many citizens by collecting many samples and conducting scientific experiments that cannot be realized by researchers alone (on a scale of 10,000 people, with the assumption that it will start by FY2022).

1 Interdisciplinary Theoretical and Mathematical Sciences Program

JST has been contributing to promote research activities through the creation and fusion of knowledge and to enhance the literacy of science and technology in society, by building opportunities for dialogue and collaboration (co-creation) through the Science Agora and its related activities in collaboration with local public entities and universities and networks of various stakeholders named CHANCE.

Additionally, at the Citizen Science Research Center established by Fukuoka University in 2021, the ideal way to promote citizen science in collaboration with citizens is being examined.

3 Promoting university reform and enhancing functions for strategic management

As nodes of diverse knowledge and the largest and most advanced knowledge base, universities are expected to play a leading role in Society 5.0. To successfully survive in a highly uncertain society by utilizing a rich knowledge base, the goal is to form a diverse group of universities by developing individual strengths and clarifying the missions appropriate for each university.

❶ Transformation of national university corporations into truly corporate management

MEXT will review the modalities of the medium-term goals in preparation for the 4th medium-term target period and set out the basic matters concerning the roles and functions that the government as a whole requires of national university corporations in the "National University Corporation Medium-Term Goals Overview," and each corporation will formulate a draft of its medium-term goals based on it.

In addition, during the 2021 ordinary Diet session, the "National University Corporation Act" (Act No. 112 of 2003) was amended to abolish the annual evaluation system. As a general rule, it was decided to evaluate the work performance of the university over six years. In addition, each national university corporation publishes a report on compliance status with the "Governance Code for National Universities" to fulfill accountability to relevant parties.

❷ Deregulation to support strategic management

The "Act to Partially Amend the Act on National University Corporation" (Act No. 41 of 2021), which was passed in May 2021, eliminated the president's involvement in the university president selection committee and clarified the check-and-balance function of the university president selection committee. In addition, organizational restructuring procedures at national universities have been simplified, starting with projects opened in FY2022.

Furthermore, the government is working to promote donations to national university corporations through successive revisions to the tax system as well as making it easier to understand from the perspective of various stakeholders by making changes to accounting standards of national university corporations, such as abolishing balanced profit and loss accounting and examining the ideal system related to carry-over that includes the special purpose reserve funds, and making revisions to enable to set aside funds for the replacement and renewal of facilities and equipment.

The Cabinet Office established the "Leaders' Forum on Promoting the Evolution of Academia for Knowledge Society, PEAKS[1]" in May 2019 for university officials, industry and the government to hold discussions on management issues and solutions at universities, consider deregulation,

1 Leaders' Forum on Promoting the Evolution of Academia for Knowledge Society

and foster university management. Since FY2022, demonstration projects intended to establish a growth model for Japanese universities and secure and cultivate capable university manage personnel have been conducted.

❸ Enhancement of Japan's research capacity

1. Establishment of a 10-trillion-yen University Endowment Fund

Japan's research capacity has been relatively declining in recent years compared to other countries. One of the reasons is that top universities in Europe and the U.S. have been making substantial investments in research infrastructure and young researchers by utilizing the investment benefits of the fund, which is in the amount of several trillion yen. For this reason, the government established a University Endowment Fund using national funds to realize world-class research universities and started operating the fund at the end of FY2021. At present, the government is in the process of steadily preparing to commence support for FY2024.

With respect to the specific program design for the University Endowment Fund, based on the "Act on Strengthening Systems for Leveraging Research and Research Results of Universities for International Research Excellence" (Act No. 51 of 2022) established in May 2022, in November that year, Japan determined a "Basic Policy" that sets forth basic matters relating to areas such as the significance of the program and the certification of universities eligible for support from the University Endowment Fund.

In selecting Universities for International Research Excellence that are eligible for support from the University Endowment Fund, in accordance with this "Basic Policy" and so forth, MEXT plans on ascertaining the situation at the site of research and holding careful dialogue with the university side based on its indicated will to "transform" in order to realize world-class research universities (its vision) and its commitment rather than make a decision based solely on preexisting results and accumulation. Through these initiatives, under the clear vision of the universities, the Universities will radically strengthen their research infrastructure and provide long-term and stable support to young researchers, thereby leading to a significant strengthening of the research capabilities of research universities in Japan.

2. Package for Comprehensive Promotion of Research Universities with a Regional Core and Distinctive Characteristics

To raise the research capabilities of Japanese universities, it is also important for universities across the country to develop their individual strengths and form diverse groups of research universities under the mission of each university. For this reason, the "Package for Comprehensive Promotion of Research Universities with a Regional Core and Distinctive Characteristics" was decided in February 2022 to strongly support initiatives to drive social change by fully demonstrating "distinctive strengths" by regional core universities and universities with strengths in specific fields. In February 2023, in order to further develop and evolve upon the content of the package, it was revised to help achieve "quantitative expansion" for further increasing support as well as to help achieve "qualitative expansion" for clarifying the university ideal to be worked toward and strengthening cooperation between the projects of each ministry and agency. Under the revised package, a basic approach was indicated for a "compass" to reflect on the positioning of the universities themselves in their aim to realize their ideal to be worked toward from each of the following three "functions" sought of regional core and distinctive research universities:

(1) Diversity and excellence, (2) Social implementation and innovation, and (3) Regional contribution. Simultaneously, with the projects under each ministry and agency having been compiled into a single policy package, the aim behind the revised package was to make it easier for universities to accelerate the reinforcement of their functions in a selective manner and in accordance with their development stage under a portfolio strategy tailored to their own mission.

Additionally, under the second supplementary budget for FY2022, the "Program for Forming Japan's Peak Research Universities (J-PEAKS)" and other projects were newly implemented through a fund of approximately 150 billion yen created in the Japan Society for the Promotion of Science (JSPS) as a main support measure under this package. This program supports research universities to establish both hardware and software environments necessary to accelerate and elevate internationalization and social implementation of research activities.

Through this package, the government aims to improve the overall research capabilities of Japan by having diverse universities that exist throughout the country to serve the various functions of Japan reinforce their strengths and characteristics by selectively and gradually utilizing various measures in accordance with their mission and build relationships in which those universities can vie with other top-level research universities.[1]

❹ Diversification of public funds and governance to support university foundations

1. Public funds to support university foundations

Upon the commencement of the 4th medium-term target period of national university corporations starting in FY2022, efforts were made to revise the distribution of government subsidies for national university corporations, which constitute basic research funds for national universities, and support for realizing and accelerating the mission of each university was enhanced. Simultaneously, efforts were made to improve reform incentives.

For the FY2022 budget, 1.786 trillion yen was posted.

2. Development of facilities for national university corporations

Institutions such as national universities serve as a place for developing human resources responsible for the future. They are also important infrastructures to support educational and research activities, including regional revitalization and innovation creation. On the other hand, while all the large-scale facilities built in the 1960s and 1970s are now simultaneously reaching the point of necessity for improvement against aging, as the aged facilities have not been sufficiently improved, which is resulting in significant issues in terms of safety and function.

Amid such circumstances, under the "Fifth Five-Year Plan for Facilities of National Universities" (decided by the Minister of Education, Culture, Sports, Science and Technology on March 31, 2021), whose plan term is FY2021 to FY2025, as

1 Package for Comprehensive Promotion of Research Universities with a Regional Core and Distinctive Characteristics
https://www8.cao.go.jp/cstp/daigaku/index.html

MEXT steadily ensures safety through measures such as the improvement of aging facilities, it is aiming at the implementation of "Innovation Commons (Co-creation campus),[1] where the entire campus will be integrated with software and hardware and co-creation activities will be carried out by various stakeholders such as the local community and the industrial world (Figure 2-2-10, Figure 2-2-11).

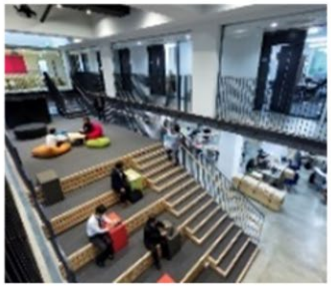
In order to realize "Innovation Commons" at various national universities and other institutions, at "Meetings of Investigative Research Cooperators on the Promotion of the Development of Facilities for National University Corporations," which have been convening since October 2021, case examples of campus and facility development for supporting co-creation activities, key points of initiatives, implementation measures and so forth were compiled, and the "Aiming to Realize Innovation Commons (Co-Creation Campus)" was publicly released. In addition, the Plan for Global Warming Countermeasures and Regional Decarbonization Roadmap call for initiatives to take the lead in net zero energy buildings (ZEB) in public and other facilities to achieve net zero greenhouse gas emissions in 2050. The government has set a goal of ensuring energy efficiency and conservation performance at the level of ZEB standards for newly constructed buildings after FY2030. For this reason, photovoltaic power generation facilities utilizing the likes of PPA and other renewable energy facilities are being installed and thorough energy conservation measures are being implemented during new expansion, remodeling and renovation projects at the national university corporations. ZEB is being promoted for facilities that will serve as leading models for other universities and local communities.

■Figure 2-2-10/Image of "Innovation Commons (co-creation campus)" at National Universities

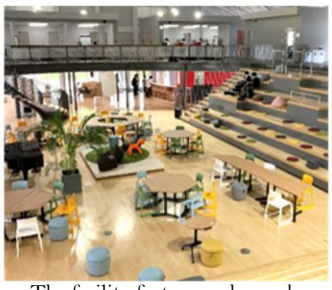
Created by MEXT

1 Innovation Commons is a campus where students, researchers, industry, public entities, and various other players can gather, interact, hold discussions and create new value through face-to-face and online exchanges in various fields and situations such as education, research, industry-academia collaboration and regional collaboration.

■Figure 2-2-11/Case examples of campus and facility development for supporting co-creation activities



Intersectional research spanning multiple fields is conducted in a large space—all under one roof



The facility fosters exchange by providing a space for all users—including businesses—regardless of university affiliation

With movable partitions and furniture, the facility can be customized to suit your needs

<Related websites>
(1) Development of facilities for national university corporations
https://www.mext.go.jp/a_menu/shisetu/kokuritu/index.htm

(2) Aiming towards realizing "Innovation Commons (co-creation campus)"
https://www.mext.go.jp/b_menu/shingi/chousa/shisetu/062/1417904_00002.htm

❺ Strengthening the functions and financial bases of national research and development agencies

The "Act on the General Rules for Incorporated Administrative Agencies" (Act No. 103, 1999) was revised in 2014. This revision led to the promotion of 27 independent administrative agencies to roles as national R&D agencies (as of March 31, 2023), which are expected to facilitate the sound development of the Japanese economy and meet the public interest by making maximum R&D efforts and raising Japan's scientific and technological standards. In addition, the "Act on Special Measures Concerning the Promotion of Research and Development by Designated National Research and Development Agencies" (Act No. 43 of 2016) passed in May 2016. This act promoted three national R&D agencies (NIMS, RIKEN and AIST) to the status of designated national R&D agencies. Their shared mission is to serve as core organizations in promoting the production, popularization and use of world-class R&D accomplishments and to lead R&D innovation in Japan.

In addition, the R&D Capacity Strengthening Act was amended in 2018. The title of the law was changed to the Act on the Promotion of Science, Technology, and Innovation Creation. The amended law expanded the scope of R&D corporations that are allowed to engage in investment and the scope of the businesses subject to their investment, and enabled them to acquire and hold shares of agency-initiated ventures. In June 2020, the act was amended further to expand the scope of R&D corporations that are allowed to invest in businesses using their research outcomes and to specify joint research, etc. and other related things. In addition, in response to this amendment, the Cabinet Office and MEXT amended the "Guidelines for Investment by Research and Development Agencies" (January 17, 2019, decision of the Director General for Science, Technology and Innovation Policy, Cabinet Office, Government of Japan and Director-General, Science and Technology Policy Bureau, MEXT, Japan) in April 2021. These amendments are

expected to create an enriched cycle of knowledge, human resources, and funds surrounding National R&D Agencies, and further stimulate science, technology, and innovation creation.

Section 3 Education and Human Resources Fostering to Realize the Well-being of Individuals and the Challenges They Face

The key to realizing Society 5.0 is the human resources responsible for achieving this. For this reason, the 6th Basic Plan emphasizes the importance of abilities and qualities that can be acquired through investigative activities wherein students identify issues and seek solutions themselves with the aim to develop human resources who will pursue diverse happiness and confront challenges by honing and enhancing these abilities and qualities. This white paper describes the measures being taken by the government toward achieving this goal.

❶ Enhancing the development of the ability to inquire by promoting STEAM education

MEXT is enhancing learning activities to discover problems and solve problems in "Inquiry-Based Study of Science and Mathematics" and "Period for Inquiry-Based Cross-Disciplinary Study" following the National Curriculum Standards for upper secondary schools, which have been implemented annually from FY2022. Also, as part of its initiatives to enhance science and mathematics education, the ministry continues to assist with the maintenance of facilities such as laboratory equipment for observation and experiments based on the Science Education Promotion Act (Act No. 186 of 1953) and support for the deployment of scientific observation and experiment assistants.

MEXT designates high schools that provide advanced science and mathematics education as Super Science High Schools (SSH). Through support from JST, 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 FY2022, 217 SSH 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 addition, JST selected and supports 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.

In addition, 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[1]), as well as supporting Japanese students' participation in competitions abroad and international competitions held in Japan (Figure 2-2-12).

1 International Science and Engineering Fair

Figure 2-2-12/Participants in the International Student Contests in Science and Technology (FY2022)

International Mathematical Olympiad (Held onsite/Norway) Participants

From left

SANNOMIYA Takumi, 3rd grade, Fukuoka Prefectural Fukuoka Senior High School (silver medalist)

KITAYAMA Yuji, 6th grade, Sapporo Kaisei Secondary School (bronze medalist)

OKI Yuya, 3rd grade, Nada Senior High School (gold medalist)

ARAI Shuto, 3rd grade, Kaijo Senior High School (silver medalist)

KITAMURA Ryunosuke, 2nd grade, Tokyo Metropolitan Musashi Senior High School (silver medalist)

IMOTO Tasuku, 3rd grade, Azabu Senior High School (silver medalist)

Source: The Mathematical Olympiad Foundation of Japan

International Chemistry Olympiad (Online/China) Participants

From left

NAKACHI Akira, 3rd grade, Ritsumeikan Keisho Senior High School (gold medalist)

NAOI Masaki, 3rd grade, Asano Senior High School (gold medalist)

KASHIWAI Fumiya, 6th grade, Isesaki Yotsuba Gakuen Secondary School (gold medalist)

ISHIKAWA Takashi, 2nd grade, Senior High School at Komaba, University of Tsukuba (gold medalist)

Source: The Chemical Society of Japan

International Biology Olympiad (Held onsite/Armenia) Participants

From left

SHIMADA Satsu, 3rd grade, Tokyo Metropolitan Tachikawa Senior High School (silver medalist)

KAWAKAMI Kohei, 3rd grade, Kurume University Senior High School (bronze medalist)

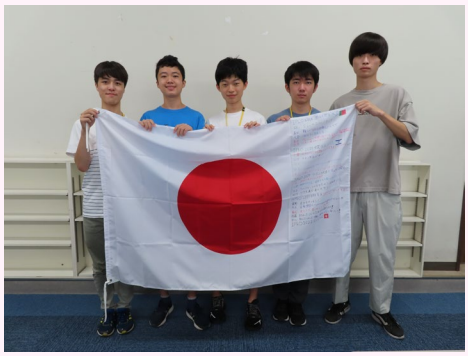
INOUE Yasunao, 5th grade, Tokyo Metropolitan Koishikawa Secondary School

MITAMURA Taiga, 3rd grade, Nada Senior High School (gold medalist)

*Local Japan team guide Ani Fall is in the center

Source: Japan Biology Olympiad Committee

International Physics Olympiad (Online/Switzerland) Participants



From left

NOGAMI Teru, 3rd grade, Miyagi Prefectural Sendai Nika Senior High School (silver medalist)

KITA Shunsuke, 3rd grade, Junior High School at Komaba, University of Tsukuba (bronze medalist)

YAMASHITA Koya, 3rd grade, Tennoji High School Attached to OKU (bronze medalist)

MIYAKE Satoshi,3rd grade, Tokai High School (silver medalist)

OKURA Haru, 3rd grade, Saitama Prefectural Omiya Senior High School (silver medalist)

Source: The Committee of Japan Physics Olympiad

International Mathematical Olympiad (Hybrid/Indonesia) Participants

From left

KODAMA Daiki, 2nd grade, Nada Senior High School (gold medalist)

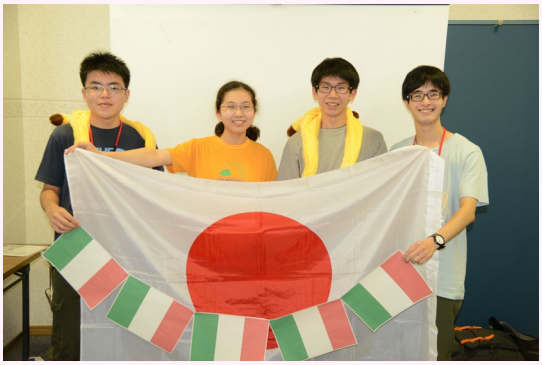
TANAKA Yuki, 2nd grade, Nada Senior High School (gold medalist)

TAMURA Yui, 3rd grade, Osaka Metropolitan University College of Technology (gold medalist)

WATANABE Yuto, 3rd grade, Shibuya Kyoiku Gakuen Makuhari Senior High School (gold medalist)

Source: The Japanese Committee for International Olympiad in Informatics

International Earth Science Olympiad (Online/Italy) Participants



From left

SHIMOKOBE Taichi, 2nd grade, Kaijo Senior High School (gold medalist)

TOMARI Asumi, 3rd grade, Kobe College Senior High School (bronze medalist)

TSUKAHARA Daiki, 2nd grade, Nada Senior High School (silver medalist)

KITAMURA Mizuki, 3rd grade, Chiba Prefectural Higashi Katsushika Senior High School (silver medalist)

Source: Japan Earth Science Olympiad Committee

International Geography Olympiad (Online/France) Participants

From left

NIIYAMA Keigo, 3rd grade, Miyagi Prefectural Sendai Nika Senior High School

IWAKURA Haruki, 2nd grade, Senior High School at Komaba, University of Tsukuba (bronze medalist)

SATO Hiroyasu, 3rd grade, Sakaehigashi Senior High School (silver medalist)

MORITA Akihiro, 3rd grade, Nada Senior High School (bronze medalist)

Source: Japan Committee for International Geography Olympiad

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

In FY2022, the "10th Japan Junior High School Science Championships" (December 2 to December 4, 2022) was held and involved teams of junior high school students from across the country competing against each other in comprehensive written and practical skills in science and mathematics. The Toyama team won the championship (Figure 2-2-13). In addition, the "12th Japan High School Science Championships" for high school students (March 17 to March 19, 2023) was held, with the Kanagawa team from Eiko Gakuen Senior High School winning the championship (Figure 2-2-14).

Figure 2-2-13/The 10th Japan Junior High School Science Championships

Winning team: Toyama team

From left

TANAMOTO Itsuki, 2nd grade, University of Toyama School of Education Attached Junior High School

KAWATA Yuito, 2nd grade, University of Toyama School of Education Attached Junior High School

HASEGAWA Yoshiki, 1st grade, University of Toyama School of Education Attached Junior High School

KATAWAKI Yuto, 1st grade, University of Toyama School of Education Attached Junior High School

FUNAKAWA Toma, 2nd grade, Nyuzen Junior High School

MOTOAKI Atsushi, 2nd grade, Tonami Shosei Junior High School

Source: Japan Science and Technology Agency

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

Figure 2-2-14/The 12th Japan High School Science Championships

Winning team: Kanagawa team
Eiko Gakuen Senior High School

From front row left

SANCHU Hideto, 1st grade, Eiko Gakuen Senior High School

KATO So, 1st grade, Eiko Gakuen Senior High School

KIMU Shiu, 1st grade, Eiko Gakuen Senior High School

NARIYAMA Yusuke, 2nd grade, Eiko Gakuen Senior High School

From back row left

NAKAMURA Haruto, 2nd grade, Eiko Gakuen Senior High School

TAKEDA Kyohei, 2nd grade, Eiko Gakuen Senior High School

MANO Keita, 1st grade, Eiko Gakuen Senior High School

YAMAGUCHI Atsushi, 2nd grade, Eiko Gakuen Senior High School

Source: Japan Science and Technology Agency

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

MEXT hosted the "Science Conference" to improve the research capacities and motivation of university students and for the development of human resources who are highly creative in science and technology. In addition to publishing videos of presentations and posters of independent research on the portal site, an online event consisting of lectures by researchers, research presentations by winners of scientific contests, talk sessions, and opinion exchange sessions was held.

MEXT, 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 (KOSEN) and universities. Students with outstanding inventions and designs are conferred awards, and are given support in the process of applying for patents, registering their designs, and obtaining rights for their submitted works. Among the entries, MEXT awards a special prize to the most creative, groundbreaking works inspired by the scientific properties and functions of familiar items.

The Cabinet Office, Government of Japan, has set up an expert panel in CSTI with the participation of the members of the Central Council for Education and the Industrial Structure Council to study specific cross-ministerial measures for the enhancement of STEAM [1] education as a source of innovation, and formulated a policy package. Based on this package, JST has made preparations for new initiatives as part of an ecosystem that supports inquiry-based and STEAM education throughout society, including the establishment of a new permanent exhibition contributing to STEAM education at Miraikan (The National Museum of Emerging Science and Innovation) (first exhibit scheduled for FY2023) and a special STEAM website on the JST Science Portal (scheduled to launch in early FY2024).

❷ Participation and utilization of external human resources and other resources in learning

MEXT has been implementing the "Project for Reform of High School Education through Regional Collaboration" to promote initiatives by high schools for the realization of inquiry-based learning, such as solving regional issues, in collaboration with local governments, higher education institutions and industry, and held a national summit to disseminate the results of this project.

In addition, necessary examination is being conducted based on the Report of Central Council for Education regarding special certificates and the special part-time teacher system since they need to further function as a double-track recruitment route from the perspective of forming a group of high-quality teaching staff with diverse expertise for the realization of "Japanese Style School Education in Reiwa."

With the cooperation of MEXT, the Cabinet Office, Government of Japan has surveyed good practices in the appropriate use of evaluation of abilities and qualities acquired through inquiry-based activities, mainly in the selection of university applicants, and prepared and published a collection of examples for active rollout of these practices.

❸ Promotion of DX in the education field

The establishment of 1 device for 1 student based on the GIGA [2] School Program has been largely completed, and is now in the stage of full-scale utilization. In January 2022, the "Measures to

1 Science, Technology, Engineering, Art(s) and Mathematics
2 Global and Innovation Gateway for All

promote the use of 1 device for 1 student (notification)" was issued to boards of education throughout Japan to promote the placement of "ICT support staff (Information and communication technology support staff)" who provide support for the utilization of ICT by teachers at each school. With regard to educational data, after publishing the "Educational Data Standards 1.0" in 2020 from the perspective of promoting data standardization for the effective use of educational data, in December 2021, the ministry mainly defined "Subject Information," which has been universally utilized in schools based on the previous system, and published it as the "Educational Data Standards 2.0." In December 2022, the Subject Information was revised and part of "Activity Information" was published as the "Educational Data Standards 3.0."

Since FY2018, regional financial measures have been implemented to introduce an integrated school affair support system that can reduce the workload on teachers in public schools throughout Japan, and the percentage of implementation has steadily increased from 52.5% in March 2018 to 81.0% as of March 2022. Since the establishment of "1 device for 1 student" under the GIGA School Program, the utilization of ICT equipment and systems in school affairs have been changing. In December 2021, considerations began by the "Expert Panel on the Informatization of School Affairs in the GIGA School Program." In March 2023, the Panel compiled a report entitled "Digital Transformation for School Affairs in the GIGA School Program: Aiming for Ease of Work for Teaching Staff and Further Advancement of Educational Activities." In addition, based on the direction of the discussions, the "Demonstration Project for the Promotion of Next-Generation Digitalization of School Affairs" was included in the second supplementary budget for FY2022 and the draft budget for FY2023.

❹ Promotion of mobility of human resources and enhancement of learning for career changes and career advancement

In FY2022, MHLW and MEXT implemented functional collaboration between "job tag," an occupational information providing website (Japanese version of O-NET) (hereinafter referred to as "job tag") and "ManaPass," a website that introduces programs for working adults at universities. As a result, it is now possible to search for ManaPass' course information from job tag's occupational information (as of March 2023).

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. In addition, MEXT has established the "Professional Engineer System" that grants the qualification of "Professional Engineer" to those who perform planning, designing, etc., with a high level of applied skill related to science and technology. 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 (7,251 successful candidates in FY2022) 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 (2,632 successful candidates in FY2022). Data on candidates who passed the Second-Step Examination in FY2022 in each technical discipline are shown in Table 2-2-15.

■Figure 2-2-15/Breakdown of successful candidates of the Second-Step Professional Engineer Examination by Technical Discipline (FY2022)

Technical discipline	No. of candidates (people)	No. of successful candidates (people)	Pass rate (%)
Mechanical Engineering	806	141	17.5
Marine & Ocean	11	3	27.3
Aerospace	40	8	20.0
Electrical & Electronics Engineering	1,023	99	9.7
Chemistry	124	23	18.5
Fiber & Textiles	33	9	27.3
Metals	86	17	19.8
Mining	21	3	14.3
Civil Engineering	13,026	1,268	9.7
Water Supply & Sewerage	1,386	142	10.2
Environmental Engineering	465	54	11.6

Technical discipline	No. of candidates (people)	No. of successful candidates (people)	Pass rate (%)
Agriculture	722	88	12.2
Forest	277	44	15.9
Fisheries	96	13	13.5
Industrial Engineering	200	28	14.0
Information Engineering	395	50	12.7
Applied Science	551	75	13.6
Biotechnology & Bioengineering	29	5	17.2
Environment	415	53	12.8
Nuclear & Radiation	48	8	16.7
Engineering Management	2,735	501	18.3

Created by 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.

MEXT and METI have been promoting the introduction of cross-appointment systems to increase the mobility of human resources (see Chapter 2, Section 1 4 ❺). The adoption of the cross-appointment system is also promoted in the "Guideline for Enhancing Industry-Academia-Government Collaboration Activities," formulated in November 2016, the supplemental version compiled in June 2020, and FAQs published in March 2022.

❺ Fostering an environment and culture in which society and companies promote continuous learning

As the environment surrounding companies and workers changes rapidly and extensively, including the acceleration of digital transformation, and as people's careers lengthen and work styles diversify, there is an increasing need to promote recurrent education to help individuals advance their careers and change careers. In this respect, necessary measures such as promoting the development of human resources initiatives in companies and improving recurrent education programs in educational institutions must be taken from a wide range of perspectives. Therefore, the Cabinet

1 https://jrecin.jst.go.jp/seek/SeekTop?ln=1

Office, Government of Japan, MEXT, MHLW and METI have set up a forum to jointly study and share information on the development of human resources measures with relevant ministries and agencies.

In addition to the number of working adults enrolled in recurrent education, MEXT has decided to develop indicators to evaluate the educational effects and social impact of recurrent education to increase social momentum for promoting recurrent education, and is promoting their consideration in cooperation with relevant ministries and agencies, based on the initiatives and results of commissioned projects related to the promotion of recurrent education, while considering opinions from the educational and industrial fields.

After deliberation and consideration by labor and management in the Labor Policy Council's Human Resources Development Subcommittee, in June 2022 MHLW formulated the "Guidelines for Promoting Education and Recurrent Education in the Workplace," which systematically outlines items to be addressed by labor and management in order to promote education and recurrent education.

❻ Provision of diverse curricula and programs at universities and colleges of technology (KOSEN)

The "Governance Code for National Universities" requires each national university corporation to disclose information that indicates the educational outcomes that students have enjoyed.

MEXT has been implementing the Program for "Human Resource Development Project for Supporting Knowledge-Based Society" to support the development of human resources possessing both broad education and deep expertise and capable of flexibly responding to new changes and developments in society and academia in the future while establishing university-wide education management, etc. In FY2022, the ministry continued to support the initiatives of universities to construct educational programs to realize a wide range of education across the humanities and sciences, as well as educational programs that bring out the best in students. It also continued to support projects aimed at realizing the high quality and density of learning through the refinement of subjects. In addition, since FY2022, the Supereminent Program for Activating Regional Collaboration (SPARC[1]) has been implemented to support the efforts of universities and other institutions to rebuild existing educational programs and develop human resources to lead the regions through collaboration between the regions and universities.

Furthermore, the "Act to Partially Amend the Act on National University Corporation," enacted in May 2021, enables all national university corporations to invest in businesses that provide consulting, training, and seminars utilizing university research results.

Colleges of technology (KOSEN) are characterized by 5-year integrated professional and practical engineering education after graduation from junior high school. MEXT is promoting the development of engineers through initiatives such as strengthening collaboration with other fields, education based on social needs, and improving the ability of engineers to play an active role overseas.

In addition, in recent years, in response to changes in industrial structures, MEXT has also been promoting the development of human resources who can contribute to solving social issues by fostering human resources and creating innovations in digital, AI, semiconductor, and

1 Superiment Program for Activating Regional Collaboration

other such fields in high demand by society. Furthermore, there have been cases of students at colleges of technology (KOSEN) starting their own businesses by utilizing their advanced technical skills, motivation to contribute to society, and ability to think freely, which they have cultivated through their education at colleges of technology (KOSEN). In FY2022, the Project for Improving the Educational Environment for Generating Startups at Colleges of Technology (KOSEN) was implemented for all colleges of technology (KOSEN) engaged in entrepreneurship education, and efforts are being advanced to enable college of technology (KOSEN) students to challenge themselves to conduct activities while concentrating on their own ideas.

❼ Co-creation of knowledge and strengthening of science and technology communication through the participation of various actors, such as citizen participation

1. Efforts by public organizations

Science & Technology Week is held every April to widely deepen the public's interest in and understanding of science and technology, and for the promotion of science and technology (approved by the Cabinet on February 26, 1960). During this period, many events related to Science & Technology Week are held throughout Japan, such as open house events at research facilities and lectures.

In conjunction with Science & Technology Week in FY2022 (April 18-24, 2022), MEXT distributed the annual S&T poster for everyone "Glass -One S&T Poster for Every Household-" to elementary, junior and senior high schools, universities, science museums and other museums throughout Japan to deepen interest in science and technology among adults and children alike. A dedicated website and videos were also released to further deepen learning. In March 2023, the FY2023 annual S&T poster for everyone "One S&T Poster for Every Household- Virus: Small Size, Big Impact" (Figure 2-2-16) was produced and released.

MAFF conducts outreach activities toward social implementation of genome editing technology, including dispatching researchers to give lessons to consumers as well as hold open laboratory tours of research facilities, and disseminating information through videos and leaflets that explain technology. The National Research and Development Agencies under MAFF open their facilities to the public and provide lectures, helping to raise awareness by facilitating interactive communication with the public about their research activities and exhibiting research results.

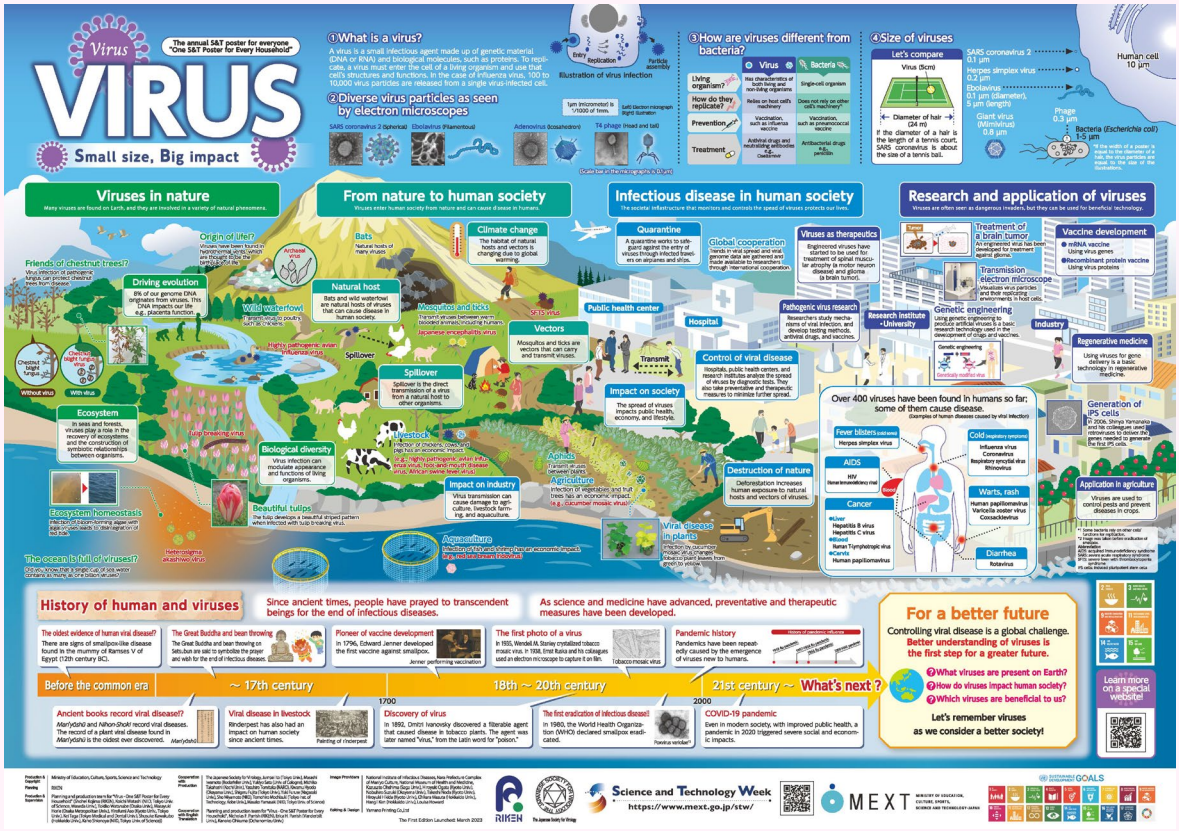
JAXA provides various educational activities in space science, such as the Cosmic College, and lecturers to schools and seminars.

RIKEN publishes booklets and releases animated videos on its website in order to enable a broader range of people to understand the latest science research. Additionally, RIKEN recommends "100 Science Books" for junior and senior high schools and public libraries to get children interested in science.

JAMSTEC conducts outreach activities using online content to promote understanding of R&D and the "Marine Discovery Course" for young people, which aims to expand the base of future marine professionals.

AIST is actively promoting S&T communication programs including operation of permanent exhibition facilities, participation in virtual and other events, open laboratories and lectures on demand. AIST also creates and publishes videos and web contents to explain the latest research outcomes in an easy-to-understand manner in an effort to communicate research outcomes.

■Figure 2-2-16/FY2023 annual S&T poster for everyone “One S&T Poster for Every Household- Virus: Small Size, Big Impact”



Created by MEXT

<Reference URL> Websites and video sites of individual organizations, etc.

○ Science & Technology Week / Annual S&T poster for everyone “One S&T Poster for Every Household”

https://www.mext.go.jp/stw/

○ RIKEN channel

https://www.youtube.com/rikenenglishchannel

○ AIST Video Library

https://www.aist.go.jp/aist_e/video/index.html

Universities and public research institutions make efforts to widely disseminate information on research results to the general public.

The Council for Science, Technology and Innovation (CSTI) encourages researchers who receive annual public research funds of 30 million yen or more for individual research projects to actively communicate with the public regarding the contents and the results of their research activities.

The National Diet Library is working to digitize its collection and convert it into full-text data. It also provides an integrated searchable database (NDL Search[1]) of materials and digital content provided by libraries, academic research institutions and other organizations nationwide to improve access and promote the utilization of knowledge and information resources shared by the public.

2. Enhancement of activities conducted by science museums

JST has been promoting multilayered science and technology communication activities such as "Science Agora,"[2] an open forum for interactive dialogue and collaboration between various people, and provision of science and technology information through the website "Science Portal"[3] to enhance the relationship between STI and society. (See Chapter 2, Section 2, 2 2 ❸) In particular, Miraikan[4] (The National Museum of Emerging Science and Innovation) is engaged in activities that encourage visitors to reflect on the relationship between cutting-edge science and technology, and society. Miraikan promotes multilayered science and technology communication activities through exhibitions and events that leverage emerging technologies such as IoT[5] and AI, as well as collaboration with local science museums and schools across the country.

The National Museum of Nature and Science[6] as the national center of natural history and S&T

1 NDL Search
https://iss.ndl.go.jp

2 [JST] Science Agora
https://www.jst.go.jp/sis/scienceagora/

3 [JST] Science Portal
https://scienceportal.jst.go.jp/index.html

4 [JST] Miraikan Channel MiraikanChannel
https://www.youtube.com/channel/UCdBvq7IgL4U6u3CzeZaeoFg

5 Internet of Things

6 [NMNS] Kahaku channel
https://www.youtube.com/user/NMNSTOKYO

history has accumulated intellectual, physical and human resources including research results, specimens and materials. Taking advantage of these resources, the museum holds exhibitions that provide opportunities to expand people's interests in nature, science and technology across generations, encouraging them to think together, and provides educational programs. In addition, the museum releases videos of researchers explaining their research activities and exhibitions and disseminates information in a timely manner through various social media.

Column 15 Co-Creation Science and Technology Communication Activities

■Promotion of Science Communication Activities at Miraikan (The National Museum of Emerging Science and Innovation)

Miraikan (The National Museum of Emerging Science and Innovation) opened on July 9, 2001, with the founding principle of "We believe that science and technology are part of our culture. We provide an open forum for all to ponder and discuss the future roles of science and technology." In April 2021, Dr. ASAKAWA Chieko, the second Chief Executive Director of Miraikan, announced the "Miraikan Vision 2030: At Miraikan, together with you, we 'Open the Future.'" The Vision outlines the ideal form of new science museums and the direction Miraikan should take in order to realize a future society where no one is left behind. This Vision expresses the desire to make Miraikan a platform where all people can connect with each other regardless of their position or location, experience various forms of science and technology, imagine a future society, and initiate actions towards a better future.

As one of its initiatives, Miraikan itself established a laboratory in April 2021 to conduct research and development to enrich the museum experience for persons with visual disabilities and other such visitors. In April 2022, the laboratory became fully operational as the Miraikan Accessibility Lab. It has been promoting research on its "AI Suitcase," an autonomous navigation robot being developed to support the mobility of people who are blind or have a visual impairment. The AI Suitcase not only guides users inside Miraikan and other facilities, but has also begun to be tested offsite from January to February 2023 as part of a demonstration test of next-generation mobility in the Rinkai Fukutoshin area in cooperation with the Tokyo Metropolitan Government and other organizations. Miraikan will continue to promote demonstration tests and science communication activities that lead to the solution of social issues and the creation of innovations in cooperation with various entities.

In addition, Miraikan is planning various initiatives, including developing new exhibits and offering activities that will contribute to STEAM education, based on government developments such as the Policy Package regarding Education and Human Resource Development toward the Realization of Society 5.0 (June 2, 2022 decision by the Council for Science, Technology and Innovation).

Miraikan (The National Museum of Emerging Science and Innovation)

"Geo-Cosmos" symbol exhibit

AI Suitcase and Miraikan Chief Executive Director ASAKAWA Chieko

Provided by: Miraikan (The National Museum of Emerging Science and Innovation) (all three)

■Thinking about Science and Society through Dialogue at Science Agora

Science Agora is one of the largest open forums in Japan to connect science and society, and is open to all people. It has been held every autumn since 2006 under the auspices of the JST. "Agora" means "public square" in ancient Greek. An agora provides an opportunity for people from various fields, sectors, and age ranges to gather and interact with science and technology through dialogue, while thinking about science and society, including people's everyday issues and how to create a better society in the future.

In November 2022, Science Agora 2022 was held in-person for the first time in three years under the theme of "Collaborate, Transcend, Create" About 10,000 children and adults participated in the event, which also included a hybrid format with online programming. During the opening ceremony, Parliamentary Vice-Minister of Education, Culture, Sports, Science and Technology YAMAMOTO Sakon gave a congratulatory address as a guest speaker. More than 140 wide-ranging events were held, including programs to address cutting-edge science, initiatives to solve social issues such as the SDGs, and programs for presentations of research by junior high and high school students, who will lead the society of the next generation.

For example, in a session co-hosted by Miraikan and the Department of Promotion of 'Science in Society' of JST, in response to the full-fledged start of inquiry-based research from FY2022, speakers with different positions including people from universities, artists, people from science museums, researchers, and high school teachers, introduced good practices in the field of education and engaged in a lively dialogue for the development of inquiry-based and STEAM education.

Science Agora 2022, the first Science Agora to be held in-person in three years
Provided by: JST

3. Efforts of the Science Council of Japan and academic societies

The Science Council of Japan hosts academic forums as part of its activities to share findings of academic activities to society. In FY2022, a total of 13 forums were held covering a wide range of topics, including "How to Ensure Resilience to Overcome National-Level Disasters," "International Year of Basic Sciences: For a Sustainable World," and "Consideration of Human Genome Editing and Preimplantation Genetic Testing: How New Medical Technologies Should be Used."

The academic societies, voluntarily organized mainly by researchers from universities and other research institutions, play an important role as a forum for exchange of personnel and research evaluation across research organizations. They contribute significantly to the development of academic research through organizing academic meetings and other events to disseminate the latest research findings and publication of academic journals.

The JAPS provides grants under the Grants-in-Aid for Publication of Scientific Research Results and subsidizes programs for international conferences and symposiums by academic societies and other initiatives to strengthen their ability to disseminate information internationally.