Cross-ministerial Strategic Innovation Promotion Program SIP
"Technologies for Smart Bio-industry and Agriculture"
Research and Development Plan

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Director General for Science, Technology and Innovation Policy

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Overview of the Research and Development Plan

Significance and Goals

To expand the bioeconomy[1] and intensify the competitiveness of biotechnology-related industries in Japan, the program "Technologies for Smart Bio-industry and Agriculture" will contribute to the realization of the following strategies proposed in the "Bio-Strategy 2019", by establishing the innovative infrastructure through the integration of the biotechnologies and digital technologies: ① "Diversified × Sustainable" primary production (Realization of the society that satisfies diversified needs of consumers utilizing sustainable primary production skills), ② Production of biomaterials with less environmental burden via sustainable production methods, ③ Enabling long-life social participation of the residents by integrating the "Medical care × Healthcare" services, ④ Development of the database (DB) infrastructure (effective use of the existing scattered and unutilized biotechnology-related DB currently available).

Accordingly, we intend to build a model for the Smart Food System by expanding the result of the SIP Phase 1 "Agricultural Data Collaboration Platform (WAGRI)" in the entire food value chain. The new model will combine a new concept of "communications between the production sites and markets" with the current model that focuses mainly on the "providers" and would thereby link the production, processing, and distribution sectors as well as integrate the post-consumer waste management and recycling strategies. With specific focus on the agricultural sector, we intend to create a Smart Food Chain platform uniformly utilizing data from the production to processing, distribution, sales, consumption, and export. Development of innovative smart agricultural technologies and systems driven by various data and technologies to promote data-driven breeding will be implemented to realize the health promoting society through "food", and create and develop innovative biomaterial and bioproduct industries. Moreover, through these initiatives, we intend to realize a sustainable growing society, a revolution in productivity, and an intensification of the competitiveness in the agriculture, forestry, and fishery industries and food industries. The goals to be achieved by the end of the program are described below.

- Build a Smart Food Chain platform that enables a substantial increase in productivity at the agricultural production fields to enhance their agri-economic performance. Moreover, the demonstration experiments administered to the individuals and companies involved in the agricultural business—the sectors from production to distribution and consumption—validate the effectiveness (e.g. 10% reduction in food loss and 30% reduction in working hours at the production sites) of the platform to achieve the prospect of its implementation in the society.
- Develop and construct evaluation systems to assess the health promotion effectiveness of foods and DBs that support a reduction in the risk for lifestyle-related diseases and an increase of healthy life expectancy and verify the usefulness of these systems and DBs with regard to expanding the agricultural product demand. By leveraging those systems and resources for maximum results, provide the services, as a model, that design and propose the diet ideal for individuals based on their health conditions and provide prospects regarding its implementation in the society.
- Based on the concept "Receiving from the Ground and Returning to the Ground", focus on the "arterial system" that provides food ingredients as well as the "venous system" on the value chain and attempt to reduce environmental burden. Establish the technologies for developing high-performance products and functional materials superior to conventional oil-derived products in terms of reduced development period, biodegradability, and biocompatibility using the biotechnologies and digital technologies, the newest scientific knowledge in synthetic biology including genome researches, and the data-driven technology for designing functional products.

In a current situation where the European countries and the US are putting strategic efforts on the bioeconomy and promoting the development of the data-driven smart agricultural technologies and systems, we will

[1] Includes the market and the industries that uses biotechnology and biomass. The OECD predicts that the bioeconomy of the OECD countries would reach approximately 1.06 trillion dollars (GDP) by 2030. Among them, industrial fields will account for 39% and agricultural fields will account for 36% (OECD report, Bioeconomy to 2030).

accelerate the industry–academia–government collaborated research development and implementation in the Japanese society through this project aiming to contribute to the acquisition of a new market (of >240 billion yen) and achievement of the national export target in the agricultural, forestry, and fishery products and food products by expanding the bioeconomy in Japan as well as the smart agricultural technologies and systems within and outside Japan.

2. Research Projects

The agriculture business in Japan is facing several issues, such as the shortage of successors and intensification of international competitiveness against the background of trade liberalization. To address those issues, it is necessary to ①expand the demand, ②construct a value chain linking the stages from production to consumption, and ③enhance the production sites. "Growth Strategy 2018" proposes the necessity of the complete functioning of the "Agricultural Data Collaboration Platform (WAGRI)" and its use in the entire value chain linking the production, processing, distribution, and consumption sectors. Therefore, in the SIP "Technologies for Smart Bio-industry and Agriculture", we will present a model of the Smart Food System that expands the WAGRI throughout the food value chain and incorporates the idea of "communications between the production sites and markets" into the current model, thereby focusing mainly on the "providers" linking the production, processing, and distribution sectors as well as focusing on the post-consumer waste management and recycling strategies. Specifically, the project will focus on the following concepts: ①expansion of the demand by increasing added value to the food ingredients and focusing on the market needs for factors such as "health and safety/trust", ②enhancement of the production sites (improving the productivity and reducing the work load) via the establishment of "data-driven agriculture" by utilizing the artificial intelligence (AI) and ICT technologies, ③Adherence to the concept of "Receiving from the Ground and Returning to the Ground" by focusing on the "arterial system" that provides the food ingredients as well as on the "venous system" on the value chain to reduce the environmental burden. Accordingly, a model would be presented that may contribute to the "promotion of agricultural management reform" and "development of food-related industries" including packaging material businesses via the "optimization and enhancement" of the Smart Food System by integrating food and agricultural businesses, comprehensively using the biotechnologies and digital technologies, and employing the newest scientific knowledge in synthetic biology including genome researches

Based on those ideas, researches in each segment of the Smart Food System (Development, Production, Distribution, Processing, Data Utilization, Construction of the Value Chain Data Infrastructure, Sales and Consumption, and Resource Circulation) are summarized in the figure below.

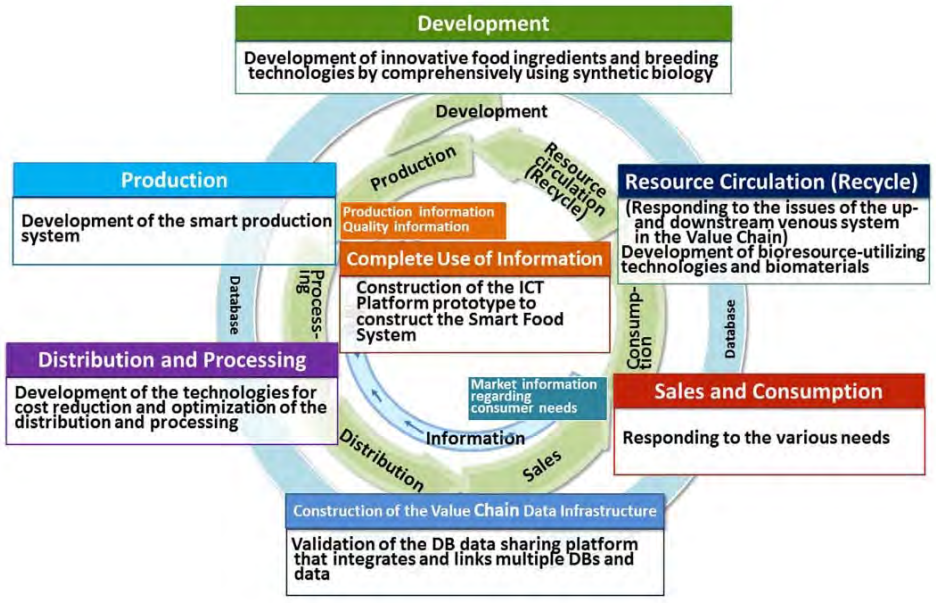


Figure: Overview of the "Generic technologies for Smart Bio-industry and Agriculture

(1) [Development] Development of Innovative Food Ingredients and Breeding Technologies by Comprehensively Using the Newest Scientific Knowledge in Synthetic Biology

To enhance the seeding development system in Japan, we develop necessary techniques for the promotion of the data-driven breeding system where new varieties are developed using new breeding technologies and a vast volume of big data on breeding and crop varieties are developed that provide the consumption and distribution sectors with new values and/or main crop varieties that contribute to the achievement of Sustainable Development Goals (SDGs).

To promote the use of biotechnology, perform research studies on the public understanding of the biotechnology and on technology trends as well as provide such information. This infrastructure would be used in the research development activities throughout the project.

(2) [Production] Development of the Smart Production Systems; [Distribution/Processing] Cost Reduction and Optimization Technology Development; and [Data Utilization] Construction of the ICT Platform Prototype Aiming at the Construction of the Smart Food System

Construct the "Smart Food Chain platform" by improving the data platform that shares the information beyond the certain industries, among various sectors—from production to processing, distribution, sales, consumption, and export—and by developing the technology that enables the production and supply of the products that accurately meet the market needs. Specifically, a two-way information transmission system that conveys information between the production and consumption in the distribution process will be constructed, and production technologies that facilitate providing the production capacity and demand both within and outside Japan as well as ship the accurate number of products based on the demand will be developed. In addition, technologies and systems that achieve the data-driven smart production, such as feed forward cultivation management technology based on information regarding the growth conditions, soil data, and environmental predictions concerning farm products, will be developed.

The two-way information sharing system that transmits information will be developed and the Smart Food System that meets the market needs based on information regarding the freshness and quality of the products as well as the demand prediction will be established.

(3) [Construction of the Value Chain Data Infrastructure] Validation of the Data Distribution Infrastructure that Integrates and Links Multiple DBs

As a foundation of innovation creation through the integration of biotechnologies and digital technologies, develop and construct application programing interfaces (APIs) that promotes the public use of biotechnology-related data owned by the national institutes and develop large-scale culture and screening techniques for the highly functional microorganisms.

(4) [Sales and Consumption] Responding to the Various Needs

In Japan, the population with lifestyle-related diseases, dementia, and cancer is increasing with the super-aging society and changes in an individual's lifestyle. The increasing national medical expenses are becoming a social issue. To address these issues, establish new healthcare systems that support the increase of healthy life expectancy with focus on "food", which is a source essential to the maintenance of health. Specifically, we construct a system that evaluates the health maintenance and health enhancement effects of the agricultural, forestry, and fishery products. Products containing various ingredients and having a milder influence on the human bodies than the pharmaceutical medications will be constructed, and data regarding the microbiome in the Japanese population will be collected and managed to create and promote the industries that contribute to the enhancement of the national health with focus on "food" based on the scientific evidences.

(5) [Resource Circulation] Development of Bioresource Utilization Technologies and Biomaterials

To reduce the dependencies on the petroleum resources and realize a sustainable growing society, productivity superior to that of oil-derived products should be achieved and high-performance products that cannot be synthesized from the petroleum resources should be developed, with the complete utilization of the non-edible parts of the foods generated in the food value chain, waste products, and unused resources of the agricultural,

forestry, and fishery products as well as biological functions to the related materials, such as wrapping materials should be applied.

Implementation System

Noriaki Kobayashi, the program director (PD), will be in charge of making and promoting the R&D plans. The PD will assume the role of the chairperson, the Cabinet Office will serve as the secretariat, and the promotion committee consisting of concerned government agencies and specialists will comprehensively coordinate the project. Using the grant provided to Bio-oriented Technology Research Advancement Institution (BRAIN, the management company) of the National Agriculture and Food Research Organization (NARO), the BRAIN will manage the researches in collaboration with the New Energy and Industrial Technology Development Organization NEDO .

Intellectual Property Management

The Intellectual Property Committee will be established as a management corporation that performs anappropriate intellectual management to secure the incentives of the inventors as well as of the individuals employed for the promotion of the sites and industrialization to enhance the public profit.

Evaluation

Prior to the annual year-end evaluation by the governing board, peer-reviewing by the external specialists and self-examination of the researchers and PD will be performed. This secures the organization to be able to improve by itself.

6. Exit Strategy

① Human resource, Physical, and Financial Contributions from the Participating Companies
The participating companies of each consortium will contribute to the R&D by providing assistance including the human resources, technologies, knowledge, and funds.

② Collaboration with the Related Tasks
The R&D working teams of the “Smart Food System” will work together with teams of the related tasks of the SIP “Smart Logistics Service”, SIP “Cyberspace Platform Technology utilizing Big Data and AI”, and the related tasks of the PRISM.

③ Destination of the Research Achievement
Upon research achievement, the products or services, which will be introduced to the market, should be commercialized by the companies participating in each consortium or their affiliated companies. The results of the platform type researches widely used by both the public and private sectors, such as the system that supports the food value chain will be launched for practical use by introducing widely the new business idea from the companies participating in the consortium as well as from the other businesses.

④ Technology Transfer to the Private Companies
For the products established for practical use or commercialized, SIP will be responsible for the processes, up to making the prototypes. Thereafter, the business partners will be in charge of launching for practical use, including mass production. For the research results to be used widely by both the public and private sectors, such as the system supporting the food value chain, SIP will be responsible for validating the effectiveness in the Use Case. Thereafter, the management and the maintenance of the system should be conducted by the companies participating in the consortium.

⑤ Human Resource Development
To create innovations through the integration of the biotechnologies and digital technologies, the development of human resources with interdisciplinary skills and expertise as well as knowledge in both fields and those with a sense of business management will be indispensable. During the R&D process of this project, the young researchers will be convened to experience the on-the-job training, in line with the recurrent education/promotion programs on the AI and informatics to aid the human resources.

Research and Development Plan

1. Significance and Goals

(1) Background: Domestic and Foreign Situations

With the recent advances in the technological innovations of IoT, AI, robotics, and genome engineering, there are opportunities to create new markets for biotechnology-based products in the biotechnology-related industries and improve the productivity in the agriculture, forestry, fishery, and food industries using a vast volume of diverse big data. Reflecting this background, to expand Japan's bioeconomy and strengthen the competitiveness of related industries, establishing a foundation for innovation through the integration of biotechnologies and digital technologies, realizing a health promoting society through "food" and, aiming to create and promote innovative biomaterial and bioproduct industries are considered as critical issues; particularly, in the agricultural field where "food" is produced, constructing a Smart Food Chain that uniformly uses data of various sectors—from production to processing, distribution, sales, consumption and export—via the development of innovative smart agricultural technology systems driven by a vast volume of big data that can result in production using biofunctions, aiming for the realization of a sustainable growth society, and achieving a revolution in productivity and strengthened competitiveness in the farming, fishing, forestry, and food industries may be mentioned as urgent concerns.

Considering the current domestic and foreign situations in the field of biotechnology, the Organization for Economic Co-operation and Development (OECD) predicts that the bioeconomy in the OECD countries will expand to 1.06 trillion dollars (GDP) by 2030. Among them, industrial fields and agricultural fields will account for 39% and 36%, respectively. The European Commission sets a goal to replace 30% of the oil-based products with biotechnology-based products by 2030. Similarly, the US has aimed to replace 36% of the oil-based products with biotechnology-based products and to create a market for trading and employment. In Japan, the "Bio-Strategy 2019" was formulated at the Comprehensive Innovation Strategy Promotion meeting. The overall objective of the strategy was "to realize the world's most advanced bioeconomy society by 2030" aiming to realize the permeation of ①bio-first concept, ②bio-community formation, and ③bio-data-driven systems.

Currently, agriculture in Japan is experiencing issues in the enhancement of production scale and in sustainable production due to the influence of labor shortage, lack of successors, and aging of the producers. Moreover, although there are diverse consumer needs and an extension of a concept of food as just-in-time delivery of an ordered amount of quality products, there is a situation where there is lack of cooperation among the sectors from production to distribution, causing issues of supply–demand mismatch and food waste loss. Because the global food market expands, meeting the market needs, particularly those in Asian countries are necessary. However, the development of production/distribution/export system responding to the needs remains midway. On the other hand, the developed countries, such as the European countries and the US, are employing cutting-edge technologies of IoT and sensor technologies to develop their precision farming[2] according to their objectives and agricultural management systems suitable for each country. In addition to accelerating the development the cutting-edge technologies in the precision agriculture field, developing systems to form a "value chain of information" by automatically collecting various sensing data from production to consumption to form big data is ongoing.

As mentioned above, it is essential to construct an innovation infrastructure in the biotechnology-based and agricultural industries by generating significant synergistic effects through the accelerated promotion of this industry–academia–government collaborated project to contribute to the realization of a sustainable society and achievement of SDGs as well as for the enhancement of productivity and competitiveness in the agriculture, forestry, fishery, and food industries and for the expansion of bioeconomy in Japan. Furthermore, for the realization of a health promoting society through "food" and agriculture field where "food" is produced, it is important to implement crucial structural reforms and environmental development, to establish a data-driven smart agriculture system (which is becoming a global trend), to develop technologies required for the Smart Food

[2] An agriculture management method. From the careful observations of farming land and products that are complicated, diverse, and random, control them precisely to improve the yield and quality, also to reduce environmental burden in the overall process.

Chain and promotion of data-driven breeding, to develop technologies utilizing bioresource that help realizing a resource-circulating society and generating biomaterials, and to conduct research and development for launching high value-added foods for practical use.

(２) Significance and Policy Importance of the Program

To expand the bioeconomy and intensify the competitiveness of biotechnology-related industries in Japan, the program "Technologies for Smart Bio-industry and Agriculture" will contribute to the realization of the following strategies proposed in the "Bio-Strategy 2019", by establishing the innovative infrastructure through the integration of the biotechnologies and digital technologies: ① "Diversified × Sustainable" primary production, ② Production of biomaterials with less environmental burden via sustainable production methods, ③ Enabling long-life social participation of the residents by integrating the "Medical care × Healthcare" services, ④ Development of the database infrastructure (effective use of the existing scattered and unutilized biotechnology-related DB currently available).

Accordingly, we intend to build a model for the Smart Food System by expanding the result of the SIP Phase 1 "Agricultural Data Collaboration Platform (WAGRI)" in the entire food value chain. The new model will combine a new concept of "communications between the production sites and markets" with the current model that focuses mainly on the "providers" and would thereby link the production, processing, and distribution sectors as well as integrate the post-consumer waste management and recycling strategies. With specific focus on the agricultural sector, we intend to create a Smart Food Chain platform uniformly utilizing data from the production to processing, distribution, sales, consumption, and export. Development of innovative smart agricultural technologies and systems driven by various data and technologies to promote data-driven breeding will be implemented to realize the health promoting society through "food", and create and develop innovative biomaterial and bioproduct industries. Moreover, through these initiatives, we intend to realize a sustainable growing society, a revolution in productivity, and an intensification of the competitiveness in the agriculture, forestry, and fishery industries and food industries.

Compared with other countries, Japan is experiencing an issue of rapid decreasing birthrate and aging population. Considering this situation, improvement of the quality of life (QOL) of Japanese individuals as well as controlling the increasing healthcare costs, including the nursing cost, are urgent issues. This program aims to reduce the risks of lifestyle-related diseases and increase healthy life expectancy of Japanese individuals, thereby reducing the increasing healthcare costs by creating and promoting "food-related healthcare industries" that propose and provide diet (food) suitable for the individuals according to their health conditions and lifestyles. In addition, the program intends to improve the additional values of Japanese cuisine and agricultural, forestry, and fishery products and food products originating from Japan by accumulating the scientific evidences of the health maintenance and promotion effects of these foods aiming to contribute increasing the producers' income and exports.

With the international agreement on SDGs and global warming countermeasure (Paris Agreement), transition to an oil-independent sustainable economy and society is an urgent global issue that needs to be addressed. This research program aims to contribute to the global issue by developing high value-added products with productivity superior to that of the oil-based products and developing those that are difficult to be synthesized from oil resources, by employing "Monozukuri" wherein the non-edible parts of the foods and waste food products produced in the food value chain as well as the unused resources in the agriculture, forestry, and fishery industries are used and by effectively using the biological functions for the related materials, such as wrapping materials.

Furthermore, it intends to contribute to the creation of new industry and employment opportunities in the rural areas through high value-added foods using the local biological resources.

With the expanding global food market, the agriculture, forestry, and fishery industry and food industry in Japan, which provide high quality and variety of products, are the industries most expected to grow in the future. This project aim to intensify the competitiveness of the agriculture, forestry, and fishery industries and food industry by substantially improving the productivity in these fields, despite the decreasing labor force, as well as by building a flexible production and distribution system and increasing the brand power of the agricultural, forestry, and fishery products as well as of the food products originating in Japan by sharing and utilizing data

among the production, processing, distribution, sales, consumption, and export sectors and achieving remarkable labor saving and complete automation of the individual work steps using the data-driven smart agriculture system.

Further, it aims to contribute to supply a stable amount of food within and outside Japan by developing the agricultural varieties that withstand the changing climates and have less environmental burden, spreading these varieties within and outside Japan and reducing food loss in the entire food value chain through a flexible production and distribution system meeting the market needs.

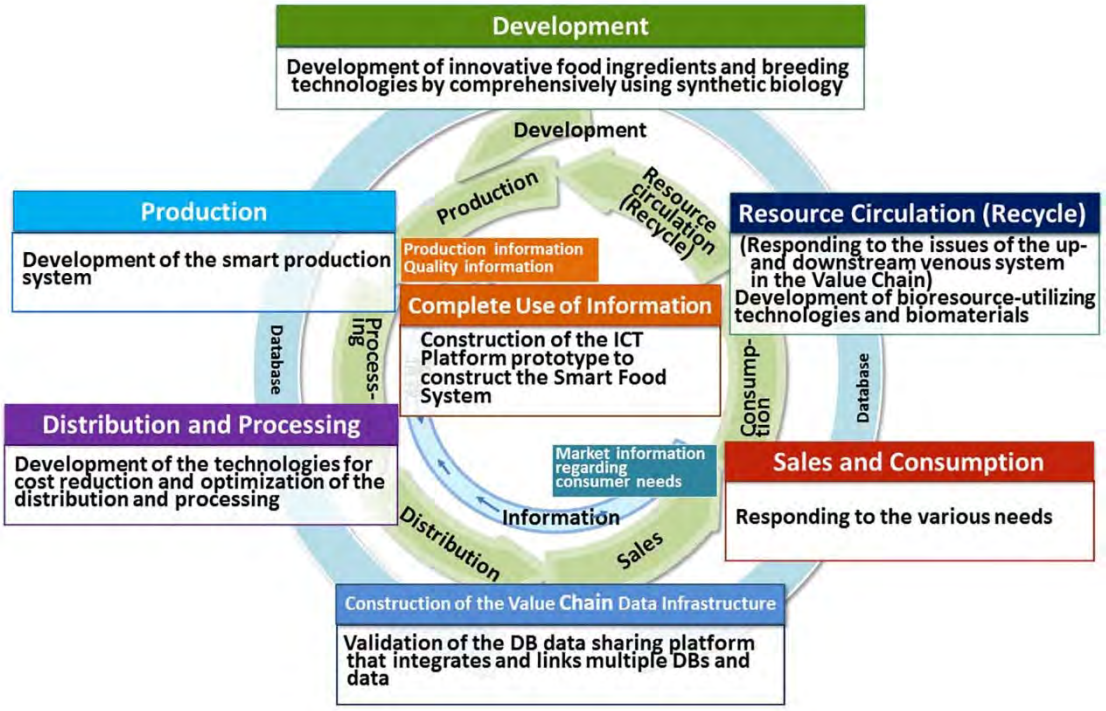


Figure 1-1　Overview of the "Technologies for Smart Bio-industry and Agriculture"

(３) Goals and Targets

① Toward the realization of the Society 5.0

- Construction of the Smart Food Chain platform that would enable the production and supply of agricultural, forestry, and fishery products and food products meeting the market needs including the needs for export and realization of the data-driven smart agriculture. These goals should be achieved by sharing and using data across the sectors from production, processing, distribution, sales, to consumption.
- Building an architecture that supports the cross-sectorial data linkage of the verification projects using geographic data.
- Realization of the "data-driven breeding" technique that enables the development of crop varieties that meet the market needs and withstand climate changes in a short time period.
- Creation of a new industry and a Sound Material-Cycle Society by linking the functional design and epoch-making production technologies for innovative biomaterial and high-performance chemical production, with industries forming various value chains.
- Creation of an over 240-billion-yen market by expanding the bioeconomy (including the food-related industries) and strengthening its technological foundation, and increasing productivity and intensifying competitiveness in the agriculture, forestry, and fishery industries and food industries, including the expansion of the functional food market. This scenario is feasible by developing and constructing the system for assessing the health promotion effectiveness of foods and its related DB which may reduce the risks of lifestyle-related diseases and increase the healthy life expectancy of Japanese individuals.

② Social Goals

- Contribution to a reduction of food loss by supplying food according to the needs using the Smart Food Chain platform.
- Contribution to the worldwide stable supply of foods through the development of agricultural varieties that withstand the climate changes and have less environmental burden.
- Contribution to the realization of a carbon recycling society through the production of high value-added products using local biological resources.
- Contribution to a reduction of the risk of lifestyle-related diseases and an increase of healthy life expectancy in Japanese individuals through the construction and use of a new healthcare system that enables suitable foods and diet to be proposed to the individuals according to their health conditions and lifestyle.

③ Industrial Goals

- Contribution to expand* the bioeconomy market comparable to or larger than the prospective expansion of the world bioeconomy market size (The OECD predicts that the GDP growth rate for the bioeconomy markets in the OECD countries will reach approximately 1.06 trillion dollars by 2030) by developing data-driven technologies and implementing them in the society. (*calculating Japan's current GDP growth ratio to the total GDP growth rate of the OECD countries, the Japan's GDP growth rate in 2030 will be ≥20 trillion yen).
- Contribution to improvement of the environment where almost all the individuals involved in farming would be able to perform agriculture using the data system by 2025.
- Contribution to the acquisition of a 100-billion-yen market by expanding the smart agricultural technology and system within and outside Japan by 2025.
- Contribution to achievement of the government's export goal in the agricultural, forestry, and fishery products and food markets (increased to 1 trillion yen in 2019 and based on the achievement, set a new goal to reach 5 trillion yen by 2030).
- Creation and promotion of the industries that support the health maintenance and improvement of Japanese individuals through "food" by comprehensively using an integrated DB containing health information related to the agricultural, forestry, and fishery products and food products by 2025. In addition, increasing the fresh food varieties with function claims by a factor of 3, i.e., from current 5 to 15 items, is planned. (This will contribute to an increase in market size for fresh foods with function claims to approximately 30 billion yen from the current 8.9 billion yen).
- Contribution to the development of 1-trillion-yen industry-related market by developing innovative biomaterials and high-performance chemicals by 2030.

④ Technical Goals

(Unless otherwise noted, the goals will be achieved by 2022)

(A) [Development] Development of Innovative Food Ingredients and Breeding Technology by the Thorough Use of the Newest Scientific Knowledge in Synthetic Biology

- Development of the technologies for the API for breeding etc. to promote the "data-driven breeding" program run by the industry–academia–government collaboration.
- Development of >10 crop varieties and breeding materials that promote the innovation of distribution and expansion of export, thereby providing new values to the consumers and users.

(B) [Production] Development of the Smart Production System; [Distribution/Processing] Cost Reduction and Optimization Technology Development; and [Data Utilization] Construction of the ICT Platform Prototype Aiming at the Construction of the Smart Food System

- Construction of the ICT platform that uses the big data by the formation of a big data of various related data from production to consumption and export.

- Development of technologies for the sensing and automatic collection of cultivation management information and a technology for modeling such information into a big data on the platform by 2020.
- Development of a technology that automatically analyzes the big data and reflects the result on the operation of machines by 2021.
- Performing demonstration experiments on the constructed Smart Food Chain platform participated by the agriculture related companies and farmers, from production and distribution to consumption, to validate its effectiveness (e.g. 10% reduction of food loss and 30% reduction of working hours at the production sites), with an aim to launch its implementation in the society.

(C) [Construction of the Value Chain Data Infrastructure] Validation of the Distribution Infrastructure that Integrates and Links Multiple DBs and Data

- Promote the private sector to use the big data integrating biotechnology-related information (construction of a system to provide the biotechnology-related big data owned by the national institutes in the way that can be easily used by the companies in the private sector).

(D) [Sales and Consumption] Responding to the Various Needs

- Development and validation of the effectiveness of an easy-to-use, low cost system which represents the mild physical condition change as an index. The system can be used to measure one's health condition on a daily basis.
- Acquisition of scientific evidences regarding the health maintenance and health promotion effects of the agricultural, forestry, and fishery products and food products.
- Organization of the data on gastrointestinal microbiome and validation of the effectiveness of food ingredients that improves gastrointestinal environment.
- Development of an integrated DB containing health information related to agricultural, forestry, and fishery products and food products in which data and scientific evidences regarding the relationship between foods and health would be listed.
- Model implementation of service that designs and proposes the most suitable diet to individuals according to their health conditions using the systems mentioned above to launch its implementation in to the society.

(E) [Resource Recycling] Development of Bioresource Utilizing Technology and Biomaterials

- Development of the production systems for high-performance products and biomaterials that enable reducing the environmental burdens, including carbon dioxide emission, by 30% with lower costs by comprehensively using biological functions and launching these systems to practical use.
- Development of over five kinds of innovative biomaterials and/or functional products through the abovementioned technological development and launching these products to practical use.
- Development of next-generation core technology for the chemical industry using the unused resources of the agriculture, forestry, and fishery industries (establishment of technologies for extracting and producing multiple kinds of effective ingredients and materials in a series of processes from the unused resources in the local agriculture, forestry, and fishery industries).

⑤ Institutional Goals

- Standardizing data and defining their specifications to uniformly share and use information related to the agricultural sector with various systems and machines.
- Promotion of the national understanding about the cutting-edge biotechnologies including genome engineering.
- Building of a system for assessing the health maintenance and health promotion effects of the agricultural, forestry, and fishery products and food products and reflecting the obtained scientific evidence in the health promoting food system (assessment of the functionality depending on the characteristics of fresh foods and discussion regarding the expansion of health claims to be labeled).
- Formulation of the policies on standardizing the methods for labeling and component analysis for the functionality of foods and international specifications, by standardizing the measuring method of

gastrointestinal microbiome.

- Visualization of the usefulness and environmental performance of the products using the biological functions and resources (establishment of the labeling system, etc.).
- International standardization of the specifications and the methods for assessing biomass plastic (reflecting Japanese development technology).

⑥ Global Benchmarks

- In overseas countries, the data linkage infrastructure in the agricultural field is constructed by large global enterprises to sell their products. Japan has an advantage with regard to this infrastructure as it is led by the public sector and shared and used by several companies of the private sector. Utilizing this advantage, an open data platform expanded to sectors from production to processing, distribution, sales, consumption, and export before the remaining world to contribute to improvement of the brand power of the agriculture, forestry and fishery products, and food products made in Japan, as well as to expand the smart agriculture technology and system to the countries outside Japan would be developed.
- Considering the advantages owing to the development of the technologies for breeding and cultivating rice plant, vegetables, and fruits with high quality and high added values and demonstrating the world's top level accumulation of plant genetic resources, a supporting system of "data-driven breeding" that integrates the digital technologies and is led by the industry–academia–government collaborated project will be established, aiming to contribute to an increase in Japanese producers' income by developing high standard plant varieties that are unavailable in other countries with a considerably shorter period than before.
- Considering the advantage of being a healthy longevity country in the world, the added values of Japanese cuisine and the agricultural, forestry, and fishery products and food products made in Japan will be increased by obtaining the scientific evidences of their health promotion effects with an aim to contribute to increasing the Japanese producers' income as well as exports.
- Considering the advantages of "Monozukuri" using microbial functions, such as fermentation, and biomass application technologies, for which Japanese companies are ranked the top positions for the number of patent applications, innovative materials and high-performance products (e.g. using smart cell) will be developed to acquire a market.

⑦ Collaboration with Local Governments

- The development of a stable production technology to meet the actual market and consumer needs, which is required in the development and validation processes of efficient food distribution system using AI, will be conducted in collaboration with Japan Agricultural Cooperatives and other local governmental institutes that use the data system for cultivation and quality management.
- The human intervention studies of obtaining the scientific evidences for the health maintenance and promotion effects of the agricultural, forestry, and fishery products, and food products, will be conducted in collaboration with local governments and medical institutes striving to support the health promotion of the residents.
- For the development of next-generation core technology for the chemical industry using the unused resources of the agriculture, forestry, and fishery industries, a collaboration system will be established with the local governments from the early stage of the R&D process, aiming to commercialize the products.

2. Research and Development

We will work on the research and development programs listed below to realize a health promoting society through “food”, innovation in agriculture, forestry, and fishery industries and food industry, and a sustainable growing society, aimed at the expansion of bioeconomy and achievement of the SDGs in Japan.

[Development] Development of Innovative Food Ingredients and Breeding Technologies by Comprehensively Using the Newest Scientific Knowledge in Synthetic Biology

[Production] Development of Smart Production Systems

[Distribution and Processing] Cost Reduction and Development of Optimization Technology Development

[Data Utilization] Construction of an ICT Platform Prototype Aiming at the Construct the Smart Food System

[Construction of the Value Chain Data Infrastructure] Validation of the Data Distribution Infrastructure that Integrates and Links Multiple DBs

[Sales and Consumption] Responding to the Various Needs

[Resource Circulation] Development of Bioresource Utilizing Technologies and Biomaterials of Non-Edible Parts and Waste

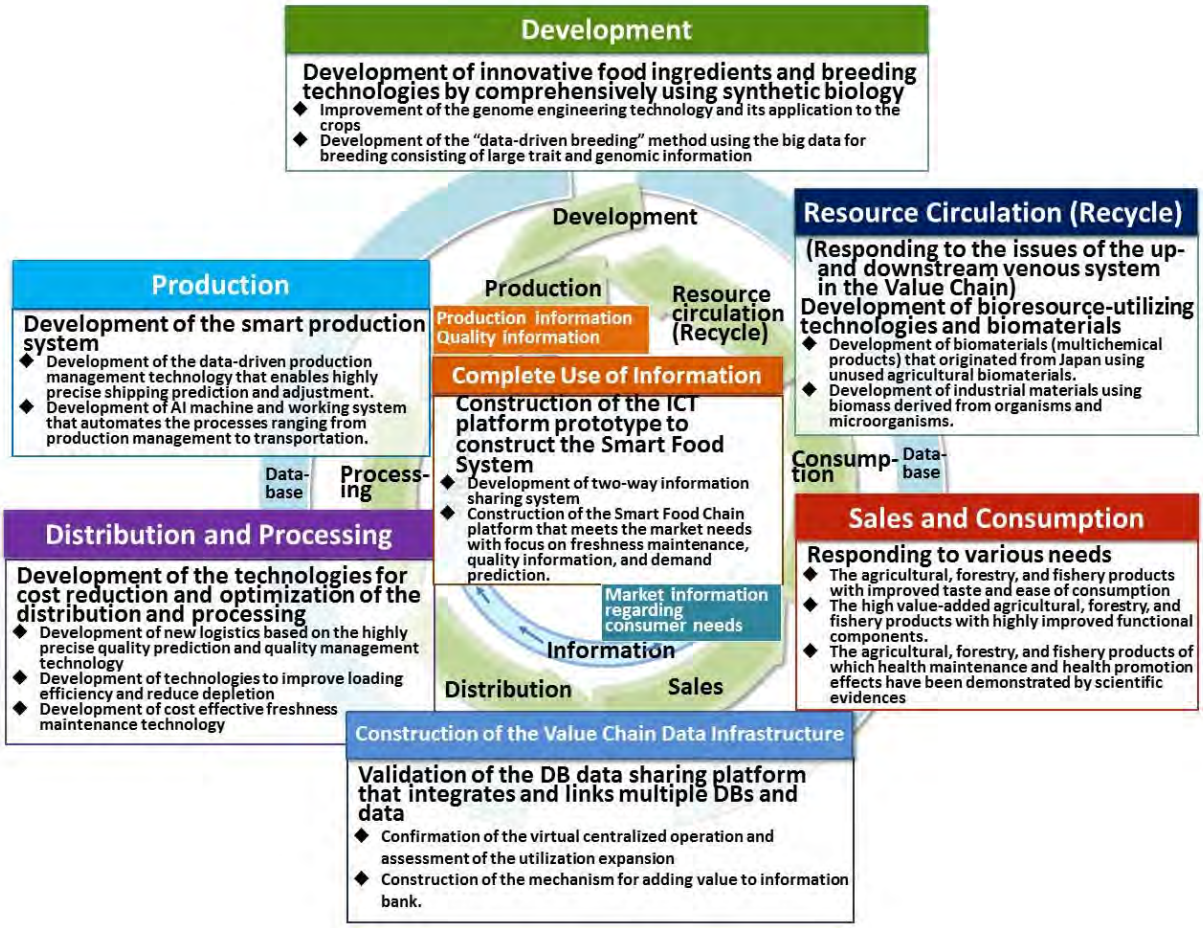


Figure 2-1: Overview of the R&D, concerning “Smart Bio-Industry and Agriculture Infrastructure Technologies”

(1) [Development] Development of Innovative Food Ingredients and Breeding Technologies by Comprehensively Using the Newest Scientific Knowledge in Synthetic Biology

[Overview]

We will develop technologies to promote the “data-driven breeding” that enables new crop varieties to be developed using big data for breeding and new breeding technologies, with an aim to strengthen the breeding development system in Japan. Moreover, we will develop agricultural varieties that will add new values to the consumption and distribution and develop main crop varieties that can contribute for achieving the SDGs.

[Necessary Expenses]

Fiscal year 2018	355 million yen
Fiscal year 2019	272 million yen

( )- Development of Technology for the Promotion of “Data-Driven Breeding”

[R&D Details]

We will promote “data-driven breeding” in which new varieties will be developed using the big data for breeding, data collected from the “Smart Food Chain platform” and new breeding technologies (such as genomic selection and genome engineering) in cross-sectional cooperation among the industrial, academic, and governmental sectors. Accordingly, we will develop technologies, such as breeding API, and through the trial use and validation of the “data-driven breeding”, we will develop agricultural varieties with new values that have been difficult to produce to date (e.g., varieties that provide new values to daily diet; those that promote innovation of distribution, expansion of export, and reduction of food loss; and those that withstand the climate changes and produce stable and large yield with less fertilizers and pesticides). Moreover, we will develop genome-engineered agricultural products by simultaneous alternation of multiple traits that are not yet achieved elsewhere in the world and develop genome engineering technologies that enable the precise replacement of DNAs. Moreover, by analyzing the data of symbiotic relationships between plant and microbe and the soil using agricultural–environmental engineering system, we will develop farming methods using the symbiotic relationships between plants and microorganisms that enable the reduction of chemical pesticide and fertilization products.

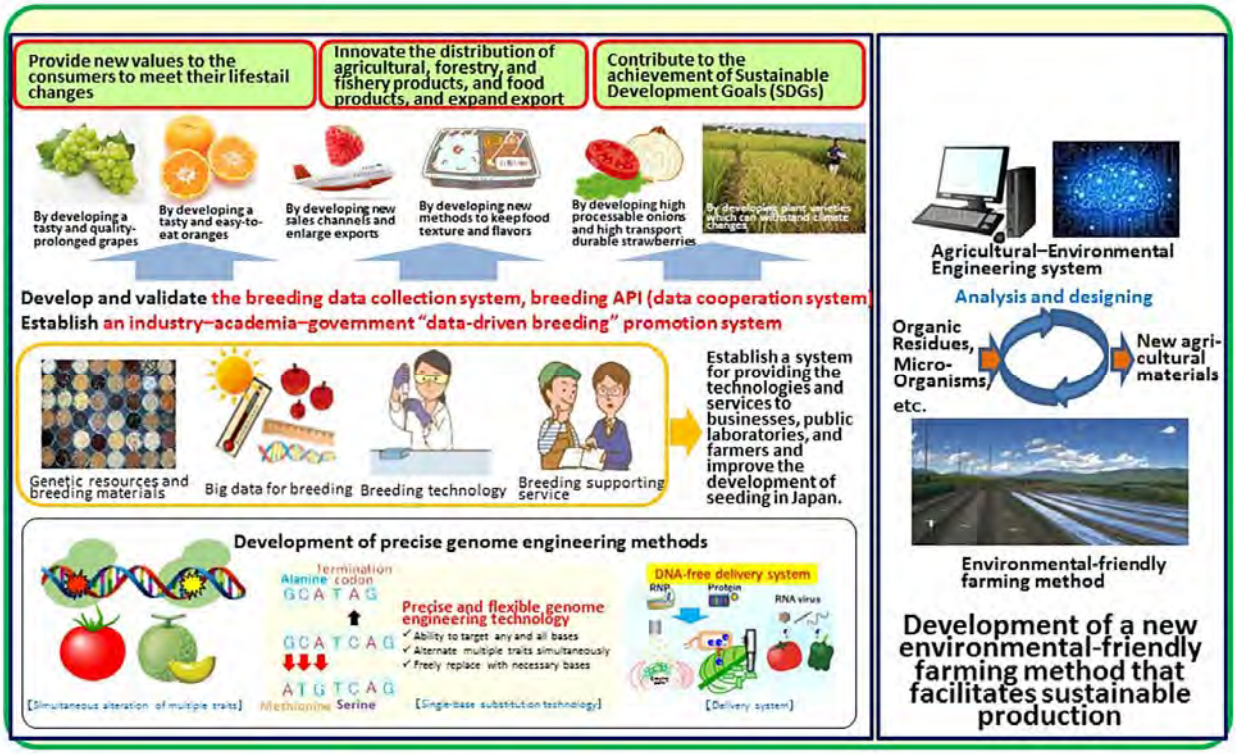


Figure 2-2: An image of the development of technologies for promoting the “data-driven breeding”

[Participating Organizations]

① Establishment of “Data-Driven Breeding” and its Use in the Development of New Value-Added Agricultural Products

Research Director: Masao Ishimoto (National Agriculture and Food Research Organization)
The University of Tokyo, ListenField Co., Ltd. Genomedia Inc., National Agriculture and Food Research Organization, Kumamoto Prefectural Agricultural Research Center Fruits Tree Research Institute, Wakayama Prefectural Fruits Tree Experiment Station, Local Incorporated Administrative Agency Aomori Prefectural Industrial Technology Research Center, Kyoto Prefectural University, Tottori Horticultural Experiment Station, Kazusa DNA Research Institute, Fukuoka Agriculture and Forestry Research Center, Kaneko Seeds Co., Ltd., Watanabe Seed Co., Ltd., Tochigi Agricultural Experimental Station, Chiba Prefectural Agriculture and Forestry Research Center, Fukui Prefectural Agricultural Experiment Station, Nisshin Seifun Group Inc., Nihon Syokuhin Kako Co., Ltd., and Japan International Research Center for Agricultural Sciences.

② Development of Precise Genomic Engineering Technology that can Contribute to Streamlining of Crop Breeding by Comprehensively Using of Genomic Information

Research Director: Seiichi Toki (National Agriculture and Food Research Organization)
National Agriculture and Food Research Organization, The University of Tokyo, Tsukuba University, Nisshin Seifun Group Inc., Nippon Norin Seed Co., Kaneka Co., Sanatech Seed Co., Ltd., Sumitomo Chemical Company, Limited, and Sumika Agro Tech Co., Ltd.

③ Establishment of Agricultural–Environmental Engineering Systems and Development of Farming Methods Using the Plant and Microorganism Symbiotic Relationships

Research Director: Yasunori Ichihashi (RIKEN)
RIKEN, The University of Tokyo, Tsukuba University, Ehime University, Fukushima Agricultural Technology Center, and Mayekawa Research Institute Co., Ltd.

[Goals of the Current Year]

① Establishment of “Data-Driven Breeding” and its Use in the Development of New Value-Added Agricultural Products

- Development of “data-driven breeding” promoting fundamental technology
  Based on the initial specifications of the breeding API decided in the first year, develop and implement an API prototype related to the phenotype data input, genomic data input, farming land environment data input, data cleansing/visualization, and data analysis.
- Development of new value-added crops using the “data-driven breeding” promoting fundamental technology
  For each crop variety, obtain genomic data using the next-generation sequencer, evaluate and collect phenotype data, and improve the accuracy of the genome selection model. For some crop products, selection of target traits will be performed. Regarding grapes, decoding of the whole genome of “Shine Muscat” to complete the linkage map derived from both the paternal and maternal lineages will be conducted.

② Development of Precise Genomic Engineering Technology that can Contribute to Streamlining of Crop Breeding by Comprehensively Using of Genomic Information

- Development of precise genome engineering and of the technology for introducing genome engineering enzymes
  We will investigate to improve efficiency of the DNA alteration technology using the gene engineering technology, which enables a single base to be accurately altered, and target recombination technology; to verify the effects on the gene expression induced by genome engineering on the phenotype through

precise regulation; and to determine the optimal conditions for introducing genome engineering enzymes by thorough use of bacterial or viral vectors as well as by employing physical techniques.

- Development of new genome engineering enzymes
  To establish CRISPR-Cas system with expanded target sequences, we will determine the crystal structure of the BlCas9-RNA-DNA complex and screen the ribozyme that cleaves the target DNA specifically according to the guide RNA for the new ribozymes that have been prepared by connecting two ribozymes.

- Development of genome-engineered crops with multiple improved traits
  Using the trait alteration technique of genome engineering, we will commence the construction of genome engineering vectors and genome transformation with an aim to produce multiple varieties of morning glory (*Ipomoea hederacea*) with higher appreciation values (such as a dwarf variety), of tomatoes, such as those with high GABA content and automatic parthenocarpy, and of melons with multiple valuable traits added.

③ Establishment of Agricultural–Environmental Engineering Systems and Development of Farming Methods Using the Plant and Microorganism Symbiotic Relationships

- System establishment project: We will work on the entire process ranging from attainment of data to informatics analysis. The project team will acquire comprehensive agricultural data on plant–microorganism–soil related to the materials and farming methods provided by the companies in the private sector and the NARO based on the conditions determined in the previous year by field agriomics and further analyze them using bioinformatics analysis.

- Technology development project: We will verify whether targeted technology can be applied in agricultural production for commercialization. Based on the previous year's results, the companies in the private sector and NARO participating in the technology development team will list new candidate materials and farming methods that can be used to produce high profit agricultural products for each business in this industry. They will conduct preliminary laboratory experiments to select the candidate technologies. Moreover, the industrial strategy team formed by the companies in the private sector will perform marketing researches.

[Intermediate Goals]

① Establishment of "Data-Driven Breeding" and its Use in the Development of New Value-Added Agricultural Products

- Development of "data-driven breeding" promoting technology
  We will complete a prototype application to use API. The cooperative companies from the private sector will evaluate the system. The open–closed system will be introduced for DB of public research institutes and independent administrative agencies.

- Development of new value-added agricultural products using the "data-driven breeding" promoting infrastructural technology
  For crops, we will clarify the relationships between phenotypic and genotypic data of the target traits and develop a prediction model to conduct the investigating on line selection. For strawberries, in particular, five operative organizations will conduct research on the selection of target groups, develop the second-generation variety, plant the chosen variety, evaluate the phenotype and analyze the genes, and finalize the model.

② Development of Precise Genomic Engineering Technology that can Contribute to Streamlining of Crop Breeding by Comprehensively Using of Genomic Information

- Development of precise genome engineering and development of genome engineering technology to introduce enzymes
  To develop a single-base genome engineering technology, we will evaluate the genome engineering efficiency of BlCas9 and its variants in plant cells. To improve the efficiency of the targeted

recombination, we will identify factors, such as the conditions suitable for homologous sequence length and number of cuts and positions, and acquire multiple candidate genes that can contribute to the improvement of the efficiency. To control gene expression, we will create several genome engineering populations and evaluate the correlation between the base sequence and phenotype. For the genome engineering using bacteria, we will evaluate the variant strain of *Xanthmonas* sp. using model genome engineering and perform base substitution on tobacco using viral vectors to verify the absence of any residue of virus and foreign nucleic acids. TALENs protein will be introduced in wheat using a physical method to confirm the chimeric mutancy and mutation transfer to the next generation.

- Development of new genome engineering enzymes
  Based on the information obtained from the crystal structure, BlCas9 variants with different PAM specificities will be created. To develop a new RNA-dependent DNA cutting enzyme, we will use the SELEX method to screen ribozymes that cleave the target DNA specifically according to the guide RNA, among a pool of RNAs with 200–300 bases of random sequences.

- Development of genome engineering products with multiple improved traits
  We will evaluate the genome engineering effects on the cultivated morning glory. A method for introducing Cas9/gRNA complex directly into cyclamen will be established. For tomatoes and melons, the development of genome-engineered varieties containing traits of high GABA content, automatic parthenocarpy, and long shelf-life will be initiated. Furthermore, we will evaluate the gene types of T0 generation, select the potential lines to initiate the promotion to the next generation, and obtain nullsegregant and mutant homo lines.

③ Establishment of Agricultural–Environmental Engineering Systems and Development of Farming Methods Using the Plant and Microorganism Symbiotic Relationships

- System establishment project: We will complete the idea for the agricultural technology innovation base. According to the conditions defined in the previous year, we will obtain comprehensive agricultural–environmental data on the relationship among plant–microorganism–soil, related to various materials and farming methods using field agriomics and analyze that data using bioinformatics analysis. By verifying the analysis results, the attainment of the big data required for agricultural–environmental engineering system prototype and development and improvement of the analysis technology will be completed.

- Technology development project: We will verify whether the target technology can be applied in an actual agricultural field.

  Considering the previous year's results, the technology development team consisting mainly by cooperative companies from the private sector will provide crops and soil samples as the new candidate materials and farming methods for high profit agricultural products. The team will obtain and analyze comprehensive agricultural–environmental data on the relationship among plant–microorganism–soil using field agriomics and bioinformatics analysis to clarify the efficiencies of the candidate technologies at an actual farming field. The results obtained will be compared with the market trend.

[Final Goals]

① Establishment of "Data-Driven Breeding" and its Use in the Development of New Value-Added Agricultural Products

- Development of the "data-driven breeding" promoting infrastructural technology
  We will employ and initiate a complete operation of the data-driven breeding method at actual breeding sites and diffuse the breeding support system that optimizes the breeding strategies and helps in making decisions in the breeding steps. A data-driven breeding promotion system will be established as the industry–academia–government collaborated project. After completion, the team will provide the system widely with some charge.

- Development of new value-added agricultural products using the core "data-driven breeding" promoting infrastructural technology
  From the implementation of the data-driven breeding, we will develop >8 varieties of paddy rice,

strawberry, and onions that will promote varieties, breeding materials, innovation of distribution, and export as well as rice plants with less environmental burden that can withstand the climate changes.

② Development of Precise Genomic Engineering Technology that can Contribute to Streamlining of Crop Breeding by Comprehensively Using of Genomic Information

- Development of precise genome engineering and genome engineering technology to introduce enzymes
  We will establish a base substitution system to introduce a Cas9-base editor as a Cas9/gRNA complex in a plant cell. The system should be free from the foreign DNA and is efficient. For the genome engineering that uses a donor, its effectiveness will be validated on the base recombination in accordance with the design plan by applying the method to actual crops. For the genome expression control of the genome engineering, its effectiveness will be demonstrated in modifying the phenotype to the desired design by selecting the appropriate target section. For the development of enzyme introduction genome engineering technology, we will achieve successful genome engineering of the endogenous gene in actual crops—such as *Xanthomonas* sp.—that are altered to introduce the proteins and obtain tomato plant varieties by virus vector base substitution. We will complete the enzyme direct-introduction genome engineering technology based on new logic, which is different from others.
- Development of new genome engineering enzymes
  We will enable BlCas9-base editor to be used and expand the base substitution target. For the development of new RNA-dependent DNA cutting enzyme, we will rationally design and construct new RNA-dependent DNA cutting ribozymes based on their 3D structures.
- Development of genome-engineered crops with multiple improved traits
  We will conduct trial cultivation of the genome-engineered cyclamen and final evaluation for new varieties of morning glory and cyclamen. For the development of tomatoes and melons with multiple useful traits, we will cultivate the F1 commercial varieties that would be developed by 2021, in a special isolated room, and evaluate their traits.

③ Establishment of Agricultural–Environmental Engineering Systems and Development of Farming Methods Using the Plant and Microorganism Symbiotic Relationships

- System establishment project: We will complete the development of prototype for the agricultural–environmental engineering system. A system containing the entire agricultural-environment data obtained in this research project will be constructed.
- Technology development project: We will develop new agricultural materials and farming methods based on the agricultural ecosystem based on the knowledge obtained from the agricultural–environmental engineering system. Moreover, the business model using the system will be completed.

( )-2 Research investigations: public understanding of biotechnology and biotechnology trends

[R&D Details]

To promote the use of biotechnology, we will perform research investigations on public understanding of biotechnology and biotechnology trend, intellectual properties, and regulations of the cutting-edge biotechnologies and its provision of the obtained information to the business industry.

This project constructs an advanced collaborative R&D infrastructure, focusing on the agriculture, forestry, and fishery industries, considering its applications in industrial, medical, and healthcare fields. The project should be conducted through ministerial collaboration and the industry–academia–government collaboration.

We will perform research investigations of the communication methods to effectively attain consumers' and various stakeholders' understanding and involvement in the use of biotechnology. We will engage in promoting the nation's understanding regarding biotechnology by practicing communication methods and transmitting information to media. Moreover, we will investigate and organize the trends of technology, intellectual property, and regulation of the cutting-edge biotechnology for constructing and operating a website that provides the

information to venture capital companies and various industries.

[Participating Organizations]

Research Director: Shoichiro Sembon (National Agriculture and Food Research Organization)
National Agriculture and Food Research Organization, Tsukuba University, Nagoya University, The University of Tokyo, International Christian University, Hokkaido University, Centcrest IP Attorneys, Japan Association for Techno-innovation in Agriculture, Forestry and Fisheries, and Life & Bio plaza 21.

[Goals of the Current Year]

- Collect, organize and transmit information on the trends of R&D, intellectual property, and regulations of the cutting-edge biotechnology; post information via website, distribute newsletters; and transmit information to media.
- Commence the investigation of an AI-based analysis method under the guidance and suggestion of the specialists.

[Intermediate Goals]

- Continue collecting information on the cutting-edge biotechnology R&D trends within and outside Japan, regulations concerning the biodiversity and food safety, and information regarding the intellectual properties to be considered to launch the results to practical use, and transmit timely information to the media and educational community.
- Determine the degree of effectiveness of the provided information in promoting consumers' understanding and provide feedback to the communications technology.
- Commence the investigation of an AI-based program that will link to the development of a new information transmission method and collect information to be provided to the AI system.

[Final Goals]

- Based on the information obtained from the cutting-edge R&D technology and related regulations and continuous trend survey on intellectual properties, update and improve the website until the completion of the project and construct and develop a continuous management system for transmitting information using a new type of AI-based communication method.

(２) [Production] Development of the Smart Production Systems; [Distribution/Processing] Cost Reduction and Optimization Technology Development; and [Data Utilization] Construction of the ICT Platform Prototype Aiming at the Construction of the Smart Food System

[Overview]

We will develop the data systems that share information from production to processing, distribution, sales, consumption, and export beyond the industrial framework and construct a “Smart Food Chain data platform” by developing a technology that facilitates achieving the needs for production and demand precisely. In particular, a two-way information transmission system that enables information to be transmitted during the distribution process, from production to consumption, will be developed, along with production technologies that enable transporting products according to the demand, i.e., technology that matches production and demand both within and outside Japan. Moreover, we will develop technology and system that will realize the data-driven smart production, such as feed forward cultivation management technology based on growing conditions and soil information data of the plant and environmental predictions.

This project handles high level ICT/AI technologies, various big data including the agricultural and biological information, and biotechnology in integrated and complex ways. The project requires collaboration among ministries and agencies to realize collaboration between the research institutes and universities specialized in industrial, agricultural, and biological fields and the businesses in the private sector.

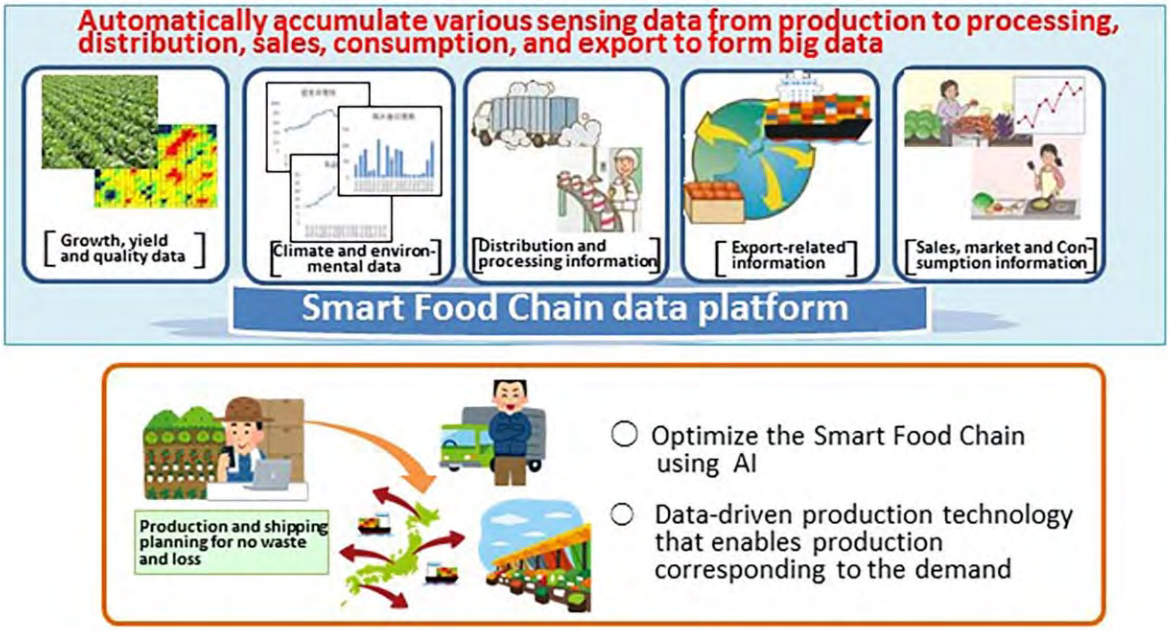


Figure 2-3: An image of data platform construction of the Smart Food Chain

[Necessary Expenses]

Fiscal year 2018 1,164 million yen
Fiscal year 2018 (revised) 200 million yen
Fiscal year 2019 1,086 million yen

[R&D Details]

We will share information on the needs within and outside Japan to develop a production system consistent with such needs. A new Smart Food Chain including the stages from production to processing, distribution, sales, consumption, and export will be developed. With complete traceability and tamper prevention, this Smart Food Chain creates new values by ensuring its reliability. The system will support the stable supply of the products by

deciding the accurate amount of products to be stocked and shipped at the production stage and by forming a network with different production sites optimally. Optimization of the distribution by considering the production information and facilitating the stabilization of the supply–demand balance will lead to the reduction of food loss. Moreover, the system will allow the promotion of the export by providing the feedback about the consumer preferences within and outside Japan to the production sites. For the realization of goals mentioned above, following technological developments will be implemented.

① We will construct a big data that is able to optimize the distribution by developing an information sharing system that connects each stage of production, distribution, sales, and consumption of the agriculture, forestry, and fishery industries and by expanding the functions of WAGRI and accumulating the information. Further, we will develop an AI-based production/demand matching technology for within and outside Japan. In particular, we will develop a Smart Food Chain architecture and run verification projects of joint logistics for the expansion of agricultural products' export and will construct the architecture from data obtained from the actual results on the individual crop exports and other logistics.

② We will develop a production technology that would facilitate ship according to the demand using the big data accumulating the growth information of various production sites and use of WAGRI as well as considering the open-field cultivation cases. To build a smart machine systems and appliances, we will develop technologies and systems that automatically manage the production, based on the soil data and climate predictions. For the consideration of expansion to mountainous areas in Japan and the South Asian countries, we will develop robust robotic farm machine operation systems that can be used in the agricultural road and develop automated work machines that can be used for various products and at various geographical features.

③ In addition to the above mentioned elemental technologies, we will develop an ICT platform that covers all stages from production to consumption that enables the provision of primary products with ensured reliabilities in the price, quantity, quality, and timing that match the needs. During the test operation of the Use Case, we intend to achieve the goals of food loss reduction and stabilization of the supply and demand balance. Verification project of export in ① will be used as the Use Case. As for the development of technologies required for the improvement of primary products' distribution efficiencies (e.g. reduction of lead-time before the supply), we will collaborate with the SIP "Smart Logistics Service".

[Participating Organizations]

Research Director: Kazuo Terashima (National Agriculture and Food Research Organization)
National Agriculture and Food Research Organization, Keio Research Institute at SFC, Fujitsu, Fujitsu Research Institute, NEC Solution Innovators, Ltd., Gifu University, Kinki University, General Incorporated Association Agri Open Innovation Institution, Chiba University, Mie University, Yamagata University, RIKEN, Azabu University, Horiba Ltd., Kikkoman Corporation, The University of Tokyo of Agriculture and Technology, Kewpie Corporation, NEC Corporation, Akita Prefectural University, The Distribution Economics Institute of Japan, Local Incorporated Administrative Agency Hokkaido Research Organization, Kumamoto Agricultural Research Center, Shikaoi Agricultural Cooperative, Zukosha Co., Ltd., E-supportlink Ltd., Agri Communications Co., Ltd., VisionTech Inc., Academic Express Inc., Hitachi Zosen Corporation, Shibuya Seiki Co., Ltd., Space-Agri Corporation, Calbee Potato, Memuro Agricultural Cooperative, Hokkaido University of Education, Kyoto University, Ritsumeikan University, Iseki & Co., Ltd., Yanmar Co., Ltd., Kubota Corporation, Mitsubishi Chemical Corporation, NTT Data, Panasonic Corporation, Takii & Co., Ltd., Nagoya University, Tohoku University, Kagoshima University, Kyusyu University, Miyazaki University, Yamato Global Logistics Japan Co., Ltd., Tokachi Federation of Agricultural Cooperatives, Ritsumeikan University, National Institute of Advanced Industrial Science and Technology, Hokkaidou University, Kitami Institute of Technology, Toyonoki Corporation, Suzuki Motor Corporation, and Kanagawa Agricultural Technology Center.

[Goals of the Current Year]

- Make advances in the development of infrastructural technologies for constructing the Smart Food System and development of their applications; standardize and regulate individual product identification and distribution data; and propose indices for the freshness and hygiene of cut vegetables based on nondestructive measurements.

- Develop precise growth information collecting system, automated crop transportation and control system, and unattended operation system for the transport vehicles as well as commence developing technologies for robust robotic farm machine operation systems that can be used in the agricultural road (supported by the additional budget).
- Perform a Use Case through test operation of the Smart Food Chain to extract the issues; further, by running verification projects for the Smart Food Chain architecture construction and joint logistics for the expansion of agricultural products' export, conduct the export demonstrations for each crop (supported by the amended budget).

[Intermediate Goals]

- Standardize and regulate the data that enables sharing the information from production to consumption and develop technologies for standardizing and data collection by 2020; and perform the test operation of the developed and implemented system to verify the appropriateness of the constructed system and extract the issues required for the horizontal expansion of the system as well as accumulate the operation know-how.
- Considering the entire Smart Food Chain, apply Use Case of the ICT platform prototype, which contributes to an increase in added values, including the expansion of export to the actual demonstration, and verify whether the operation is accurately performed using the actual data by 2020.
- Develop a technology that automatically obtains cultivation management information to allow cooperative operations between the harvesting and transportation robots by 2020.

[Final Goals]

- Develop demand prediction technology, matching-information processing technology, and quality evaluation and quality maintenance technologies to construct the Smart Food Chain data platform that enables necessary information to be provided and mutually shared on time by 2022.
- Develop production and shipping management technology responding to demands and intelligent machines and systems that reflect the production management operations based on the big data and perform a field test of the developed technologies by 2022.
- Perform verification tests to verify the appropriateness when using the elemental technologies, such as production/demand matching technologies and production technology that respond to demands (the Use Case at the test operation to present 10% reduction of the food loss and 30% reduction of the working hours at the production sites) by 2022.

(３) ［Construction of the Value Chain Data Infrastructure］ Validation of the Data Distribution Infrastructure that Integrates and Links Multiple DB Data

[Overview]

Work on the technological development to provide “information” and “products” that serve as the foundations for innovative creation by harmonizing biotechnologies and digital technologies; further, implement the research studies and provision of information to promote the use of biotechnologies. These foundations will be used in the other programs of the related projects.

Regarding the “information,” to promote the public use of the biology-related data owned by national institutes, develop and construct the API to share biological data. It should be developed considering the results of research investigations of the industrial needs.

Regarding the “bioresources” , develop a common infrastructural technology that allows the mass culturing and screening of high-functional microorganisms for constructing a high throughput microorganism cultivation and screening platform.

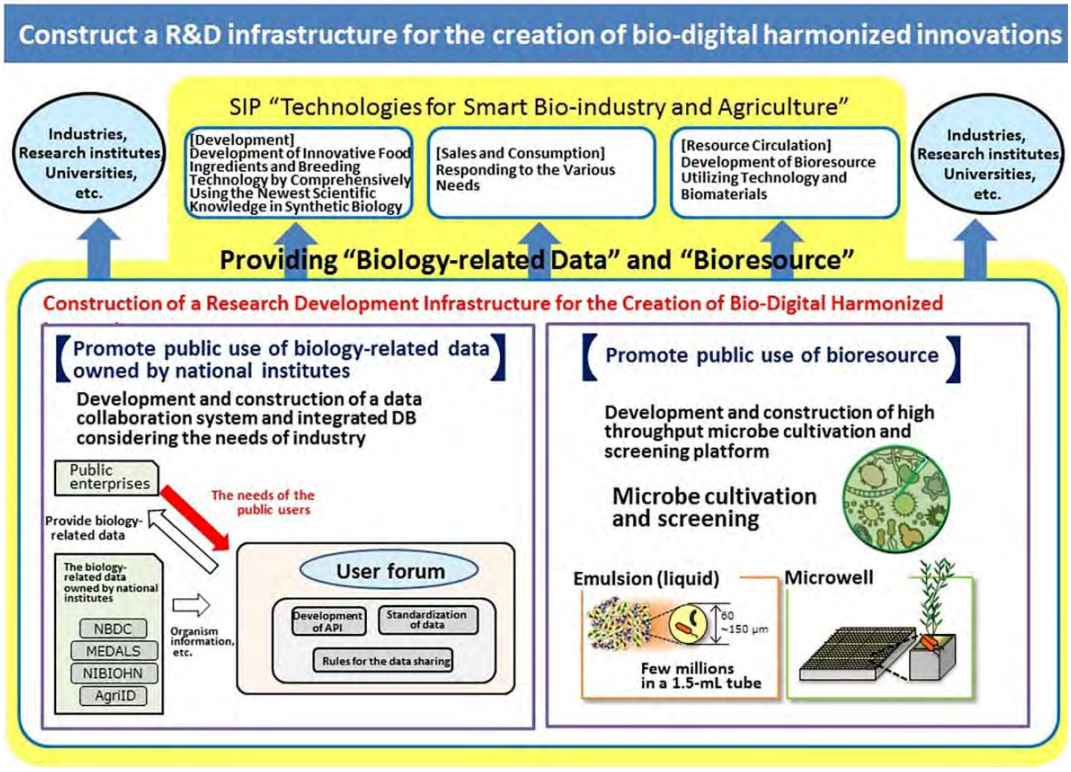


Figure 2-4 An image of constructing a research development foundation for the creation of bio-digital harmonized innovations

[Necessary Expenses]

Fiscal year 2018	185 million yen
Fiscal year 2019	142 million yen

[R&D Details]

First, we will conduct a research investigation on the needs for biological information use in the industry; based on the result, we will develop an API to link the data in advance on the biology-related DB that the national institutions had strongly been promoting and develop an application that systematically analyzes data from multiple DBs using AI; from these, we will construct a linked/integrated use biology DB (Integrated DBs) with AI analysis function. Further, we will develop an API and standardize the data to facilitate the use of biology-related DB constructed by this SIP project in the Integrated DBs. Moreover, by establishing a security

foundation, such as block chain technologies and a framework to provide data, we will promote the businesses in the biology field to share their uncompetitive data and thereby accelerate the innovation.

To open up a new field that Japan can take advantage of, we will develop an infrastructural environment for easily obtaining data effectively from the Integrated DBs and perform the AI analysis as well as introduce an open–closed system for the Integrated DBs. This will stratify the data to be opened to the general public and to the user forum. We will accelerate efforts to integrate such biology-related DB and promote initiatives toward the development and establishment of a bio-digital collaboration base through the promotion of such DB use.

By leveraging the strengths of the respective technologies and know-how provided by businesses in the private sector, research institutes and universities, we will develop miniaturized technology for fast separation, cultivation, and screening of microorganisms. By establishing a cultivation method using the microchannel and microsubstrate, the process, which previously required 1,000 agar culture plates, can be conducted using an extremely compact device. Using such technologies, we will construct a platform that allows the mass cultivation and screening of high-functional microbes, gastrointestinal microorganisms, and plant growth-promoting microorganisms. This will render it possible to discover new functional microorganisms and create a large collection of biological resources. Among the obtained microorganisms resources and microorganisms, the genetic information and functional information of those with potential usefulness will be converted into data and stored in the Integrated DBs (that would be built simultaneously) to promote their usage.

[Participating Organizations]

Research Director: Yuji Kohara (Research Organization of Information and Systems)
Research Organization of Information and Systems, National Agriculture and Food Research Organization, Hitachi Ltd., National Institutes of Biomedical Innovation, Health and Nutrition, National Institute of Technology and Evaluation, Research Organization of Information and Systems, National Institute of Genetics, RIKEN, Kazusa DNA Research Institute, Nagaoka University of Technology, The University of Tokyo, University of Yamanashi, Niigata University of Pharmacy and Applied Life Sciences, National Institute of Technology, Tsuruoka College, Research Organization for Nano & Life Innovation, Waseda University, National Institute of Advanced Industrial Science and Technology, Kyushu University, On-chip Biotechnologies Co., Ltd., Nikon Instech Co., Ltd., National Institute of Technology, and Nagaoka College.

[Goals of the Current Year]

- Commence building of a Resource Description Framework (RDF) for the data from collaborating research institutes and develop an API for searching for the data from multiple DBs.
- Implement the data acquisition method to develop an AI-based integrated analysis application and apply it to the initial data that are generated in the other programs.
- Update the data management plan based on the data sharing policy defined in the first year and create it with the updated policy known to the participating members of the programs.
- Commence the development of an open–closed system prototype and store initial data generated in other programs as samples.
- Investigate and design elementary techniques necessary for the security foundation, following which commence the development of the prototype.
- Continue to hold meetings to understand the industrial needs for the use of biology-related data and establish the strategies and methods to promote collaborative research between the businesses in the private sector and between the businesses and national research institutes. This should support acquisition of the data from the businesses and metadata.
- Identify >1 new surfactant that can be used to produce water-in-oil droplet (WODL); construct a technology to cultivate microorganisms in WODL for two months; identify the optimal cultivation conditions for the uncultured microorganisms; and construct a technology to collect droplets of propagated microorganisms at a high speed and high accuracy. For the assay systems that screen microorganisms with useful enzyme, we will construct a high throughput platform using the WODL

technique and investigate the possibilities of developing a micro device suitable for the observation of the microorganisms propagated in WODL and the technology that can be used for the production and storage of WODL replicas. Considering the need of providing the data to the Integrated DBs in the future, construct a platform (DNA collection, nucleic acid amplification, etc.) for the genome analysis of the microorganisms propagated in WODL.

[Intermediate Goals]

- Continue working on making RDF for the data from the collaborating research institutes and open the API for searching data in multiple DBs.
- Using the open–closed system prototype as a base, commence the development of the linked/integrated use system with an AI analysis function for the biology DB (Integrated DBs).
- Commence the test operation of the open–closed system prototype, and from the obtained feedback, determine the points that require improvement.
- Continue to work on standardizing the biology data collected from other projects and commence storing them in the open–closed system.
- Continue to work on developing the security foundation prototype and perform test operation of the system using the data collected from other projects as samples; further, request the industries working for each project to use the system and obtain feedback.
- Continue to hold meetings to understand the industrial needs for the use of biology-related data and the uncompetitive research data from the businesses in the biology field and continue to update and reflect the findings to each system.
- Establish an effective technology for bioresource searching in Japan that aims at collecting the bioresource in Japan and obtaining their biological information data and accelerate the validation of mass cultivation/screening using the ultra-fast separation/cultivation platform for the microorganisms, which would be developed by the second year of the project. This involves the steps of establishing the technology for cultivating gastrointestinal microbiome in WODL and constructing the assay systems for screening microorganisms that survive symbiotically with plants; performing the screening in combination with actinomycete isolation technology for terrestrial plant rhizosphere and WODL cultivation; using the allocated budget in most efficient way; performing 16S/18S amplicon sequencing analysis for the obtained microorganisms; and obtaining the data to be included in the Integrated DBs. For the development of cultivation/screening platform for the microorganisms in WODL, we will construct a single-drop isolation system for the propagated microorganism droplet.

[Final Goals]

- Officially open the developed Integrated DBs and continue to collect feedback for system improvement.
- Continue to work on standardizing the biological data obtained from other projects and store them in the open–closed system.
- Commence the actual operation of the security system (including the uncompetitive data) in combination with the open–closed system and continue to collect the uncompetitive data that can be shared in the system.
- Integrate the DBs that are already available in Japan to ensure that they can be actively used by the society and the industries; construct the bio-digital distribution base; and investigate a structure that enables the system to be automatically and continuously operated.
- Complete the versatile technology platform that is easy-to-use for managing the bioresource that meets the needs of businesses; using the platform, manage bioresource and biological genetic resources and launch the developed platform to practical use; and strengthen the promotion of the public use of biological data and bioresource. This involves the following steps: completing the ultra-fast separation–cultivation–screening technology for the cultivation of microorganisms in WODL, which is the

integration of developed elemental technologies; and collaborating with the businesses in the private sector to build a structure that uses the developed technologies. For example, a successful development of the reagent kit that can be used with commercially available instruments. Among the elemental technologies, we will aim to quickly launch the potential products to practical use following the completion of the project. The potential products include the microdevice suitable for the observation, replication, and storing of the WODL and reagent kit for detecting the propagated microorganism droplet using fluorescent probes. By appropriately working in collaboration with other teams, we will continue to collect more gastrointestinal microbiomes and microorganisms that live symbiotically with plants; collect their metagenomics data and continue storing them to the Integrated DBs; and taking the advantages of having access to their genomic information as well as the microorganisms themselves, involving further effort to collect actual data by culturing them. From these, we will aim to contribute to enhance the international competitiveness of Japanese bioresource.

(4) [Sales and Consumption] Responding to the Various Needs

[Overview]

In Japan, the cases of lifestyle-related diseases, dementia, and cancers are increasing with the super-aging society and the changes in people's lifestyle. The increasing national medical expenses are becoming a social issue. To counter this issue and contribute to the expansion of the demand for agricultural, forestry, and fishery products, we will establish a new healthcare system that increases the healthy life expectancy with focus on "food", which is an indispensable factor for human health. The actual plan includes the development and construction of a system that assesses the health maintenance and health enhancement effects of the agricultural, forestry, and fishery products. These products contain various components and have milder influence on human health than the pharmaceutical medications. Simultaneously, we will collect and manage the microbiome data of Japanese individuals, evaluate the functionalities of the foods that are considered to help in the conditioning of the gastrointestinal microbiome environment, with focus on "food" and scientific evidences, and promote and support the industries that contribute to the enhancement of the national health. Moreover, we will construct a "through food" self-medication system that is able to suggest and provide diet and food based on the individual's health condition and lifestyle.

The objectives of this project are to comprehensively develop the "system for determining mild physical condition changes", perform research investigations of the effects of agricultural, forestry, and fishery products and food products on human health, and construct the health-related DB. The success of the project requires the collaboration among ministries, research institutes, and universities specialized in industrial, agricultural, medical, and biological fields and the businesses in the private sector.

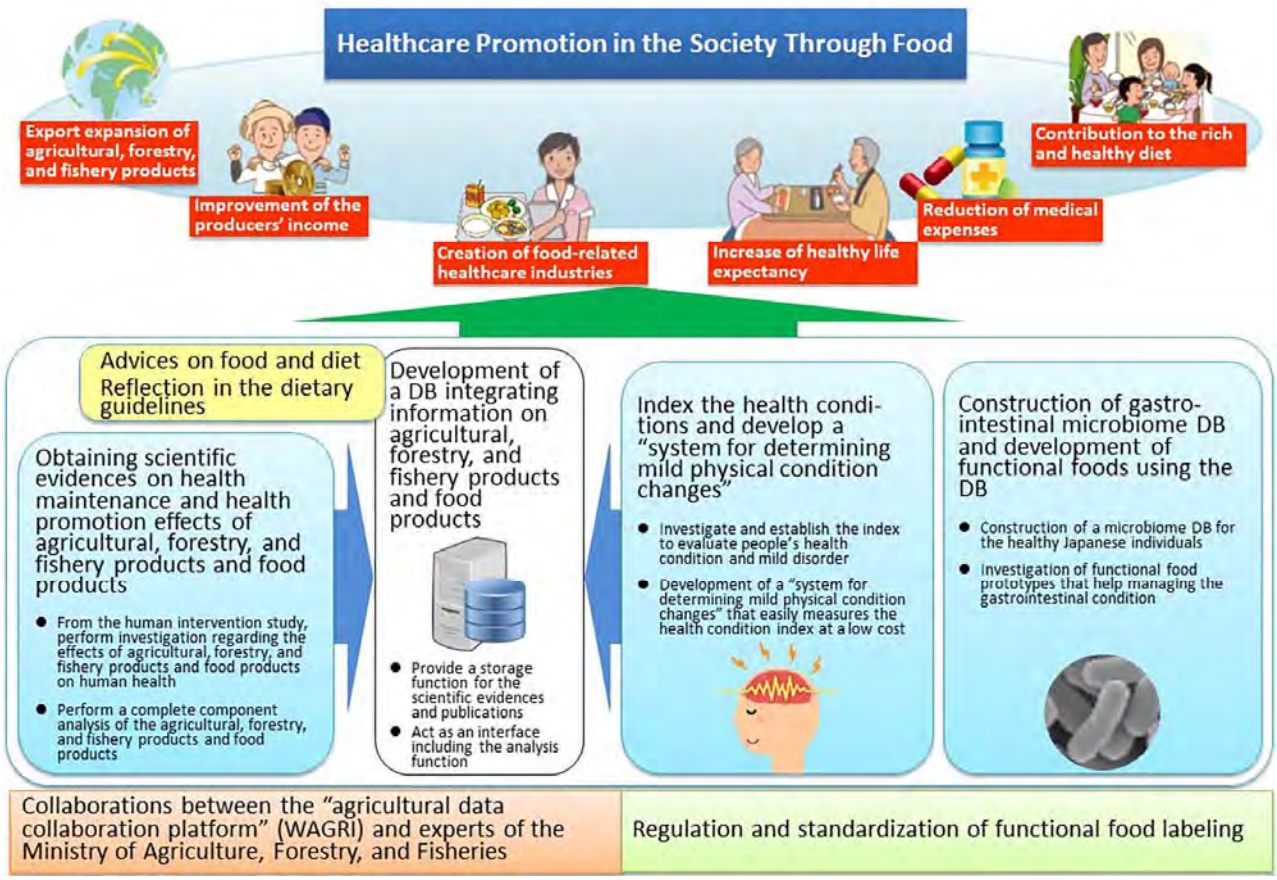


Figure 2-5 : An image of responding to various needs

[Necessary Expenses]

Fiscal year 2018	445 million yen
Fiscal year 2019	341 million yen

[R&D Details]

We will undertake the following:

Index health conditions and mild physical condition change and develop a “system for determining mild physical condition changes”; obtain scientific evidences on the health maintenance and health promotion effects of agricultural, forestry, and fishery products and food products; and organize gastrointestinal microbiome data. We will develop an “integrated health information database for agriculture, forestry, and fishery products and food products” to analyze the health maintenance and health promotion effects of the agriculture, forestry, and fishery products and food products using scientific evidences and obtained data. The actual research plans include the following:

① Indexing health conditions and developing a “system for determining mild physical condition changes”

Investigate and establish an indexing method that evaluates health conditions and mild health condition changes. Develop a “system for determining mild physical condition changes” that easily measures the health condition daily at a low cost.

② Obtaining the scientific evidences of health maintenance and health promotion effects of the agricultural, forestry, and fishery products and food products

From the human intervention study of the “system for determining mild physical condition changes,” scientifically prove mild advantageous health influences of the agricultural, forestry, and fishery products and food products. Through a comprehensive analysis, clarify the effective components in the agriculture, forestry, and fishery products and food products.

③ Management of gastrointestinal microbiome data and verification of the functional food prototypes

Collect and organize gastrointestinal microbiome information on general Japanese individuals including the metagenome and metabolomic information required by the business in the industry. Develop a sampling and data analysis protocol related to foods and perform the verification test for the appropriateness of data using the functional food prototypes.

[Participating Organizations]

Research Director: Mari Yamamoto (Maeda) (National Agriculture and Food Research Organization)

National Agriculture and Food Research Organization, Hokkaido Information University, Kyoto University Graduate School of Medicine, Kyoto University Graduate School of Agricultural Science, University of Miyazaki, University of Nagasaki, Sapporo Medical University, Kyushu University, National Institutes of Biomedical Innovation, Health and Nutrition, RIKEN, Research Organization of Information and Systems, National Institute of Genetics, Nagasaki Agricultural & Forestry Technical Development Center, Japan Microbiome Consortium, PGV Inc., Link & Communication Inc., Japan Food Research Laboratories, Asahi Quality and Innovations Co., Ajinomoto Co., Inc., Ezaki Glico Company, Limited, Kagome Co., Ltd., Kikkoman Corporation, Kirin Holdings Company, Limited, Gekkeikan Sake Co., Ltd., Sapporo Holdings Limited, Suntory Holdings Limited, Shimadzu Corporation, Taisho Pharmaceutical Co., Ltd., Chitose Laboratory Corp., Nisshin Seifun Group Inc., Mitsubishi Chemical Corporation, Mitsubishi Corporation, Meiji Co., Ltd., and Lawson, Inc.

[Goals of the Current Year]

The goals are as follows: evaluation of the prototypes; performing pilot operation of the DB; and commencement of the pilot study to evaluate the functionality and investigate the production of prototypes (measurement method, DB) for the development of actual products (evaluation method).

To achieve the goals, we will undertake the following:

- Perform autonomic nerve measurement and sleep EEG measurement based on the measurement method decided in the previous year, analyze the stress load condition and sleeping stage, and perform correlation analysis with the subjective evaluation to make a model of the pattern of the mild health condition changes.

- Perform a human intervention study and obtain measured data to investigate the relationships between food and health; obtain the measured data; and conduct pilot studies for the intervention test of >5 agricultural, forestry, and fishery products and food products.
- Analyze gastrointestinal microbiome data of Japanese individuals and collect their metabolomic data.

[Intermediate Goals]

To achieve the goals, we will undertake the following:

- Prepare devices to measure quality of sleep and changes in autonomic nerve functions that are the indices of mild health condition change evaluation; obtain data through the human intervention study to investigate the relationships between foods and health; and from the obtained measurements, analyze the change mode between health and mild health change to define the evaluation index.
- Continue the human intervention study and analyze relationships between the diet, daily lifestyle, vital signs, and blood components to clarify the diet that contributes to the health maintenance and health promotion. Further, conduct pilot studies for the intervention test of >5 agricultural, forestry, and fishery products and food products to establish a protocol for the main examination.
- Analyze gastrointestinal microbiome data of Japanese individuals and collect their metabolomic data to clarify the microbiome profile of these individuals.

[Final Goals]

To achieve the goals, we will undertake the following:

- Develop a “system for determining mild physical condition changes” and introduce the system in collaboration with convenient stores and supermarkets in the model area to verify the health maintenance and health promotion effects of foods.
- Conduct the intervention test of >5 agriculture, forestry, and fishery products and food products to evaluate their health maintenance and health promotion effects on the improvement of mild disorders.
- Using the standard DBs prepared up to the previous year, analyze the above new foods and food components from the intervention test samples; evaluate and scientifically prove the effectiveness of foods and their components for the improvement of intestinal flora; and perform the intervention test for >2 foods and their components for evaluating their advantageous effects on gastrointestinal microbiome.
- To prepare for the social implementation, following strategies are planned: construction of a food–microbiome–health integrated information DB, development of high value-added functional foods that exert advantageous effects on mild disorders, sale of the personalized readymade healthcare meals, providing health management services based on the mild health change index, and providing new simple devices for determining mild health changes.

（５） [Resource Circulation] Development of Bioresource Utilizing Technology and Biomaterials

[Overview]

To reduce the dependencies on the petroleum resources and to build a sustainable society, we will develop new biomaterials and high value-added products based on the biological function design and develop technologies that eliminate the bottleneck issues in the supply chains of biomaterials.

This project will create new multisectorial biology-related industries across the existing boundaries among the industries, accordingly the project would involve efforts for collaboration among ministries, research institutes, and universities specialized in agricultural, medical, and biological fields and businesses in the private sector.

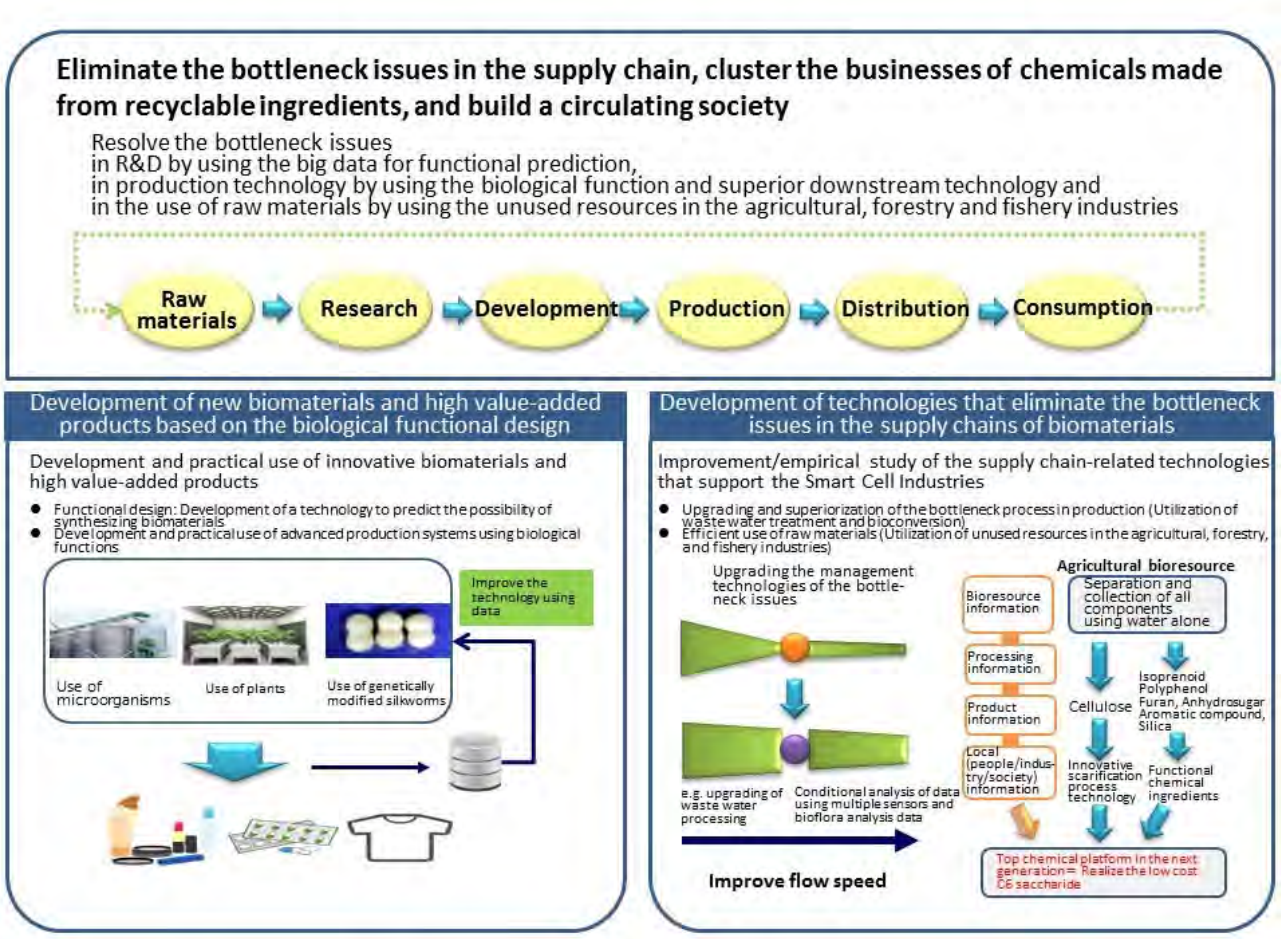


Figure 2-6: An image of building a sustainable growing society using “biological functions”

[Necessary Expenses]

Fiscal year 2018	761 million yen
Fiscal year 2019	584 million yen

( )- Development of new biomaterials and high value-added products based on the biological functional design

[R&D Details]

Development of new biomaterials and high value-added products based on the biological functional design

① Functional Design and Production Technologies for the Development of Innovative Biomaterials and High Value-added Products

The originally planned construction of the basic informatics technology for biomaterials using big data will not be established further. Through the computational scientific molecular design using the data from simulation (cyber) and from actual measurements (physical), develop a method that accelerates the functional designing and production of innovative biomaterials and high value-added products. We will select the applicable targets, such as aromatic high value-added materials derived from microorganisms and biodegradable materials that contribute to the circulation of resources, for implementing them in the society at the earliest.

② Development and Practical Use of Innovative Biomaterials and High Value-Added Products Using Biological Functions

Considering the advantages of the technologies at our disposal, we will develop the technologies to produce innovative biomaterials and high value-added products using the microorganisms, animal cells, plants, and insects that are designed to have high functionalities. Using the data collected during the development, we will upgrade the production system to be further competitive.

As part of the development of high-functional and high value-added products, we will focus on biopolybenzimidazole (PBI), an aromatic amine polymer, to improve the efficiency of the production of aromatic compounds derived from microorganisms, apply PBI with an introduced amide group to ultra-high heat-resistant coating materials, and apply PBI with lithium ion conductivity to the secondary battery electrolyte. Further, we will produce polyphenol derived from microorganisms and perform the verification test to use the product for high-functional materials. Moreover, we will develop new high-functional materials to expand the use of bio-aromatics.

The other project aims to use silkworm as a bioreactor to establish practical production technologies for proteins and high-functional materials that can be used in medical, diagnostic, and electronic fields. Through the collaboration among ministries and the industry–academia–government collaboration, it will advance the commercialization of the developed products and implementation of them in the society. It will create the precedent cases and establish the quality/production management technologies considering various regulations and standardization.

[R&D Details of Participating Organizations]

① Functional Design and Production Technologies for the Development of Innovative Biomaterials and High Value-Added Products

Research Director: Takahito Nakajima (RIKEN)

RIKEN, Institute of Advanced Industrial Science and Technology, Research Institute of Innovative Technology for the Earth, Nagoya University, Kyushu University, Kyoto University, Tohoku University, National Institute for Materials Science, and SyntheticGestalt Inc.

② Production of High Value-Added Materials Using Aromatic Biomass derived from Microorganism

Research Director: Yasuo Ohnishi (The University of Tokyo)

The University of Tokyo Graduate School, Tsukuba University, and Japan Advanced Institute of Science and Technology.

③ Development and Implementation of the Production Technology for Obtaining Useful Proteins and New High-Functional Materials derived from Insects (e.g., Silkworm)

Research Director: Hideki Sezutsu (National Agriculture and Food Research Organization)

National Agriculture and Food Research Organization, Immuno-Biological Laboratories Co., Ltd., Kumamoto University, Kyorin Co., Ltd., Nippon Bio-Test Laboratories Inc., AI Silk Corporation, Kyushu University, KAICO Ltd., University of the Ryukyus, Kagoshima University, Nippon Zenyaku Kogyo Co., Ltd., Atsumaru Holdings Co., Ltd., Nippon Institute for Biological Science, and Tokyo City University

[Goals of the Current Year]

① Functional Design and Production Technologies for the Development of Innovative Biomaterials and High Value-Added Products

To achieve these goals, we will undertake the following:

- In addition to the thermal properties (melting point and glass transition point) investigated in the previous year, select tensile elasticity for the mechanical property and hydrolyzability of the high temperature compost for the biodegradability property as other characteristic indices, and from those four interacting indices, aim to specify the basic characteristic of the polymer.
- Achieve a highly precise technique for extracting the structural feature quantity and using the obtained index, validate the effectiveness of elemental technologies, such as the proposal of a monomer list with highly feasible enzyme reaction.

② Production of High Value-Added Materials Using Aromatic Biomass derived from Microorganism

- Prior to working with the team responsible for the goal of ① Functional Design and Production Technologies for the Development for the Innovative Biomaterials and High Value-Added Products, develop prototype materials. Moreover, for the metabolism and enzyme design, work together with the team responsible for the goal ①.
- Construct a base to produce PBI-related candidate compounds using a new route and optimize the production system for 3-amino-4-hydroxybenzoic acid (AHBA). In addition, produce pyrazine compounds derived from microorganisms, purify them to a high purity level, and provide them to the chemical group.
- Under the most optimal compositional conditions of the PBI ion gel electrolyte found in the previous year, produce test batteries to demonstrate the battery performance; establish a technique to control the PBI/polyamide (PA) membrane structure and determine the PBI/PA membrane composition that provides the most suitable mechanical properties; and create microorganisms that provide the potential production source of the polyphenol materials (PPM) to reveal the basic physical properties of the target chemicals for their functionalities.

③ Development and Implementation of the Production Technology for Obtaining Useful Proteins and New High-Functional Materials derived from Insects (e.g., Silkworm)

- Produce test proteins using a low-environmental burden silkworm production system; prepare a trial AGEs assay kit using receptors; collect data for the preparation of GMP-compatible antibody drug intermediates to evaluate their activation efficiency; and perform clinical trials for the diagnostic drug for dogs using antibodies and evaluate bovine leukemia vaccine and its diagnostic drugs.
- Produce silk, a non-petroleum fiber, fused with an antibody against fish-disease causative bacteria for testing and produce test clothes from conductive silk with an installed ECG measurement device to complete the production of prototypes.
- Perform an inventory analysis for environmental burden during the production of silkworm products using the basic data to be used for evaluating a reduction in environmental burdens, such as carbon dioxide emission and DB for the life cycle assessment (LCA); and collect the transcriptome data for the upgrading of data-driven production system and construct the prototype for the gene network using AI.

[Intermediate Goals]

① Functional Design and Production Technologies for the Development of Innovative Biomaterials and High Value-Added Products

To achieve these goals, we will undertake the following:

- For all the targeted seven characteristics (thermal, mechanical, and biodegradability properties), develop a calculation method that can predict the characteristics of the polymer from their structures; construct a prototype tool that estimates and predicts the physical properties of polymers with a new structure that can be produced from bio-monomers; in particular, regarding the biodegradability of the product, complete a hydrolyzability prediction tool for high-temperature composts; and develop the methods to estimate the degradability in the soil and sea.

- Using this computational scientific molecular design technology, propose new candidate high-functional polymers in the targeted three areas (high heat-resistant and highly rigid polymer, rubber and elastomer, and biodegradable polymer).
- Advance the clarification of the decomposition mechanisms in the sea and develop a prototype of a rapid evaluation method that predicts polymers' degradability in the sea.
- Propose >2 potential monomers that can be used to produce biopolymers; and demonstrate the effectiveness of the basic evaluation technologies to search/modify/evaluate the high-functional enzymes that are required as the core enzyme reactant for synthesizing the biopolymer.
- Perform genome analysis for the strains of potential bio-monomer synthesis material; design bio-monomer production microorganisms using the metabolic pathway design required for the effective production of the bio-monomers; and design the data-driven enzyme high functionality technology.

② Production of High Value-Added Materials Using Aromatic Biomass derived from Microorganism

- Establish the method to effectively produce PBI-related monomers or their precursors from microorganisms to the level that their functionalities are evaluable; establish a method to purify the candidate chemical compounds from the fermentation liquid; clarify the electronical chemistry of the PBI ion gel electrolyte in the batteries; synthesize an ion gel containing PBI-derived lithium sulfonate; and produce a PBI/PA membrane with the most optimal electronic properties and produce a PBI/PA membrane that maintains the electricity under the high temperature condition.
- With regard to the PPM-related materials, continue investigating the PPM producing genes and improve the productivity of the relevant microorganism up to five times the existing method; establish the methods to effectively produce protocatechuic acid (PCA) from microorganisms and collect PCA from the fermentation liquid; clarify the basic physical properties of the target PPM chemical compounds including the purity and thermodynamic properties; improve the efficiency of microorganism production system for caffeic acid; and establish a synthetic method to produce lithium borate-based solid polyelectrolyte compounds from caffeic acid.
- Modify and improve the PBI and PPM chemical compound production system using the functional design and production technologies developed in ① and provide the collected digital data on enzymes, metabolisms, polymerization of monomers, physics of the polymer, and electronical chemical properties to the biomaterial information DB in the "Base Construction of the Value Chain Data".

③ Development and Implementation of the Production Technology for Obtaining Useful Proteins and New High-Functional Materials derived from Insects (e.g., Silkworm)

- Using the proteins produced in the silkworm production system, produce a candidate AGEs assay kit, conduct a nonclinical study for the antibody drug intermediates, and perform the antibody evaluation test of the bovine leukemia vaccine and its diagnostic drugs on small animals.
- Produce and evaluate test products using antibody-fused silk, a simple diagnostic kit for carp ulcer disease, and a preventative filter device; produce test clothes from conductive silk with an installed ECG measurement device and complete the prototype of the silk clothes with an ECG measurement function.
- Select an evaluation method to determine the potential impact of carbon dioxide emission, create a DB and a catalog of gene expressions for upgrading the data-driven production system, and apply them to the gene network model.

[Final Goals]

To achieve these goals, we will undertake the following:

- Through the computational scientific and molecular design using the data from simulation (cyber) and from actual measurements (physical) as well as using the efficient production technologies of the data-driven enzyme construction technology (DRY) and enzyme modification technology (WET),

establish a technology for the development of high value-added products and functional materials that surpasses the biodegrabilities of petroleum-derived products and reduce the time and cost of the development to less than one-fourth of the existing methods.

- Develop and commercialize the production systems for high value-added products and biomaterials with lower costs that can reduce the environmental burden such as reducing the carbon dioxide emission by >30% than current emission using biological functions.
- Using those developed technologies, develop >5 innovative biomaterials and functional products and aim for the actual production.

① Functional Design and Production Technologies for the Development of Innovative Biomaterials and High Value-Added Products

- Propose >1 candidate high-functional biopolymer in each of the targeted three areas (high heat-resistant and highly rigid polymer, rubber and elastomer, and biodegradable polymer).
- Propose candidate polymers that are composed of bio-monomers having the desired polymer characteristics and construct a tool to indicate the synthetic metabolic pathway of the monomer. In addition, evaluate the effectiveness of the prototype tool in collaboration with the businesses in the private sector.
- As a key performance indicator (KPI), propose >6 kinds of new polymers in the three target areas and evaluate their possibilities.
- Develop a rapid method to evaluate the degradability in the sea and clarify the correlations between the new method and the existing methods.
- Create >2 high monomer-productive strains that are superior to others.
- Propose >2 monomers to produce targeted high-functional polymers; identify the prototype enzyme required for the biosynthesis of the polymer; modify the enzyme genes to improve its functionalities and introduce the gene into the microorganisms; and evaluate the bio-monomer productivity to improve its efficiency.
- Use a compact electronic chemical reactor to demonstrate the bio-monomer productivity and verify that the modified electrosynthetic microorganism can be used to synthesize bio-monomers.

② Production of High Value-Added Materials Using Aromatic Biomass derived from Microorganism

- Microorganism-derived PBI and PPM materials in a pilot scale; further produce (i) a test lithium ion conductor as a solid electrolyte and (ii) a wire covering; and evaluate data on the high heat insulation test material and obtain standard data. Specifically, produce new aromatic monomers from the microorganisms, obtain candidate chemical compounds that have suitable purity and properties for the materialization process, and polymerize the biomass-derived aromatic monomers. In addition, clarify the interface and deterioration behaviors in batteries; produce a battery cell that has sufficient discharge capacity after 500 charge/discharge cycles; produce a high heat insulation material that can sufficiently withstand voltage at 300°C; and obtain PCA/PPM with the suitable purity and properties for the materialization to produce sample bio-PPM products.
- For the PBI-related tasks, develop a production technology for the lithium ion conductor as a solid electrolyte and wire covering, which are “functionally designed innovative high-functional biological products”; build a solid foundation for their practical applications; and regarding PPM-related tasks, introduce one type of polyphenol (chemical compound X) to practical use and clarify that the chemical compounds, such as caffeic acid, can be used as a “functionally designed innovative high-functional biomaterial.”
- New aromatic materials and physical properties evaluations of the new high-functional materials prepared from the produced materials, expand the use of targeted bio-aromatics. The task ① provides the results of production system and data regarding the improvement of the material function together with tasks

achieved in the present study. Because this research plan includes the effectiveness evaluation of the functional design and production technologies developed in ①, it is one of the most important plans in the SIP. Moreover, it contributes to the construction of biomaterial information DB and fusion of biomaterial and digital researches.

③ Development and Implementation of the Production Technology for Obtaining Useful Proteins and New High-Functional Materials derived from Insects (e.g., Silkworm)

- Produce and evaluate the AGEs assay kit for the clinical diagnosis using the proteins produced from the silkworm production system; produce antibodies of antibody drug intermediates and conduct a clinical study (P1). In addition, produce canine babesiosis diagnostic drugs and commercialize the product.
- Evaluate the test products for a simple diagnostic kit for various fish diseases and improve the product for actual commercialization; further, complete the production and launch the conductive silk wearable sensing device that records various vital data such as ECG, EMG, and EEG.
- Analyze the contribution to the environmental impact reduction; demonstrate that the established technologies reduce the environmental burden, such as greenhouse gas emission, by >30% than that reported previously. For upgrading the production system using the DBs and data-driven system, introduce the DB to public and evaluate the production improvement achieved by the gene network modifications.

( )- Development of technologies to eliminate bottleneck issues in the supply chains of biomaterials

[R&D Details]

We will develop technologies to eliminate bottleneck issues in the supply chains of biomaterials and functional products.

① Advancement and Empirical Studies of the Supply Chain-Related Technologies that Support the Smart Cell Industries

For the realization of carbon recycling society, it is important to replace the fossil fuels, on which the industries and their several products were dependent, with the recyclable ingredients. Accordingly, it is important to eliminate the bottleneck issues in the supply chain that comprises a range of processes from raw material procurement, production, and product extraction to distribution.

The wastewater treatment is a big issue in the actual production of biomaterials. Therefore, the project intends to upgrade the operations for the membrane separation technology using various sensors. The process is expected to improve the efficiency of wastewater treatment as well as the quality of the treated water. Further, the project plans the creation of a DB that stores the analytical and observational results of the bioflora in the activated sludge, thereby aiding in the development of a rational operation method to achieve a reduction of the operation cost. Further, it will produce a local bioeconomy simulation tool to promote the implementation of the smart cell industry.

② Development of the Next-Generation Core Technology for the Chemical Industry Using the Unused Resources in the Agricultural, Forestry, and Fishery Industries

The bottleneck issue in the creation of new businesses in the chemical industry that uses unused resources of agricultural, forestry, and fishery industries as raw materials is the lack of an established system technology to stably supply the key chemical compounds at a low cost. To eliminate this issue, first, we will separate and collect the structural components in the agricultural, forestry, and fishery industries at high yield as multiple useful components with additional values and as high-quality biomaterials (e.g., isoprenoids, polyphenols, C5 monosaccharide, C6 monosaccharide, functional cellulose, oligosaccharide, furans, and aromatic compounds). Thereafter, for some components, we will convert them to functional chemical compounds, and from them, we will develop an integrated supply value chain to stably supply the key chemical compounds at a low cost and help implementing the process in the target areas and construct a business model aiming to implement it to

multiple areas. Moreover, to eliminate the bottleneck issue in the supply chain and the organic residues, we will develop technologies to facilitate their use as raw materials in the next-generation businesses in the chemical industry.

[Participating Organizations]

① Advancement and Empirical Studies of the Supply Chain-Related Technologies that Support the Smart Cell Industries

Research Director: Tomohiro Tamura (National Institute of Advanced Industrial Science and Technology)

National Institute of Advanced Industrial Science and Technology, RIKEN, Saga University, Saga City, Mitsubishi Chemical Corporation, Ajinomoto Co., Inc., and Chitose Laboratory Corp.

② Development of the Next-Generation Core Technology for the Chemical Industry Using the Unused Resources in the Agricultural, Forestry, and Fishery Industries

Research Director: Junichiro Hayashi (Kyushu University)

Kyushu University, Kyoto University, Tohoku University, Nagaoka University of Technology, Kagoshima University, Akita Prefectural University, National Agriculture and Food Research Organization, National Institute of Advanced Industrial Science and Technology, Akita Research Institute for Food and Brewing, Mizuho Information & Research Institute, Inc., Japan Bioindustry Association, DKS Co. Ltd., Kao Corporation, Toray Industries, Inc., Shinko Sugar Co., Ltd., Fuji Oil Holdings Inc., and Akita Prefectural Livestock Experiment Station.

[Goals of the Current Year]

To achieve these goals, we will undertake the following:

① Advancement and Empirical Studies of the Supply Chain-Related Technologies that Support the Smart Cell Industries

- Perform 16S rRNA gene flora analysis, shotgun metagenomics sequencing, and metabolomic analysis for approximately 50–70 samples of the industrial wastewater and sludge generated from the bioprocess and model reactors and collect the analysis data.
- Prepare a bioeconomy simulation tool for the specific industrial network (use of fiber biomass) in the test study area. Create a model for materials and energy circulation and study its environmental influences in the test area.
- Using the data collected in the previous year, evaluate the economic aspects and environmental effects for the bioprocess. In addition to the current wastewater treatment process, collect data on >1 bioprocesses and use them for process simulation.
- Work on the development of an advanced membrane occlusion prevention technology, perform experiments on various wastewater components (e.g., proteins and polysaccharides) and membranes with different physical properties (such as crystal and amorphous) to clarify the factors that affect the membrane occlusion of the separation reactor. Moreover, obtain time-course data for the potential variations of the model membrane separation reactors.
- Prepare >4 separation membranes to evaluate the membrane separation performance for the two-component solvent, containing water and organic matter, among the solvents with potential usage in the biological system and continue data collection.
- For over three types of biomass, understand the effects of pressure, temperature, and entrainer for the supercritical carbon dioxide extraction of the targeted chemical compounds and determine the most optimal condition.
- Define pretreatment system and dilution factors for the treatment of industrial wastewater generated from the bioprocess suitable as a microalgae cultivation solution. With microalgae cultivation performed using the industrial wastewater, achieve 50% reduction in the nutrient removal rate.

② Development of the Next-Generation Core Technology for the Chemical Industry Using the Unused Resources in the Agricultural, Forestry, and Fishery Industries

- Provide the proof of concept (POC) at the laboratory levels for all key technologies, processes, and system technologies that would be developed in this project, following which finalize the basic specifications of the processes and system. Initiate the scale-up study of the multistage water extraction process (warm /hot water percolation) in 2019 (1 year earlier than the original plan) and provide the products, such as agripulp, silica (including silica acid solution), lignin/silica composite, xylooligosaccharide, and C5 monosaccharide, to the existing and future collaborating institutes engaged in other researches.

[Intermediate Goals]

To achieve these goals, we will undertake the following:

① Advancement and Empirical Studies of the Supply Chain-Related Technologies that Support the Smart Cell Industries

- Perform 16S rRNA gene analysis, shotgun metagenomics sequencing, and metabolomic analysis for the industrial wastewater and sludge generated from the bioprocess and model reactors and collect the analysis data.
- Use machine learning to identify >2 candidate indices for the prediction diagnostics related to the treatment of industrial wastewater generated from the bioprocess.
- Construct a cross-industrial network scenario for the model area. Improve a bioeconomy simulation tool to match the scenario, and input various data regarding the model area to evaluate the results related to economic aspects and environmental effects.
- Evaluate the economic aspects and environmental effects of the bioprocess and clarify its effectiveness. Validate these aspects and effects of the developed technologies (wastewater treatment and new base technologies) and clarify their effectiveness. Provide the resulting data for the development of a bioeconomy simulation tool.
- Work on the development of an advanced membrane occlusion prevention technology, perform experiments on various wastewater components (such as proteins and polysaccharides) and membranes with different physical properties (such as crystal and amorphous) to clarify the factors that affect the membrane occlusion of the separation reactor. Construct a potential control system for the development of the advanced membrane occlusion prevention technology for the membrane separation reactor.
- Improve the membrane functions of >2 separation membranes to evaluate the membrane separation functions of >4 separation membranes using the test fermentation liquid containing three components and continue data collection.
- For >10 types of biomass, systematically extract usable chemical compounds using the supercritical carbon dioxide extraction.
- Culture microalgae on a 100-L scale using industrial wastewater generated from the bioprocess. Achieve >80% reduction in the nutrient removal rate.

② Development of the Next-Generation Core Technology for the Chemical Industry Using the Unused Resources in the Agricultural, Forestry, and Fishery Industries

- Regarding the agribiomaterial supply and their conversion and functionalization to chemicals, propose a technology package for collection, storage, and quality optimization. Prove the efficacy of the technologies for chemical product and intermediate raw material production through bench-scale experiments or whole process examination. Particularly, for the “stable supply of C6 saccharide at a strategic price”, which is a goal of this project, clarify its technical and economical rationality. On the

other hand, for the development of supply value chain, establish technologies to evaluate an agribiochemistry system and optimize the supply value chain to enable the availability of the user.

[Final Goals]

To achieve these goals, we will undertake the following:

- Establish a high efficiency biochemical wastewater treatment technology that allows the use of treated wastewater.
- Develop technologies to use organic residues as raw materials in the new next-generation businesses in the chemical industry.

① Advancement and Empirical Studies of the Supply Chain-Related Technologies that Support the Smart Cell Industries

- Identify candidate prediction diagnosis indices for the bioprocess-generated industrial wastewater treatment facility and for a model membrane separation reactor that would be employed in the companies of the industry and specify the prediction diagnosis indices for the actual wastewater treatment facility and the model membrane separation reactor. With the aim to increase the amount of treated wastewater by approximately 10%–20% and improve the treatment speed by approximately 10%–20%, the prediction diagnosis indices will be used to control the operation.
- Based on the studies of the bioeconomy trend both within and outside Japan, develop a bioeconomy simulation tool that can cater to Saga city and other locations in Japan and be employed for other Asian countries as well. Discuss and evaluate the scenarios adapted for the target locations' characteristics and determine their contribution to the bioeconomy as well as their environmental effects.
- Improve the occlusion percentage of the membrane separation reactor by approximately 30% by the perturbation of the key factors noted in the previous year. In addition, agitate the electrochemical oxygen concentration level to improve its occlusion percentage in the membrane separation reactor by approximately 30% using the electrocatalyst material that is evaluated and improved until the previous year.
- For >5 separation membranes, evaluate the membrane separation efficiency for the fermentation liquid that simulates the actual fermentation liquid and contains >4 components and continue data collection.
- The optimal conditions for the extraction of the supercritical carbon dioxide, a usable chemical compound, using the actual algae biomass cultured using the bioprocess wastewater.
- Design a minimal treatment system for a mass cultivation considering the actual volume of treated bioprocess industrial wastewater.
- Start Initiate the joint research on the use of algae biomass cultivated using the bioprocess industrial wastewater with the businesses in the industry.

② Development of the Next-Generation Core Technology for the Chemical Industry Using the Unused Resources in the Agricultural, Forestry, and Fishery Industries

- Demonstratethe technology that supplies agribiomaterial at 20 yen/dry-kg and the technology that produces >10 kinds of chemicals (excluding C6 saccharide) from the agribiomaterial. Verify the technology that stably supplies the C6 saccharide at 30 yen/kg with the additional values of the chemical products. Finalize the specifications of the process and system on the implementation scale. After the technical assessment, user test, and process design, improve the proposed system to the level implementable in Yokote area, Akita, Japan. Further, verify whether the proposed system can be implemented in other areas of Japan.

3. Implementation System

( ) Use of the NARO BRAIN

This program will use the grant provided to the NARO BRAIN (the management company) and follow the system described in the Figure 3-1.

The management corporation will follow the decisions of the PD and promotion committee to recruit the research participants, commands the selection/evaluation committee, and concludes the contracts. Moreover, the management corporation manages the budget and progresses of the projects (including the intellectual property management), organizes planning review meetings and peer review meetings, and conducts public relation activities of the projects and the research achievements. It supports the office work related to the self-examination of the research participant and that related to the third-party evaluation for the self-examination of the PD, according to the instructions of PD and the Cabinet Office secretariat.

( ) Appointment of the Research Director

The management corporation will follow the plans of this program and recruit the research participants. Based on the examination results of the selection/evaluation committee consisting of PD, sub-program directors (sub-PDs), and external specialists, the corporation will select research participants. The management corporation will undertake the official work for the examination.

The committee members for the selection/evaluation committee as well as the examination criteria to be undertaken will be decided by the PD and the Cabinet Office. The committee member who has conflict with the research institute that proposes a candidate research topic may not join the examination of the proposal.

( ) Optimization of the Research System

① Establishment of the Promotion Committee

To make necessary adjustments for the progress of this program, the PD will assume the role of chairperson, the Cabinet Office will assume the role of secretariat and establish a promotion committee consisting of the acting PD, sub-PDs, strategy coordinators (strategy Cs), participating ministries, the management corporation, and specialists.

② Collaboration with the New Energy and Industrial Technology Development Organization

The management corporation will collaborate with the New Energy and Industrial Technology Development Organization (NEDO) for the advancement of the program to generate its synergistic effects.

③ Research System

(ⅰ) Promotion of researches working in consortium as a unit

This program aims to establish a consortium consisting of universities, national research and development agencies, and businesses in the private sector that can employ the research results into practical use; such consortiums would be engaged in comprehensive research and development ranging from the basic researches to the commercialization of the research results for each publicly offered research subject,.

Under the guidance and suggestions of the PD and sub-PDs, the research director of each consortium should promote close communications between the participating organizations to enable the thorough use of the synergistic effects for the progress of the project.

(ⅱ) Multiple consortium collaborations

The PD or sub-PDs should monitor the research progresses of each consortium to provide guidance and suggestions with regard to the matters requiring collaboration between multiple consortiums to each research director, and gather the related parties to discuss regarding the effective collaboration work, as necessary.

( ) Cross-Ministerial and Agency Collaboration

For the sake of the growth of bioeconomy and creation of innovation in Japan that increases the productivities and strengthens the competitiveness in the agricultural, forestry, and fishery industries and food industry, it is necessary to integrate various cutting-edge technologies—such as biotechnology, IoT, robotics, data science, and AI—that different ministries are involved in as well as basic and core technologies. It would be important to undertake a systematic and multi-layered approach for each R&D subject.

In addition, to promote the use of the R&D achievements in the businesses in the private sector, improving the environment, such as the construction of data linkage system and an integrated DB that links the data across the ministries, and working in collaboration with the supervisory ministries responsible for the related regulations and systems are required.

Therefore, the PD will play a main role to ensure that the concerned ministries and agencies work in close cooperation with each other while engaged in the R&D, environmental improvement, and reformation of the regulations and systems.

( ) Contributions from the Businesses in the Industry

The businesses that participate in each consortium will provide human resources, technologies, knowledge, and funds to contribute to the R&D. The expected investment ratio from the participating/cooperating companies in the entire R&D expense will follow the strategic innovation operation guideline.

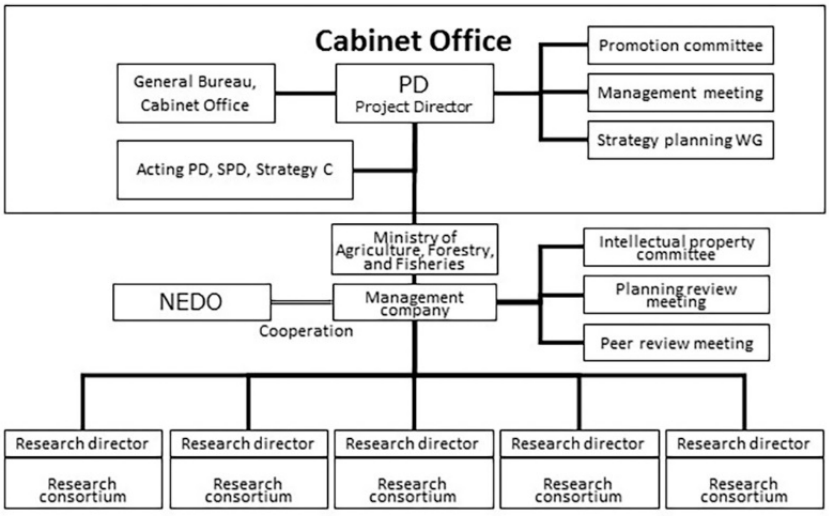


Figure 3-1: Implementation System

Organization	Members
Promotion committee	PD (chairperson), acting PD, sub-PDs, strategy Cs Cabinet Secretariat Information & Communication Technology Strategic Office, Cabinet Office National Space Policy Secretariat, National Tax Agency, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Agriculture, Forestry, and Fisheries, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism, Ministry of the Environment, Cabinet Office (secretariat), the management company, etc.
Management meeting	PD (chairperson), acting PD, sub-PDs, and strategy Cs, etc.
Strategy planning WG	PD (chairperson), acting PD, and strategy Cs, etc.
Peer review meeting	Peer review evaluation committee (includes the chairperson), PD, acting PD, sub-PDs, strategy Cs, and acting researchers, etc.
Planning review	PD (chairperson), acting PD, sub-PDs, strategy Cs, and external specialist, etc.

meeting	

Position	Name	Institution
PD	Noriaki Kobayashi	Kirin Holdings Company, Limited
Acting PD	Noboru Noguchi	Research Faculty of Agriculture, Hokkaido University
Sub-program directors (sub-PDs)	Yoichi Kamagata	National Institute of Advanced Industrial Science and Technology
	Toshihiko Komari	Japan Tobacco Inc.
	Wataru Mizunashi	Mitsubishi Chemical Corporation
Strategy coordinators (Strategy Cs)	Izumi Okoshi	Dentsu Inc.
	Kouichi Kadowaki	National Agriculture and Food Research Organization
	Takayoshi Kawakami	Industrial Growth Platform, Inc.
	Shoji Masahiko	Musashi University
	Atsuhiro Hagiwara	Object of Null, Inc.
	Yasufumi Miwa	The Japan Research Institute, Limited

4. Intellectual Properties

( ) Intellectual Property Committee

- For each project or for each research item that construct the project, set up an intellectual property (IP) committee at the management corporation or at the affiliate or contracted institute of the selected research director.
- The intellectual property committee will decide the policies regarding the application and maintenance of the publications and patent rights on the results of the researches conducted by the responsible institute. They would make necessary adjustments related to the enforcement of the intellectual property license .
- As a general rule, the intellectual property committee should be composed of a PD or acting PD and the main concerned parties and specialists.
- The details of the management method should be defined at each of the institutes where the intellectual property committee will be set up.

( ) Agreement on the Intellectual Properties

- The management corporation and others should make an agreement with regard to the following terms with contractors in advance: confidentiality, background IP (the IP reserved before the research directors and their affiliate institutes join the program and the IP granted after joining the program but not using the SIP budget), and foreground IP (the IP obtained during the program using the SIP budget).

( ) Licensing the Background IP

- The owner of the IP can grant the license to use the background IP to the participants in the other program in accordance with the conditions and terms decided by the owner of the IP (or the agreement among the program participants).
- In cases where the conditions decided by the owner of the IP interfere with the progress of the SIP (with regard to the R&D as well as commercialization and industrialization of the research results), the intellectual property committee will address such issues and find a reasonable solution.

( ) Handling the Foreground IP

- In principle, according to the Industrial Technology Enhancement Act Article 19 (1), the foreground IP will be attributed to the affiliate or contracted institute of the research director (the inventor). On the IP obtained from the collaborative research between the contractors or contracted institutes and the participating institutes, a joint application agreement between the concerned parties and the IP can be shared between the parties. The share of the entitlement will be decided between the concerned parties based on their contribution to the research.
- In cases that the owner of the IP has less interest in commercializing his/her IP, the intellectual property committee will promote another party that will actively function to commercialize, transfer, or grant the use of the IP to hold the IP or use the IP.
- For those who quit the project during the participation period, the management corporation can set the rule to transfer all or part of the results obtained during the participation period using the SIP budget (if participation was for multiple years, include all the results from the beginning of the participation) for free.
- In principle, the fees required for the application and maintenance of the IP will be paid by the owner of the IP. For the joint application, the ratio of the cost distribution will be decided between the concerned parties.

( ) Licensing the Foreground IP

- The owner of the IP can grant the license to use the foreground IP to the participants in the other program in accordance with the conditions and terms decided by the owner of the IP (or agreement among the program participants).
- In cases where the licensing of the foreground IP to the third party is not more advantageous than the program participants, the owner of the IP can grant the license to use the IP in accordance with the conditions decided by the owner of the IP.
- In cases the conditions decided by the owner of the IP interfere with the progress of the SIP (with regard to the R&D as well as commercialization and industrialization of the research results), the intellectual property committee will address such issues and find a reasonable solution.

( ) Agreement on the Transfer of the Foregrand IP and Granting /Transfer of the Exclusive License of the Foreground IP

- Industrial Technology Enhancement Act Article 19 (1) iv, the transfer of the foreground IP and granting and transfer of the exclusive license will require an approval of the management corporation, except in cases where the transfer occurs by merging or splitting of the institutes or the exclusive license is being granted and transferred to subsidiary or parent companies (henceforth referred to as the transfer of IP because of merging etc.).
- The transfer of IP because of merging etc., the owner of the IP shall be required to get an approval from the management corporation and others in accordance with the agreement between the management corporation and the owner of the IP.
- Even after Despite the transfer of the IP because of merging etc., the management corporation can hold the re-licensing rights of the IP. If the condition is not accepted, the transfer will not be approved.

( ) Handling of the IP after the Completion of the Project

- At the completion of the project, if no individual is interested in holding the IP, the intellectual property committee will discuss the handling of the IP (abandon or transfer to the management corporation etc.).

( ) Intervention of the Foreign Organizations (Foreign Companies, Universities, and Researchers)

- If intervention of foreign organizations is necessary for the advancement of the projects, they are allowed to participate.
- In principle, for the appropriate execution management, a contact or agent who processes the paperwork for the consignment of the R&D should be present within Japan.
- The IPs obtained through the work with foreign organizations shall be shared between the organizations and the management corporation.

5. Details of the Evaluation Process

(1) Evaluation Committee

The governing board will invite external specialists for evaluation based on the results of the self-examination that the PD and the management corporation perform. The governing board can be held for each field or for each project.

( ) Evaluation Timings

- Evaluation would be conducted before the project execution, at the end of every fiscal year, and at the end of the project.
- After the completion of the project, follow-up evaluations will be performed after a certain time period (in principle, three years later), if necessary.
- In addition, evaluation may be performed in the middle of the fiscal year if necessary.

( ) Evaluation Items and Evaluation Criteria

Based on "General guideline for National R&D evaluation (Dec., 21th, 2016, decision by the Prime Minister)", the evaluation items and evaluation criteria shall be defined as below in the standpoints of the evaluations of necessity, efficiency, and validity. The evaluation will focus on the achievement and underachievement of the project as well as include the analysis of causes and factors for the underachievement and a propose methods for improvement.

① Significance of and conformity to the purpose of the SIP system

② Validity of the goal (particularly the outcome goal), including the degree of achievement of the project in the targeted time schedule

③ Checking whether appropriate management has been performed, with particular focus on the effectiveness of cross-ministerial collaboration

④ Determning the strategies and degree of progress toward commercialization

⑤ Determining the expected effects and ripple effect at the final evaluation and after completion, checking whether the follow-up methods are clearly and appropriately defined

⑥ Following items

1) Conformity to the Society 5.0.
2) Degree of priority in the field that requires production innovation
3) Contribution to the social innovation
4) Contribution to solving the social issues and for strengthening the Japanese economy and industrial competitiveness
5) Clarity of the exit strategy for the commercialization and social implementation (i.e. clear commercialization plan in five years)
6) Presence of the system related to the exit strategy including IP strategy, international standardization, regulatory reformation
7) Degree of cross-ministerial work that requires cross-ministerial collaboration
8) R&D strategy that considers the process from the fundamental research to commercialization
9) Existence of the distinction between "cooperation area" and "competitive area" settings (if open–closed strategy is present)
10) Degree of establishment of the industry–academia–government collaborated system and the participating businesses to commercialize the R&D results and the matching fund

⑦ The achievement in the Technology Readiness Levels (TRL) in each research subject of each project

( ) Reflecting the Evaluation Results

- The pre-evaluation will be conducted for the plan for the next fiscal year or after and the result will be reflected in the plan for the next fiscal year or thereafter.
- Acording to the evaluation results at the end of every fiscal year, the projects and research participants will be reduced or added as necessary.
- The evaluation at the end of every fiscal year will be conducted for the achievement up to the end of the year, and the plans for the next fiscal year or later as well as the results will be reflected in the plan for the next fiscal year or thereafter.
- The final evaluation will be performed for determining the achievement up to the end of final year and the result will be reflected in the post-completion follow-up period.
- The follow-up evaluation will be performed for the progress in the commercialization of each project's achievement to propose improvement method.

( ) Publication of the Results

- In principle, the evaluation results will be open to the public.
- The governing board that evaluates the projects will handle undisclosed R&D information; therefore, it will not be open to the public.

( ) Self-Examination

① Self-Examination of the Research Director

The PD will select the research director who performs the self-examination (in principle, select a researcher and a research institute that undertakes the main role in each research subject). The selected research director will follow 5.(3) Evaluation Items and Evaluation Criteria to check both the achievements following the previous evaluation and the future plans. They would judge the achievement or underachievement but analyze the causes and factors and put together the improvement methods.

② Technical Evaluation from the Professional Perspective (Peer Review)

The management corporation will use the technical evaluation from the professional perspective (peer review) for the self-examination and report the result to the governing board.

③ Self-Examination of the PD

The PD will follow 5.(3) Evaluation Items and Evaluation Criteria and by referring to the results of the research director's self-examination and the peer review conducted by the external specialists, PD will check both achievements and future plans of PD himself, the management corporation and each research director. The PD should judge the achievement or underachievement, but analyze the causes and factors and summarize the improvement methods. From this evaluation result, the PD will decide the possibility of continuing each research and provide necessary advices to each research director. This enables the system to improve by itself.

Based on the results, the PD with a support of the management corporation will prepare documents for the governing board.

④ Self-Examination of the Management Corporation

The self-examination of the management corporation will evaluate its appropriate administrative procedures for the budget implementation.

6. Exit Strategy

( ) Promoting the Goal-Oriented Researches

① Personnel, Material, and Fund Contributions from the Participating Companies

The companies that participate in each consortium will provide human resource, technologies, knowledge, and funds to contribute to the R&D. The expected investment ratio (assumed) from the participating/cooperating companies to the whole R&D expense will follow the strategic innovation operation guideline.

② Collaboration with Other Related Projects

To achieve the production innovation and increased profitability in agricultural, forestry, and fishery industries and food industry using the “Smart Food System” by comprehensively using various data, we will work together with related working groups responsible for the SIP “Smart Logistics Service”, SIP “Cyberspace Platform Technology utilizing Big Data and AI”, and PRISM to elicit the synergistic effects.

③ The Destination of the Research Achievement

As an exit strategy with regard to research achievements, the company participating in each consortium, to which the IP has been transferred from the National Research and Development Agency or the university that holds the IP, shall launch the products or services on the market.

For the platform-based research achievements—such as the Smart Food System—that is widely used by both the public and private sectors, new business ideas will be requested from participating companies in each consortium as well as from the other participants from various fields to launch such achievements for practical use. The management and maintenance of the platform system should be led mainly by the participating companies in each consortium.

④ Technology Transfer to the Businesses in the Private Sector

For the products to be launched for practical use or commercialized, SIP will create their prototypes and the private companies that have been granted the license to use the IP will launch the products for practical use as well as be involved in their mass production.

For the research achievements that is widely used by both the public and private sectors, SIP will validate the effectiveness in their Use Cases, following which their management and maintenance should be undertaken mainly by the companies participating in the consortium.

⑤ Human Resource Development

To create the innovative fundamental base through the harmonization of the biotechnology and digital technologies, the development of human resources with skills, expertise, and knowledge in both fields as well as a sense of business management is indispensable.

During the R&D process of this project, we will provide on-the-job training to the young researchers and promote the participants to undergo recurrent education programs on AI and informatics to develop human resources.

( ) Strategies for Spreading the Idea and the Products

① [Development] Development of Innovative Food Ingredients and Breeding Technologies by Comprehensively Using the Newest Scientific Knowledge in Synthetic Biology

We will improve the environmental infrastructure that enables the major nursery companies and the responsible departments of the prefectural governments in Japan to use the “data-driven breeding” system. This may facilitate the production of the varieties that meet the needs of markets within and outside Japan market and the users in shorter periods, thereby strengthening the Japanese breeding development system.

Moreover, by lowering the technical barrier, we encourage other industries to enter the breeding development business.

By overcoming the hurdles imposed to meet the regulations and gain the understanding of a nation, we will present practical cases for the production and commercial sales of genome-engineered agricultural products to promote the firms and businesses in the agricultural, forestry, and fishery industries and food industry to be involved in the production, use, and sales of the genome-engineered agricultural products.

② [Production] Development of the Smart Production System; [Distribution, Processing], Cost Reduction, Optimization Technology Development; and [Data Utilization] Construction of the ICT Platform Prototype Aiming at the Consruction of the Smart Food System

The established technology will be commercialized by the participating companies or those that obtain the IP from the owner (e.g., institute) of the IP. For the Smart Food System, we intend to increase the number of participating institutes and continue improving its function even after the completion of the program.

③ [Construction of the Value Chain Data Infrastructure] Validation of the Data Distribution Infrastructure that Integrates and Links Multiple DBs

We will establish a collaboration system for the related DBs held by different organizations including the Japan Science and Technology Agency (JST) and the National Bioscience Database Center (NBDC) for the improvement and operation of the biology-related big data. Through this system, we will improve the infrastructure that enables the use of omics data linked with biological functions, such as metabolic capacity, as one big data and establish the systems for open–closed data and those that provides an incentive to offer the closed data, with an aim to promote the industrial use of biological information by encouraging the industries to access the data.

④ [Sales and Consumption] Responding to the Various Needs

Along with the promotion of research projects, we will expand the industry–academia–government collaboration network to accumulate the scientific evidences even after the completion of this program, following which we will continuously construct and improve the developed system.

By comprehensively using the “Integrated database of analysis data for health information in the agricultural, forestry, and fishery industries, and food industry,” we will fulfill research reviews on the health promotion effects of agricultural, forestry, and fishery products, and food products published by research institutes, universities, and businesses in the private sector and allow the secondary analysis of the obtained data. This will promote the agricultural corporations, food businesses, businesses of readymade meals, restaurants, and catering services to submit reports on agricultural, forestry, and fishery products and food products with functional claims and commercialize the products. Based on the development of new diet guidelines that would help one’s health maintenance and health promotion, it is expected that the supply and use of agricultural, forestry, and fishery products and food products with health maintenance and health promotion effects, supported with scientific evidences, will be increased.

We will select model areas (city, town, or village) to test the new service proposing suitable food and diet based on the individual’s health conditions. The service will employ the developed health check technology, such as a system to detect mild physical condition changes, to obtain information on one’s health condition and commence the use of the service in the model area to prove its effects. In addition, we will share the results with media to publish the results and expand it further as a nationwide service.

Regarding the “integrated database of analysis data on health information for agricultural, forestry and fishery products, and food products,” the National Research and Development Agency will play the main role in establishing a maintenance and operation system while collaborating with the businesses in the private sector and related research institutes. For the gastrointestinal microbiome data, the businesses in the private sector and related research institutes will work in concert to establish a management and operation system for the DB that can serve the purpose of industrial use.

⑤ [Resource Circulation] Development of Bioresource Utilizing Technology and Biomaterials

For the production system development and commercialization of high-functional products and biomaterials using the biological functions, we will conduct pilot-scale experiments to prove its effectiveness and promote the businesses to providing financial support to construct a full-scale plant and for opening a new industrial business.

For the “development of next-generation core technology for the chemical industry using the unused resources in the agricultural, forestry, and fishery industries,” we will establish a collaboration system aiming for launching an industrial business from the early stage of the R&D. We will request the related companies, related organizations in agricultural, forestry and fishery industries, and local governments to participate. Further, we will investigate the collection system for the unused resources of the agricultural, forestry, and fishery industries and the business model considering the cost effectiveness and stable supply, which will help organizing the environment for the future industrial business opportunities.

7. Other Important Matters

( ) Overall Program Flow

In the fiscal year of 2019, we will use a stage-gate process at the peer review stage to select the research products according to those suitable for implementation into the society to enable the optimization and refining of the entire Smart Food System.

( ) Flexible Plan Modifications

The program will be reviewed and modified on a case-by-case basis to ensure that the achievements may be completely obtained and rapidly implemented for use.

( ) Grounds Laws and Ordinances

The project will be conducted in accordance with laws and ordinances listed below:

Cabinet Office Settlement Law
(Act No. 88 of 1999) Article 4 Paragraph 3 Item 7-3

The Basic Policy for the Scientific Technology Innovation Promotion Fund
(May 23rd, 2014, Council for Science)

Cross-ministerial Strategic Innovation Promotion Program (SIP) second term (2017 amended budget measures) Implementation Policy
(March 29th, 2018, Council for Science)

Cross-ministerial Strategic Innovation Promotion Program (SIP) (2018 amended budget measures) Implementation Policy
(February 28th, 2019, Council for Science Governing Board)

2019 Cross-ministerial Strategic Innovation Promotion Program (SIP) Implementation Policy
(June 27th, 2019, Council for Science Governing Board)

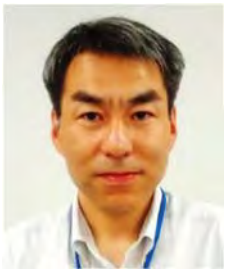
Cross-ministerial Strategic Innovation Promotion Program Operation Guidelines
(June 27th, 2019, Council for Science Governing Board)

( ) Program Director and Person-in-Charge (Assigned Date)

① Program Director

Noriaki Kobayashi (from April 2018)

② Councilors (Planning Officers)

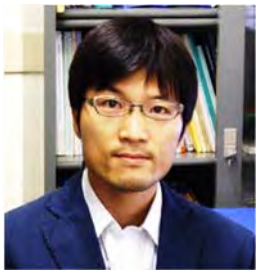


Kiyoshi Nakashima
(from April 2018 to December 2018)

Sachiko Mori
(from January 2019)

③ Persons-in-Charge

Takeshi Ishii
(from April 2018)



Akifumi Ogino
(from April 2018 to April 2019)

Hisakata Numa
(from April 2019)

Attachments

Financial Plan and Estimates

Fiscal year 2018 Total 3,200 million yen

(breakdown)

1. Research expenses etc. (includes general management expenses and the secondary cost) 2,910 million yen

(breakdown for each R&D item)

(A) Establishment of a new healthcare system that increases the healthy life expectancy with focus on "foods" 445 million yen

(B) Revolution in productivity and strengthening of the competitiveness in the agricultural, forestry and fishery industries and food industry by comprehensively using various data 1,489 million yen

(C) Realization of a growing sustainable society using "biological functions" for the products 761 million yen

(D) Construction of a research development infrastructure for the creation of bio-digital harmonized innovation 215 million yen

2. Project promotion fund (labor costs, evaluation fee, meeting expenses) 90 million yen

3. Necessary expenses for the enhancement of the project
(*the budget added during the allocation, which would be adjusted in the following year) 200 million yen

Total 3,200 million yen

Fiscal year 2018 amended budgetary measures Total 200 million yen

(breakdown)

1. Research expenses etc. (includes general management expenses and the secondary cost) 194 million yen

(breakdown for each R&D item)

(2) [Production] Development of the smart production system, [Distribution, Processing] cost reduction, optimization technology development and [Data Utilization] construction of the ICT platform prototype for the establishment of the Smart Food System 194 million yen

2. Project promotion fund (labor costs, evaluation fee, and meeting expenses) 6 million yen

Total 200 million yen

Fiscal year 2019 Total 2,500 million yen (includes the adjustment of breakdown 3 in 2018)

(breakdown)

1. Research expenses etc. (includes general management expenses and the secondary cost) 2,425 million yen

(breakdown of each R&D item)

(1) [Development] Development of innovative food ingredients using newest scientific knowledge in synthetic biology and breeding technologies 272 million yen

(2) [Production] Development of the smart production system, [Distribution, Processing] cost reduction, optimization technology development and [Data Utilization] construction of the ICT platform prototype for the establishment of the Smart Food System 1,086 million yen

(3) [Construction of the Value Chain Data Infrastructure] Validation of the data distribution of the DB that integrates and links multiple DBs 142 million yen

(4) [Sales and Consumption] Responding to the various needs 341 million yen

(5) [Resource Circulation] Development of bioresource utilizing technology and biomaterials 584 million yen

2. Project promotion fund (labor costs, evaluation fee, and meeting expenses) 75 million yen

Total 2,500 million yen

Time Schedule