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# Plan to Achieve the Medium to Long-term Objectives of RIKEN
## (Medium to Long-term Plan)
## (draft)

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Preface

Based on the provisions of Article 35-5, paragraph (1) of the Act on General Rules for Incorporated Administrative Agencies, the Institute of Physical and Chemical Research, National Research and Development Agency (hereinafter referred to as "RIKEN") prepares the plan for achieving the medium to long-term Objectives (hereinafter referred to as "Medium to Long-term Plan" for the period from April 2013 as follows.

## I. Measures to be taken to achieve the objectives to maximize the research and development achievements and to improve the quality of business

RIKEN will establish a system to maximize the research and development outcomes in order to address various issues faced by humankind listed in the Science and Technology Basic Plan toward the realization of sustainable growth and the development of society in the future. Under such a system, RIKEN will allow a diversity of research fields and systems to coexist and generate a synergy effect in accordance with the Medium to Long-term Plan, and take initiatives taking advantage of its multifaceted collectiveness. Moreover, RIKEN will contribute to science and technology, industry and society by conducting the business provided for in Article 16 of the Act on RIKEN (Institute of Physical and Chemical Research, National Research and Development Agency) based on its long-maintained traditions and characteristics such as the research systems open not only to Japan but also to the rest of the world, researcher training systems, and new research operation and evaluation systems. RIKEN will recognize that any misconduct in research seriously compromises the trust of society in science so that it takes effective preventive measures therefor and establish organizational and operational systems that serve as a model for research institutes in Japan.

RIKEN will, by taking these initiatives, aim to serve as a core body that strongly drives innovation systems through creating the world's highest level of R&D outcomes, disseminating them, and promoting its use under the leadership of the President, and thereby to contributing to the development of national economy and public life.

### 1. Promotion of strategic and focused R&D based on national and social needs

As one of the core players of the R&D functions of Japan, RIKEN will promote research and development in a focused and strategic manner to overcome issues to be addressed by the

government listed in the Science and Technology Basic Plan and issues considered to be attainable by science and technology among diversified social needs.

To this end, RIKEN will bring together talented Japanese and overseas researchers and efficiently, effectively and systemically conduct research and development in close collaboration with domestic and overseas universities, research institutes and businesses. The details of the following researches are described in Appendix 1.

(1) Emergent matter science
(2) Sustainable resource science
(3) Brain science
(4) Developmental biology
(5) Life science research
(6) Integrative medical sciences
(7) Advanced photonics
(8) Information science and technology

Moreover, individual research and development projects whose necessity has decreased because their objectives have been achieved, or whose priority has decreased in the light of scientific impacts and social needs, are strictly reviewed as needed including their discontinuance. Moreover, RIKEN swiftly responds to projects whose need has increased in view of different circumstances. Based on the Action Plan for Renewal of Higher Morals including Prevention of Research Misconduct formulated in August 2014, RIKEN implements necessary reviews concerning its operation and research systems.

## 2. Promotion of development and shared use of world's highest level research infrastructures and researches using such infrastructures

RIKEN promotes researches on advanced infrastructures taking advantage of its highest-level research infrastructures such as the RI Beam Factory, Spring-8, X-ray free electron laser SACLA and supercomputer "K Computer" as well as the development of cutting-edge research infrastructures required in common in the life scientific field and of infrastructures for collecting, preserving and providing bioResources, and research and development toward the addition of values thereto.

Moreover, RIKEN is intending to promote complementary collaborations with external organizations by means of steadily developing and operating research infrastructures including its highest level large research facilities and provided Japanese and overseas researchers with them for shared use, and endeavor to create research and development outcomes and disseminate fundamental technologies.

Furthermore, RIKEN strives to widely open its door to external researchers, fairly and justly

select research agendas subject to shared use and provision of facilities and equipment, and to further promote external use by introducing the beneficiaries-pay principle of usage fees.

A system in which several research infrastructures in RIKEN can be used on a cross-sectional basis will be established from the user's point of view.

Furthermore, RIKEN will strive to steadily carry out the service provided for in Article 5 (excluding usage promotion services by registered institution for facilities use promotion) of the Act on the Promotion of Public Utilization of the Specific Advanced Large Research Facilities.

In addition, RIKEN will determine needs for external use of its facilities and equipment with the aim of further promoting the use of those that can be used by external users.

The details of the following researches and projects are described in Appendix 2.

(1) Accelerator-based science
(2) Synchrotron radiation
(3) BioResource
(4) Life science technologies infrastructure
(5) Researches on computational science and technology

3. Promotion of advanced integrative researches through establishing systems for RIKN to demonstrate its collective strengths

A global mega-competition over knowledge has intensified in the 21st century. In order to explore new scientific fields, it is necessary to bring together researchers from various fields, to foster researches under flexible and cross-sectional research systems in which they can address cutting-edge research agendas and to strategically nurture researches. RIKEN will strengthen the function of giving advice to business judgment on a bottom-up basis for the purpose of achieving this goal and introduce the systems to promote cutting-edge integrative researches that has been established by its core laboratories in the entire organization in the second period for medium to long-term objectives. This allows RIKEN to establish system to explore new research areas and flexible research environments and to conducts its business under strict scrutiny.

It should be noted that RIKEN will examine the progress of individual research and development projects and steadily explore research areas through appropriately verifying their results. If the necessity of conducting those projects has decreased because their objectives have been achieved, or whose priority has decreased in the light of scientific impacts and social needs, are strictly reviewed as needed including their discontinuance. Moreover, RIKEN will swiftly respond to projects whose need has increased in view of different circumstances.

(1) Creative research proposal system

RIKEN will establish a creative research proposal system for the purpose of strengthening the functions of the entire organization of selecting and cultivating seeds of new research areas that bring about a major breakthrough in science and technology. Agendas promoted under this system are selected by the RIKEN Science Council consisting of chief researchers mentioned in (2) below from the point of view of their possibility of evolving into new research fields in the future and their degree of challenge and creativity and then put into action. After a research terminates, a strict review is held based on social and policy requests. If it is judged that the research should be promoted, the Board of Executive Directors makes a decision that it is to be conducted as a strategic or priority area which RIKEN aims to develop or expand based on national and social needs and promotes this research.

(2) Establishment of a recruitment system of core researchers

RIKEN will hire researchers (chief researchers) who play a core role in cutting-edge researches with the aim of playing a role as a comprehensive promotor of basic research to the fullest extent possible.

Chief researchers are selected from persons who have particularly-outstanding research achievements, strong leadership in research and knowledge as scientists and who are expected to produce outstanding results and to create new fields in the future. They promote their advanced researches undergoing strict evaluations. Moreover, they serve as the members of the RIKEN Science Council that makes proposals on directions of researches to be promoted by RIKEN, recommendations for outstanding researchers who should be invited to RIKEN and fostering of young researchers.

4. Establishment and promotion of industry-academia-government collaborations in order to produce high-impact outcomes that result in innovation

RIKEN is aiming to integrate scientific and technical needs of the society and industry with cutting-edge research seeds owned by RIKEN and disseminate them, and maximize research and development outcomes through creating a place for promoting the process from basic research to practical application (baton zone) together with businesses and medical institutions taking advantage of its collective strengths in order to respond to social demands and address issues of the industrial world and through establishing cross-sectional management systems for innovation in the entire organization. Specifically, the following initiatives are promoted.

Moreover, individual research and development projects whose necessity has decreased because their goals have been achieved, or whose priority has decreased in the light of industrial or social needs are strictly reviewed as needed including their discontinuance. Moreover, RIKEN will swiftly

respond to projects whose need have increased in view of different circumstances.

(1) Integrative collaborations with industry

RIKEN will enhance not only internal collaborations but also organizational and comprehensive collaborations with businesses and medical institutions that can make optimal use of resources for the purpose of solving issues by integrating social and industrial needs with cutting-edge research seeds owned by RIKEN. The details are described in Appendix 3.

Moreover, RIKEN will be committed to open innovation through such activities as the formation of consortiums with universities and private businesses so as to create the world's highest level of research and development outcomes and to promote their dissemination and practical application. Moreover, RIKEN is intending to strengthen its planning and designing functions and upgrade its organization thorough initiatives for innovation design that draws a roadmap from the extraction of issues to be addressed for realizing desired future images of society to the realization of innovation.

(2) Promotion of cross-sectional collaborations

RIKEN is aiming to cultivate cutting-edge research seeds to the point where they can be utilized actually in industrial and medical fields by making cross-sectional use of its research infrastructures that have been fostered in the entire organization such as technologies and resources including strategic and focused research and development taking into account national and social needs, and to hand over the seeds to businesses. To this end, the following collaboration facilitating projects are promoted in the entire organization. The details are described in Appendix 3.

(i) Promoting the collaboration on biomass engineering

(ii) Promoting the collaboration on drug discovery research

(3) Promotion of effective intellectual property strategy for translating researches into practical application

RIKEN will strengthen its organization to promote intellectual property strategies such as the utilization of external experts and appropriately protect and actively utilize intellectual property with the aim of effectively carrying out technology transfer toward practical application of research and development outcomes. Moreover, RIKEN will acquire patents whose scope of right is broad, so-called robust patents, based on sufficient working examples so as to build a basis for full-fledged research and development by businesses aiming at their practical application and result in the expansion of working fee revenues.

Moreover, the value of practical application of acquired patents including licensed patents and its cost-effectiveness are verified periodically and the necessity of maintaining those rights is reviewed

with a view to efficient maintenance and management thereof.

In addition, RIKEN intends to enhance its technology transfer functions such as the transmission of information utilizing the website and exhibitions, activities by researchers themselves to explain technologies and certification of RIKEN ventures.

These activities are expected to raise the working rate of patents owned for more than 10 years to 65% or higher at the end of the period for medium to long-term objectives.

## 5. Improving research environments and fostering and producing talented researchers

The following initiatives are taken with the aim of exercising the collective strengths of RIKEN that has various research fields and the flexible organizational systems to deal therewith to the maximum extent possible and of creating a number of research and development results.

### (1) Development of open and vibrant research environments

#### (i) Creation of competitive, strategic and swift research environment

RIKEN will conduct fair and transparent evaluations and reflect their results in the distribution of research resources in order to build a more competitive research environment and reap creative research and development outcomes.

Moreover, under the leadership of the President, a strategic research deployment project is promoted with the aim of reaping useful research and development outcomes by setting strategic themes. Furthermore, under the leadership of the RIKEN Science Council, RIKEN will strive to further strengthen the cross-sectional collaborations between its departments that have broad research fields and a diversity of research approaches through the creative research proposal system aiming at the production of creative research and development outcomes under competitive environment and to promote researches to which priority should be given in science and technology of next generation by integrating different research fields and techniques. Additionally, RIKEN will flexibly and swiftly adapt a desired image of research systems and the distribution of research resources in line with the nature of each research. In order to attract the brains from the world and overcome a competition for acquiring talents, RIKEN will prepare for treatment and research environment suitable for internationally distinguished researchers and flexibly and promptly deal with researches that should be initiated urgently from the perspective of national strategy or social needs, researches that need to be accelerated at an early stage, and emerging researches.

#### (ii) Improvement of incentives for research toward the creation of achievements

It is required to enhance research environments in which talented researchers can

demonstrate their capabilities to the maximum extent possible and a system to provide them with support. Therefore, RIKEN will strive to develop an appropriate employment system for researchers in accordance with research projects and to build career paths that allow them to participate in more activities.

RIKEN also endeavors to enhance trainings for laboratory management and for support for individual capacity building so as to maintain the researcher-friendly research environments and carry out active R&D activities.

(iii) Establishment of research systems open to the world

It is necessary to provide living environment giving due consideration to foreign researchers in order to secure talented foreign researchers. RIKEN will secure housing for foreign researchers, provide their families with support in terms of daily life, and promote the simplification of various life-related procedures, and further raise the bilingual abilities of each administrative department that deals with the acceptance of researchers from overseas.

Under such environmental development, RIKEN will actively accept foreign researchers and aim to raise the rate of foreign researchers who engage in researches to 20% in the period for medium to long-term objectives.

(iv) Promotion of young researchers and creation of challenging research opportunities

For the purpose of ensuring fluidity and diversity of researchers and bringing about a great breakthrough in science and technology, talented young researchers are selected by fair means and actively recruited. Moreover, RIKEN will establish a system in which they can demonstrate their capabilities to the maximum extent possible providing appropriate support.

Furthermore, RIKEN will enhance a system to foster outstanding young researchers by integrating and reorganizing the system in which a leading position as the independent laboratory director is granted to young researchers to supervise the laboratory (associate chief researcher system) and the system in which internationally distinguished young researchers are allowed to form a research unit temporarily to independently conduct a research (independent/international senior researcher system) through incorporating the advantages of the two systems. The recruitment of researchers under this integrated system has started from FY2013.

Moreover, an open application system of research agendas was newly introduced to the creative research proposal system in FY2013 in order to foster young researchers.

(v) Improvement of research environment to encourage the further participation of female researchers

RIKEN will promote environmental upgrading so that female researchers can continue R&D

activities at the time of childbirth, childcare and nursing care and before and after such events and take initiatives for realizing work life balance based on the philosophy of gender equality. Moreover, various types of initiatives already in place are reviewed or improved in order to improve their convenience. These initiatives are expected to raise the rate of female researchers who occupy a leading position to at least 10%.

(2) Fostering and producing human resources who have internationally distinguished capability

RIKEN will strive to foster and produce human resources who have internationally distinguished capability utilizing national systems for the purpose of conducting the world's highest level and challenging research and development.

(i) Fostering young researchers of next generation

In order to foster future researchers and revitalize RIKEN, programs to invite postgraduate and young researchers who have flexible mindset and energy are utilized.

Specifically, postgraduates are actively accepted by assuring their quality by making use of such programs as the Postdoctoral Researchers Program and the Junior Research Associate Program. In particular, opportunities for researches are provided to about 210 postgraduates annually under the Junior Research Associate Program with a focus on fostering researchers who have knowledge, experience and skills related to basic medical science.

Moreover, taking into account the fact that nurturing young researchers who have outstanding creativity and originality is becoming more and more important, RIKEN will promote the Basic Science Special Researcher Program and the International Special Researcher Program to provide young researchers who received a PhD with environments where they can conduct researches with creative and original ideas for three years and intend to improve their qualifications including independence and autonomy. RIKEN will maintain a system to accept around 170 basic science researchers and special international researchers annually, and among them, more than one-third should be foreign researchers for globalization of human resources.

Furthermore, RIKEN will actively accept researchers and engineers from businesses to foster researchers and engineers of the two sides and to promote smooth technology transfer from RIKEN.

(ii) Improving the fluidity of researchers and producing human resources

Project-based researches that are conducted within a fixed period of time have effectively produced research and development outcomes by gathering talented fixed-term researchers and promoting concentrated researches in a short period of time. RIKEN will contribute to the provision of career paths for talented Japanese and foreign researchers by helping researchers to

acquire specialized knowledge and skills required for them through those R&D activities and to foster them as engineers who have expertise and broad insights.

Moreover, RIKEN will endeavor to enhance support for voluntary capacity building by researchers and trainings that can lead to the development of various career paths in the future, and promote the improved fluidity of human resources by strengthening collaborations with university and industry.

Furthermore, RIKEN will intend to further improve the fluidity of human resources by expanding the annual wage system introduced to chief researchers and chief associate chief researchers to nom-management permanent staff.

The special fixed-term employee system continues to be utilized in which young researchers who are expected to acquire capabilities and qualities as independent researchers are hired for a fixed-term of 5 years and may be promoted to permanent employees through examinations on their eligibility for employees who work under the mandatory retirement system after three years out of their 5-year period pass.

(3) Transmission of information on research and development outcomes in an easy-to-understand manner and raised understanding on R&D activities

(i) Presentation of achievements by means of papers and symposiums

RIKEN will strive to disseminate research and development outcomes through submitting research papers to scientific journals and giving oral presentations at symposiums.

Specifically, RIKEN is intending to submit around 2,300 papers annually to academic journals. Moreover, from the perspective of maintaining the exceptionally high-quality of papers as a comprehensive research institution of Japan, RIKEN aims that around 27% of papers occupy the top 10% of the ranking of the most cited papers.

(ii) Enhanced understanding on R&D activities

A public relations strategy of RIKEN will be formulated with a focus on raising awareness of people as a research institution that has the raison d'etre for our country and actively transmit information on extinguished research and development outcomes based thereon through press releases, public relations magazines (RIKEN News, etc.) and the website.

Moreover, RIKEN will actively have bilateral communications with citizens based on the Science and Technology Basic Plan. Specifically, in addition to initiatives taken in the past such as open day and various lectures, RIKEN actively offers opportunities for dialogue with citizens such as seminars on specific themes, on-site lectures and social

networking service. RIKEN is aiming to increase the number of outreach activities by 20% or so in the period for medium to long-term objectives through the above initiatives.

Furthermore, opinions of citizens who receive information are collected, investigated and analyzed to reflect them on public relations activities. To be specific, surveys on the levels of understanding and recognition of citizens and questionnaire surveys targeting visitors to various events and exhibitions and visitors to RIKEN's facilities are conducted. Based on these results, RIKEN will improve the public relations strategy taking opinions of experts into consideration so that it attracts support as an attractive research institution with high social presence.

RIKEN will enhance explanatory articles with simpler terms in addition to explanations for science journalists with the aim of issuing press releases in an easier-to-understand manner for citizens and give presentations by making effective use of images.

Moreover, regulations for procedures for operation of press releases concerning research achievements are formulated in order to build an appropriate public relations system and securely operate it.

RIKEN will also strive to enhance the functions of transmitting information to other countries with the aim of strengthening broad collaborations and of securing global human resources, and transmit information so as to further increase the presence of RIKEN in the international community. As part of these initiatives, around 30 press releases are issued annually for international media.

(4) Collaboration and cooperation with national and international research institutes

RIKEN will strengthen a "Science and technology hub" function formed together with domestic and overseas universities, research institutes, local governments and industry and conclude agreements on human resources exchange and collaborations through establishment of collaboration centers and cross appointment with the aim of creating innovation.

From the perspective of acquiring and fostering human resources who can play a leading role all over the world, operating and improving research centers as international hubs, and addressing global issues toward the survival of mankind, international strategies of RIKEN are formulated. RIKEN will sufficiently scrutinize the necessity of researches in line with these strategies to proceed with research exchanges through research cooperation agreements and joint researches with overseas research institutes and universities, accept overseas students by concluding international cooperative graduate agreements, and provides them with research environments and guidance on research agendas.

In addition, collaborative research centers (branches and collaboration centers) are established to promote collaborative researches. In particular, RIKEN will examine the status of

research and development in Asia and intend to promote research exchanges. During the period for medium to long-term objectives, about 5 research centers will be newly established in collaboration with overseas organizations. A system required for appropriate execution of budgets is established to operate these overseas centers, and collaborative research bases are abolished promptly after collaborative researches are terminated.

RIKEN will also promote diversified types of researches such as joint researches and funded researches in order to actively promote research exchanges with domestic and overseas universities, research institutes and businesses, so that the number of joint researches with the private sector reaches 450 annually. Furthermore, RIKEN will conclude research cooperation agreements with domestic universities and research institutes in order to promote collaborations therewith and international cooperative graduate agreements to accept postdoctoral students (second semester) and to provide them with research environments and guidance on research agendas.

(5) Strengthening of the functions of strongly supporting R&D activities through administrative affairs and technologies

(i) Strengthening the organizational system in the administrative affairs department and improving the quality of business

RIKEN will clarify the headquarters function and strengthen a system to promote individual research projects. Moreover, the quality of business is improved by streamlining the business by means of constant review of the business flow. RIKEN is also intending to improve the quality of human resources of the administrative affairs department by founding and operating the administrative affairs specialist system to nurture human resources who are specialized in acquisition and management of intellectual property, research ethics, safety management and public relations and by enhancing trainings for nurturing such specialists. Furthermore, RIKEN will strengthen research support functions by assigning these human resources to appropriate positions and organize an employment system in a way that research assistants can participate in more activities.

In addition, RIKEN will strive to secure talented research assistants and strengthen research support functions so as to reduce the burden of researchers for routine works related to their research and maintenance, management and evaluations of facilities so that they can concentrate on research.

Moreover, RIKEN will actively hire and promote female employees and aim to raise the rate of female administrative management employees to 10% in this period for medium to long-term objectives.

(ii) Strengthening the function supporting RIKEN's business judgment

RIKEN will upgrade its systems by establishing the Management Strategy Committee consisting of the executive board members, industry and external experts of the scientific field in addition to the Committee for Research Strategy for the purpose of enhancing a function of receiving appropriate advice on operations of RIKEN from external sources. The Committee for Research Strategy is operated to effectively and swiftly provide laboratories with advice on specialized matters on research. The Management Strategy Committee is operated to reflect advice on matters concerning the strengthening of laboratory operations and other important matters given to laboratories.

RIKEN will endeavor to strengthen governance of the entire organization by flexibly and swiftly improving its organization and systems and having the headquarters transmit the principles for business management to each unit so that each unit produces the maximum achievements.

## 6. Promotion of initiatives for appropriate business operation

Strategic corporate operations are required to produce outstanding achievements as the world's class research and development organization. In order to achieve this goal, it is of importance to ensure an operation structure in which the President can demonstrate his/her leadership to the fullest extent. RIKEN will enhance a management system that can receive opinions from a variety of experts inside and outside of RIKEN as needed for the purpose of supporting the leadership and judgment of the President from diversified knowledge and experiences. Moreover, it will ensure a flexible and swift budget execution system by establishing an appropriate, effective and efficient business operation system for the entire organization under the appropriate distribution of responsibilities and authorities, enhancing and strengthening internal control, and developing a system to ensure proper enforcement of budget allocation.

### (1) Response to national policies and guidelines as well as social needs

Under the President's leadership and clear missions toward the accomplishment of policy issues, RIKEN will, as a core player of the research and development functions of Japan, address research and development in an organized manner based on innovation policies for science and technology such as the Science and Technology Basic Plan and promote research and development in a strategic and focused manner in response to various social needs.

Moreover, a dedicated organization to collect and analyze information on trends of policies and researches is established with a view to accurately capturing policy and social needs and supporting the Board of Executive Directors, Management Strategy Committee and Committee for Research

Strategy so that such information is appropriately reflected on R&D activities of RIKEN. Moreover, the organization strives to make proposals on policy planning.

Additionally, if any innovative knowledge about science and technology is found or any significant change in national or international circumstances occurs in the science and technology field and it becomes necessary to conduct research and development on the knowledge or to take any other measure, RIKEN will have sufficient communications with Minister of Education, Culture, Sports, Science and Technology to take responses.

Furthermore, RIKEN views science and technology as a part of culture and is intending to widely disseminate knowledge and experiences obtained through research activities and deepen people's understanding on the relationship between science and technology and society.

(2) Compliance and maintenance of the ethics

Acts such as violation of law, fabrication and falsification of papers, plagiarism, harassment and inappropriate execution of research budgets will not be permitted. In order to raise consciousness about illicit acts and ethics and help each employee to acquire a high sense of compliance with norms, RIKEN will undertake awareness-raising activities by repeatedly providing education and trainings necessary for preventing research misconduct such as lectures and legal seminars for the entire organization and regularly check awareness of its employees on research ethics to improve it. Appropriate education programs are offered particularly concerning the prevention of research misconduct. Moreover, based on national guidelines, RIKEN will develop a necessary system such as the formulation of related regulations including the establishment of research compliance headquarters, appointment of persons responsible for education on research ethics, clarification of authority and responsibilities of persons responsible for research misconduct as well as build a system to ensure the reliability of papers and operate it appropriately. RIKEN will transmit information on the progress of enforcement of these initiatives to society.

Furthermore, RIKEN aims to enhance consultation services by providing counseling trainings to counseling staff and holding opinion exchanges between business establishments and by making use of external consultation organizations, and properly and swiftly respond to any suspected misconduct reported through the consultation/whistle-blowing systems within RIKEN.

Additionally, when a research that uses any human-originated material or a research for humans is conducted, it is also necessary to give due consideration to the protection of human dignity from the perspective of bioethics based on opinions of persons other than experts of natural science. In addition, it is important to properly conduct tests on animals taking the viewpoint of welfare into consideration. In conducting this type of business, RIKEN examines scientific and ethical adequacy of researches based on national guidelines and ensures transparency of researches through publicly announcing the contents of such examination.

(3) Implementing appropriate research evaluations and reflecting their results

Evaluations by internationally-recognized external experts are made actively for the purpose of making evaluations on RIKEN's operations and research agendas at an international level. The RIKEN Advisory Council (RAC) is held periodically in order to evaluate the operations of the entire organization and an advisory council is established for each research center to evaluate its research operation. Moreover, all agendas of researches conducted by laboratories are subject to ex-ante and ex-post evaluations, in principle. An intermediate evaluation is made on a regular basis for a research agenda whose period is 5 years or longer when, for example, when three years lapse from its commencement

Evaluation results including review on closure or modification of laboratories are reflected on the allocation of resources such as budgets and human resources and actively utilized to examine measures for revitalizing R&D activities and strengthening research fields that should be further developed. Evaluation results are made available on the RIKEN's website, in principle, to transmit them to the wide public.

RIKEN will strive to grasp the expectations on and needs for the business of RIKEN through lectures for the general public, science café, questionnaire and monitor surveys to reflect them on the business operation from the viewpoint of the public interest.

(4) Promotion of disclosure of information

RIKEN will actively provide information always keeping in mind the responsibility specified in the Act on Access to Information Held by Incorporated Administrative Agencies (Act No.145 of 2001) that it will "endeavor towards greater disclosure of information held by incorporated administrative agencies thereby ensuring to achieve accountability of the Government to the citizens for its various activities." Transparent information particularly on contracted businesses and related corporations is disclosed publicly.

(5) Initiatives conducive to strengthening audit function

RIKEN will enhance an assistant system for strengthening its audit function based on government's principles and strengthen governance of laboratories by building a system that allows it to conduct swift and specialized audits.

## II. Measures to be taken for achieving the objectives on rationalization and improvement of business operations

RIKEN will make efforts for reviewing necessary projects, improving systems and streamlining

business operations by adding originality so that each project is carried out efficiently and rationally. By taking the following initiatives, RIKEN will be committed to reducing its general administrative expenses (excluding special expenses and taxes and public dues) by more than 15% in the period for medium to long-term objectives and improving business efficiency for each business year by more than 1% concerning other business expenses (excluding special expenses). Moreover, care should be taken to the status of accrual of the total amount of debts for government funding for operation in calculating the annual amount thereof (adjusting).

1. Rationalization of the allocation of research resources

Based on the swift decision-making mechanism of the President, research resources such as research expenses are distributed and utilized efficiently from the viewpoint of the entire organization after hearing opinions of external experts. In particular, for strategic and competitive research projects promoted under the leadership of the President, experts will select projects to be promoted in a fair and transparent manner, and the President distributes research resources such as budgets and human resources to those projects based on results of evaluations made by external experts and others.

Moreover, the President shall check the progress of budget execution periodically, and take necessary measures such as review of the amount of budgets allocated to each project depending on the situation. This allows RIKEN to conduct the business effectively and efficiently taking advantage of its potential and characteristics.

2. Rationalization of utilization of research resources

(1) Promotion of informatization

RIKEN is to promote information security measures based on the government's principles to ensure safety and security and encourage utilization of comfortable and convenient information in order to further develop an IT environment that supports R&D activities.

Moreover, RIKEN will upgrade the administrative information infrastructure systems that integrally manage the organization, human resources and accounting systems and information stored in those systems to strengthen system-based internal collaborations and rationalize the business. The introduction of these systems improves security and reduces human errors, and contributes to revitalization of research activities through reducing operational burden in laboratories achieved as a result of labor saving. In the administrative affairs department, its workload is reduced by 2,030 persons/day. RIKEN will accelerate rationalization by means of replacing its employees with human resources specialized in intellectual property, research

ethics, safety management, human resources development and labor management and assigning these human resources to appropriate positions.

(2) Initiatives for cost management

RIKEN will analyze cost management based on propensity to spend and budget implementation plans with a view to ensuring appropriate operations of research projects. Based on its results, RIKEN will efficiently operate its business and formulate appropriate execution plans.

(3) Improvement of capabilities of employees

RIKEN will enhance different types of trainings including skill-up trainings for its employees and management-level employees so as to improve the capabilities of all of its employees and foster as well as secure a diversity of human resources in response to globalization by offering various business experiences and language training courses for the purpose of improving the capabilities of human resources of the administrative affairs department.

(4) Measures for energy saving and utilization of facilities

RIKEN will implement environmental improvement to respond to constant energy saving, endeavor to save usage of electricity, energy and water and control $CO_2$ emissions as well as develop an environment in which the business operation can continue when power saving is requested or in any other circumstance.

Moreover, RIKEN will efficiently promote cross-sectional researches by strengthening a system to adjust the allocation of research space at an organizational level and effectively utilize limited research space.

3. Rationalization of wage levels

RIKEN will take into account the necessity of securing human resources who engage in businesses that need to be undertaken utilizing the world's highest level of advanced expertise and experiences as a specified juridical person who have internationally distinguished capability based on government's principles such as the Basic Principle for Promotion of Research and Development by Specified National Research and Development Agencies (decided by the Cabinet on June 28, 2016).

As for the wage levels (of administrative and technical staff), RIKEN will verify the categories of organization, structure of employees, categories of positions, locations of work and academic background of national public officers and compare such data with that of private businesses after giving sufficient consideration to the capabilities of administrative and technical staff, distribution of

employees and age structure required to execute the business of RIKEN for the purpose of checking whether its own wage levels can be acceptable to citizens. RIKEN will take necessary measures in cases where there is no justifiable reason for maintaining the wage levels and disclose the progress of their verification and these initiatives.

RIKEN will also strictly review the total labor costs based on government's principles.

4. Rationalization of contracted business

RIKEN will perform procurement of goods and services in an effective and expeditious manner taking into account the fact that research and development is conducted under global competition and establish a necessary system for appropriate procurement. A competitive contract method such as general competitive biddings will be used, in principle, for concluding contracts. RIKEN will ensure sufficient fairness and transparency by steadily taking initiatives based on the Procurements Rationalization Plan, and, in cases where a discretionary contract is concluded, disclose reasons therefor. Moreover, RIKEN will ensure required performance and effectively and efficiently undertake procedures for contract adapted to the characteristics of research and development, and perform procurement of goods and services giving due consideration to costs and the appropriate balance between quality and price. At the same time, RIKEN will strive to do its best to properly take the above initiatives and take necessary measures after verifying the progress of those initiatives.

5. Securing of sponsored funds

RIKEN will notify the entire organization of information on public offerings, status of application therefor, and the rate of adoption with the aim of actively acquiring competitive funds and raise awareness of researchers. Moreover, RIKEN is intending to acquire further sponsored funds by prompting funded researches, joint researches and receipt of contributions from industry with the aim of increasing own revenue. In particular, in order to acquire sponsored funds given in response to individual applications, RIKEN will strengthen focused guidance and support for foreign researchers who are not familiarized with how to acquire sponsored funds in Japan.

6. Securing of safety of business

In conducting its business, RIKEN will comply with laws and regulations and take sufficient note of safety.

III. Budget (including the estimation of labor costs), revenue and expenditure plan and financial plan

See Appendix 4.

IV. Limit on the amount of short-term borrowing

The limit on the amount of short-term borrowing is 21 billion yen. Short-term borrowing are assumed when receipt of administrative cost subsidy from government will be delay at the beginning of fiscal year or there will be tentative advanced payment of costs coming with commissioned business.

V. If the agency has any unnecessary property or any property that is expected to be unnecessary, a plan therefor

RIKEN will transfer the Itabashi Branch for which a decision of abolishment has been made during the period for medium to long-term objectives according to the provision of Article 46-2 of the Act on General Rules for Incorporated Administrative Agencies, and pay the amount calculated by the competent minister within the amount of revenues generated thereby to the national treasury.

VI. Plan to alienate or dispose of any important property

There is no plan to alienate or dispose of any important property other than unnecessary properties or properties that are expected to be unnecessary property.

VII. Use of surplus

When there is any of surplus in its settlement of account, it will be credited to the following:

- expenses for priority research and development
- expenses for energy measures
- expenses for intellectual property management and technology transfer
- expenses for improvement of the capabilities of employees
- expenses for maintenance of research environment, and
- expenses for public relations activities conducted by RIKEN.

VIII. Other matters on business operations thereof specified by ordinance of the competent

ministry

1. Plan for facilities and equipment

It is necessary to keep and maintain favorable research environment at all times with the objective of improving the standard of research and development business of RIKEN and growing as the world's highest level research and development center. To this end, RIKEN is to effectively utilize existing research facilities and facilities/equipment to be installed during the period for medium to long-term objectives and systematically focus on modification, renewal and maintenance of facilities and equipment including measures against their deterioration. Moreover, RIKEN will undertake procedures for lodgings for its employees for which a decision of abolition has been made giving sufficient consideration to smooth move of residents.

It could be that any modification, renewal and maintenance corresponding to research and development which is necessary to achieve the medium to long-term objectives or safety measures which become necessary due to deterioration will be added to the plan.

2. Plan for personnel affairs

(1) Principle

RIKEN will secure talented human resources, assign employees to appropriate positions and improve the capabilities thereof for the purpose of efficient and effective promotion of business operation. Also, RIKEN will continue to utilize fixed-term employees so as to revitalize and efficiently promote researches and promote the introduction of the cross-appointment system.

(2) Personnel indicators

RIKEN will rationalize its business and strive to properly allocate employees based on the scale of business.

3. Debt burden beyond the period for medium to long-term objectives

Debt burden for developing research infrastructures will be executed where the construction of research infrastructures exceeds the period for medium to long-term objectives, and when necessity of debt burden act is judged to be reasonable upon taking into account the effects on financial plans.

4. Use of reserve funds

In case where reserve funds remained at the final year of previous period for medium to long-term objectives after accounting settlement specified under Article 44 of Act on General Rules for Incorporated Administrative Agencies, the amount approved by Minister of Education, Culture, Sports, Science and Technology, will be used for the followings;

- Expenses for priority research and development, expenses for energy measures; expenses for intellectual property management and technology transfer; expenses for improvement of capabilities of employees; expenses for maintenance of research environment; and expenses for public relations activities conducted by RIKEN, as defined in use of surplus in the medium to long-term plan;
- Accounting settlement on undepreciated balance equivalent amount of fixed properties acquired by its own revenues;
- Payment of consumption tax accrued in the period for medium to long-term objectives among consumption tax returned in the previous period medium to long-term objectives.

[Appendix 1] Promotion of strategic and focused research and development based on national and social needs

(1) Emergent matter science

Innovation of energy use technologies which are not on an extension of the existing technologies but are based on a completely new concept is required to create green innovation through environmental and energy technologies. Solid/molecular assemblies and nano devices can present physical properties or functions which cannot be explained as a mere assembly of individual constituents such as electrons, spins and molecules. Under such a new concept of emergent matter, RIKEN will promote research and development on device technologies that revolutionarily reduce power consumption and technologies which convert energy with high efficiency by means of creating completely-new academic theories different from traditional science and technology through organic collaborations of such fields as strong correlation physics, supramolecular chemistry and quantum information electronics, and by means of obtaining huge emergent response and phenomenon from a small quantity of electricity, magnetism or thermal stimulation.

Moreover, as a core research and development center of matter science of Japan, RIKEN will gather world-class researchers and promote concentrated researches and comprehensively promote initiatives for fostering human resources who have higher and international visions and lead next-generation researches on emergent matter science in collaboration with domestic and overseas research institutes, universities and businesses and for converting cutting-edge research and development outcomes into the basis for future industrial technology development.

(i) Strong correlation physics

This type of researches aim to explore an academic theory of expression of the emergent function presented by the strongly correlated electron system in which a large number of electrons strongly repel each other in a solid and discover principles of innovative energy functions. That is, this research aims to reveal ultralow-loss energy transport surpassing the existing semiconductor technologies and the ultrahigh-efficiency mutual conversion mechanism of energy such as light, electricity, magnetism and heat.

These researches help magnetic information carriers to be developed which are stable in property against impurities and flaws in this period for medium to long-term objectives toward the realization of ultralow-power consumption magnetic memories and to accomplish magnetic information control at a current density which represents an indicator of power consumption by lowering it by 5 digits or more than that of the existing metallic materials.

(ii) Supramolecular chemistry

This type of researches aim to establish a basic academic theory on a supramolecular function which expresses a desired function by means of designing a structure of organic and high-molecular compounds from the molecular level and organizing them hierarchically and develop environmental load-reducing high-function materials which increase the efficiency of energy conversion, transmission and storage. Moreover, RIKEN will create a methodology of kinetic control and structure control of the process which seamlessly connects from molecules to the macroscopic scale for the purpose of improving the performance of materials.

These researches develop practical electronic devices such as organic solar cells. In particular, for organic solar cells with the function of autonomously forming a structure by means of material design from the molecular level, a conversion efficiency of around 10% will be achieved during this period for medium to long-term objectives.

(iii) Quantum information electronics

For the purpose of developing devices and computer systems which operate based on the principle of quantum mechanics as technologies to safely process information which is increasing explosively along with the dissemination of information and communication technology keeping energy consumption at a minimum level, RIKEN will strive to discover basic principles for quantum computing, quantum relays and quantum nano-devices and carry out technology development through controlling the quantum state of semiconductors and ultra-conductors optically, electronically and magnetically.

These researches realize the transition from current 2-quantum bit calculation to 5-quantum bit calculation including correction of flaws during this period for medium to long-term objectives with a view to future expansion to large-scale quantum computing to realization of quantum computers.

(iv) Integrative projects through academic-industry collaborations

RIKEN will integrally conduct cross-sectional project researches toward the realization of high-efficiency energy conversion and ultralow-power consumption electronic devices such as research and development on thermoelectric conversion materials and electronics with minimum energy loss. Moreover, RIKEN will design a material theory and conduct demonstration experiments with a focus on energy function of new types of functional materials such as topological insulator (the inside is insulator but current whose loss is extremely low flows on the surface and interface) as well as aims to realize during this period for medium to long-term objectives an electric factor of $50\,\mu\,W/cmK^2$ of strongly correlated thermoelectric materials which is a branch point of practical application.

Talented human resources who can play a leading role in researches in the future are fostered in

collaboration with domestic and overseas universities and research institutes through providing courses in cooperation with universities, forming forums by young researches and holding workshops. Furthermore, RIKEN will mutually understand needs and seeds of new industrial fields in collaboration with other organizations and agencies that engage in applied research and industry for the purpose of using cutting-edge research and development outcomes in emergent matter science as a basis for future research and development, and promote advanced research and development to effectively transfer their results.

(2) Sustainable resource science

Toward the realization of a sustainable society where cyclical use of environment-friendly resources and energy is possible, RIKEN will promote advanced researches which integrates plant science, microbial chemistry, chemical biology and synthetic chemistry based on understanding on diversified bio functions and chemical functions, and thereby contribute to the creation of useful resources and technological innovation of high-efficiency resource production systems. To this end, RIKEN will promote three systematic projects researches on “carbon,” “nitrogen” and “metals” and research and development with the aim of cyclically using such resources as carbon which continues to be consumed as petrochemical products, nitrogen which is indispensable for life activities and rare metal elements, and promote research and development by building a world-class metabolome analysis infrastructure and a strong infrastructure constructed as a results of enhancing and integrating the natural chemicals banks.

Moreover, RIKEN will review trends of related projects and social needs of industry in order to effectively transfer researches to domestic and overseas universities, research institutes and businesses. Furthermore, RIKEN will build organic cooperative relations in terms of strengthened function of the chemical engineering field and of field tests on useful plants so as to use research and development outcomes for the benefit of society. In addition, talented human resources who engage in researches in the environmental resource field are fostered to strive to raise RIKEN’s scientific and technological capabilities of this field.

(i) Researches on technologies for cyclic use of carbon

RIKEN aims to realize the production of biomaterials by photosynthesis and of chemical products by catalytic chemistry toward recycling of $CO_2$ in the atmosphere. These researches aim to develop techniques to strengthen the photosynthetic function which is the basis for fixation of $CO_2$ and control the material production and preservation functions through maneuvering metabolic pathways of plants and microorganisms, and to identify around 10 target genes whose photosynthetic function and production of useful metabolic products such as fat are to be improved. Moreover, RIKEN will develop a new direct synthesis method of carboxylic acid

which is used as raw material of chemical products from carbon dioxide and oxygen by means of searching metal complex catalyst as well as environment conscious oxidation reaction without using harmful oxidizing agents.

(ii) Researches on technologies for cyclic use of nitrogen

RIKEN will create resource-saving plants which can grow rapidly with little fertilizer for the purpose of reducing the usage of nitrogen fertilizer whose consumes enormous energy in production and aims to find a new method of fixing nitrogen with low energy.

RIKEN will, through these researches, look for genes which involve in absorption and assimilation of nutrients, environmental tolerance and disease resistance of plants and discover their controlling mechanism in order to realize high growth under the conditions of little use of fertilizer (nitrogen / phosphorus) and water saving in this period for medium to long-term objectives. Moreover, RIKEN plans to design and synthesize metal complex which can synthesize ammonia from nitrogen and hydrogen under mild conditions so as to innovate ammonia synthetic reaction which requires high temperature and high pressure (500 degrees and 300 atmospheric pressure) and discover the optimal reaction conditions through fixing molecular complex to carriers, thereby improving production efficiency of ammonia.

(iii) Researches on technologies for cyclic use of metal elements

RIKEN aims to realize the efficient collection of rare metals based on biofunctions and develop innovative catalysts taking advantage of specific characteristics of elements.

RIKEN will, through these researches, look for plants and microorganisms with the capabilities of preserving heavy metals and rare metals and find out their metal selectivity and preservation mechanism in this period for medium to long-term objectives. Moreover, RIKEN will conduct research and development on efficient resource recovery techniques with low environmental load and environmental restoration techniques utilizing biofunctions and establish three or more types of metal separation/recovery systems. Furthermore, RIKEN will design and synthesize metal complex catalysts based on innovative molecular design taking advantage of a diversity of reactivity of rare earths and transition metal elements and create new types of recyclable catalysts with high activity and selectivity utilizing universal elements.

(iv) Establishing research infrastructures for search of cyclic resources and for researches using them

RIKEN will develop infrastructures to analyze diversified metabolites of living organisms, their metabolic pathways, and genes as well as strengthen its research infrastructures for production and use of biological resources by upgrading techniques for searching and assessing

physiologically active substances conducive to discovery and improvement of biofunctions in large volume and at high speed.

RIKEN will identify or annotate around 1,000 types of metabolites and construct a database for efficient artificial synthetization of biological chemicals using plants and microorganisms for which chemical synthetization is difficult to achieve. Moreover, around 50,000 chemicals accumulated in the RIKEN's research infrastructures are provided to domestic and overseas universities, research institutes and businesses.

(3) Brain science research

Comprehensive brain science research is integrated science which constitutes the basis for understanding of humans beyond the traditional boarders of natural science and humane/social science. Its achievements have scientifically-important values and greatly contribute to social, economic and cultural development. Moreover, in recent years, the number of patients of mental and neurological diseases such as dementia and depression has increase and the social importance of response thereto has increased. Therefore, research and development to combat these diseases is expected.

Taking into account these social needs, RIKEN will, as a core research and development center for brain science in Japan, play a leading role in researches on brain science which integrate different fields as concentrated and strategic researches based on discussions at the Brain Science Committee established under the Ministry of Education, Culture, Sports, Science and Technology.

International researches on brain science conducted in the past have made it possible to discover higher brain functions such as mind and intelligence and the mechanisms of cerebral and neurological diseases by controlling neural circuits. RIKEN will give priority to "discovery of neural circuit functions" as its core research theme using such a comprehensive and multilayered approach from molecules which control neural circuits to individual organisms. Moreover, RIKEN will develop advanced fundamental technologies which bring about a breakthrough in researches on brain science and clarify "brain function in the healthy state" and "brain function in the state of disease" by comparing these functions. RIKEN will actively employ young researchers and effectively and efficiently manage researches by deciding the distribution of resources based on strict evaluations in accordance with its research strategy that it conducts researches on those four fields as an academic research project. These initiatives allow the complete brain mechanism from molecules through neural circuits to the heart to be decoded.

(i) Research to clarify neural circuit function

RIKEN will enable the measurement of actions of individual organisms and behaviors of neural cell assemblies by making use of laboratory animals such as mammals, fishes and

invertebrates and gene manipulation techniques for the purpose of clarifying their operating principles such as how to control actions of specific neural cell dynamics. A mechanism of formation, maintenance and plasticity of neurite growth cone and synapses is clarified at the molecular level, and a technique to control target neural circuits is further developed to find out a causal relationship between activities and actions of specific neural circuits. To be more specific, RIKEN will (a) improve the multielectrode recording method which can make a simultaneous record only with dozens of cells whose type is unknown and the neural activity visualization method in order to measure and analyze neural activities in hippocampus, cerebral cortex, basal ganglia and the limbic system in large scale, and realize activities of more than hundreds or thousands neural cell assemblies and their interaction after identifying cell species. Moreover, large-scale four-dimensional imaging of neural circuits with time base is realized by applying the above technique to animals that actuate under actual experimental environment and virtual reality environment similar thereto. One or more activity patterns of neural cell assemblies that appear in close relationship with memory, recognition, behavior control and emotional control will be identified by analyzing synchrony of actions and behaviors of specific neural cell assemblies and interactions between them in these regions using the above technique; (b) specifically control activities of neural cells related to information processing, memory and behavior control of sensory input changing timing and cell species by means of improving techniques for gene manipulation, optical genetic and introduction of virus vector genes for the purpose of analyzing effects of this manipulation on actions. A causal relationship between operating characteristics of specific neural cells and their behaviors is confirmed based on results of such analysis. In addition, a mathematical model on operating characteristics of neural circuits is utilized to demonstrate that activities of specific neural cell assemblies observed along with the behaviors mentioned in the research theme (a) cause corresponding behaviors, hereby, one or more mechanisms in which recognition, learning, emotions and decision making are controlled by neural networks consisting of neural cells are identified; (c) conduct researches on mental and neural disease model animals and analyze what type of functions candidate factors and candidate neural circuits of etiology revealed as a result of genetic analysis of patients and tests on mental and neurological-disease model animals have in normal neural circuits, and find out what type of abnormalities in operations of neural circuits is caused by such dysfunction and how it results in the appearance of disease; and (d) develop a technique to accelerate recovery after neural damage and to treat a brain with developmental disorder based on the understanding of dynamics of neurite growth cone and synapses at the molecular level.

(ii) Research to clarify brain functions and actions in the healthy state

RIKEN will, in order to clarify mechanisms of such higher functions as behavior control, concept formation, sociality and language, interpret higher brain functions through identifying the functions of each field or region and deciding information to be processed and interactions between regions by means of conducting researches based on functional block using animal models of monkeys, etc., records of neural cell activities which are carrying out any task and imaging researches using humans. Specifically, RIKEN will (a) clarify behavior control by the frontal lobe in purpose-oriented actions and create a function model of behavior control in purpose-oriented actions and a function-sharing map; (b) clarify expression of semantic concept by neural cell assemblies in the temporal lobe, and identify a mechanism of expression forming in the brain of semantic concept and abstract concept by revealing changes of bodily expression caused by the use of tools in the parietal lobe; (c) specify a mechanism of large-scale networks of socially-cooperative behaviors by means of analyzing neural activities in behaviors performed in relation to others with a particular focus on interactions between fields or regions; and (d) reveal the language learning process using rhythm by means of observing behaviors and measuring neural activities of infants in their developmental process. This process dissolves higher and complex brain functions such as action plans, concept formation and sociality into element and process and leads into researches on neural circuit functions mentioned in (i) and clarification of underlying symptoms of mental diseases and developmental disorder mentioned in (iii). Moreover, RIKEN will present knowledge to allow humans to live a more comfortable life by bringing out their higher cognitive ability in rearing of infants, language development process and human-machine system design.

(iii) Research to clarify brain functions and actions in the disease state

RIKEN will clarify a pathogenic mechanism of mental and neurological diseases based on abnormal functions of neural circuits utilizing knowledge obtained from researches on neural circuit functions mentioned in (i) and researches conducted in the healthy state mentioned in (ii), and establish basic knowledge for the development of therapies. Specifically, for depression, RIKEN will develop model mice that repeatedly present voluntary depression state and can be used to develop therapies and prophylaxes, specify any alteration of shapes of dendrites and spines of neural cells caused by the state of depression which contribute to biological diagnosis classification of depression, and identify circulating metabolites that fluctuate depending on the state of depression and are applicable to screening tests on depression. As for neurodegenerative diseases such as Alzheimer's, RIKEN will develop model mice that reflect clinical conditions, analyze a mechanism from the accumulation of responsible proteins to neurodegeneration, and establish new principles for therapies that can be seeds of development of breakthrough medicines including the development of a method of accelerating decomposition of substances

accumulated in the brain due to Alzheimer's. With regard to developmental disorders such as autism, RIKEN plans to clarify clinical conditions of model mice at the synapse level and develop new model mice based on human genetics. Furthermore, one or more diversified common pathological pathways of autism, which may lead to development of therapies, are identified. For schizophrenia, target molecules for discovery of new drugs are identified by building upon phenotypic analysis of mice which may lead to development of new medicines with effect profiles which traditional psychotropic drug do not have.

One or more these research and development outcomes are translated into clinical researches with the aim of conducting clinical tests and granting license to businesses.

(iv) Development of advanced fundamental technologies

RIKEN will develop world-class research support technologies required to clarify brain and neurological mechanisms. Specifically, RIKEN will develop an optical imaging technology which simultaneously visualizes neural activities and other phenomena in the brain of living mice, and establish a fundamental technology which analyzes neural circuits from multifaceted perspectives by combining it with optical control techniques. With respect to a technology to visualize neural activities and other phenomena from the brain surface in the whole brain of mice, a depth of over 2mm, which is the longest operating distance of current commonly-used objective lenses, will be achieved to evolve into a technology to analyze functional communications between surface layers such as cerebral cortices and deep structures such as the thalamus and the hippocampus. By incorporating fluorescent protein to be newly developed into these technologies, RIKEN aims to disseminate them for practical application. Furthermore, it will establish a imaging technology of wider and deeper parts through combining fluorescence and luminescence with optical CT (computed tomography) and MRI (magnetic resonance imaging) as well as a high-resolution imaging technology combining fluorescence and luminescence with an electronic microscope, and develop a unique advanced fundamental technology which is capable of zooming in detailed parts of the brain but at the same time capable of zooming out of the whole individual organism. This technology makes it possible to functionally investigate a coordination of activities which occur in various regions in the brain and a connection of activities inside and outside the brain.

Moreover, RIKEN will proceed with researches conducted based on organic collaborations with domestic and overseas universities, research institutes, businesses and research projects, provide and disseminate research and development outcomes, fundamental technologies and research materials, and foster human resources who contribute to the development of the brain scientific field. These initiatives allow RIKEN to lead the research and development centers in Japan as a core research and development center of brain science, to build a research

environment where foreign researchers can play an important role, and to continue to transmit cutting-edge and creative research and development outcomes to the world.

(4) Comprehensive developmental biology

The comprehensive developmental biology builds upon achievements made so far so that dynamics of life phenomena in development and regeneration can be understood, and establishes an academic infrastructure for medical application based thereon. In the third phase, in addition to three areas related to development and regeneration, RIKEN will establish a new multidisciplinary research area called “emergent biology” to clarify behaviors that appear for the first time when a number of cells form a group such as self-assembly. Physical and mathematical approaches are also introduced to specify principles for developmental dynamics which decide shapes of organs and a mechanism of growth control which decides size of organs. These approaches establish “artificial control techniques of cell populations” and “in-vitro regenerative techniques of genesis phenomena” which enable advanced realization of regenerative medicine. Moreover, RIKEN will actively take initiatives for developing these basic research achievements into actual medical application and industrialization, while it will, as one of the core centers in the Kobe Biomedical Cluster, strengthen mutual collaborations with domestic and overseas universities, research institutes, research hospitals and private businesses. Furthermore, RIKEN will carry out technology transfer and provide support, and focus on nurturing of researchers of next generation through joint graduate school programs, summer schools and acceptance of researchers from businesses.

(i) Field to look for the embryogenic mechanism

In an animal embryo, the differentiation and proliferation from one fertilized egg progress spatially and temporally, and a complex organization is formed autonomously. However, in the embryogenic process, a dynamic program for many types of cells to become differentiated “at a right place at a right time” has not been fully understood yet. Therefore, RIKEN will clarify a differentiation control system which is programmed in a complicated manner at a place of development through introducing the latest imaging technologies and advanced analysis methods such as the profile technology of single-cell gene expression and epigenome analysis. A basic principle allowing accurate differentiation patterns to be formed in an animal embryo is clarified, in particular, at the genetic and cellular levels by comprehending control signals of undifferentiated cells and differentiated cells of ectoderm, mesoderm and endoderm spatially and temporally. This clarified principle contributes to the development of accurate differentiation-inducing techniques from stem cells and of control techniques of transdifferentiation between differentiated somatic cells and blast transformation from mature cells, and specify operational principles for spatiotemporal of gene networks required to form

early mouse embryos.

(ii) Field to look for the principles for the development of organs

RIKEN will specify accurate structures of biological organs based on operational principles for stem cells and differentiating cells. To be specific, RIKEN will specify a system to control adhesion, deformation and migration of cells caused by genes and proteins, principles for formation of tissue polarity, a molecule entity in the tissue microenvironment in which tissue stem cells are formed and maintained, a molecule entity of interactions between epithelial tissue and mesenchymal cells and extracellular matrix required for the development of organs, and principles for coordination between the development of several organs in the process of development of individual organs. From FY2015 to FY2017, control principles for the formation of such organs as the trachea, follicle, intestine, musculoskeletal system, genital and brain is clarified from the above viewpoint, and more universal operational principles are investigated in collaboration with the emergent biology research mentioned in ④ below.

(iii) Field to develop and heal organs

RIKEN will apply research and development outcomes obtained from (i), (ii) and (iv) to the culture system of such stem cells as human iPS/ES cells to develop highly-functioning tissues and basic units of organs in vitro. Specifically, RIKEN will build tissues such as the pituitary and lens similar to living organisms by FY2015 and develop artificial tissues which imitate human clinical conditions in this period for medium to long-term objectives. Moreover, in close collaboration with businesses, RIKEN will proceed with upgrading of steric culturing techniques obtained in previous researches on the retina, etc., and establish fundamental technologies conducive to regenerative medicine and drug discovery by applying those techniques to other organs. RIKEN will actively contribute to practical application utilizing integrated research and development facilities to be established in proximity to RIKEN in FY2013. Furthermore, RIKEN will build and operate support facilities necessary for preclinical researches and clinical tests, and promote clinical tests on regenerative medicine for retinal disease and other diseases in cooperation with neighboring research hospitals for the purpose of realizing clinical application at an early stage. RIKEN will, in particular, initiate treatment of age-related maculopathy using transplantation of retinal pigment epithelial cells within 12 and 18 months after it is approved by a RIKEN's ethical review and a government's review.

(iv) Emergent biology research area

How macroscopic shapes and sizes of organs and tissues are decided accurately based on genome information of each animal is an unsolved underlying issue in biology. With a view to

finding out an answer to this issue, RIKEN will explore a multidisciplinary research area called "generative biology" to analyze "emergent operating principles by interactions between cells in multicellular assemblies" as a dynamic multilayer system. More specifically, RIKEN will develop a technique to measure interactions between cells in the tissue formation process from stem cells, and clarify mechanical characteristics of tissues which decide their "shape" and "size" and proliferation control. Moreover, RIKEN will establish an advanced control approach by introducing mathematical models and simulations in order to analyze an enormous volume of information obtained from the above measurement and to discover basic principles for control of complex "shapes." Systematic understanding of emergent biology contributes not only to basic researches on embryogenesis and evolution but also to the formation of fundamental academics which dramatically advance medical application of organs and tissues such as regenerative medicines, and specify operating principles for interactions between cells which decide shapes and sizes in generative phenomena such as the formation of the retinas, corneas, cerebrum, trachea, follicle and blastocyst.

(5) Life science research

The research on life dynamics system science is considered as an important area which significantly contributes to the creation of various types of life innovation such as regenerative medicine, development of new medicines and prediction of clinical conditions. Moreover, as the needs for integrative techniques not limited to life science have been increasing rapidly in international researches, this is a research area which is expected to strengthen international competitiveness of Japan by nurturing human resources who can take responsibility of integrative areas.

In order to clarify and control complex self-control systems of life, RIKEN will regard life as a system and capture dynamics of complex ever-changing life phenomena from both theory and calculation. Moreover, RIKEN will establish an organic collaboration system of researchers having diverse backgrounds such as biology, information science, engineering and physics and promote quantitative biology research with the aim of dynamic understanding of life activities and establishing artificial controlling techniques by means of making verifications through experimental reconfiguration in simplified systems and creating new systems.

The quantitative biology research sets forth three research areas; namely, cell kinetic measurement, life modelling and cell design.

(i) Research on cell kinetic measurement

Individual cells are not uniform, and they change significantly. However, they have been captured uniformly. A research on cell kinetic measurement aims to capture the ever-changing

state of individual cells and to clarify a system of expression of unique cell functions. Moreover, it aims to provide feedback obtained in line with the time axis to researches on life modeling and cell design to improve understanding on cell dynamics.

To be specific, RIKEN will develop techniques to make high-sensitive quantification measurement and analyses from molecular dynamics in one cell to cell dynamics in one tissue beyond layers. Particularly, the RIKEN will develop a probe for measurement of dynamics of biological molecules in cells and a measurement technique of one molecular dynamic in cells so as to clarify a mechanism of expression of functions of intracellular molecule systems at the one-molecular level. Moreover, a quantification measurement technique is developed to analyze metabolic products along with changes in the state of cells.

The combination of these techniques realizes dynamics measurement of one intercellular molecule at 250nm and 33 milliseconds of space resolution and time resolution in relation to around 100 molecular types which have not been made before. Moreover, RIKEN will strive to apply these techniques to researches such as prediction of clinical conditions and regenerative medicine by improving space resolution and time resolution of the techniques to measure dynamics of one molecular in cells of individual organisms to 500nm and 100 milliseconds.

(ii) Research on life modelling

It is considered that the characteristics of cells and their changes by time are caused by dynamic diversification of molecules in cells and molecular networks. Therefore, the research on life modeling aims to quantitatively understand and duplicate cell dynamics from the molecular level based on cell modelling and simulations.

RIKEN will conduct integrated research and development on molecular design and behavior prediction and techniques to simulate molecular dynamics, intracellular biochemical reaction paths and cell-to-cell interactions under the cell environment in order to convert an enormous volume of data into mathematical models using high-performance computers and to establish a method of quantitatively handling complex life systems. RIKEN will particularly make dynamic prediction of protein-1 molecules by developing molecular simulation techniques at a scale of reaction time of life-giving molecules and dedicated computers, and disseminate a kinetic simulation technique for protein molecules which can calculate at an order of millisecond obtained as a result of the above prediction. In addition, RIKEN will establish a simulation technique for intracellular reaction networks taking movements of each molecule into consideration, realize dynamic prediction of intracellular reaction based on such calculation results, and disclose a simulation platform to be established.

(iii) Research on cell design

It is required to artificially reconfigure life phenomena in an individually-controllable manner and test them in order to understand dynamic and complex life phenomena like cells. A research on cell design aims to develop fundamental technologies to adjust, design and control elements for life such as genes and proteins with a view to understanding the principles for characteristic movements and design of quantitative biology. RIKEN will, in particular, toward design and control of intracellular gene network dynamics, realize design and control of dynamic molecular networks responsible for cellular functions by developing a new DNA synthesis method to freely design and connect sequences in cut and bonded sites and a quantitative method of proteins based on the high-speed and parallel synthesis of peptides and proteins by means of the cell-free synthesis system.

For the purpose of disseminating the DNA synthesis method and quantitative method of proteins to be developed, RIKEN will conduct joint researches with domestic researchers from the prototype stage so as to realize adjustment, design and control in accordance with various purposes.

RIKEN will, with a focus on the above three research areas, create models and conduct mathematical analyses based on measurement results in each layer of life phenomena such as cells and intends to quantify the state of the complicate systems, as well as connect layers of molecular networks and cells. Moreover, it will establish a roadmap to clarification and control of the operating principles for quantitative biology, in particular, cell systems, by allowing verifications to be made through reconfiguration. This allows RIKEN to earn its position as a world-class research and development center which plays a leading role in cellular modelling and manipulation techniques, and accelerate the medium to long-term development of this research field. Once it becomes possible to establish a model of and manipulate cells in the dynamic state, they are expected to contribute to diagnosis and treatment concerning the control of initialization and differentiation of iPS cells and conversion of cells into cancer.

Moreover, RIKEN will disseminate research and development results and fundamental technologies and promote joint researches by proactively participating in conferences which help it to advance researches with domestic and overseas universities, research institutes and businesses based on organic collaborations, and foster human resources through lectures in order to attract young researchers to this research field and expand its base. These initiatives help this research field and integrative fields to progress.

(6) Integrative medical sciences

This research aims to realize next-generation medical care targeting tailored medical care and preventive care through exploiting achievements of comprehensive researches on genome medical science and allergy science in the second phase. In order to achieve this goal, RIKEN will establish a

system to integrally conduct medical science researches on diversity of diseases toward the realization of tailored medical care and preventive care, integrative analyses of disease expression process toward the realization of innovative preventive care, researches on homeostatic medical science and researches on innovation toward the creation of innovative medical techniques based thereon.

(i) Medical science research on diversity of diseases

RIKEN will build research infrastructures to comprehensively analyze the diversity of human genomes and conduct research and development toward the realization of tailored medical care and preventive care through analyzing genetic and environmental factors involved in expression and progress of multifactorial diseases.

In order to realize medical care and preventive care based on individual genetic information, it is necessary to develop a comprehensive analysis technique of personal genomes, clarify the diversity of human genomes by means of comprehensive genome analyses, collect fundamental information applicable to medical researches and medical care, and find out a relationship between the diversity of human genomes and expression/progress of diseases and responsiveness to drugs. In this research area, RIKEN will develop tailored medical care and preventive care by means of conducting genome analyses targeting not only SNP but also all base sequences with a main focus on the diversity of diseases which need to be tackled urgently in society and attract the attention of citizens (cancer, cardiovascular diseases and lifestyle-related diseases including diabetes) and of responsiveness to drugs, and establishing a research infrastructure for analyzing genomes of the Japanese people involved in diseases and responsiveness to drugs utilizing the mathematical analysis techniques to comprehensively analyze a number of genetic and environmental factors. In this period for medium to long-term objectives, RIKEN will establish a database covering more than 1% of gene polymorph of genomes of the Japanese nation.

(ii) Integrative measurement and modelling research

The modelling of the process of onset of diseases at an individual organism level from information on disease-related genes is essential in order to unravel disease morbidity from genome information. Conducting individual researches based on the traditional reduced approach or researches focusing on specific layers is not sufficient. It is required to conduct quantitative analyses in various layers and connect layers by adding meanings thereto.

To this end, RIKEN will establish new informatics and metrology infrastructures which link medical science researches on diversity of diseases and those on homeostatic medical science and develop a technology to extract networks of functions which constitute the basis for

homeostasis by means of multidisciplinary approaches including the systematic production of disease-specific model mice, measurement of integrated genomics and mathematical modelling with a focus on the process of expression of intractable immunological allergic diseases. Whether or not these networks work on humans will be verified in collaboration with researches conducted using disease humanized mice and disease-specific iPS cells and genome cohort researches. RIKEN will complete the establishment of a system to integrally measure specimens, establish a network extracting system through modelling by FY2016, and submit a multilayer model of onset of dermatosis on which previous researches have been built.

(iii) Homeostatic medical science research

We need to comprehensively understand the expression process of diseases from the immune system which constitutes the basis for homeostasis to environmental factors so as to realize innovative preventive care,

This research area aims to specify the expression process of intractable dermatosis, autoimmune diseases, primary immunodeficiency disease, allergies, infectious diseases, lifestyle-related diseases linked to such chronic inflammation as diabetes and arteriosclerosis and inflammatory bowel disease with a principal focus on diseases which present similar clinical conditions by genetic mutation in mice and humans. Specifically, RIKEN will establish and verify a multilayer model which explains each disease expression process in collaboration with the integrative measurement and modelling research, and look for expression predictive markers, treatment and prognosis predictive markers, targets of treatment and principles therefor, and develop treatment technologies based on the results obtained by converting the disease expression model demonstrated by using model animals into humans using multidisciplinary approaches. RIKEN will verify a model for dermatosis on which previous researches have been built by FY2016 and identify disease expression predictive markers and candidate therapeutic targets until the period for medium to long-term objectives ends. RIKEN will complete in the period verifications on the models for allergies, autoimmune diseases and immunodeficiency disease. The expression models of the immunodeficiency disease, an intractable disease of children, are established, in particular, from causal genetic mutation found out in this report during this period for medium to long-term objectives with the aim of contributing to the progress of researches on diagnosis and treatment of intractable children's diseases.

(iv) Medical innovation program

RIKEN plans to conduct the following projects with the aim of translating achievements obtained in the second phase into the creation of innovative medical technologies.

(a) Developing innovative therapeutic techniques of allergies and handing over them to businesses (by FY2017);
(b) Developing immune cell techniques and next-generation therapeutic techniques of cancers targeting stem cells through developing therapeutic drugs for relapsed leukemia (by FY2017); and
(c) Optimizing the cell standardization technique and differentiation-inducing technique toward the realization of immune cell therapies using iPS cells and conducting research and development toward cell banking based thereon (by FY2017).

(7) Advanced photonics

The development of new optical technologies by means of generating undiscovered lights and active control of lights is essential in order to take advantage of optical engineering techniques as tools to solve social issues. In this field, RIKEN will play a leading role in comprehensively promoting optical science researches in broad wavelength range and realize the generation of lights in the untamed range and ultimate light control techniques conducive to a significant breakthrough in optical science researches and overall researches using lights. Moreover, RIKEN will formulate and promote research and development strategies with the aim of contributing to the solution of important social issues such as diagnosis of deterioration of social infrastructures through techniques realized as a consequence of this advanced photonics research.

(i) Extreme photonics research

RIKEN will create and exploit undeveloped optical technologies and further develop unique laser and fine measurement techniques which have been studied and developed by RIKEN in the past in order to visualize various objects and phenomena which could not be directly observed in the past.

To be more specific, RIKEN will, based on the high-intensity femtosecond laser technique, develop high-intensity attosecond pulse radiation sources using high-order harmonic and explore super-resolution real-time imaging techniques of deeper parts of biological bodies which surpass traditional techniques, monitoring techniques of biological bodies using fluorescent proteins, and new applications thereof.

Based on these researches, RIKEN will develop high-intensity attosecond laser whose wavelength is 13 nanometers by FY2015 and complete an attosecond electronic measurement technique in the period for medium to long-term objectives. Moreover, it will develop a technology to downsize optical lattice clocks to a transportable size in the said period by attaining the precision of errors at $10^{-18}$ seconds by FY2015. Moreover, RIKEN will develop a

real-time imaging technique capable of capturing images up to 1mm of depth with laser microscopes by FY2015, and a new measurement technique using fluorescent proteins in the period for medium to long-term objectives.

(ii) Terahertz photonics research

RIKEN will establish fundamental technologies for more advanced use of terahertz lights such as upgrading of terahertz radiation sources and development and downsizing of new detection systems for the purpose of realizing industrial application and wide use of terahertz lights, and develop a contactless and unrestricted monitoring technique of information on biological bodies based on the understanding of interactions between high-temperature operating techniques of quantum-cascade laser and terahertz lights and biological bodies.

These researches realize 100MV/m of strength of light-collecting electric fields in the terahertz range by FY2015 and non-linear optical phenomena can be observed. Moreover, RIKEN will realize laser oscillation in an untamed range (5~12 THz) using quantum-cascade laser in the period for medium to long-term objectives.

(iii) Development of optical technology infrastructure

RIKEN will establish element technologies for further upgrade of unique laser techniques, cutting-edge optical elements and microfabrication techniques and for non-destructive tests on special materials and large structures and plants using small portable neutron-beam sources for the purpose of developing element technologies for the utilization of untamed radiation sources and ultimate light-control techniques.

RIKEN will, based on these researches, develop small neutron-beam sources for industrial application by FY2015 and develop a technique for observing the inside of concrete structures whose thickness is 50cm at a 1cm of resolution. Moreover, it will develop lasers whose wavelength is variable between 5 and 8 micrometers by F2015 and a technique for varying wavelengths at a higher speed of 1 millisecond in the period for medium to long-term objectives.

(iv) Nurturing of human resources

RIKEN plans to lead this research area by conducting researches from the perspective of practical application in collaboration with domestic and overseas research institutes, universities and businesses and nurture talented human resources who contribute to the expansion of the basis of optical technology field.

(8) Information science and technology

New knowledge is being created from an enormous volume of data in response to the dramatic expansion of networks and the use of cyberspaces due to the progress of information and communication technology (ICT), and the use of IoT (Internet of Things) has been expanding. It is indispensable to develop fundamental technologies which create added values from big data in order to form an ultra-smart society ahead of other countries under such circumstance.

RIKEN will, through exploiting its characteristics as a comprehensive research institute of overall natural science, establish a new research and development center for innovative artificial intelligence (AI) techniques under its global organization that gathers Japanese and overseas researchers and build up a system to promote research in this field.

These initiatives help RIKEN to promote research and development mainly on innovative artificial intelligence techniques which support advanced communication and on cutting-edge technologies in the information science and technology field such as IoT and big data analysis, and develop next-generation fundamental technologies for experiment and practical application by integrating those technologies. Furthermore, RIKEN will contribute to the implementation of a number of applicable areas which create specific social and economic values, deal with ethical and social issues in the society into which AI penetrates deeper, and foster data scientists.

(i) Development of next-generation fundamental technologies

In order to bring about innovation to science and technology and realize practical application in various applicable fields, RIKEN will develop next-generation fundamental technologies which integrate such technologies as IoT and big data analysis based mainly on innovative artificial intelligence techniques learnt from the principles of intellectual activities of humans. RIKEN plans to drastically improve four research techniques, namely, experiment, theory construction, computer simulation and big-data processing through developing and utilizing innovative AI based on research achievements produced in such fields as mathematical science and brain science over which Japan has advantage, and develop ahead of other countries new scientific areas which have not been subject to research.

(ii) Research and development for experiment and practical application

RIKEN will construct a framework in which new knowledge is acquired by analyzing a large volume of high-precision science and technology data over which Japanese research institutes have advantage through the use of next-generation fundamental technologies. Moreover, it will build up a society in which everyone is taken care of by means of applying technologies to the medical and social welfare fields, and explore and promote research and development for the purpose of making contributions to economic growth by the aid of significant improvement of productivity through applying technologies to industrial fields.

(iii) Ethical and social research

RIKEN will explore and promote complex researches including humanities and social science to identify ethical, legal and social issues (ELSI) caused by the progress of research and development on artificial intelligence techniques and prevent such issues so that next-generation artificial intelligence techniques do not threaten existence of mankind or impede social development.

(iv) Nurturing of human resources

RIKEN continues to nurture data scientists who can support the progress of research and development and applicable fields in the field of information science and technology from a medium and long-term point of view and deals with the calling of a new era.

[Appendix 2] Promotion of development and shared use of the world's highest level research infrastructure and of researches using such infrastructure

(1) Accelerator-based science

This research aims to clarify the mysteries relating to the creation of materials by discovering the reality and nature of atomic nuclei and elementary particles which constitute them, advance the application of accelerators to such industries as agriculture and engineering as a research infrastructure, and conduct research and development for upgrading.

By taking advantage of its world's best accelerator device and core experimental facilities to the maximum extent possible, RIKEN will conduct researches aiming at clarifying the mysteries relating to the origin of elements and formulating an ultimate image of atomic nuclei and experiments on synthesis of elements whose number is 119 or higher as researches designed for a new direction of arriving at a so-called "island of stable nucleus," and establish a nucleosynthesis technique. RIKEN will further upgrade the accelerator and other equipment at the RI Beam Factor and transmit outstanding achievements as a global research center for atomic nucleus and particle physics by uniting domestic and overseas researchers of theory and experiment.

Furthermore, RIKEN will conduct creative researches in organic and bilateral collaborations with the Brookhaven National Laboratory in the United States and the Rutherford Appleton Laboratory in the United Kingdom based on international agreements on science and technology cooperation.

(i) RIBF

(a) Promotion of upgrade and shared use

RIKEN is striving to ensure the maximum operating time in order to produce achievements through taking advantage of the world's best collection of RIBF's devices installed in the past. Moreover, it will fairly select research agendas which use RIBF's devices and enhance an organization to accept users by strengthening collaborations with domestic and overseas research institutes.

Moreover, RIKEN intends to maintain its facilities and upgrade them based on the progress of researches conducted in Japan and other countries and of maintenance of facilities so as to smoothly promoting researches by use of RIBF's devices.

As for the RI beam generation system, the strength of heavy element beams will be improved more than 3-fold to assist experiments conducted on untamed RI ranges.

(b) Promotion of researches by use of RIBF's equipment

RIKEN will initiate researches aiming at the generation of ultralong lifetime

superheavy nuclei and the arrival to an island of stable nucleus, both of which are the great goals of nuclear physics. That is, it will conduct experiments on synthesis of elements whose number is 119 or higher which have not been realized so far as a next goal of the synthesis of element 113 to accumulate data leading to the acquisition of its naming right, and establish a nucleosynthesis technique through conducting experiments by use of the measurement device of various particles which is the core experimental equipment.

Moreover, RIKEN will experimentally clarify the nuclear structure near the nucleus which has so-called magic number and push forward the formulation of an ultimate image of atomic nuclei. These researches help us to understand the composition of all atomic nuclei including abnormal nuclear structures which cannot be explained from past understanding. RIKEN will also clarify the characteristics such as mass and life of RI near the path of the r process where elements from iron to uranium are said to have passed when they were formed at the time of the explosion of a supernova through conducting experiments with the assistance of facilities such as the rare RI ring, one of the core experimental facilities, for the purpose of discovering the mysteries of the birth of elements.

Furthermore, RIKEN will continue to promote researches on plant breeding as industrial application and design a system to enhance application of product evaluations to industries in this period for medium to long-term objectives.

In addition, RIKEN, with the aid of its advantage that it counts on the RIBF, intends to produce achievements by uniting domestic and overseas researchers of theory and experiment and by forming a consortium of atomic nucleus and particle physics as well as promote the development of human resources who can contribute to these fields.

(ii) Spin physics research

RIKEN will clarify how proton spins are divided into quarks, antiquarks and gluons by use of the silicon track detecting device and the Muon detecting device installed on the Relativistic Heavy Ion Collider (RHIC) owned by the Brookhaven National Laboratory in the United States (BNL) which is the world's only accelerator capable of conducting experiments on proton polarization collision with the aim of clarifying the proton spin structure. Moreover, it will compare experiment data on those particles with theoretical knowledge based on quantum chromodynamics and conduct verifications so as to acquire knowledge to specify the origin of proton spins.

(iii) Muon science research

In the Muon facility of the Rutherford Appleton Laboratory in the United Kingdom which

owns a proton accelerator (ISIS), RIKEN will measure and analyze an internal magnetic-field structure of materials with the assistance of the world's most precise particle of pulsed beams called muons and clarify the expression mechanisms of such characteristics as superconductivity, magnetism, conductivity and insulating properties of new functionality materials. Moreover, it will upgrade the ultralow-speed muon beam generating technique.

It should be noted that the agreement on this research in cooperation with the RAL terminates in this period for medium to long-term objectives. Where and how researches on this area are conducted after this period terminates will be judged based on circumstances in Japan and other countries.

(2) Synchrotron radiation

(i) Operation and shared use of the specific synchrotron radiation facilities

RIKEN is be responsible for safe and stable operation, maintenance, management, development and upgrading of the specific synchrotron radiation facilities (the large synchrotron radiation facility (SPring-8) and the X-ray free electron facility (Angstrom Compact Free Electron Laser named SACLA)), and allow their shared use for users by providing the world's highest level of synchrotron radiation required thereby.

In particular, RIKEN will continue to allow users to have access to Spring-8 around 80% of its annual operating time by striving to efficiently conduct test and adjustment operations, push forward reviews on its upgrading with a view to producing more efficient and effective achievements taking into account future trends of researches by use thereof, and reflect such achievements in necessary research and development and maintenance.

RIKEN will endeavor to stably operate SACLA through conducting test and adjustment operations in order to figure out its performance and characteristics and aims to make it available to users around 70% of its annual operating time in the period for medium to long-term objectives. Moreover, it will introduce the self-seeding technique and construct the third beam line by FY2013 and proceed with designing and reviews on reinforcement of facilities such as the remaining two beam lines by means of giving sufficient consideration to opinions of users.

RIKEN will, when its synchrotron radiation facilities are provided for shared use, allow them to be utilized by wide users and make efforts for improvement of fair selection of research agendas and of the beneficiaries-pay system (however, usage promotion services provided by registered institution for facilities use promotion when these services are excluded when any of these businesses is conducted).

As for interfacility collaborations, RIKEN will promote the complementary and synergistic use of Spring-8 and SACLA which are located at the same site and provide users with the mutual usage facilities. Moreover, it will promote researches by synergistically using the Japan Proton

Accelerator Research Complex (J-PARC) and the super-computer (K Computer) taking collaborations between registered institutions for facilities use promotion into consideration. RIKEN will particularly develop information infrastructures and establish an infrastructure capable of advanced and high-speed analyses in order to promote collaborations with the SACLA and the K Computer, and thereby upgrading their synergistic use. Furthermore, it will promote the human resources development conducive to photon science with the aim of forming the world's most advanced center through collaborations and cooperation with domestic and overseas synchrotron radiation facilities and X-ray free electron laser facilities.

(iii) Promotion of researches on development of advanced technologies by use of RIKEN's facilities

RIKEN will play a leading role in high-energy photon science through maintaining the world's highest performance of Spring-8 and SACLA and developing and providing tools and know-how conducive to research and development conducted in Japan and other countries as a core center of this field in Japan. Moreover, it will contribute to the creation of innovation with the aid of the both facilities by means of the development, upgrading and general-use of usage techniques and systems and the establishment of collaboration systems with domestic and overseas research institutes.

(a) Research on development of leading radiation sources

RIKEN will play a leading role in global high energy photon science and develop radiation sources equipped with high brightness, high coherence and ultrashort pulses in a range of wavelengths under nanometer and photoregulation techniques.

More specifically, RIKEN will advance designing and reviews with the aim of reaching the diffraction limit of storage ring radiation sources which can have a brightness of 100-fold higher than traditional radiation sources so that Spring-8 is upgraded through taking advantage of its characteristics that it is located at the same site as the world's only X-ray free electron laser facility taking into account trends of plans for upgrading of overseas third-generation large radiation facilities. Moreover, it will conduct technology development and maintenance required as constituent devices of storage rings. Furthermore, RIKEN will explore a possibility of converting deflection electromagnets into permanent magnets as research and development aiming at saving energy by more than 20% compared to the current level.

At SACLA, RIKEN will push forward the improvement of stability of the self-seeding technique and development of other seeding techniques in order to realize stronger and more stable oscillation of X-lay lasers, and realize observation of transient phenomena at the

atomic level (spatial resolution: around 0.1 nanometer, time resolution: less than 10 femtoseconds) and non-linear optics research in X-ray ranges which have not been attainable in the past by use of the world's highest level of beam stability to the fullest extent.

(b) Researches on usage technique exploitation

RIKEN will develop new ways of exploiting Spring-8 and SCALA in order to upgrade researches conducted by use of synchrotron radiation.

It will advance research and development such as analysis of the magnetic state by means of polarization and structural analysis by means of nanocrystal taking advantage of the world's highest level of radiation sources with a view to improving the beam stability at the nano-level from the current level (one hour) to half day. Moreover, it will apply a technique to set the resolution of each dimension in three-dimensional X-ray imaging to less than 10 nanometers to the shared beam lines.

(c) Researches on usage system development

RIKEN will develop and establish advanced systems to use its facilities by integrating different techniques so as to promote researches by broad researchers of RIKEN and other organizations conducted by use of its facilities, and realize their common use as a core center of global high-energy photon science. This helps the cutting-edge beamlines to be maintained and improved.

Specifically, RIKEN will build new usage techniques such as the highly-stabilized nano-level analysis technique and the high-resolution 3-D imaging technique obtained as a result of researches on usage technique exploitation as systems and promote their common use, and demonstrate their usefulness by pushing forward advanced use in broad areas such as biology, material science and high polymer chemistry and by contributing to the production of achievements.

(3) BioResource

Bioresources are essential research infrastructures for promoting innovation in science and technology, and their development greatly contributes to the solution of issues faced by Japan such as health, environment, food and energy.

In the BioResource business, RIKEN will, as a core research center, set "reliability", "continuity" and "leadership" as its basic principles and develop the world's highest level of bioResources in order to meet the needs of diversified users taking into account the viewpoint of quality enhancement, and widely provide national and overseas researchers with such resources. It will also develop fundamental technologies required for maintaining and providing bioResources and conduct

research and development toward the addition of higher values.

Moreover, RIKEN will further bring forward the backup up of bioResources and establish a stable preservation system even at the time of any disaster.

Furthermore, a committee consisting of domestic and overseas academics and experts will be established to promote close collaborations with research communities that develop and at the same time use bioResources.

(i) BioResource development project

RIKEN will achieve the following goals taking the needs of users into consideration concerning laboratory animals such as mice and Arabidopsis, human-derived and animal-derived cell materials, gene materials such as DNA, and microorganism materials such as bacterium, which are important bioResources in the research and development of life science and information related thereto.

| | Number of animals, plants or materials preserved | Total number |
|---|---|---|
| Laboratory animals | 7,000 lines | 14,000 |
| Laboratory plants | 660,000 lines | 10,000 |
| Cell materials | 8,000 lines | 20,000 |
| iPS cells among them | 625 lines | 300 |
| Genetic materials | 3,728,000 lines | 5,000 |
| Microorganism materials | 23,000 lines | 14,000 |

Before the project is to be carried out, RIKEN will give priority to development of bioResources with high social needs or needs of researchers such as disease-specific iPS cells and information thereon, and perform quality management in accordance with international quality management standards and guidelines.

Moreover, RIKEN will provide technical trainings and perform awareness-raising activities for fostering and securing human resources who engage in bioResource projects and for technology transfer in cooperation with such related organizations as universities.

Moreover, from the viewpoint of ensuring global dominance and international cooperation in the bioResource field, RIKEN will participate in international initiatives for the development of bioResources such as the International Mouse Phenotyping Consortium, and play a central role particularly in Asia by performing information exchange, people-to-people exchanges and technical trainings together with related organizations such as the Asian Research Resource Center Network.

(ii) Promotion of research and development-related to bioResources

(a) Project to develop fundamental technologies

It becomes possible for RIKEN to respond to the increase in bioResources by contributing to efficient preservation and transport thereof and securing of safety by means of developing a technique for stably freezing and preserving resources for which no freeze storage technique has been established and a technique for restoring such resources to biological bodies without fail so that high-quality bioResources can be available on a continuous basis.

(b) Research and development programs related to bioResources

RIKEN will develop tissue-specific Cre mice so that the spatiotemporal control of genetic expression indispensable for analyzing gene functions becomes possible, and establish various characterization techniques, analytical platforms and databases and widely provide research communities therewith.

(4) Life science technology infrastructure

RIKEN will, for the purpose of promoting life innovation, promote efficient evaluations of medicines and medical devices by advancing outstanding technical infrastructures of researches on structure synthesis biology, functional genomic analysis and life function dynamic imaging and newly combining them, and contribute to the creation of medicines and medical devices unique to Japan and the realization of tailored medical care. Moreover, it will create new techniques to measure and analyze molecular functions that maintain life at the atomic, cellular, organic and individual levels in order to promote next-generation life science study. Furthermore, a system to effectively use research outcomes to the benefit of society is established as drug discovery and medical technology infrastructures through initiatives for supporting drug discovery researches in the academic sector in collaboration with related ministries and agencies as well as organic collaborations with domestic and overseas universities and businesses. RIKEN aims to conduct around 300 collaborative researches and provide support for analysis in around 100 cases annually.

(i) Researches on structure synthesis biology

RIKEN will establish and upgrade (a) techniques to prepare target molecules for drug discovery and to obtain structural information, (b) designing and screening techniques of candidate compounds for medicines on computers by use of structural information, and (c) techniques to generate candidate biopharmaceuticals with a view to forming an efficient and effective drug discovery process.

To be specific, a preparation technique of new samples will be developed by FY2015 to reproduce the kinetic function state of biomolecules. RIKEN will improve around 2-fold a

preparation efficiency of important samples for drug discovery such as membrane protein and modified histone. The exploitation of this technique helps RIKEN to establish a technology infrastructure capable of conducting at Spring-8/SACLA micro/nano-crystal structure analyses and supramolecular structure analyses beyond the current limit of ultrasensitive analyses by developing ultra-1GHz nuclear magnetic resonance (NMR) by use of high-temperature superconductivity with the objective of realizing conformational analyses of samples in the networks of genes, proteins and RNA which are difficult to be analyzed at this moment. Moreover, RIKEN will by FY2015 establish an infrastructure for new drug designing techniques (fragment-based drug discovery (FBDD), etc.) aiming at difficult targets of development of pharmaceuticals such as protein-protein interaction targets. RIKEN will utilize such techniques to develop synthesis techniques for biopharmaceuticals with the use of non-natural amino acids and artificial base pairs.

(ii) Researches to analyze functional genomes

In order to establish fundamental technologies conducive to drug discovery and medical care, RIKEN will establish and upgrade the (a) techniques for measuring cell assemblies at the cellular level, analyzing gene-expression networks and comprehending genome information; (b) techniques for changing cellular functions and translating them to safe differentiation of stem cells, and (c) techniques for detecting target nucleic acids.

Specifically, RIKEN will, by FY2015, develop new technologies to comprehend genome information such as techniques for investigating genome functions which involve in single-cell transcriptome and for analyzing gene-expression networks which capture any abnormality therein. It will utilize these techniques to analyze the diversity of expression control at a level of individual organisms such as cancers and iPS cells and at a level of individual cells and gene-expression networks of around 10 types of cells including untranslated RNA. Moreover, it plans to develop a technique for converting cells through selecting important factors which involve in expression control or epigenome control and establish an evaluation technology to lead it into safe and complete differentiation of stem cells such as iPS cells. A simple and prompt method of detecting nucleic acids and judging devices will be developed and upgrading of detection techniques realized. Furthermore, RIKEN will construct an infrastructure for verifying target molecules for drug discovery by use of the gene-expression network analysis technique through advancing functional genome analysis techniques and standardizing them on a global scale.

(iii) Researches on life function dynamic imaging

For the purpose of establishing fundamental technologies conducive to drug discovery and

medical care, RIKEN will establish and upgrade the (a) kinetic analysis techniques of biomolecules in the disease state, (b) techniques for analyzing functional changes in biomolecules and cells on a time-series basis and (c) next-generation imaging techniques such as simultaneous imaging of several molecules.

To be specific, RIKEN will, by FY2015, develop around eight types of new molecular probes by means of designing and labelling probes and candidate drug discovery molecules with the aim of quantitatively analyzing the dynamics of target molecules which involve in the vital functions and clinical conditions in biological bodies. The utilization of these probes rapidly results in the advancement of techniques for analyzing the dynamics of pathological biomarkers in sites of onset of such diseases as lifestyle-related diseases, and around five types of clinical studies will be conducted by use of new molecular probes. Moreover, RIKEN will build up a technology infrastructure for temporospatially analyzing differences in cellular functions of humans and animals in the regular state and disease state and related molecules. Furthermore, with the aim of creating new approaches to evaluate vital functions, Also, RIKEN will develop integrated image analysis methods using PET and MRI and upgrade simultaneous imaging techniques of several molecules by FY2015, The utilization of these techniques will result in the establishment of an infrastructure for verifying dynamics of candidate compounds for drugs in biological bodies and effects of new medical technologies such as tailored medical care.

(5) Researches on computational science and technology

RIKEN will conduct researches on upgrading of the specific high-speed computer facilities through effectively operating the supercomputer “K” for efficient operations of facilities and improved user friendliness, promote leading research and development in computer science and computational science and strive to develop computational science and technology on a continuous basis.

(i) Promotion of improvement and shared use of the specific high-speed computer facilities

RIKEN will appropriately operate, manage and maintain the specific high-speed computer facilities including the ultrahigh-speed computer (supercomputer “K”) which is a core system of the innovative High Performance Computing Infrastructure (HPCI). In particular, the supercomputer “K” is operated more than 8,000 hours annually to provide researchers with more than 663,552,000 node time of computing resources (82,944 nodes x 8,000 hours) by means of its shared use.

Moreover, it will develop a new (post “K”) ultrahigh-speed computer in view of solving a variety of social and scientific issues which surround Japan aiming at starting its operation by

2020. Specifically, basic design of each element such as central processing units (CPU) and networks and detailed design (design of the entire system) will be conducted. Furthermore, RIKEN will develop related system software, applications and libraries and aim to develop an execution environment of broad applications after the commencement of its operation through promoting the coordinated designing which mutually connect applications, architectures, software and programming environments.

It will also conduct researches on upgrading such as strengthened functions of system software, improved execution performance of application programs and establishment of common infrastructures including the development of advanced algorithms with the aim of improving the efficiency of operations and user-friendliness of RIKEN's facilities as well as strive to foster researchers who engage in computational science and technology under the appropriate division of roles with the registered institution for facilities use promotion and other related organizations. In addition, it will effectively and smoothly operate the specific high-speed computer facilities taking into account the needs of users in active collaboration with the registered institutions for facilities use promotion, HPCI Consortium, HPCI Strategic Program, organizations that develop applications conducive to the solution of social and scientific issues, universities, research institutes and industry so that the specific high-speed computer facilities which serve as an anchor of RIKEN are utilized actively by more researchers, and intends to develop them as a center for state-of-the-art computing research and education which provides a place for exchanges among the top-class researches from Japan and other countries by means of transmitting excellent research and development outcomes. RIKEN will particularly foster researchers who engage in computational science and technology through developing a post-K supercomputer by accepting internships and holding lectures in collaboration with businesses and universities that engage in the development of a post-K supercomputer.

(ii) Establishment of fundamental technologies toward the advancement of computational science and technology

In the period for medium to long-term objectives, RIKEN will establish a collaborative research organization with the Emergent Matter Science Research Project, develop high-precision calculation techniques of electronic state and physical property characteristics and applications using them through taking advantage of knowledge and technologies concerning computational science and technology owned by the Advanced Institute for Computational Science, and contribute to the promotion of research and development on device technologies that revolutionary reduce power consumption and technologies that convert energy with high efficiency.

RIKEN will strive to provide information to the wide public through facility open day and lectures in order to gain understanding of citizens at the time of taking these initiatives.

[Appendix 3] Effective use of research and development outcomes for the benefit of society by means of strategic and focused collaborations and construction of networks

(1) Promotion of integrative collaborations

RIKEN will conduct integrative collaborative researches under its research promotion organization which integrates cutting-edge research seeds owned thereby and industrial and social needs utilizing the baton zone for the purpose of promoting the creation of innovation in science and technology.

To be more specific, it will advertise for businesses on joint researches and promote researches led thereby through appropriately sharing their burden between RIKEN and businesses after strictly selecting research agendas which are expected to grow toward the creation of next-generation technical infrastructures and early practical application of achievements. RIKEN will provide specialized and technical support in terms of technologies and know-how in order to steadily transfer their achievements. Such a support helps this program to be promoted effectively in a way that more than five research agendas conducted under the integrative research program in collaboration with industry can be transferred to the stage of development or commercialization in expectation of their practical application in businesses.

RIKEN will produce achievements which result in the transfer from the research stage to the development stage. For example, a partner business starts to develop an actual device after the development stage or for its mass production. Moreover, it will actively promote the collaboration center system with industry which deals with broad needs of businesses in a comprehensive and organized manner and at least two centers be established in the period for medium to long-term objectives.

(2) Promotion of collaborations in biomass engineering

RIKEN will play a central role ranging conducting basic technology development to handing over technologies to industry under the integrative research system in organizational collaboration with domestic and overseas universities, research institutes and businesses and promote open innovation in order to establish practical bioprocessing techniques and translate them into a new industry in view of constructing new sustainable and recycling social system infrastructures enabling the use of $CO_2$ as a resource. Specifically, it will develop new technologies for establishing an innovative and consistent bioprocess using biomass with a view to achieving the following three goals by FY2019.

(i) Conducting outdoor tests on poplar trees and develop plants which present characters useful for practical application of plant biomass with the aim of developing “super plants equipped with high productivity and ready biodegradability” through strengthening the functions of

plants;

(ii) Developing an efficient designing technique of microorganisms with the aim of developing an efficient "integrated synthesis technique" of raw materials for chemical products by use of biotechnology, specifically, an integrated degradation and synthesis process of biomass through microbial conversion; and

(iii) Transferring one or more elementary technologies to businesses by developing new biopolymer materials with the aim of developing new bioplastics comparable to polylactate.

Moreover, it is necessary to examine scientific and technical needs called for by the public and industry and strengthen the function of making proposals on joint researches in response to such needs, in order to promote open innovation. To this end, RIKEN will establish a research promotion system which has a program director who supervises cross-sectional researches and a collaboration promotion coordinator who plays a central role in organizational collaborations and integration and serves as an intermediator with businesses. The collaboration promotion coordinator will examine scientific and technical needs called for by citizens and industry by exchanging information on each elementary technology including research areas of different fields from the early stage, conduct strategic joint researches with industry, domestic and overseas universities and public research institutes under the program director toward practical application, and broadly disseminate technologies and products obtained to society.

(3) Promotion of collaborations concerning drug discovery-related researches

RIKEN will promote collaborations in drug discovery-related researches and implement a program for drug discovery and medical technology platforms which conduct research and development on drug discovery and medical technologies for the purpose of providing pharmaceutical businesses and medical institutions with seeds obtained from basic researches as technologies which can be employed for actual drug discovery processes and medical fields through cross-sectional exploitation of its world's highest level of research platforms. Moreover, it will conduct a developmental program for preventive care and diagnostic techniques which invent important diagnostic methods in order to effectively use medicines and medical technologies.

The program for drug discovery and medical technology platforms promotes researches on drug discovery and medical technologies aiming at the creation of new candidate materials for drugs such as low-molecular compounds, antibodies and nucleic acids from drug discovery targets (disease-related proteins) found by a variety of basic disease researches conducted at each Research Center of RIKEN and universities and the acquisition of effective intellectual property under the collaborations among the Drug Discovery Platform Units established under the Research Centers. Moreover, RIKEN will promote projects for drug discovery and medical technologies which evaluate safety as trans-relational researches in the non-clinical research stage and pass on these

projects to their results at an appropriate stage. To achieve this goal, RIKEN will open a management office for this program and assign appropriate specialists therefor to give priority to prospective researches and projects on drug discovery and medical technologies in terms of resources and manage their progress in relation to the stage-up goals for every fiscal year, and the Drug Discovery Platform Units work together to establish a management system for efficient and effective promotion. RIKEN will promote researches and projects on drug discovery and medical technologies and perform activities to transfer them to businesses and medical institutions in collaboration with techniques for analyzing target proteins which have been difficult to be analyzed and techniques for identifying new drug discovery targets. Moreover, it will strengthen its collaborations with universities and medical institutions and plan and coordinate for applying advanced technologies to drug discovery researches through initiatives for support provided therefor taken by the academic sector under the collaborations between the ministries and agencies. RIKEN will promote drug discovery researches on seeds owned thereby and other organizations through the above initiatives. With regard to the search of seeds and researches on drug discovery and medical technologies in the stage of lead optimization, RIKEN intends to reach a stage of acquiring patents including final products and 2 or more patents are transferred to businesses. Moreover, it intends to upgrade 2 or more projects for drug discovery and medical technologies from the non-clinical stage to the clinical stage and to transfer them to businesses or medical institutions in the period for medium to long-term objectives.

Furthermore, the development program for preventive care and diagnostic techniques will adopt a similar management system and promote initiatives for search of biomarkers capable of measuring, detecting and predicting diseases before their onset or at an early stage and for development of diagnostic techniques using them based on seeds and needs discovered by various basic studies which are being conducted at the Research Centers of RIKEN, medical institutions and businesses through the collaborations among the Development Unites established under the Research Centers. RIKEN will, in order to achieve this goal, carry out around 8 joint researches with businesses and universities and promote research and development in view of pharmaceutical application or commercialization of diagnostic/detection kits capable of simply detecting biomarkers by FY2015. One or more researches will be transferred to businesses or research institutes at an appropriate stage in the period for medium to long-term objectives.

[Appendix 4] Budgets (including the estimation of labor costs), income and expenditure plan and fund plan

1. Budgets (medium to long-term plan)

FY2013~FY2017

(Unit: million yen)

| Category | Amount (*1) |
|---|---|
| Income | |
| Governmental operational funds | 274,702 |
| Government subsidies for maintenance of facilities | 3,348 |
| Government subsidies for maintenance of equipment | 3,224 |
| Government subsidies for maintenance of specific advanced large-scale research facilities | 2,839 |
| Government subsidies for operations of specific advanced large-scale research facilities | 114,516 |
| Government subsidies for construction project for research and development centers such as next-generation artificial intelligence techniques (*2) | 1,450 |
| Miscellaneous income | 1,833 |
| Income from shared use of specific advanced large-scale research facilities | 2,041 |
| Commissioned projects income | 24,502 |
| Total | 428,453 |
| Expenditure | |
| General administration expenses | 20,544 |
| (General administrative expenses excluding taxes and public dues) | 10,065 |
| Labor costs (administration) | 6,648 |
| Properties expenses | 3,417 |
| Taxes and public dues | 10,479 |
| Operational expenses | 255,990 |
| Labor costs (research) | 25,779 |
| Properties expenses (including the salary for fixed-term employees) | 230,211 |
| Facilities maintenance expenses | 3,348 |
| Equipment maintenance expenses | 3,224 |
| Expenses for maintenance of specific advanced large-scale research facilities | 2,839 |
| Expenses for operations of specific advanced large-scale research facilities | 116,557 |
| Expenses for construction project for research and development centers such as | 1,450 |

| | |
|---|---|
| next-generation artificial intelligence technology (*2) | |
| Commissioned research | 24,502 |
| Total | 428,453 |

*1 The cumulated value of each column and the total amount may not coincide due to rounding.

*2 A planned amount for the project for FY2016 is reflected.

[Estimation of labor costs]

A total of 102.201 billion yen will be spent in the period.

[Note 1] Rules for calculation of governmental operational funds

Governmental operational funds (A) granted for each business year is calculated based on the following formula.

$A(y)=\{(C(y)-T(y))\times\alpha1(\text{coefficient})+T(y)\}$

$+\{(T(y)+Pr(y))\times\alpha2(\text{coefficient})\}+\varepsilon(y)-B(y)\times\lambda(\text{coefficient})$

$R(y)=R(y-1)\times\beta(\text{coefficient})\times\gamma(\text{coefficient})$

$C(y)=Pc(y-1)\times\sigma(\text{coefficient})+E(y-1)\times\beta(\text{coefficient})+T(y)$

$B(y)=B(y-1)\times\delta(\text{coefficient})$

$P(y)= Pr(y)+Pc(y)=\{Pr(y-1)+Pc(y-1)\}\times\sigma(\text{coefficient})$

Each expense and each coefficient value are explained as follows:

B(y): An estimation of self-income for the applicable business year. B(y-1) represents B(y) for the previous business year.

C(y): Administrative expenses for the applicable business year.

E(y): Properties expenses in administrative expenses for the applicable business year. E(y-1) represents E(y) for the previous business year.

P(y): Labor costs for the applicable business year (including retirement allowance). P(y-1) represents P(y) for the previous business year.

Pr(y): Labor costs in business expenses for the applicable business year. Pr(y-1) represents Pr(y) for the previous business year.

Pc(y): Labor costs in administrative expenses for the applicable business year. Pc(y-1) represents Pc(y) for the previous business year.

R(y): Properties expenses in operational expenses for the applicable business year. R(y-1) represents R(y) for the previous business year.

T(y): Taxes and public dues for the applicable business year.

ε(y): Special expenses for the applicable business year. Special expenses are generated only in the applicable business year due to any priority measure, accident, the increase or decrease in the

number of retired employees and may affect the rules for calculation of governmental operational funds. They are decided specifically in the budget-making process for each business year reflecting measures for reduction in administrative expenses such as the streamlining of labor costs.

α1: Administrative expenses streamlining coefficient: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year based on the target for reduction in administrative expenses described in the medium to long-term objectives.

α2: Business operation streamlining coefficient: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year based on the target for reduction described in the medium to long-term objectives.

β: Consumer price index: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year.

γ: Business policy coefficient: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year.

δ: Self-income policy coefficient: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year taking past performance into consideration.

λ: Income adjustment coefficient: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year taking into account the ratio of revenues to self-income in past performance.

σ: Labor costs adjustment coefficient: A specific coefficient value for the applicable business year is decided in the budget-making process for each business year taking into account the rate of increase in salary.

[Specific coefficients used for making estimations for the medium to long-term plan budget and grounds therefor]

The trial calculations were made based on the above calculation rules and the following assumptions.

- The estimation of governmental operational funds does not take ε (special expenses) into consideration. The trial calculation was made by setting α1 (administrative expenses streamlining coefficient) as a reduction of 3.2% on average for each business year (a reduction of 15% in the period for medium to long-term objectives based on the standard of the budget for FY2012), α2 (business streamlining coefficient) as a reduction of 1.0% for each business year, and λ (income adjustment coefficient) as 1 uniformly.
- Properties expenses in business expenses were estimated by setting γ (business policy coefficient) as 1 uniformly on the assumption that β (consumer price index) does not change (±0).

- Labor costs were estimated on the assumptions that σ (labor costs adjustment coefficient) does not change (±0) and the number of retired employees does not increase nor decrease.
- Own revenue was estimated by setting δ (own revenue policy coefficient) as ±0.
- Commissioned projects income was estimated without making any change taking past performance into consideration.

2. Income and Expenditure Plan

FY2013~FY2017

(Unit: million yen)

| Category | Amount (*1) |
|---|---|
| Expenses | |
| Operating expenses (*2) | 491,024 |
| Administrative expenses | 20,313 |
| Labor costs (administration) | 6,648 |
| Properties expenses | 3,186 |
| Taxes and public dues | 10,480 |
| Operational expenses (*2) | 283,511 |
| Labor costs (research) | 25,779 |
| Properties expenses (*) | 257,732 |
| Commissioned research | 17,654 |
| Depreciation and amortization (*2) | 169,404 |
| Financial expenses | 141 |
| Extra loss | 0 |
| | |
| Revenues | |
| Governmental operational funds | 231,664 |
| Government subsidies for research (*2) | 72,863 |
| Commissioned projects revenue | 21,903 |
| Self-income (other revenues) | 3,755 |
| Reversal of asset-offsetting liability (*2) | 159,320 |
| Extra revenue | 0 |
| | |
| Net loss | △1,518 |
| Reduction from reserves brought forward from the previous period for medium to long-term objectives | 3,756 |
| Reduction from appropriated surplus | 0 |
| Gross profit | 2,238 |

*1 The cumulated value of each column and the total amount may not coincide due to rounding.

*2 For government subsidies for construction project for research and development centers such as next-generation artificial intelligence techniques, a planned amount for the project for FY2016 is reflected.

3. Fund plan

FY2013~FY2017

(Unit: million yen)

| Category | Amount (*1) |
|---|---|
| Funds outflow (*2) | 558,981 |
| Expenditure for business activities (*2) | 348,420 |
| Expenditure for investment activities (*2) | 196,974 |
| Expenditure for financial activities | 4,332 |
| Balance carried forward to the next period for medium to long-term objectives | 9,256 |
| | |
| Funds inflow (*2) | 558,981 |
| Income from business activities (*2) | 448,642 |
| Income from governmental operational funds | 274,702 |
| Income from government subsidies (*2) | 119,190 |
| Commissioned projects revenue | 27,115 |
| Self-income (other revenues) | 27,636 |
| Income from investment activities | 98,706 |
| Income from facilities management expenditures | 6,186 |
| Income from withdrawal of time deposit | 92,520 |
| Income from financial activities | 0 |
| Balance carried forward from the previous period for medium to long-term objectives | 11,633 |

*1 The cumulated value of each column and the total amount may not coincide due to rounding.

*2 For government subsidies for construction project for research and development centers such as next-generation artificial intelligence techniques, a planned amount for the project for FY2016 is reflected.