

Comprehensive Strategy on Science ,
Technology and Innovation for 2017
(Excerpt)

June 2, 2017

Cabinet Decision

Provisional

On Comprehensive Strategy on Science, Technology and Innovation for 2017

June 2, 2017
Cabinet decision

Comprehensive Strategy on Science, Technology and
Innovation for 2017 is determined as shown in the enclosed paper.

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(The Enclosed Paper)

Comprehensive Strategy on
Science, Technology and
Innovation for 2017
(Excerpt)

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Introduction

A year has now passed since the implementation of the Fifth Science and Technology Basic Plan (hereinafter referred to as “Fifth Basic Plan”) was launched in FY 2016. During that time, the Council for Science, Technology and Innovation (CSTI) has worked steadily to promote initiatives toward the plan’s implementation, including efforts aimed at achieving the realization of Society 5.0, the social paradigm newly devised for the Fifth Basic Plan. In addition, working jointly with the Council on Economic and Fiscal Policy, CSTI has set up the Committee for the Activation of STI and Economy and Society, and in December 2016 compiled the Public & Private Investment Expansion Initiatives for STI, which aims to stimulate STI and economy and society to reposition Japan as “the world’s most innovation-friendly country.” In addition, we have recently seen new developments including the entry into third medium-term target period for national university corporations and the launch of the Designated National Research and Development Institute. On the other hand, looking to the social and economic situation in Japan and overseas, we also see the gradual emergence of environmental changes such as shifting policy trends in other countries.

The Comprehensive Strategy on STI (hereinafter “Comprehensive Strategy”), under the mid- and long-term direction set out in the Fifth Basic Plan, identifies priority initiatives for each fiscal year while paying attention to new initiatives and changes that have arisen since the formulation of the plan.

In the Comprehensive Strategy on STI for 2017, in light of changes that have occurred over the Basic Plan’s initial year, we lay out priority initiatives for the 2017 and 2018 fiscal years. Particularly important matters are summarized in Chapter 1, while items enhancing capacity to promote STI and corresponding to the four main pillars of the Fifth Basic Plan are set out in Chapters 2 through 6. Measures to reinforce STI “fundamentals” Japan should take in response to a decline in Japan’s research capabilities that has been the subject of particular attention in recent years, are described in detail in Chapter 4.

The integrated operation of the Fifth Basic Plan and Comprehensive Strategy will ensure the thorough implementation of policy PDCA cycles to promote effective STI policies based on the verification of past efforts. In addition, we will constantly improve the quality of these policies by assessing the achievement of target values and the status of indicators that have been set in order to gauge the progress and results of the Fifth Basic Plan.

CSTI exercises a “control tower” role with regard to Japan’s STI policy. After deepening policy discussions among relevant ministries and agencies in the context of organizing the science and technology budget for the government as a whole, as well as working to focus resource allocation on important areas and toward measures with high efficacy with a view to the implementation of the Fifth Basic Plan and this Comprehensive Strategy, we also aim to expand public and private investment in research and development.

Chapter 1: Priority Matters

This chapter provides an overview of matters of particular importance for aiming at being a world leader in the realization of Society 5.0, the vision of future society proposed in the Fifth Basic Plan, as well as directions and initiatives for matters that have been singled for effectuation in future.

It is also worth noting that one of the sources of STI is academic research, basic research and the power of personnel. As well as stimulating science and technology by implementing university reform and attracting private investment, it is also important to take note of the importance of establishing outstanding research hubs that will serve as a base for the generation of innovation in basic research that is less likely to attract private investment and a research environment that promotes a diverse spectrum of academic research. Moreover, it is also important that Japan's universities and national R&D institutes be required to adopt a strategic "management" perspective as key players responsible for STI in Japan.

(1) Realizing Society 5.0

Society 5.0, the vision of future society to which the Fifth Basic Plan proposes that we should aspire, will be a human-centered society that, through the high degree of merging between cyberspace and physical space, will be able to balance economic advancement with the resolution of social problems by providing goods and services that granularly address manifold latent needs regardless of locale, age, sex, or language to ensure that all citizens can lead high-quality, lives full of comfort and vitality.

After the Second World War, Japan, by investing in basic science and developing and introducing advanced technologies to achieve high-level automation and higher quality, was able to shift its industrial structure from a labor-intensive model focused on industrial production to a capital accumulation model to take its position as the world's second-largest economic power. Currently, however, with the rise of other Asian countries, that position is beginning to be overshadowed. In addition, given the major challenges now being posed by the demographic trends of population decline and hyper-aging and the elimination of disparities between small and medium enterprises (SMEs) and the large corporations resulted from above mentioned shift in industrial structure, as well as between cities and rural areas, a transition to the next social model is required.

The next society to which we should aspire as Society 5.0 is one that, through the high degree of merging between cyberspace and physical space, seeks to maximize the wisdom and potential of each and every citizen. It is a society in which the intensification of knowledge will deeper at an accelerating rate, and where sustainable value will be produced and developed by respecting diversity and allowing it to flourish. Such a society will no longer be threatened by population decline, while disparities between SMEs and large corporations and between cities and rural areas may also be lessened. In addition, advances in areas such as data utilization and artificial intelligence (AI) technologies will lead to new business models that will transcend the traditional industrial categories of primary, secondary, and tertiary industries and by realizing a high level of added value in all of these areas will bring about a paradigm shift in economic and social systems. With the adoption of new measures, the possibility will also emerge for the various challenges that have been difficult to resolve under the framework of conventional capital accumulation-

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type economic and social systems to be solved at a single stroke.

In realizing the game-changing economic and social shift of the transition to Society 5.0, it will be crucial to maintain and make effective use of those strengths that Japan has already placed in stock, such as advanced manufacturing capabilities, materials science, and basic scientific capabilities. In addition, data utilization and the training of diverse personnel able to generate wisdom from that data, the strengthening of knowledge in the basic sciences and technologies that support the fusion of cyberspace and physical space, and the construction of data utilization platforms and infrastructure such as basic scientific research facilities will also be key. Realizing Society 5.0 will require that we proceed with these initiatives proactively and with a sense of urgency.

With a view to the realization of Society 5.0, as well as encouraging sincere and mutual cooperation and promoting public participation in the activities of the government, industrial sector¹, and academic community, we will also broadcast the concept of Society 5.0 so that it can be shared worldwide. In particular, the Strategic Innovation Promotion (SIP) program², which carries out research and development with an encompassing view firmly focused on path from basic research to practical application and commercialization, is being promoted with the aim of realizing Society 5.0, and it will be important to find synergies by promoting this program in step with the direction of initiatives in the relevant ministries and agencies. Furthermore, as well as strengthening fundamental technologies that will support the realization of Society 5.0, including IoT systems technologies, big data analysis technologies, and AI technologies, we will also promote initiatives in connected industries³.

In addition, as well as stimulating ambitious projects by younger researchers and startup companies and linking the results of research and development to social implementation, it will also be essential to aim to realize this future vision of society ahead of the rest of the world, including efforts being promoted overseas.

CSTI, as Japan's overall "control tower" for STI policy, will continue to share its values, strategies, and directions for Japan toward the realization of Society 5.0 with related organizations, and we will continue to promote initiatives that bring together the relevant government ministries and agencies with the business world and academic community.

(2) Steady Implementation of the "Public & Private Investment Expansion Initiatives for STI"

The "Public & Private Investment Expansion Initiatives for STI" seeks to activate STI as an engine of growth toward realizing an economic GDP of 600 trillion yen. As well as strengthening the CSTI's "control tower" role, its goals include tripling investment by industry in universities and national R&D institutes by 2025, together with the goals for government research and development investment set forth in the Fifth Basic Plan. It proposes three Actions to accomplish this, namely ① Budget-Making Process Reform Action, ② Systemic Reform Action, and ③ Evidence-Based Investment Action. We will promote efforts toward the realization of these actions as follows.

¹ The action plan published in February 2017 by the Japan Business Federation (Keidanren) positions the realization of Society 5.0 through the promotion of a "Fourth Industrial Revolution" as a new growth model for Japan.

² See Chapter 3: Addressing Economic and Social Challenges

³ "Connected industries" refers to the nature of the industries that will make up Society 5.0, the future vision of society to be aimed at by utilizing a "Fourth Industrial Revolution" to be sparked by technological innovation.

① Budget-Making Process Reform Action

In the “Public & Private Investment Expansion Initiatives for STI,” with regard to the “STI Promotion Expenses for Expansion of Public-Private Investment” (provisional name; hereinafter “Promotion Expenses”) to be established in FY2018, the STI Promotion Expenses for Expansion of Public-Private Investment Target Area Investigation Committee convened under the umbrella of the CSTI will proceed with the investigation of R&D investment target areas (hereinafter “target areas”) that will use Promotion Expenses to direct measures implemented by individual ministries and agencies. The Committee has recently selected three areas⁴ for preparation on the assumption of being set in FY2018 and ten areas⁵ that would be desirable for setting in or after FY2019.

From now on, as well as determining which measures are eligible for Promotion Expenses through joint evaluations with industry in response to proposals related to each of these three areas by various ministries and agencies, the CSTI will coordinate with the Ministry of Finance and the Council on Economic and Fiscal Policy to ensure that appropriate budget measures for the target measures are taken in the budget formation process.

It should also be noted that as noted in “Toward Achieving Goals for Government R&D Investment and Promoting Society 5.0” (CSTI, April 21, 2017), we will endeavor to secure a sufficient budget that will be appropriate for Promotion Expenses to be able to take advantage of the synergistic effects as a twin-track measure together with the SIP program (this assumes securing funding while continuing to develop the SIP program. At such time, the broad expansion of private investment toward social implementation will also be promoted alongside the review of the associated measures).

② Systemic Reform Action

Measures are already underway to expand public and private investment in the context of initiatives such as the Japan Revitalization Strategy, and based on the fact that further investigations are also being undertaken by the Future Investment Council convened in September 2016, it will be important for government initiatives to take a unified approach.

i) Blanket Enforcement of Reforms to Universities and National R&D Institutes without exception⁶ and Deepening of Collaboration between Academia and Industry

In an environment that is rapidly changing, the creation of continuous innovation will depend largely

⁴ These are (1) innovative cyberspace fundamental technologies (AI, IoT, databases), (2) innovative physical space fundamental technologies (sensors, actuators, processing devices, robotics, photonics and quantum), and (3) innovative construction and infrastructure maintenance technologies and innovative disaster prevention and reduction technologies.

⁵ These are (1) innovative database construction and utilization technologies (System of Systems), (2) innovative ICT platform technologies (cybersecurity, networks, processing), (3) innovative automobile traffic technologies, (4) innovative 3D mapping information utilization technologies, (5) innovative manufacturing technologies, (6) innovative food production and distribution technologies, (7) innovative nursing care and assistive technologies, (8) innovative medical and drug discovery technologies, (9) innovative bio-industrial fundamental technologies, and (10) innovative raw materials and innovative materials development technologies.

⁶ See Chapter 5: (1) Enhancing Mechanisms for Promoting Open Innovation

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on the clarification of management strategies such as the optimization of the cost burdens of joint research, the visualization of outcome targets and achievement timelines, and the implementation of risk management strategies by the universities and national R&D institutes as the key drivers of open innovation. Also important in this regard will be to undertake blanket enforcement of bold reforms without exception with the aim of escaping from a “stewardship” to a “management” mentality. These might include reviewing human resources systems, including personnel evaluations that consider collaboration between industry and academia and strengthening the financial base. Continuing to promote full-scale “organization-to-organization” collaboration between industry and academia by solidifying partnerships and good relationships of trust with the private sector will also be crucial.

ii) Enhancing Efforts to Acquire Diverse Funds⁷

To strengthen the operating base of universities and national R&D institutes to respond to the social mandate, it will be important to work actively to acquire not only public funds such as operational subsidies but also external funding from non-public sources such as the expansion of donations as an expression of civic support, as well as to more effectively utilize assets held. For this reason, universities and other institutions of higher education⁸ will be called on to carry out self-help efforts to enhance the sustainability of external funding acquisition, such as by strengthening cooperation with alumni associations and improving considerations for high-performing fundraisers.

At the same time, it will also be important to foster a culture of donations that takes advantage of resources such as donation forums and to improve the giving environment by such means as reducing burdens in donation deduction procedures. Further, following empirical analysis of factors contributing to why donations of evaluation assets to national universities have remained stagnant, it will also be necessary to work closely with organizations such as the Council on Economic and Fiscal Policy and Growth Strategy Council–Investing for the Future on possible systems to facilitate donations.

iii) Strengthening the Creative Capabilities of R&D Startup Companies and Investigating Public Procurement as a Means of Creating New Markets⁹

In the USA, startup companies play a major role in STI, and the significance of new startups originating from universities and national R&D institutes is considerable. In addition to promoting efforts to support startup companies through investments in national universities, encouraging the creation of startup companies that originate at universities and national R&D institutes by bringing in commercialization expertise from private industry will be an effective means of creating a virtuous

⁷ See Chapter 4: (3) © Diversification of Funding Sources by Strengthening the Acquisition of External Funding

⁸ National universities (including auxiliary research institutes and research facilities), Inter-University Research Institute Corporations, national higher professional schools, private universities, public universities, auxiliary research institutes and research facilities attached to non-national universities, private or public junior colleges, and higher professional schools(excluding national).

⁹ See Chapter 5: (2) Enhancing the Creation of SMEs and Startup Companies to Tackle New Business Opportunities

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cycle for human resources, knowledge, and capital. Such occasions will call for the promotion of efforts by diverse startup company stakeholders to match market needs with seeds technology and a consideration of acquiring and holding shares or stock options as compensation for services and licenses in universities and national R&D institutes.

In addition, the adoption of R&D outcomes by means of public procurement represents a prescription for linking innovative technologies still weak in terms of price competitiveness with the creation of new markets. For this reason, on the presumption of securing transparency and fairness, it will be important to consider strategies which involve the expansion of STI-oriented public procurement.

iv) Innovation as a Means of Promoting Regional Revitalization¹⁰

In order to stimulate local communities through STI, it will be important to encourage initiatives that make use of special zoning measures and other systems linked with regional revitalization, and for regional universities and public research institutes¹¹ to become the nucleus of efforts to strengthen collaboration between industry and rural communities. Further, cooperation at a deeper level with local government by universities and other bodies that play a leading role in regional revitalization can also be an effective means of stimulating local communities. In such instances, cases exist of initiatives by local governments, universities, and national R&D institutes that have promoted STI creation by leveraging voluntary contributions such as the so-called “Hometown Tax” (*furusato nōzei*). Accordingly, as well as gathering information about such cases, it will also be important to establish systems that can support local efforts in concert with related national organizations and to heighten awareness of outstanding individual initiatives.

v) Promoting the Development of STI Personnel through Partnerships between Industry, Academia, and Government¹²

An indispensable aspect of encouraging STI advancement will be the promotion of investment in STI personnel and ensuring the mobility of research personnel. While working to come to grips with the actual state of the outcomes of personnel development through joint research project involving industry and academia and promoting the active utilization of existing systems, it will also be important to enhance teaching and research programs, including university training mechanisms for company personnel and other human resources desired by industry, as well as to promote the active participation of researchers in a wide range of industry, academia, and government settings. Desired initiatives include the establishment of diverse career paths, such as by enhancing personnel

¹⁰ See Chapter 5: (4) Developing Innovation Systems that Contribute to “Regional Revitalization”

¹¹ Universities; national R&D institutes; R&D corporations prescribed in the Attached Table 1 of Act on Improving the Capacity, and the Efficient Promotion of Research and Development through Promotion of Research and Development System Reform; R&D institutes prescribed in the Order for the Enforcement of the Act on Improving the Capacity, and the Efficient Promotion of Research and Development through Promotion of Research and Development System Reform; universities and research institutes established by local municipalities; and universities and research institutes that operate as local independent administrative agencies

¹² See Chapter 4: (1) Developing High-Quality Human Resources

databases and accelerating career mobility by taking advantage of cross-appointment systems that allow personnel of all ages to play an active role in the most appropriate settings, as well as the training and retention of personnel through the introduction and expansion of tenure-track systems. With the inclusion of perspectives that further promote such efforts to invest in personnel, it will also be necessary to take full advantage of R&D support systems, such as the different ways that funds can be contributed from the private sector.

③ Evidence-Based Investment Action ¹³

The promotion of effective STI and strengthening of the “control tower” role played by the CSTI requires the appropriate allocation of limited resources to the necessary fields and measures, which must be informed by a holistic view of STI policy. Additionally, while the execution of the Fifth Basic Plan and this Comprehensive Strategy requires securing R&D investment, this will necessarily entail working to expand R&D investment on the part of both government and the private sector. Government resource allocation and policy planning on the basis of objective evidence will be crucial for the effective advancement of such efforts.

For this reason, it is desirable that we should work toward the “visualization” of government investment in R&D and policy effects. Moreover, as well as providing materials to provide a basis for the judgment of policy formation, it is also desirable that we aim to realize appropriate resource allocation and evaluation and the external transmission and sharing of information. Further, it is a prerequisite that policy PDCA cycles be established based on objective evidence with explicit inputs, outputs, and outcomes.

As well as systematically collecting and forging mutual connections between information leading from STI inputs, to outputs, and ultimately to outcomes, we will build systems to provide an evidentiary basis for the determination of important policy tasks and make use of these in the context of policy formation.

In addition to analyzing policy options for promoting private R&D investment as well as policy options aimed at incubating and strengthening startup companies and promoting active participation among younger researchers, we will also build policy formation systems that relate to important policy tasks, such as providing information that will contribute to the designation of target areas. In addition, with regards to indicators based on the Fifth Basic Plan, we will carry out continuous examination and the assessment and publication of data on an annual basis, and will follow up to review the Basic Plan in conjunction with qualitative information. Through these efforts, we will promote the formation of policy on the basis of objective evidence.

(3) Steady Implementation “Towards Achieving Government R&D Investment Target and Promoting Society 5.0”

As an initiative for realizing (1) and (2), CSTI formulated “Toward Achieving Goals for Government

¹³ See Chapter 6: ㊦ Promoting Effective STI Policy and Strengthening the “Control Tower” Role

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R&D Investment and Promoting Society 5.0” in April 2017.

Based on this decision, as the CSTI, with a view toward the realization of Society 5.0, we will identify projects expected to contribute to STI among those newly registered as STI-related projects (including those aiming to realize Society 5.0 by introducing STI elements into existing projects) in budget appropriation requests from each ministry and agency and work with the Ministry of Finance to ensure that emphasis is given to the budget formation process for these measures.

Through these efforts, we will aim to achieve the Government Research and Development Investment Target (1% of GDP)¹⁴ prescribed in the Science and Technology Basic Plan and endeavor to secure a budget of the requisite scale.¹⁵

In addition, in response to this initiative, the business community has announced it will set a target for R&D investment by private industry at 3% of GDP, and will work to keep pace with increases by the government. As the government, we welcome this as a step that will strengthen efforts towards the creation of STI in both the public and private sectors that will demonstrate to Japan and to the world our intention to set a combined target of at least 4% of GDP for public and private R&D investment.

¹⁴ Science and Technology Basic Plan (approved by Cabinet January 22, 2016) (excerpt)
“in terms of government R&D investments [...] based on confirmation that this conforms to the Plan to Advance Economic and Fiscal Revitalization, the government R&D investment target level is 1% of GDP”

¹⁵ From “Toward Achieving Goals for Government R&D Investment and Promoting Society 5.0” (CSTI, April 21, 2017) (Appendix 1)

Cabinet Office trial calculation (based on certain assumptions):

GDP in FY2020: 600 trillion JPY

× 1% = 6 trillion yen (initial budget, supplementary budget, local public bodies)

Initial: 4.4 trillion JPY; Correction: 1.1 trillion JPY (maximum from the past 10 years)

Rural areas: 0.5 trillion JPY (same level as FY2017)

Science and technology budget in FY2017: 3.5 trillion JPY (initial)

Difference of 0.9 trillion yen

Chapter 2: Acting to Create New Value for the Development of Future Industry and Social Transformation

In an era of drastic change, when economic and social forms and industrial structures are undergoing rapid transformation, we must ambitiously pursue bold new attempts to create new ideas and knowledge that will change the rules of the game, and strengthen initiatives that will actively yield discontinuous innovation. In addition, to take on economic and social challenges through the fusion of cyberspace and physical space (real space), we must lead the world in realizing Society 5.0, a society in which people will be able to lead high-quality lives.

(1) Fostering R&D and Human Resources that Boldly Challenges the Future

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

(2) Platforms for Realizing “Society 5.0” as a New Mode of Socio-Economy

[A] Basic Perceptions

In order to bring about Society 5.0 as a New Mode of Socio-Economy, it will be necessary to move forward with the precedent and steady development of 11 systems¹⁶ based on economic and social challenges. In particular, for the perspective improving Japan’s industrial competitiveness, it will be important to develop intelligent transport systems (ITS), the optimization of Energy Value Chain, and New Manufacturing Systems as core systems and to build platforms that facilitate the creation of new values. These platforms, along with databases as a source of value creation, and in addition to the technical aspects of realizing the advanced fusion of cyberspace and physical space, should also play a role in promoting the development of strategies, systems, and personnel for improving industrial competitiveness. Specifically, it will be necessary to engage from the following five standpoints: 1) the Construction and Utilization of Databases as a Foundation for the Creation of New Values and Services, 2) strengthening fundamental technologies that support these platforms, 3) promoting intellectual property (IP) strategies and international standardizations 4) promoting regulatory and institutional reforms along with the fostering social acceptance, and 5) promoting capacity development and personnel training. In addition, with a view to realizing Society 5.0, and in recognition of the fact that

¹⁶ Optimization of Energy Value Chain, Developing the Global Environment Information Platform, Realizing the Efficient and Effective Maintenance, Upgrading, and Management of Infrastructure, Realizing a Resilient Society in the Face of Natural Disaster, Intelligent Transport Systems (ITS), New Manufacturing (*monozukuri*) Systems, Integrated Material Development Systems, Systems for Community Living to Foster a Health-Oriented Nation, Hospitality (*omotenashi*) Systems, Smart Food Chain Systems, Smart Food Production Systems

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the utilization of public and private data will be of key importance, it is vital that the measures outlined in this strategy be implemented in a steady and effective manner in tandem with the Basic Plan for the Advancement of Utilizing Public and Private Sector Data based on the Basic Act on the Advancement of Utilizing Public and Private Sector Data (Act No. 103 of 2016).

① Construction and Utilization of Databases as a Foundation for the Creation of New Values and Services

The Basic Act on the Advancement of Utilizing Public and Private Sector Data has heightened momentum toward the proper and effective use of data, the construction of platforms. As a result, the construction of platforms will need to entail the precedent promotion of the construction of databases able to promote value creation through common usage with a view to increasing systems sophistication and promoting step-by-step collaboration and coordination between the 11 individual systems identified above, as well as the continued identification and steady response to associated challenges. Moreover, this should be linked to practical application and commercialization through value creation by the utilization of the various databases managed by individuals, corporations, universities and research institutes, and national and regional governments. Accomplishing this, while recognizing that the quality, quantity, and circulation velocity of the data available for use by corporations and individuals are directly linked to company and national competitiveness, and especially to lifestyle convenience, and while taking into consideration privacy and the protection of personal information, will require the creation of an environment that facilitates the aggregation, analysis, and distribution of varied and voluminous data (e.g., PDS [personal data stores, a type of mechanism for promoting data distribution and utilization on the basis of individual participation], information banks, and data transaction markets).

② Consolidating Fundamental Technologies that Support Platforms

It will be necessary to strengthen fundamental technologies as well as to further strengthen technologies in areas where Japan's strengths lie, which will form the core of new value creation in individual systems. In particular, so-called AI-related technologies such as AI technologies, IoT systems construction technologies, and big data analysis technologies will be crucial to the realization of Society 5.0, and it will be essential to make a quantum leap to a world-leading standard and further to work rapidly to promote social implementation.

When strengthening these fundamental technologies, in order to progress in spiral fashion from basic research to applied research, and then to development with a view to social implementation, it will be necessary to undertake the further enhancement of R&D systems involving industry, academia, and government through the use of institutions such as Japan's national R&D institutes (including the designated national R&D institutes).

The basic perceptions regarding the individual fundamental technologies specified in the 5th Basic Plan are as given below.

i) Cyberspace Technologies

- **AI-related technologies** (including big data analysis technologies and IoT systems construction technologies): The AI R&D Goals and Industrialization Roadmap (hereinafter “Industrialization Roadmap”) prepared by the AI Technical Strategy Committee, a body established on the instructions of the Prime Minister of Japan to gather the collected wisdom of industry, academia, and government and positioned under the Growth Strategy Council–Investing for the Future, should be adopted as a unified national strategy by all levels of government, irrespective of ministry or agency silos, and it will also be important to strongly promote social implementation alongside structural reforms.
- **Cybersecurity technologies**: It will be important to achieve a high level of security quality in IoT systems (here referring to safety and security as elements of quality expected from services by individuals and companies in the market). For this reason, we will promote the concept of “security-by-design,” which entails ensuring security from the overall planning and design stage.
- **Device technologies**: It will be important to develop technologies for achieving high speeds and real-time processing for large volumes of data in ultra-compact forms with ultra-low power consumption.
- **Network technologies**: It will be important to build networks able to provide stable operation even when interfacing with huge numbers of IoT devices and receiving a variety of data transmissions.
- **Edge computing**: With a view to the speeding up of real-time processing, promoting the construction of distributed processing technologies and building architecture that gives consideration to ensuring the security of gateways and other terminating units (or their lack thereof) will be important.

ii) Physical Space (“Real Space”) Technologies

- **Robotics**: Utilization can be expected in a variety of fields in which Japan has traditionally been strong, such as communications, welfare and workplace assistance, and manufacturing (*monozukuri*), and it will be important for Japan to engage in this field as a world leader.
- **Sensor technologies**: In addition to various other forms of information acquisition technologies, as well as engaging in the development of more sophisticated technologies for remote monitoring and implementing remote functionality updates, Japan should also engage in R&D related to new materials, devices and implementation technologies.
- **Actuator technologies**: Should be promoted on the basis of considerations of basic research into technologies for reliable evaluation relating to mechanisms, driving, and control as well as collaborations with AI technologies to create intelligent actuators.
- **Biotechnology**: In addition to promoting the development of technologies such as biosensors, biocompatible interface devices, and bioactuators, it will be important to engage in basic

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research into biotechnology more generally.

- **Human interface technologies:** Considering advances in individual devices and technologies, as well as in fields such as virtual reality (VR), augmented reality (AR), Kansei engineering (also known as affective engineering), and neuroscience, human coexistence with intelligent machines as typified by robots will also place increased importance on research into areas including differences in social acceptance, such as whether robots should be considered as equivalent to human beings or as their tools.

As technologies that provide cross-sectoral support for the development of the cyberspace and physical space (real space) technologies listed above, it will be necessary to endeavor to reinforce efforts in connection with the following fundamental technologies.

- **Materials and nanotech:** We should promote the development of innovative structural and functional materials that support areas such as energy, infrastructure, and health care, as well as the creation of new materials and new raw materials and the development of more sophisticated components with application in these areas.
- **Photonic and quantum technologies:** In order to provide cross-sectoral support in a wide range of fields such as information communication, medical care, environment, and energy, and to continue to contribute to the formation of higher-order social and industrial infrastructure to intermittently solve the limitations of conventional technologies and meet social demand in various points such as accuracy, sensitivity, capacity, energy efficiency, and security, it will be important to promote basic and applied research oriented to the further advancement of measurement technologies, simulation technologies, imaging and sensing technologies, information and energy transmission technologies, and processing and manufacturing technologies

③ Implementation of Intellectual Property Strategies and International Standardization

In the context of the successive emergence of new values and services as a result of technological breakthroughs such as the Internet of Things (IoT), for Japanese companies to secure a global competitive advantage, it will be extremely important that they engage on a company-wide basis by putting in place an intellectual property strategy and an open-close strategy based on international standardization as a part of their management and business strategies, such that even if a company were to develop superior technology, there would be no expectation of market acquisition in the case where the open-close strategy were not appropriate or where the technology or goods in question did not conform to international standards. Furthermore, the promotion of open innovation will necessarily entail the expansion and deepening of the reach of open-close strategies. Namely, through the addition of “data” as a source of new competitive power, it will be necessary to build new strategies that use data to supplement intellectual property and standardization, which form the pillars of conventional open-close strategies. While working in partnership with the international community, it will also be necessary for Japan to be proactive by taking the initiative with regard to international

standardization activities, including the proposal of international standards.

④ Promotion of Regulatory and System Reforms and Fostering Social Acceptance

When introducing new goods and services through scientific and technological advances, situations may also arise in which existing legal systems work to inhibit social implementation. The particular tendency in Japan, whereby activities that fall into legal gray areas tend to be disdained or shied away from, calls for the adoption of a stance that seeks to envision the shapes of new business models and industries emerging from STI so as to anticipate regulatory revisions on the basis of issues observed in the field and the enactment of rules that will be considered necessary.

In addition, the promotion of “Society 5.0” will necessarily entail the sharing of the vision of its ideal society, and the formation of social consensus will be vital, particularly the shared recognition that it will result in more comfortable, high-quality lives for each and every citizen. For this purpose, it will be essential to carry out a multi-faceted examination of the various impacts and challenges that technologies will have on the social mode of production, and to seek out possibilities for regulations, institutions, and social customs that will help achieve both innovation and peace of mind.

⑤ Promotion of Capacity Development and Personnel Training

The implementation of Society 5.0 in advance of other countries will necessarily entail the training and recruitment of personnel to drive the requisite fundamental technologies. Particularly important in this regard will be the promotion and training of personnel in the fields of mathematical science, computational science, and data science and its related technology, which constitute cross-sectoral scientific and technological fields underlying the required fundamental technologies.

It will also be vital to train personnel who will contribute to ensuring cybersecurity against sophisticated threats.

The possibility that many of the jobs that are now carried out by human beings will come to be automated through utilization of technologies such as the IoT, robotics, and AI means that it will be necessary for human beings to transition to other jobs with higher added value or that will have been newly created. Technological progress is swift, and working people will also be required to relearn skills in accordance with their individual abilities and expertise.

[B] Priority Challenges

① Construction and Utilization of Databases as a Foundation for the Creation of New Values and Services

It will be necessary to build databases and move quickly to promoting the social implementation of IT systems to strengthen Japan’s industrial competitiveness and create markets with the potential for global expansion. Keeping in mind how they will be used in practice, conceivable examples of databases available for shared usage will include geographical, environmental, cybersecurity, material, and medical databases. Initiatives to create the following types of databases will be particularly urgent.

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To address any problems, as well as engaging proactively by making precedent use of the Strategic Innovation Promotion (SIP) program, it will also be necessary to draw on the results of the Impulsing PARadigm Change through disruptive Technologies (ImPACT) program and work in close conjunction with measures being implemented by the relevant ministries and government agencies.

- **Geographical database:** Built based on “G-space” information (i.e., geospatial information consisting of “information indicating the spatial position of a specific point or area [including temporal information about that information]” or else positional information and “information associated with positional information”), satellite observation data, mapping data for autonomous vehicles, etc.
- **Environmental database:** Built based on climate change prediction data and Earth observation data from weather data, satellite observation, oceanic observation, etc.
- **Cybersecurity database:** Organizations that share information regarding cyber-attacks and other threats should make it possible to take advantage of useful information such as incident data compilations by processing sensitive materials into an appropriate format and limiting the scope of sharing as necessary.

As shared problems when building the databases, in addition to enabling users to extract the necessary data through their logical design as a single database able to accommodate third-party use by specifying the APIs (Application Programming Interfaces), it will also be necessary to implement data formats that will be easy to utilize and to organize information that relates to the various data linked to the logical databases. Additionally, when building the databases, we should not only work to promote the alignment and utilization of basic data formats (including the date stamping and geo-stamping of various data), but also develop with an awareness of the automation of data updates and improvements the efficiency of database operation and management.

In addition, with regard to image information associated with each database, it will be important that social implementation be promoted through technological developments that give proper consideration for the protection of personal information and privacy.

Ensuring high-level security when building these databases will be indispensable. It will also be necessary to promote the sophistication and social implementation of security technologies common to all systems, which include vulnerability handling and securing encryption levels, as well as to build mechanisms for the proper handling of risk management. When providing goods and services in accordance with cybersecurity strategies, it will be important to engage on the basis of a philosophy of mission assurance (i.e., a commitment to fulfill an agreed mandate), which will entail aspects such as promotion on the basis of a security-by-design mindset that incorporates security considerations from the design and planning stages.

When promoting data utilization, while working to strike a balance between data utilization and making considerations for privacy and the protection of personal information, databases should in principle be made machine-readable and rendered open access so that data housed in various places

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(e.g., national and local governments) will be made accessible to third-party users. This will encourage the imaginative use of these databases by the industrial sector, especially by startup companies and small and medium enterprises (SMEs), and link them to the creation of industry for the society of the future, which will usher in the realization of safe, secure and comfortable lives. To that end, it will be necessary to engage by ensuring that data users can utilize data with a sense of reassurance while recognizing the merits of data providers, as well as to work towards harmony with international institutions so as to promote data utilization at the global level.

② Consolidating Fundamental Technologies that Support Platforms

AI-related technologies (including big data analysis technologies and IoT systems construction technologies) and cybersecurity technology initiatives are important research subjects that can serve as a foundation for all other technologies, and should be emphasized as priority initiatives.

In addition, as fundamental technologies for realizing the advanced fusion of cyberspace and physical space (real space) and the creation of new value, we will need to work to strengthen cyberspace technologies such as network technologies and information processing technologies and physical space (real space) technologies such as robotics, sensor technologies, actuator technologies, and biotechnology. Furthermore, it will also be necessary to work to strengthen materials technologies and nanotechnology, as well as photonic and quantum technologies, both areas that represent cross-sectional technologies supporting fundamental technologies.

Innovative materials and products will lead to social implementation only once they are accepted by society. For this reason, it will also be necessary to engage in the construction of technologies and mechanisms for appropriately evaluating the safety and environmental impact of such materials and products. With a view to early practical application and commercialization of nanotech materials, an area in which Japan is strong, and which is also expected to be applied in next-generation electronics and innovative structural and functional materials, among other sectors, it will be necessary to develop safety assessment method and promote the formulation of safety standards, as well as to examine the collection of safety data and systems for engaging with international partnerships and international strategies through cooperation between government ministries and agencies.

In addition, with a view achieving Society 5.0, it will also be important to pursue and deepen technological development and scientific research into areas such as cognitive science, neuroscience, and systems science that relate to the nature of humanity and society.

i) Cyberspace Technologies

- **AI-related technologies** (including big data analysis technologies and IoT systems construction technologies): In the Industrialization Roadmap, as well as engaging with the fields of “productivity,” “health, medical care and nursing care,” and “spatial mobility,” which have been identified as priority areas from the perspectives of (1) the necessity of urgent issues as social issues, (2) contributing to economic ripple effects, and (3) the expectation of contributions from

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AI technologies, it will also be important to engage in the field of “information security” (which has been identified as a field cross-cutting the first three), form research and development through social implementation.

- **Cybersecurity technologies:** On the basis of the security-by-design concept, it will be important to build trust and pursue R&D into lightweight cryptographic technologies that can be installed in IoT equipment, with an emphasis on the sophistication of security technologies common to all systems, including vulnerability handling and cryptographic strength, and building mechanisms to ensure the proper handling of risk management.
- **Network technologies:** It will be necessary to engage in R&D in areas that relate to edge computing technologies, which deal with the real-time analysis and assessment of explosive volumes of data from a variety of device inputs.
- **Information processing technologies:** The development of component technologies such as 3D-integrated chips and quantum devices and architecture will be crucial to the realization of high-speed and large-scale information processing.

ii) Physical Space (“Real Space”) Technologies

- **Robotics:** From a welfare and workplace-assistance perspective, we should promote the development of basic robotics technologies that will contribute in areas such as safety and security in the lives of the elderly or persons with disabilities, or ensuring productivity in a variety of economic activities.
- **Sensor technologies:** The emphasis here will be on R&D of new high-sensitivity sensors that will bridge cyberspace and physical space in fields such as energy and the environment, social infrastructure, and health and medicine. We will promote the shift to higher performance and ultra-compact and ultra-low power consumption devices and engage in the development of a variety of sensors (e.g., high-sensitivity magnetic sensors and temperature sensors) including biosensors that enable the collection of biological information. In terms of device technologies, the assumption that IoT devices will have long lifecycles and will not be supplied with power on a frequent basis entails the desirability of continuous efforts toward energy savings. R&D into areas such as high-capacity memory storage that incorporate the use of spintronics and ultra-compact, ultra-low power devices, as well as organic electronics that enable large-area, low-cost sensors and display elements will also be important. Furthermore, it will also be necessary to pursue developments in other areas such as power sources for sensors and other devices, power control technologies, and energy harvesting technologies (e.g., solar cells, thermoelectric elements, and vibration-generated power).
- **Actuator technologies:** We will pursue incorporation of such as micro-electro-mechanical systems (MEMS). In addition, we will promote the development of bioactuators.
- **Biotechnology:** We will establish a technological foundation for constructing innovative manufacturing systems and bio industries using production systems involving new and useful

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materials derived from the advanced use of biological functions.

- **Materials and nanotechnology:** It will be necessary to endeavor to continue strengthening the following technologies, which contribute to increasing systems sophistication (e.g., the optimization of Energy Value Chain):
 - Technologies that contribute to the efficient control of electricity supply and demand (e.g., low-cost, high-accuracy sensing technologies, storage cell technologies, fuel cell technologies), which will become increasingly important with the spread of variable renewable energy (VRE)
 - Power semiconductor technologies that will lead to high-efficiency power controls
 - Catalyst technologies that will contribute to process innovation
 - Materials technologies such as biomaterials and structural and functional materials that possess new functions and features
 - The realization of a sustainable, energy-saving society and innovative separation process technologies for isolating substances that will help address environmental problems
- **Photonics and quantum technologies:** We will promote basic and applied research into photonic and quantum technologies, which play a contributing role in sophisticated measurement and simulation technologies, imaging and sensing technologies, information and energy-transmission technologies, and processing and manufacturing technologies.

In strengthening these fundamental technologies, we will promote the sophistication of advanced measurement technologies, microfabrication technologies and manufacturing technologies (including self-assembly technologies), as well as the early establishment of Integrated Material Development Systems¹⁷. In addition, it will also be important to take a medium-to-long-term perspective by promoting basic research into areas such as nano-level thermal control technologies (i.e., phonons) and biotechnologies that will contribute to areas such as the sophistication of measurement and diagnostic imaging and the creation of useful substance.

③ Implementation of Intellectual Property Strategies and International Standardization

The promotion of standardization will entail identifying zones of competition and zones of cooperation for basic functions, as well as the formulation of strategies that take into account the acquisition of de facto standards together with de jure standards by working to develop international service projects while also giving appropriate consideration to the open-close strategy of Japan's national industry.

In particular, with regard to the standardization of platforms in Society 5.0, it will be important to identify challenges by employing reference models used for the identification of zones of competition and zones of cooperation and the ensuring of mutual connections between systems, and to link these

¹⁷ See Chapter 3: (1) ③ ii) Integrated Material Development Systems

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to social implementation.

In terms of platform construction, it will be important to proceed with standardizations in areas, such as data formats and interfaces, which will encourage the construction of databases and data utilization. Moreover, it will be important to proceed in a stepwise fashion, building shared platforms that will be able to be used in a variety of services, including new services that have yet to be imagined.

④ Promotion of Regulatory and System Reforms and Fostering Social Acceptance

It will be necessary to move forward with a variety of related initiatives that aim to promote sciences that contribute to the creation of appropriate regulations and institutions. These include strengthening social measurement functions that reveal social costs and impacts to society and the economy, protecting personal information, addressing challenges that relate to areas such as the responsibility of service providers and manufacturers, strengthening ethical, judicial, and social initiatives through interdisciplinary engagements aimed at social implementation, and investigating regulatory relaxation and institutional reforms that will make the provision and implementation of new services possible.

With regard to robots, especially, given the aspect that social implementations will serve to promote their further evolution and development, it will be necessary to carry out preliminary investigations with a view to social implementation, with reference to the development of social institutions that can be used with security.

⑤ Promotion of Capacity Development and Personnel Training

Personnel training represents an important challenge for protecting the platforms of Society 5.0 from sophisticated threats.

In addition, advances in STI such as the IoT and AI can be expected to lead to major changes in production and employment structures, as well as other economic and social systems. Accordingly, together with working to deepen the recognition of the kinds of jobs that can only be done by human beings, even in society with advanced AI, such as developing concepts, producing businesses, and exerting creativity, it will be important to examine potential methods for developing capabilities that pertain to these jobs and ways of training personnel beginning from the elementary and secondary school levels.

Furthermore, beyond traditional human resources development, voluntary and proactive measures to tackle the training of personnel to be responsible for jobs in, for example, project management and new business creation through technologies such as the IoT are needed from industry in cooperation with universities and graduate schools.

[C] Priority Initiatives

Omitted

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Chapter 3: Addressing Economic and Social Challenges

In order to realize the visions for “Sustainable Growth and Self-sustaining Regional Development,” “Ensuring Safety and Security for Our Nation and its Citizens and a High-Quality, Prosperous Way of Life,” and “Addressing Global Challenges and Contributing to Global Development” set out as challenges in the Fifth Basic Plan, we will continue to mobilize STI and work to resolve issues under the guidance of the SIP initiative. As well as bringing visibility to scientific and technological accomplishments and moving forward with their social implementation so that their significance will be readily apparent to many people, It will also be important to recognize the inherent ambivalence of science and technology (in that a single scientific or technological accomplishment can be used for multiple purposes) and work to resolve issues and to ensure that such outcomes are put to proper use.

We will also continue to promote measures necessary for achieving an early recovery and revival from the Great East Japan Earthquake, such as initiatives leading to the creation of new industries and the use of next-generation innovative technologies in the affected areas, including the Fukushima Innovation Coast Initiative¹⁸ provided for in the Act on Special Measures for the Reconstruction and Revitalization of Fukushima (Act No. 25 of 2012).

(1) Sustainable Growth and Self-sustaining Regional Development

① Ensuring Stable Energy, Resources and Food

i) Optimization of Energy Value Chain

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

ii) Smart Food Chain Systems

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

¹⁸ An initiative composed of local representatives and experts from industry, academia, and government and chaired by the director of the local nuclear emergency response headquarters. Formulated by the Fukushima International Research-Industry City Initiative (“Innovation Coast”) Study Group, the initiative seeks to create new technologies and industries that Japan can be proud of internationally and establish an innovation-driven industrial base by developing new bases of research and industry (e.g., a robotics research and demonstration facility and a research center for decommissioning nuclear plants based out of the Hamadori region of Fukushima Prefecture) and aspires boldly to the realization of an attractive vision of regional revitalization.

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[C] Priority Initiatives

Omitted

iii) Smart Food Production Systems

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

② Achieving a Sustainable Society to Handle Hyper-Aging, Depopulation, Etc.

i) Establishment of a Society in Which People Enjoy Long and Healthy Lives with World-Leading Medical Technology

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

ii) Intelligent Transport Systems

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

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iii) Systems for Community Living to Foster a Health-Oriented Nation (e.g., Promotion of Comprehensive Community Care Systems)

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

③ Improving Competitiveness in Manufacturing and Value Creation

i) New Manufacturing Systems

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

ii) Integrated Material Development Systems

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

(2) Ensuring Safety and Security for Our Nation and its Citizens and a High-Quality, Prosperous Way of Life

Omitted

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① Maintenance, Upgrading and Management of an Efficient and Effective Infrastructure

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

② Attaining a Resilient Society against Natural Disasters

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

③ Addressing National Security Issues

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

④ Hospitality Systems

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

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[C] Priority Initiatives

Omitted

(3) Addressing Global Challenges and Contributing to Global Development

Omitted

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

(4) Pioneering Strategically Important Frontiers

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

Omitted

Chapter 4: Reinforcing the “Fundamentals” for STI

Japan is coming into an era of drastic change, in which the structures of the economy and society are shifting on a daily basis. In particular, new scientific and technological advances that are influencing the very nature of human existence (e.g., technological innovation such as the IoT, robotics, and AI as well as advances in the life sciences such as regenerative medicine and neuroscience) are requiring that we reimagine the relationship of science and technology to society. For Japan to continue to develop sustainably in such circumstances, wherein the future outlook is difficult to foresee, it will be necessary to establish basic capacities able to respond flexibly and accurately in the face of any new challenge or change of situation. To this end, it will be essential to continue to strengthen the basic capacities of funding support for STI activities, academic research and basic research to produce the diversified and superior knowledge that will engender innovation, the personnel who will form the backbone of STI. For these initiatives, it will be important for all stakeholders – including universities, public research institutes, and industry – to come together as one to engage with these initiatives at the national level.

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(1) Developing High-Quality Human Resources

[A] Basic Perceptions

Omitted

[B] Priority Challenges

① Developing, Securing and Improving Career Prospects of Human Resources as Intellectual Professionals

i) Developing and improving career prospects of young researchers

Omitted

ii) Training Diverse Personnel as Leaders in STI

Omitted

iii) Promotion of Graduate School Education Reforms

Omitted

iv) Development of Personnel as Future Leaders in STI

Omitted

② Promoting Diversity and Career Mobility

i) Improving women's career prospects in STI

Omitted

ii) Strengthening the Construction of International Networks

Omitted

iii) Promoting Human Resources Mobility across Fields, Organizations, and Sectors

Omitted

[C] Priority Initiatives

Omitted

(2) Promoting Excellence in Knowledge Creation

[A] Basic Perceptions

Strengthening the foundation for producing diverse knowledge of surpassing quality as a source of innovation will be indispensable for the production of continuous innovation, and it will be especially important that research be characterized by flexible thinking and innovative ideas. However, in terms of the number of articles published, the number of highly cited, and the number of joint publications with

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international authors, Japan is falling behind other developed countries, and this relative decline in our country's basic research capacity is becoming increasingly serious.

The importance of the role of universities and public research institutes in knowledge creation is growing. While properly addressing new trends such as open science, it will be essential to promote reforms and enhancements with a view to promoting academic and basic research. In doing so, not only enhancing the facilities and infrastructure that support R&D activities, but also to strengthening the information infrastructure necessary for handling big data will be indispensable.

[B] Priority Challenges

① Promoting Academic and Strategic/On-Demand Basic Research as Sources of Innovation

Academic research based on researchers' intrinsic motivations has the possibility to create new interdisciplinary and combined-field areas as well as to generate innovation in a broad spectrum of fields. On the other hand, we must also respond to a social mandate for academic research, and it will be necessary for the national government to promote reforms and enhancements from the standpoints of ambitiousness, comprehensiveness, convergence, and international scope. Moreover, it will be important to continue to ensure the healthy diversity of academic research while balancing the demands of the age with the continuity of academic research based on the allocation of academic research funding to different fields.

Specifically, it will be necessary to work to further enhance the Grants-in-Aid for Scientific Research (KAKENHI) program through such means as adopting multilateral perspectives in the selection of excellent research topics, strengthening support that will enable researchers to proactively seek out and undertake new research challenges, and facilitating the use of research expenses by creating funding sources suited to the nature of research categories.

While strategic and needs-oriented basic research is important for linking the diverse knowledge generated by academic research to the production of social and economic value, it is also important from the standpoint of further promoting interdisciplinary cooperation and the integration of different fields. Since basic research entails a high degree of uncertainty and unpredictability when generating results, it will be necessary that the national government, in addition to formulating strategic goals grounded in objective evidence, will also need to reform and strengthen initiative including the promotion of ambitious research by young researchers and women academics as well as research that transcends disciplinary, institutional, and national boundaries. Additionally, the creation of innovation that will have a major impact from a long-term perspective will require the sharing of a future vision and identification of challenges to be addressed by industry, academia, and government to work towards further reforms and enhancements that will provide consistent and flexible support from basic research stage to the proof of concept (POC) stage, while working together with relevant measures.

These initiatives will entail the provision of continuous support in accordance with the progress of research and aiming at the further visualization of research data and results by developing databases and networks. Doing so will ensure that research outcomes will be used as fully as possible and linked to the

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creation of social and economic value.

Furthermore, from the standpoint of international scope, it will be necessary to incorporate global knowledge by eliminating Japanese researchers' inward orientation and encouraging active participation in international settings. In addition, we will need to endeavor to promote large-scale academic research and the strategic encouragement of international joint research, as well as to form world-class research centers that can boast high research standards and outstanding research environments and can build a research center that can become a hub of global brain circulation in order to attract leading researchers from throughout the nation and around the world.

From this standpoint, Promoting Academic and Strategic/On-Demand Basic Research as Sources of Innovation will entail the steady implementation of measures in line with the orientation set out in the CSTI's position statement "Strengthening Basic Research and the Creation of Science, Technology, and Innovation as Sources of National Strength" (December 2016). Specifically, this refers to 1) the blanket reform, leaving nothing sacred, of the higher education sector (review of strategic management and personnel systems) and building partnerships with the private sector to attract investment in basic research, 2) for CSTI to show the direction of institutional reforms and the optimal portfolio for the total combined research funding from the public and private sectors, and 3) for the government to steadily carry out its three actions set out in its Public & Private Investment Expansion Initiatives for STI under the direction shown by CSTI.

② Strategic Enhancement of Common-Platform Technology, Facilities, Equipment, and Information Infrastructure Supporting R&D Activities

The maintenance and sharing of advanced research facilities and infrastructure possessed by research institutes such as universities and the world's most advanced large-scale research facilities is expected not only to strengthen Japan's R&D foundations, but also to accelerate the creation of STI through interactions among diverse personnel. For this reason, the government, having worked to strengthen the shared fundamental technologies, advanced research equipment, and basic facilities supporting R&D activities and achieved an overall picture of available research facilities and equipment, will need to promote the strategic sharing according to their scale and characteristics and endeavor to establish a virtuous cycle of sharing for research and development.

Additionally, while joint-use initiatives transcending university boundaries are already underway at Inter-University Research Institutes and other Joint Usage / Research Centers, the sharing of medium- and small-sized research facilities and equipment in universities is centered mainly on use at the level of individual laboratories, while no progress has been made with regard to shared usage at the organizational level. The maximization of the effectiveness of R&D investment by universities to generate outstanding research outcomes will entail the strengthening of management systems, such as the systematic management of research facilities and equipment at the level of the entire organization and the recruitment and allocation of specialized staff. On the assumption of such initiatives, it will be necessary to promote an integrated vision of facility sharing from the level of individual organizations

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to the level of the entire nation, beyond the boundaries of academia.

③ Promotion of Open Science

Open science, which consists of open access and open data (i.e., making research data publicly available), in addition to promoting science itself, also serves as a basis for the creation of innovation. In Japan, while concrete discussions are underway in the Science Council of Japan and concerned ministries and agencies, it will also be necessary to investigate this area in accordance with the characteristics of different fields of research and research communities. Also important in this regard will be the continued and active promotion of international regulatory measures concerning matters such as personnel development and incentives for spreading open data and the evaluation of researchers and specialists in partnership with individual countries. For this reason, while paying attention to the national interest and the implementation of measures to protect intellectual property, for the national government to expand as much as possible shift to an open access model for data and results obtained from publicly funded research, it will be necessary to promote open science in collaboration with all stakeholders, who include funding bodies, universities and other research institutes, and individual researchers.

Moreover, collaboration between universities and national R&D institutes and the development from an international perspective of ultra-fast, secure, and high-quality data platforms and networks will be important in terms of building state-of-the-art infrastructure that will form a core of industrial clusters in a knowledge-based society.

[C] Priority Initiatives

Omitted

(3) Strengthening Funding Reform

[A] Basic Perceptions

An important part of the reform and strengthening of funding support for STI activities will be the more effective and efficient utilization of research funds provided by the government and the promotion of the strategic use of external funding acquired by universities and public research institutes from non-government sources.

Research funding spent by the government consists of fundamental funds to provide stable and continuous support to research and education in universities and other educational institutions and open-application research funding grants allocated for the promotion of research excellence and studies that will contribute to specific goals.

In particular, while the various reforms underway in the national universities that receive such funding have already achieved some results, in the midst of a changing social environment characterized by increasingly stiff global competition, the continued maximization of their sustained knowledge creation and utilization functions as engines of STI will necessarily entail that reforms continue to be pursued at a fundamental level. Accordingly, as well as putting in place university environments that make effective

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and efficient use of diverse sources of research funding, functional enhancements will be required through the promotion of reforms such as the strengthening of university governance.

For this reason, as well as the promotion of reforms to both fundamental funds and open-application research funding, it will also be important for the Japanese government to take an integrated approach to the promotion of research funding reforms and the organizational reform of national universities. In this regard, constant consideration will need to be given to the balance of fundamental funds with open-application research funding.

[B] Priority Challenges

① Fundamental Funds Reform

The reduction of fundamental funds available to Japan's universities and national R&D institutes has been accompanied by a corresponding decline in funding that can be used for research. This has given rise to various problems, including the deterioration of basic research capabilities, education and research infrastructure, and employment instability for younger personnel.

Under such circumstances, for national universities to further fulfill their role by maximizing their particular strengths and features – such as by contributing to their local communities, establishing outstanding Centers for Teaching and Research in particular fields, and promoting outstanding teaching and research in an internationally competitive environment – it will be necessary for university presidents to exercise leadership to meet the demand for firm cost-consciousness (including the visualization of expenditures) and more efficient and effective management in the strategic allocation of budgets, facilities, and other campus resources. At the same time, university leaders will be required to continue strengthening universities' financial base by acquiring external funding from non-government sources.

For this reason, it will be necessary for the Japanese government to endeavor to accelerate reforms to national universities and other educational institutions¹⁹ through special discretionary funding for university presidents and frameworks of priority allocation corresponding to the orientations of the three functional enhancements (i.e., contributing to local communities, forming Centers for Teaching and Research, and promoting outstanding teaching and research) in the operating grants for national university corporations introduced in the third medium-term target period for national university corporations. Additionally, it will be necessary for university presidents, as well as endeavoring to stimulate teaching and research activities that maximize institutional strengths and features, to exercise leadership and promote the development of environments for the strategic allocation of budgets, facilities, and other campus resources based on the core vision of their respective universities.

Strategic management through the exercise of executive leadership is also important in the context of national R&D institutes, and it is expected that we will proceed with the development of environments that will facilitate the strategic allocation of assets held.

While taking advantage of these various initiatives, each national university will be required to

¹⁹ I.e., national universities (including auxiliary research institutes and research facilities) and Inter-University Research Institutes

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promote reforms to human resources (HR) and payroll systems through the introduction of strategies such as annual salary systems and cross-appointment systems, and to continue with efforts to convert existing payroll systems to systems more suitably tailored to their needs. Furthermore, on the assumption that such reforms to HR and payroll systems will be carried out, it will be necessary for the Japanese government to consider paying personnel expenses to principal investigators directly from competitive grants.

② Diversification of Funding Sources by Strengthening the Acquisition of External Funding

Together with fundamental fund reform, it will simultaneously be necessary to examine ways to secure diverse funding through the acquisition of external funding. Strengthening initiatives aimed at acquiring external funding (other than that distributed by the government) in universities and national R&D institutes²⁰ and tripling the level of investment by private companies in universities and national R&D institutes by 2025 will entail the active collection by the national government of information about exemplary initiatives from throughout Japan and around the world and efforts to share information through symposia and the creation of case studies. In particular, the government shall dispatch representatives to visit universities and other institutions attempting pioneering initiatives in order to grasp details concerning specific initiatives and circumstances. It will also be important to seriously address consultations about problematic points and issues arising in implementation settings and to provide advice and adjustments to ensure that the most effective use is made of existing systems.

Private donations are an important element of acquiring diverse funds, and in addition to encouraging efforts toward strengthening the acceptance of donations by universities and other institutions, the government will also be required to participate actively in initiatives to foster a culture of donation. For example, given Japan's donation culture cannot really be described as fully mature in comparison with Europe and the United States, it will be important for universities and other institutions as well as concerned ministries and agencies to promote partnerships with donation agencies and to continue working to raise awareness among a broad base of stakeholders about case studies of pioneering initiatives by universities and other institutions to expand individual donations. In particular, it needs to be firmly recognized that initiatives by universities that firmly recognize alumni as a source of energy for the university community which seek to strengthen ties between the university and its alumni will be indispensable for fostering a culture of donations. In addition, it will also be necessary for the national government, while also paying attention to revisions to the charitable trust system, to accelerate examinations in partnership with national universities and related institutions toward expanding the donation of land and other evaluation assets as well as the effective use of assets obtained from donations, and to work to raise awareness by gathering case studies about those that can be dealt with in the systems as it currently operates. While recognizing that national universities and related institutions have, as a result of their incorporation, become separate entities from the national government, they may be

²⁰ I.e., national R&D institutes and R&D corporations prescribed in the Attached Table 1 of Act on Improving the Capacity, and the Efficient Promotion of Research and Development through Promotion of Research and Development System Reform

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considered to retain the same responsibility to respond to citizens' expectations and mandates as they did prior to incorporation. Accordingly, the analysis of factors contributing to why donations of evaluation assets to national universities and related institutions have remained stagnant will be important for the purposes of institutional review. On the other hand, the May 2016 revision to the National University Corporation Act loosens regulations governing the loan by universities of buildings and other facilities to third parties. In light of this, while simultaneously strengthening the management basis of universities and related institutions, it will be necessary to voluntarily engage in the constant review of teaching and research in accordance with these changes. For universities and related institutions to be able to make the fullest possible use of assets held, it will be necessary to review the loan conditions for facilities and usage classifications that restrict their functional improvement, as well as to examine measures to ensure the flexible utilization and facilities developed by national R&D institutes with assistance from government grants.

Furthermore, in order to attract diversified investments from private companies, it will be important to enhance the appeal of assets held by universities and related institutions by creating activity space while improving facility functions through measures to combat infrastructural aging combined with strategic facilities management.

In addition, the investigation of matters relating to institutional reform should also be pursued in close cooperation with organizations such as the Council on Economic and Fiscal Policy and Growth Strategy Council—Investing for the Future.

The conventional lack of adequate measures by universities and national R&D institutes to review of rules for execution in line with current conditions will sometimes pose an operational barrier when conducting R&D jointly with companies or overseas institutional partners. In cases where such operational improvements are desirable, the national government will be required to take the initiative to collect information and endeavor to formulate and publicize uniform guidelines.

③ Reform of Open-Application Research Funding

In view of the fact that competitive grants and open-application research funding for proposed research by university-based academics (not funded by competitive grants) represent important sources of funding that ensure diversity in R&D in Japan and contribute to the formation of competitive R&D environments, the Japanese government will need to work to maximize the research capacity and research outcomes for such grants, with a view to their more effective and efficient utilization.

With regard to competitive grants, while measures have been introduced to earmark in principle 30% of all competitive grants for indirect costs, further improvements will require the thorough and uniform enforcement of rules across all government ministries.

Additionally, with regard to open-application research funding for proposed research not funded by competitive grants, as well, it will be necessary to take advantage of the Relevant Ministries Liaison Committee on Research Funding and to examine previous examples of the introduction of indirect costs and further usability improvements with a view to promoting initiatives such as university reform.

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Furthermore, for expenses aimed at promoting system reform at universities, it is also necessary to consider mechanisms that will be able to sustain the accomplishment of objectives while utilizing resources other than government funding following project completion.

④ Integrated Promotion of Research Funding Reforms alongside Reforms to National Universities and National Research Institutes

For national universities and national R&D institutes to further fulfill their role by taking maximum advantage of their particular strengths and characteristics, in conjunction with the functional enhancements listed above (under “① Fundamental Funds Reform”), they will be required to work toward the strengthening of universities’ financial bases and management structures.

To strengthen the fiscal foundation for national universities and national R&D institutes, it will be indispensable to have a diverse array of funding sources in addition to operating expense grants and other public funding, including securing joint research and contract research arrangements with private industry that make appropriate provision for indirect costs, the expansion of donation income and income from intellectual property such as patent applications, the effective leveraging of assets, and the acquisition of stock options or dividends from investments in startup companies. Additionally, strategic and organizational initiatives and similar collaborations and partnerships with private industry and national governments will be particularly important for promoting the diversification of funding sources. While venture entrepreneurship represents one such way of capitalizing on the R&D results, under the current system investment projects by national R&D institutes are permitted for only certain national R&D institutes. Further improving the generation of innovation from the results of R&D at national R&D institutes will entail the investigation of ways to make further use of investment projects at national R&D institutes, making consideration for ensuring operational and fiscal soundness. In conjunction with such efforts, it will also be necessary to investigate the clarification of cases where it will be possible for national universities and national R&D institutes to acquire stock options from startup companies and other ventures.

Currently, a clear majority of joint research carried out with companies in the private sector is minimally funded, and is limited in terms of research scope and organizational involvement. However, there will be a need in future to promote large-scale joint research projects that match organization to organization through closer partnerships with private sector companies. In such instances, with regard to the necessary indirect costs it will be necessary to continue to promote joint research in line with ideas about the burden of expenses that will satisfy both universities and national R&D institutes and private sector companies. To do so, it will be necessary for universities and national R&D institutes to promote evidence-based cost visualizations by clarifying investment strategies that will involve the training and recruitment of personnel who will be in charge of collaborations between industry and academia, and to foster cost consciousness and work to improve management efficiency. Based on these investment strategies, national universities and national R&D institutes will be required to work toward the dissemination of mechanisms for covering a certain percentage of anticipated future expenses for joint

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research and contract research (e.g., Strategic Industry-Academia Collaboration Expenses), as well as to continue to promote corporate management in pursuit of clear management strategies.

In the strengthening of management structures, in order to carry out continuous reforms to governance under presidential leadership, it will be necessary to continue the systematic training and recruitment of professional personnel who will be able to support presidents in their respective national universities and national R&D institutes as well as play a key role in their management. Potential reference examples include overseas models such as the post of provost that exists in universities in the United States (the equivalent of a vice president responsible for research and academic affairs).

In addition, in order to expand cash donation revenue as a part of strengthening of their financial base, in addition to carrying out the formulation of strategies and targets and systems development such as making arrangements for professional staff at each university and national R&D institute, it will also be necessary to develop measures for increasing donor incentives targeting individuals and private sector companies. Furthermore, possible options for diversifying financial resources through the investment of assets might include the investment of surplus funds or the effective utilization of businesses and other revenue-generating activities, as well as the measures needed to promote such initiatives.

In conjunction with the initiatives described above, particularly with regard to designated national universities that meet certain conditions and which have the potential to address the intense competitive international environment, there is a need to dramatically promote efforts (including those at the institutional level) to build organizational bases such as management structures and diversify funding sources as drivers of national university reform.

For this reason, the Japanese government, in designated national universities, in addition to outstanding teaching and research activities that meet the world's highest standards, is being called on to promote initiatives to establish governance systems that will be trusted on and off campus as a result of the visualization of university management as well as to strengthen the financial base by bringing in external funding and managing assets. Designated national universities will be required to serve as models of university reform, to overcome challenges within and beyond the university – from the external challenges of creating startup companies and large-scale joint research projects with private companies to overseas challenges such as partnering and collaborating with foreign universities.

It will also be important to accelerate the integrated promotion of reforms to universities and national R&D institutes along with research funding reform by strengthening partnerships between designated national universities and designated national R&D institutes and helping to deploy the development of these pioneering initiatives at other institutions.

For this reason, designated national universities and designated national R&D institutes, in addition to implementing complementary initiatives by promoting regular consultations, will also be expected to make use of the Innovation Strategy Council and to endeavor to disseminate and deploy pioneering case studies to a wide audience of other universities and national R&D institutes.

In addition, from the perspective of heightening incentives to acquire private funding at universities and national R&D institutes in terms of ways to execute external funding from sources other than

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government expenditures, the Japanese government will need to investigate more effective and efficient measures to utilize self-generated income, under proper management and based on the characteristics of research and development.

[C] Priority Initiatives

Omitted

Chapter 5: Establishing a Systemic Virtuous Cycle of Human Resources, Knowledge and Capital, for Innovation

Due to the increasing severity of global competition, the speed with which the fruits of scientific research can be commercially implemented and rendered profitable has become a very important economic factor in today's world. In this regard, amidst the worldwide push for open innovation initiatives that mobilize all aspects of knowledge and technology both inside and outside organizations, it is essential that Japan, too, continue to make use of human resources, knowledge, and capital both inside and outside organizations, and to rapidly promote the creation and social implementation of new value. In addition, turning to domestic matters, with Japan's entry into a period of population decline after peaking in 2008, the promotion of regional revitalization has become an urgent challenge, and it will be necessary to hasten the establishment of mechanisms to enable the autonomous and sustainable creation of innovation at the regional level.

(1) Enhancing Mechanisms for Promoting Open Innovation

[A] Basic Perceptions

While it is primarily companies that bring innovation to fruition, the new areas of knowledge and values necessary for innovation are now being generated by universities, public research institutes, and companies around the world. On the other hand, when we consider the situation in Japan, the necessary human resources, knowledge and technology, and capital required for innovation is unevenly distributed among large companies, SMEs and startup companies, universities and public research institutes, and the thinness of organic connections among these various entities means that the value of these resources cannot be utilized in full.

For this reason, the use of domestic and international intellectual resources by Japanese companies and entrepreneurs and the expansion of opportunities leading to rapid social implementation will require the circulation of human resources, knowledge, and capital across organizational, sectoral, and even national boundaries, and the ongoing construction of societal-level mechanisms that can fully capitalize on the inherent potential of these respective resources. In addition, the realization of rapid social implementation will enable Japanese companies and entrepreneurs to secure profits, and it is desirable that reciprocally beneficial and autonomous innovation systems should be constructed by reinvesting a portion of those profits back into reinforcing the "fundamentals" for Japan's science, technology, and innovation (STI). It will also be necessary to engage promptly and constantly with regulatory reform and rule-making so as not to hinder company innovation. On the other hand, Japanese industry should also take note of the not inconsiderable number of cases of overseas companies that have pioneered businesses that challenge existing paradigms without necessarily waiting for rule formation; while provoking social debate, such companies have also earned their customers' support and subsequently moved to take the initiative in the global market.

Establishing a systemic virtuous cycle of human resources, knowledge and capital to generate innovation in academia and industry will require the strengthening of mechanisms for the full-scale promotion of open innovation. It will be important for companies, universities, and public research institutes, to not only work

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to increase their respective competitive strengths, but also to encourage putting the right human resources in the right settings by increasing the mobility of human resources and knowledge to commit fully to collaborative activities between industry, academia, and government. This will entail the need for cross-appointment systems and similar measures.

[B] Priority Challenges

Although it has primarily been private companies that have been responsible for realizing the fruits of innovation, victory in the global competition over Society 5.0 will require that value creation takes place with an unprecedented sense of urgency, and collaboration with universities and public research institutes will be essential to achieving rapid use of the fruits in society. In order to promote open innovation on a global scale, it is important to build mechanisms that can tap the unique strengths of individual companies, universities, and public research institutes, and then synergistically combine and merge them. From this perspective, we will push to strengthen initiatives that promote open innovation by each of these entities. We will also strive to increase the flexibility of the human resources, knowledge, and capital that are now unevenly distributed between large corporations, SMEs and startup companies, universities, and public research institutes, and to set up environments conducive to the flourishing of innovation. In addition, we will establish “spaces for co-creation” for urging the human resources, knowledge, and capital available to industry, academia, and government to come together and nurturing collaborative innovation between these sectors.

Nevertheless, if we consider the ideology of self-sufficiency and of existing value chains of the Japanese business community and the low level of flexibility of human resources and capital in post-war Japanese society, it would seem that pivoting to open social systems will require a transitional period for adjustments and a change in consciousness among stakeholders, as well as the review of existing systems. For this reason, it will be necessary to place an emphasis on initiatives for encouraging changes in social and corporate cultural mechanisms and habits that will be necessary for sitting down to engage in a medium-to-long term manner. Within this process, it will also be necessary to keep an eye on progress while being careful to obtain social consensus.

Specifically, in universities first of all, as well as recognizing that new values such as knowledge and technology can be derived through outside partnerships, it will be necessary to improve systems that will enable addressing the increased complexity of the organizational management challenges that will accompany the development of open innovation, to proceed with reforms to the operational and organizational modalities of management systems for handling the risks associated with intellectual resources and research activities, as well as to work toward the construction of mechanisms for promoting the use of private funds by improving financial transparency and taking maximum advantage of unique strengths and features. In addition, in public research institutes, as well, it will be necessary to proceed with the development of management and organizational systems identical to those in universities. In particular, in national R&D institutes, it will be necessary to engage in the development and strengthening of frameworks in which initiatives such as joint research and contract research will be encouraged, as well as

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the building up and strengthening of management systems that will be able to effectively exercise a bridging function linked with the commercialization of promising seed technologies and to otherwise derive the maximum advantage from R&D outcomes. Companies in the industrial sphere, the review of systems and a shift in consciousness relating to the review of corporate culture's traditional tendency towards ideologies of self-sufficiency that have become factors inhibiting open innovation will be essential. The Japanese government, as well, will have a role in redefining zones of competition and cooperation in addition to taking steps with regard to creating various environments that will be conducive to promoting the form of both inter-industry and industry-academia-government collaborations in both types of zone, together with the diversification of research funding for universities and public research institutes as a result of such collaborations.

In addition, in order to rapidly and effectively achieve innovation, it will be necessary to continue increasing the flexibility of intellectual resources now unevenly distributed between large corporations, SMEs and startup companies, universities, and public research institutes as well as creating environments that will be conducive to innovation. In particular, it is human resources that give rise to innovation, and the exchange of people between organization and sectors, will forge connections between various bodies of knowledge, leading to the creation of new values and the circulation of knowledge. To this end, the utilization and promotion of cross-appointment systems will be required. Furthermore, from the standpoint of developing environments where partnerships and exchanges among companies, universities, and public research institutes can be actively pursued, as well as strengthening research bases that generate diverse and outstanding knowledge and capital, it will be necessary to promote the formation of "incubator" sites that will connect human resources, knowledge, and capital from sources in industry, academia, and government to stimulate joint creation and channel these diverse actors toward the rapid production of innovation.

[C] Priority Initiatives

Omitted

(2) Enhancing the Creation of SMEs and Startup Companies to Tackle New Business Opportunities

[A] Basic Perceptions

Generating innovations capable of transforming technology "seeds" into new businesses in a short period of time is naturally better suited to SMEs and startup companies that are quick and agile than to large corporations that are restricted by their required minimum market size and slow decision-making processes. Up to now, however, Japan has invested little in venture capital compared to other major industrialized nations. Additionally, due to the strong reluctance of highly talented people to work in smaller startup companies, the number of startup companies has not been increasing, making it difficult to generate innovation. In addition, whereas the essential nature of innovation is that the creation of new value is realized on the basis of a considerable number of failed attempts, the level of social acceptance in Japan for failure is still quite low. As such, the growth of an entrepreneurial spirit has been slow to penetrate, and

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this situation is becoming a barrier to the success of startup companies and new industry.

For this reason, it will be important to generate and incubate startup companies with an appreciation for speed and the potential to tackle social implementation on a proactive or experimental basis, to strengthen standardization strategies and the effective use of intellectual property in society as a whole, and to implement and review systems for the creation of innovation in order to support rapid and flexible marketization and encourage a virtuous cycle of human resources, knowledge, and capital. Furthermore, based on the fact that the knowledge and technology as sources of innovation, needs, and business opportunities exist in Japan's various regional communities and in the various nations and regions of the world, it will be important to adopt a global perspective when encouraging the creation of innovation and to further motivate companies to challenge the status quo by taking on their own risks to create new values, so as to develop an environment in which the undertaking of various challenges lead from one to another in a chainlike fashion. In order to promote the establishment of such an environment, we will be required to heighten the sense of speed in R&D, such as by accelerating procurement procedures at national universities and national R&D institutes so as not to hinder company activities.

In addition, matching projects to link seeds technology produced by R&D-type SMEs and startup companies with market needs are currently underway in various fields. From the perspectives of stimulating open innovation within the industrial sector and between academia and industry and accelerating the creation and incubation of R&D-type SMEs and startup companies, the establishment of environments that will facilitate a broader base of active and independent interactions by various stakeholders, such as through the transfer of seeds technology and cross-sectional partnerships by different types of businesses, will be important in making these matching projects more effective.

[B] Priority Challenges

Transforming itself into a society that puts a high value on SMEs and startup companies that strive to create new businesses, and the government is committed to helping startup companies without sacrificing the speed to establish new markets, it will be required that provide appropriate assistance in areas such as entrepreneur training, starting businesses, and commercializing products and services, and providing continued support until the new companies reach their growth phase. To facilitate this, it is vital to organically integrate and establish links venture-related policies that have thus far proved insufficiently effective because they were deployed separately by various different entities, and to develop a unified system across industry, academia, and government aimed at sustainably and effectively supporting SMEs and startup companies.

In particular, we will try to expand the human resource base of entrepreneurially minded people and increase the social acceptability and status of entrepreneurial activity and startup companies through a variety of education and training initiatives at the elementary, secondary, and high school levels and we will intend to expand opportunities for intercultural contact, including study abroad programs for high school and university students and posting younger staff to communities with a high concentration of startup companies, so as to support the training of personnel who will be active at the global level.

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In addition, it will be necessary to enhance support targeting the creation of startup companies based out of universities and national R&D institutes, which are expected to be innovation leaders who will generate new businesses from the results of research at universities and national R&D institutes. Specifically, from the pre-commercialization stage, we will take an integrated approach to supporting R&D connecting innovative technologies possessed by universities and national R&D institutes with new products and facilitating business development by management human resources such as veteran entrepreneurs with practical experience in commercialization. To this end, it will be important for the Japanese government to build supportive environments for new business so as to facilitate the creation of successive startup companies from universities, national R&D institutes, and corporations by increasing mobility for human resources and knowledge between industry, academia, and government. Possible initiatives include strengthening collaboration between large companies and startup companies spun out from universities and national R&D institutes, technology development and management support tailored to the needs of SMEs and startup companies, supporting the creation of R&D-type ventures, and promoting the enhancement of staff involved in these initiatives. In this regard, it will be necessary to promote the loosening of regulations to ensure that existing institutes do not hinder entrepreneurial activities. In addition, it will be necessary to take care in endeavoring to foster environments conducive to undertaking new challenges even after businesses have been created.

Additionally, because market creation and the appropriate acquisition of intellectual property rights represent significant challenges in relation to the setting up of new businesses for the provision of advanced technologies and services by SMEs and startup companies, from the point of view of improving the handling of consultations about patent applications; ensuring initial demand in order to prime the pump for market creation; the evaluating new products and services; reflecting that evaluation; and supporting market development, it will be necessary for the Japanese government to adopt a demand-side standpoint to carry out the appropriate measures in consultation channels concerning intellectual property support as well as to investigate possibilities for public procurement. Particularly in those ministries and institutes that require advanced technology, it will be important to continue building realistic and sustainable mechanisms that will expose and reflect in procurement the technologies and ideas of R&D-type SMEs and startup companies characterized by speed and technical proficiency.

[C] Priority Initiatives

① Training Personnel with an Entrepreneurial Mindset

Omitted

② Promoting the Creation of Startups at Universities and National Research Institutes

Omitted

③ Creating an Environment for New Business

Omitted

④ Securing Initial Demand for and Giving Credibility to New Products and Services

Omitted

(3) Reviewing and Improving IP and Standardization Strategies and the Regulatory Environment for Innovation

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

① Strategic Development of Global Intellectual Property

Omitted

② Promotion of International Standardization

Omitted

③ Standardization for Social Implementation and Review and Development of Systems

Omitted

④ Promoting and Fostering Social Acceptance of Regulatory and Institutional Reforms for Realizing Society 5.0

Omitted

(4) Developing Innovation Systems that Contribute to “Regional Revitalization”

[A] Basic Perceptions

In Japan, where population levels peaked in 2008 before entering the present era of decline, coupled with the exodus of young people from rural areas against a backdrop of large economic disparity between rural areas and the metropolitan Tokyo region, many local communities are grappling with the real risk that population decline and faltering regional economies will trigger a vicious spiral. To overcome such structural issues and promote regional revitalization, it will be essential to secure and expand employment opportunities by stimulating regional economies with a view to autonomy over the medium- and long-term. This will necessarily entail working towards the sustained creation of open innovation that makes the fullest use of the resources of local industry, academia, and government in all administrative districts.

At the regional level, where resources are constrained, it will be important for local stakeholders in industry, academia, government, and finance to work to optimize cooperation based on their own individual

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strengths and distinctive qualities. In addition, it will be important for them to engage from a medium-to-long term perspective while mobilizing all relevant measures available from the national and local governments, as well as to continue promoting the acquisition and utilization of patents that originate in the region.

In addition, while endeavoring to stimulate and raise the level of local economies by encouraging the creation and growth of core companies, it will be necessary to continue to strengthen the establishment and embeddedness of mechanisms that will allow various stakeholders in industry, academia, government, and finance to work to independently coordinate in line with regional strengths and characteristics. Moreover, once the national government has established a continuous grasp of the current status of local regions, it will be important for the relevant national government agencies to work in concert with local governments to support regional initiatives more than they have in the past.

[B] Priority Challenges

Regional officials, including the heads of local governments, will be required to recognize that (1) even though measures on the part of the relevant ministries and agencies inevitably wind down to be replaced every few years, for local innovation proposals to overcome difficulties leading to commercialization will require a span of decades; (2) various rules of thumb obtained from individual case studies relating to concrete successes and failures should be repeatedly disseminated and shared as incentives and hints for numerous local stakeholders and the students and youth who will lead the next generation; (3) regional technologies and intellectual property should be transmitted between different industry sectors on a continuous basis among funding providers and individuals with technology, ideas, or translational capabilities inside and outside local regions; and (4) that under circumstances where the R&D resources of local industry, academia, and government are faced with inevitable deterioration in terms of both quality and quantity, it will be necessary to conceptualize flexible collaborations not necessarily limited by administrative areas, such as for example the mutual exchange and complementing of R&D resources by local public institutes in neighboring communities.

Keeping this in mind, efforts by the national government will need to be based on the essential premises of scenarios leading to commercialization from voluntary and realistic technological development based in local commitments and close coordination by industry, academia, government, and finance inside and outside local regions. Even more than in the past, the relevant ministries and agencies will need to continue working in concert to promote the establishment of effective systems for supporting local initiatives, and to work constantly to create environments in which excellent regional initiatives that can serve as role models will be widely spread to other areas as successful rules of thumb. Specifically, at the same time as strongly promoting the encouragement of the creation and growth of companies that will serve as core drivers in local economies, concerned organizations involved in industry, academia, government, and finance will need to work together autonomously and flexibly based on regional strengths. Dedicated efforts between these concerned organizations to embed sustainable mechanisms in local regions to establish what could be described as an ecosystem for the creation of innovation will also be essential.

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To this end, there are cases of initiatives by local governments, universities, and national R&D institutes that have promoted STI creation by leveraging voluntary contributions such as the so-called “Hometown Tax” (furusato nōzei). Accordingly, as well as gathering information about such cases, fine-grained support and consulting will be required for local universities and national R&D institutes as well as local governments embarking on pioneering collaboration initiatives in local communities. In addition, it will also be necessary to promote coordination and collaboration with bodies such as the Growth Strategy Council–Investing for the Future and the Regulatory Reform Promotion Council and to encourage the rapid implementation of innovation that will contribute to “regional revitalization”. In such instances, it will also be important for regional universities to leverage regional assets, as well as to consider efforts to demonstrate superiority by engaging in distinctive teaching and research.

[C] Priority Initiatives

① Supporting the Creation and Growth of Core Companies as a Driving Force for Regional

Economies

Omitted

② Supporting the Establishment of Innovation Systems Based on Regional Strengths and Characteristics

Omitted

③ Steady Implementation of the Regional Relocation of Government-Related Research Institutes

Omitted

④ Improving the Effectiveness of Coordination Systems in National and Municipal Governments Organizations Supporting Local Initiatives

Omitted

(5) Cultivating Opportunities for Generating Innovation in Anticipation of Global Needs

[A] Basic Perceptions

Omitted

[B] Priority Challenges

Omitted

[C] Priority Initiatives

① Broadcasting Japan’s STI Initiatives in International Arenas like the G7

Omitted

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② R&D to Anticipate Global Needs and the Establishment of Long-Term Analysis Systems and Science and Technology Forecasts to Create New Business

Omitted

③ Promotion of Frameworks for International Joint Research with Developed Countries and for International Science and Technology Collaborations with Emerging and Developing Countries

Omitted

Chapter 6: Enhancing Functions for Promoting STI

[A] Basic Perceptions

It will be important to proceed with the reform and functional enhancement of the organizational foundations of the universities and national R&D institutes that constitute the principal drivers of STI activities, undertaking the strengthening of their financial base such as through the diversification of funding sources and the implementation of firm measures with regard to fundamental funds, and pushing the further intensification of the National Innovation System initiative. In addition, it will be indispensable to enhance our ability execute policies by strengthening systems to promote STI policies in a strategic and integrated manner domestically and overseas. In particular, it will be necessary to strengthen the “control tower” role of the Council for Science, Technology and Innovation (CSTI) in order to enhance its ability to drive STI forward on a Japan-wide basis.

For this reason, as well as grasping the situation with regards to the progress and outcomes of the 5th Basic Plan and reflecting these in policy-related control cycles (PDCA), once we have been able to grasp the overall picture of STI policy, we will be required to make the fullest possible use of this Comprehensive Strategy to realize the appropriate allocation of limited resources to the necessary fields and measures.

The steady implementation of the Fifth Basic Plan and this Comprehensive Strategy and the maintenance and improvement of Japan’s international status in terms of science and technology will require securing R&D investment. The stated goals of R&D investment, as well as aiming for the combined total of public and private R&D investment to equal or exceed 4% of GDP, also aim for government investment in R&D to equal 1% of GDP while ensuring consistency with the Japanese government’s Plan to Advance Economic and Fiscal Revitalization. If we estimate the nominal GDP growth rate during this period as being based on the economic revitalization case of “Economic and Fiscal Projections for Medium to Long Term Analysis” the total amount of government R&D investment required during the term of the Fifth Basic Plan would amount to approximately 26 trillion JPY.

[B] Priority Challenges

Since the promotion of STI and other efforts to realize Society 5.0 will themselves be the keys to a growth strategy that will realize a 600-trillion JPY economy by around 2020, as well as making efforts toward the realization of Society 5.0, it will be essential for the Japanese government to expand investment into R&D that will contribute to its realization and, in combination with the R&D investment that will be attracted as a result, to expand public-private R&D investment.

This expansion will entail the blanket reform of universities and national R&D institutes, as well as a review of their strategic management and personnel systems. By promoting such bold reforms, it will become possible for universities and national R&D institutes to establish partnerships and good relationships of trust with the private sector, and it must be strongly recognized that R&D in Japan’s universities and national R&D institutes has the ability to attract significant investments of capital from the private sector. At the same time, as well as securing the necessary expenses for strategic management through the appropriate handling of indirect costs and private funds through transparent management and

Provisional

decision-making processes, such as cost visualization and anti-fraud measures, it will also be necessary to promote efficient budget execution.

To build an environment for producing STI, it is also important to carry out procurement that takes into consideration uncertainty and unpredictability based on the characteristics of R&D. In particular, when involved in international competitive bidding procedures, the long period leading up to the publication of public notices has sometimes been highlighted as an obstacle to rapid and efficient budget execution, and consideration should be given to ways to shorten the period leading up to publication in government gazettes (including online publication).

In addition, to promote policies based in objective evidence, it will be necessary to promote initiatives oriented to the systematic provision of information on STI and the implementation of analytical and development methodologies.

[C] Priority Initiatives

Omitted