

MOONSHOT

RESEARCH & DEVELOPMENT PROGRAM

April 2026

〈Three target areas〉

Society Overcoming the limits of our aging society by harnessing diversity and innovation. **Environment** Supporting the recovery of the natural environment and sustainable urbanization.

Economy Exploring the frontiers of human activity with science and technology.

Moonshot Goal	Society	Environment	Economy
1 Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050.	★		
2 Realization of ultra-early disease prediction and intervention by 2050.	★		★
3 Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050.	★		★
4 Realization of sustainable resource circulation to recover the global environment by 2050.		★	
5 Creation of industry that enables sustainable global food supply by exploiting unused biological resources by 2050.		★	
6 Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050.			★
7 Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one's life with relief and release from health concerns until 100 years old.	★		
8 Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050.		★	★
9 Realization of a mentally healthy and dynamic society by increasing peace of mind and vitality by 2050.	★		★
10 Realization of a dynamic society in harmony with the global environment and free from resource constraints, through diverse applications of fusion energy, by 2050.		★	★

Moonshot R&D Program Overview



〈About the Moonshot R&D Program〉

 **Cabinet Office** Moonshot Research and Development Program
<https://www8.cao.go.jp/cstp/english/moonshot/top.html>

〈Funding Agencies and their assigned Moonshot Goals〉

 **Japan Science and Technology Agency**
Moonshot Goal : 1、2、3、6、8、9、10
<https://www.jst.go.jp/moonshot/en/>

 **New Energy and Industrial Technology Development Organization**
Moonshot Goal : 4
https://www.nedo.go.jp/english/news/ZZCA_100007.html

 **Bio-oriented Technology Research Advancement Institution**
Moonshot Goal : 5
https://www.naro.go.jp/laboratory/brain/english/moon_shot/

 **Japan Agency for Medical Research and Development**
Moonshot Goal : 7
<https://www.amed.go.jp/en/program/list/18/03/001.html>

Here begins our new MIRAI.

Let's repaint the future
to be brighter, more vibrant, more beautiful.
Our planet and its people now face many serious challenges,
so let's gather our collective strength.
We can overcome old limits
by converging global knowledge,
and break convention with radical innovation.

This is our new MIRAI.
A future inspired by science, but shaped by human spirit.

Don't think it's impossible. Don't be afraid to fail.
Don't feel constrained by prior expectations.
Let's paint the future to be full of smiling faces,
by our hands as we live courageously today.

Here begins our new MIRAI.

10 GOALS

To tackle important social issues including our shrinking and aging societies, global climate change and extreme natural disasters, the Moonshot R&D Program is pursuing disruptive innovations in Japan and promoting challenging R&D based on revolutionary concepts. The program's research aims to achieve ten ambitious Moonshot Goals.

1

Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050.

HAGITA Norihiro Chair and Professor, Art Science Department, Osaka University of Arts

2

Realization of ultra-early disease prediction and intervention by 2050.

SOBUE Gen Distinguished President, Aichi Medical University /
Director, Center for Neurological Disease Therapeutics, Aichi Medical University

3

Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050.

KUNIYOSHI Yasuo Director, Next Generation Artificial Intelligence Research Center of The University of Tokyo /
Professor, Graduate School of Information Science and Technology, The University of Tokyo

4

Realization of sustainable resource circulation to recover the global environment by 2050.

YAMAJI Kenji President, Research Institute of Innovative Technology for the Earth (RITE)

5

Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050.

YOSHIZAWA Fumiaki Executive Director and Vice-President, Utsunomiya University

6

Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050.

KITAGAWA Masahiro Director, Center for Quantum Information and Quantum Biology, The University of Osaka

7

Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one's life with relief and release from health concerns until 100 years old.

HIRANO Toshio Professor Emeritus, The University of Osaka / President, Osaka International Cancer Treatment Foundation

8

Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050.

MIYOSHI Takemasa Team Principal, Center for Computational Science, Data Assimilation Research Team, RIKEN

9

Realization of a mentally healthy and dynamic society by increasing peace of mind and vitality by 2050.

KUMAGAI Seiji Professor, Institute for the Future of Human Society, Kyoto University

10

Realization of a dynamic society in harmony with the global environment and free from resource constraints, through diverse applications of fusion energy, by 2050.

YOSHIDA Zensho Project Professor, Graduate School of Mathematical Sciences, The University of Tokyo

Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050.

Program Director (PD) **HAGITA Norihiro** Chair and Professor, Art Science Department, Osaka University of Arts

Outline

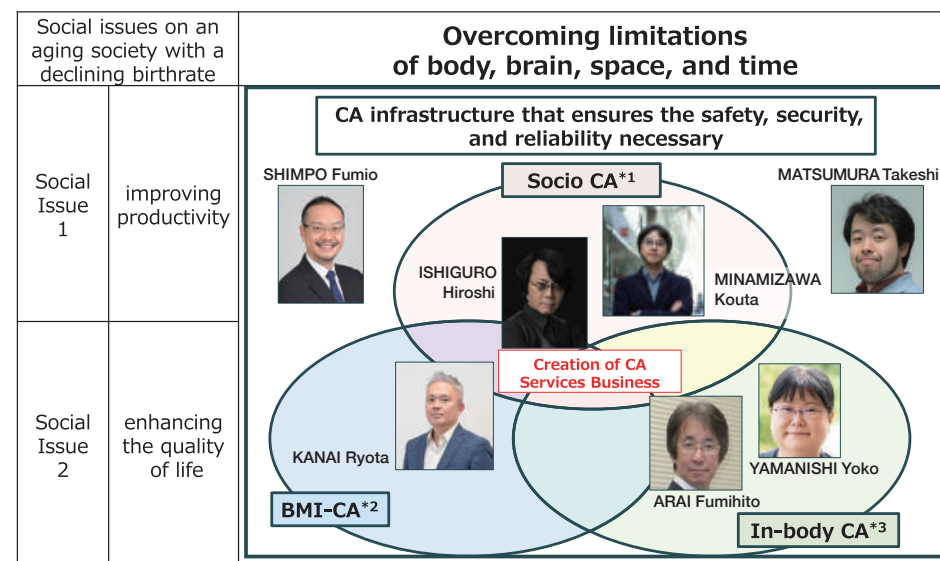
Amid a declining birthrate and aging population, which are raising concerns about labor shortages, it is crucial to enable people from diverse backgrounds and with varying values—including those who need to provide care or raise children, as well as the elderly—to participate in a wide range of activities in accordance with their own lifestyles. To this end, we aim to resolve two key societal challenges—improving productivity while enhancing the quality of life—by realizing a society by 2050 where people are “liberated from the constraints of the body, the brain, space, and time.” To expand human physical, cognitive, and perceptual capabilities, we will promote the research and development of Cybernetic Avatar (CA) technology—which involves the remote control of avatars or robots—while taking social norms into account.

Message from PD

To achieve our moonshot goals, we will advance the research and development of CA that enables people from diverse backgrounds and with varying values to expand their physical, cognitive, and perceptual capabilities to the highest levels. We will establish a CA infrastructure that ensures the safety, security, and reliability necessary for the societal implementation of CA and the resolution of institutional challenges. Building on this infrastructure, we will develop the following three types of CA to address two societal challenges: “improving productivity” and “enhancing the quality of life”:

- (1) “Socio CA,” which enhances the capabilities of individuals and groups by liberating them from physical, mental, spatial, and temporal constraints;
- (2) “BMI-CA,” which uses brain-machine interfaces (BMI) to enhance the capabilities of the body and brain to improve communication for people with disabilities;
- (3) “In-body CA,” which enhances physical capabilities within the body to monitor internal conditions and enable treatments with minimal side effects.

By integrating these CAs, we will promote the realization of rich work-life services that enable individuals to balance employment with a fulfilling personal life, as well as independent living services for those who find it difficult to live independently on their own.



- *1 Socio CA : CA that enhances the capabilities of individuals and groups by liberating them from physical, mental, spatial, and temporal constraints
- *2 BMI-CA : CA that uses brain-machine interfaces (BMI) to enhance the capabilities of the body and brain
- *3 In-body CA : CA that enhances physical capabilities within the body

R&D Projects

The Realization of an Avatar-Symbiotic Society where Everyone can Perform Active Roles without Constraint

Project Manager **ISHIGURO Hiroshi**
Professor, Graduate School of Engineering Science, The University of Osaka

Outline This project aims to develop a system that enables users to remotely and flexibly operate multiple customer assistants (CAs) capable of delivering rich, hospitality-oriented services while perceiving the environment and user context. This system will allow individuals to participate in a wide range of social activities (work, education, healthcare, and daily life) without the need for physical presence on site. By 2050, we envision the realization of a society in which humans and avatars coexist. In such a society, lifestyles will be dramatically transformed in terms of how people choose locations, allocate their time, and extend their capabilities. At the same time, it will foster an inclusive environment where diverse individuals are mutually recognized, connected, and able to live together harmoniously.

Project Cybernetic being: Creating an Inclusive Society through Trusted Ability Augmentation with Cybernetic Avatars

Project Manager **MINAMIZAWA Kouta**
Professor, Graduate School of Media Design, Keio University

Outline We develop cybernetic avatar (CA) technologies that enable people with diverse physical conditions to fully express their abilities and demonstrate a wide range of skills. By enabling users—including those with disabilities or mobility challenges—to share and utilize skills and experiences, these technologies expand individual capabilities and support active participation in society and independent living. In doing so, we address the safety, institutional, and ethical considerations required for such a future society, and aim to build an inclusive social infrastructure that harmonizes with both people and society. By 2050, we envision a society in which anyone can extend their abilities through cybernetic avatars and freely engage in activities and challenges beyond physical limitations.

Liberation from Biological Limitations via Physical, Cognitive and Perceptual Augmentation

Project Manager **KANAI Ryota**
Director, Corporate Planning & Innovation Co-Creation Unit, Advanced Telecommunications Research Institute International (ATR)

Outline This project aims to develop cybernetic avatars that can be controlled via intention. This intention will be estimated from brain activities and information observed on the surface of the human body and through interactions. We will integrate intention estimation methods using AI technologies, and enhance the functionality of cybernetic avatars controlled by brain machine interfaces (BMI) while considering ethical implications. By 2050, we will create the ultimate BMI-cybernetic avatars that can be freely operated by human intention.

Structuring Spatiotemporal Environmental Information in the Body Using In-body Cybernetic Avatars.

Project Manager **ARAI Fumihito**
Professor, Graduate School of Engineering, The University of Tokyo

Outline This project aims to develop an in vivo Cybernetic Avatar (in vivo CA) that can visualize the state of health in the body. We will structure spatio-temporal environmental information in the body by distributing and coordinating multiple types of millimeter-, micro-, and nanoscale in vivo CAs to realize health monitoring and ultraminimally invasive diagnostics. By 2050, it will be useful for health maintenance, diagnosis, and disease prevention, and will be used by people in their daily lives, thereby contributing to a society of health and longevity.

Creating A Society Whose Citizen's Health is Monitored by Remote Control of Intracellular Cybernetic Avatars

Project Manager **YAMANISHI Yoko**
Professor, Faculty of Engineering, Kyushu University

Outline This project aims to develop intracellular Cybernetic Avatars that extend the body's own immune capabilities. By remotely controlling multiple intracellular Cybernetic Avatars, doctors, and specialists will be able to patrol the body, inspect the malignant state of disease-causing cells, remove them if necessary, and keep the body in good condition at all times. By 2050 we aim to realize a safe and secure daily life and an increase in healthy life expectancy watched over by intracellular Cybernetic Avatars.

Realization of a Society that can Use Cybernetic Avatars Safely and Securely

Project Manager **SHIMPO Fumio**
Professor, Faculty of Policy Management, Keio University

Outline This project aims to create core technologies on CA Teleoperator authentication, CA authentication and CA notarization that proves and certifies that the teleoperator can publicly use the CA under the law to build a CA infrastructure ensuring safe and security. It does research E³LSI(Ethical, Economic, Environmental, Legal, and Social Issues) to be tackled for realization of CA lifestyle, and create opportunities for proposals and discussions both domestically and internationally. We aim to develop a new dimension of jurisprudence such as AI, robotics, and avatar law, by 2050.

Reliability-ensuring Cybernetic Avatar Infrastructure Allowing Interactive Teleoperation

Project Manager **MATSUMURA Takeshi**
Research Executive Director, Network Research Institute, National Institute of Information and Communications Technology

Outline This project aims to develop a reliability-ensuring infrastructure that enables remote control of various CAs even when unstable communication conditions such as jitter (time lag and fluctuation of signals), latency, and communication failures occur. To this end, it develops area optimization technology for wireless sections and network optimization technology including wired sections to maintain interactive connections between operators and multiple CAs to the maximum extent. We will build a reliability-assuring infrastructure that will enable CA remote control underwater, undersea, and in space by 2050.



<https://www.jst.go.jp/moonshot/en/program/goal1/>

Program Director
HAGITA Norihiro



Realization of ultra-early disease prediction and intervention by 2050.

Program Director (PD)

SOBUE Gen

Distinguished President, Aichi Medical University /
Director, Center for Neurological Disease Therapeutics, Aichi Medical University

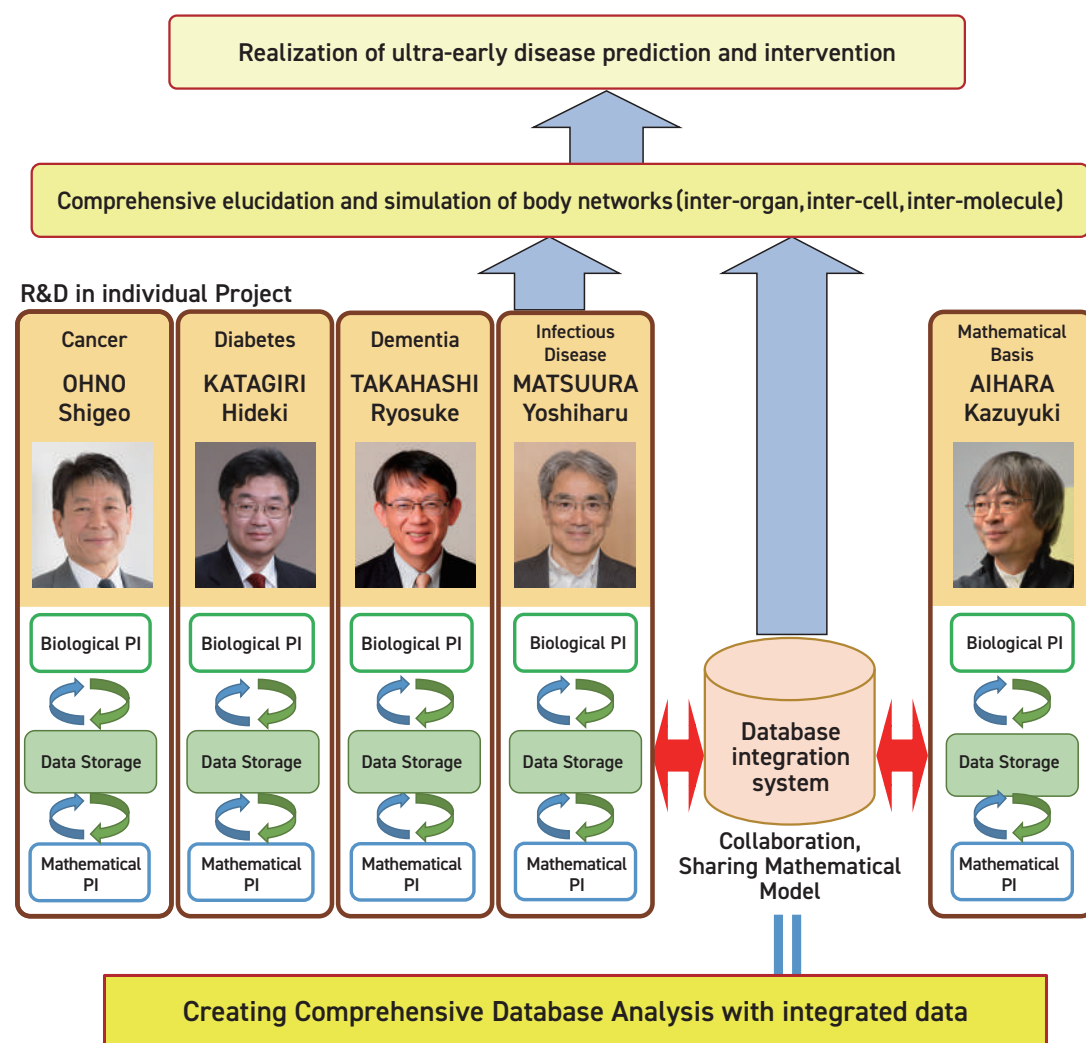
Outline

To ensure that our aging population has continued health and high quality of life, we need a new style of ultra-early disease prediction and intervention that supersedes today's conventional approach of treatment only after detection of symptoms.

To achieve this Moonshot Goal and realize ultra-early disease prediction and intervention we will promote R&D on technologies related to disease observation, manipulation, measurement, analysis, database creation and more. By integrating these technologies, we will advance our understanding of the comprehensive network connecting human organs.

Message from PD

The states of chronic diseases such as diabetes and dementia are linked to the breakdown of inter-organ networks. The key to our Moonshot Goal is establishing a method to foresee this breakdown and help at-risk individuals convert back from a pre-symptomatic state to a healthy one. Our R&D projects will contribute to our understanding of the comprehensive inter-organ network, building a database describing the network state, and developing a simulation system predicting unstable health utilizing mathematical models.



PI=Principal Investigator

R&D Projects

Comprehensive Mathematical Understanding of the Complex Control System between Organs and Challenge for Ultra-Early Precision Medicine

Project Manager **AIHARA Kazuyuki**

University Professor / Professor Emeritus, The University of Tokyo

Outline

This project will establish integrated research between mathematical studies with mathematical data analysis and mathematical modeling analysis, and experimental studies on interaction and control between organs. This project aims to realize a society equipped with ultra-early disease prevention systems by 2050 through comprehensively understanding the inter-organ network as the complex control system between organs and applying it to ultra-early precision medicine.

Challenge toward the Control of Intractable Cancer through Understanding of Molecular, Cellular, and Interorgan Networks

Project Manager **OHNO Shigeo**

Special Contract Professor, Graduate School of Medicine, Juntendo University

Outline

This project aims to unravel the mechanism of onset and malignant transformation of intractable cancers such as pancreatic cancer by employing cell biology, imaging technology, and mathematical and AI technology in an integrated manner. By doing so we aim to realize a society allowing us to predict and prevent the onset of intractable cancers by 2050.

Challenge for Eradication of Diabetes and Comorbidities through Understanding and Manipulating Homeostatic Systems

Project Manager **KATAGIRI Hideki**

Professor, Graduate School of Medicine, Tohoku University

Outline

This project aims to comprehensively elucidate the inter-organ communication systems underlying dynamic homeostasis of metabolism and circulation, taking advantage of original technologies, AI approaches and mathematical analyses. Furthermore, through understanding and manipulating the homeostatic systems, we will implement strategies which enable us to easily detect subjects in pre-symptomatic states of diabetes and comorbidities and to prevent the developments of these diseases by 2050.

Towards Overcoming Disorders Linked to Dementia based on a Comprehensive Understanding of Multiorgan Network

Project Manager **TAKAHASHI Ryosuke**

Specially Appointed Professor, Graduate School of Medicine, Kyoto University

Outline

This project aims to elucidate the interdependent multiorgan network and its breakdown at the molecular, cellular, and individual levels, focusing not only on the brain but also on the relationship between the whole body and the brain. Furthermore, we will achieve a comprehensive understanding of multiorgan network through AI and a mathematical approach. Based on this, we will develop methods for predicting disorders linked to dementia at an early stage before onset and realize preemptive medicine by using an innovative method for disease prevention by controlling the multiorgan network by 2050.

Understanding and Control of Virus-Human Interaction Networks

Project Manager **MATSUURA Yoshiharu**

Specially Appointed Professor, Center for Infectious Disease Education and Research, The University of Osaka

Outline

This project aims to analyze the interaction network between the virus and the human body in viral infections and classify/categorize its patterns to identify vulnerabilities in the human body's network. This will enable us to preemptively prepare effective diagnostic, preventive and therapeutic measures against even unknown viral infections, and thereby realize a society free from the threat of viral infections by 2050.



<https://www.jst.go.jp/moonshot/en/program/goal2/>

Program Director

SOBUE Gen



Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050.

Program Director (PD) **KUNIYOSHI Yasuo**

Director, Next Generation Artificial Intelligence Research Center of The University of Tokyo /
Professor, Graduate School of Information Science and Technology, The University of Tokyo

Outline

Considering Japan's declining birthrate and aging population, it is important that robots can be used in all aspects of society - such as working in dangerous or understaffed sites, developing human frontiers, and supporting our everyday lives. For that purpose, robots must be able to learn and act on their own through the co-evolution of AI and robots. Our R&D aims to realize AI robots with advanced bodies and self-developed AI learning.

Message from PD

Our vision for 2050 is a world where general-purpose autonomous humanoid AI robots support every aspect of human society, dramatically enhancing human well-being. In such a society, robots will be ubiquitous as part of the infrastructure, and they must be capable of being flexibly deployed in response to emergencies and labor shortages.

To realize this vision, true general autonomy—defined as the ability to perform essentially any task that a human can—is indispensable. Achieving this requires capabilities such as understanding humans, learning in real time, ensuring safety in interactions with people, possessing human-level operational skills, and exhibiting a high degree of adaptability to diverse environments. To this end, we will establish a research portfolio that integrates three complementary frameworks—integrated research, specialized research, and elemental research—thereby covering a wide range of fields while achieving advanced system integration. Through innovative thinking that goes beyond conventional extensions, together with bold new ideas from early-career researchers and interdisciplinary collaboration, we aim to achieve this critical breakthrough.

R&D Projects

Integrated Research

Smart Robot AIREC that is Close to One Person for a Lifetime

Project Manager **OGATA Tetsuya**
Professor, Faculty of Science and Engineering, Waseda University

General-Purpose Autonomous Humanoids Growing through Multilayered Instruction and Inheritance

Project Manager **KAWAHARAZUKA Kento**
Lecturer, Next Generation Artificial Intelligence Research Center, The University of Tokyo

Integrated Research and Development of Humanoids Capable of Operating in Challenging Environments

Project Manager **HARADA Kensuke**
Professor, Graduate School of Engineering Science, The University of Osaka

Specialized Research

Force Control as a Bridge between the Information World and the Physical World

Project Manager **SAKAINO Sho**
Associate Professor, Institute of Systems and Information Engineering, University of Tsukuba

Robotics Platform for Emergent Intelligence Grounded in the Order of Embodied Interactions

Project Manager **NOZAKI Takahiro**
Associate Professor, Faculty of Science and Technology, Keio University

Neuro-Robotics Pioneering Multimodal AI-Integrated Humanoid in Agriculture

Project Manager **HAYASHIBE Mitsuhiro**
Professor, Graduate School of Engineering, Tohoku University

Creation of Embodied Intelligence through Self-Reinforcing Capability Expansion

Project Manager **MORIMOTO Jun**
Professor, Graduate School of Informatics, Kyoto University

Elemental Research

Next-Generation Humanoid AI Robots through Whole-Body Tactile Intelligence

Project Manager **IIDA Fumiya**
Professor, Graduate School of Engineering, The University of Tokyo

Development of Dynamical Representation Learning for Cooperative Stable Motions and a Data-Driven Motion Primitive Generation Framework

Project Manager **KAWAHARA Yoshinobu**
Professor, Graduate School of Information Science and Technology, The University of Osaka

E-Skin-Integrated Robotic Hand Inspired by Human Tactile Perception and Cognition

Project Manager **TAKEI Kuniharu**
Professor, Graduate School of Information Science and Technology, Hokkaido University

Embodied Safety by Robotic Core Elements: Creating Intrinsically Safe Mechanisms by Extracting Principles from the Living Body's Inherent Underactuated Drive Mechanisms

Project Manager **TADAKUMA Kenjiro**
Professor, Graduate School of Engineering Science, The University of Osaka

An AI Robot with a High-Efficiency Body for Mobility in Public Spaces

Project Manager **NAKAGAWA Chihiro**
Professor, Graduate School of Engineering, Osaka Metropolitan University

Learning to Learn: Principles of Active On-Site Learning for General- Purpose Robots

Project Manager **NONAKA Tetsushi**
Professor, Graduate School of Human Development and Environment, Kobe University

An Elemental Study of Motion Assist Robots Capable of Inferring Human States

Project Manager **YOSHIMURA Natsue**
Professor, School of Computing /Institute of Biomedical Engineering, Institute of Science Tokyo

* The titles of the projects are subject to change after refinement.

* Affiliations and titles are as of May 2026.



<https://www.jst.go.jp/moonshot/en/program/goal3/>

Program Director
KUNIYOSHI Yasuo



Realization of sustainable resource circulation to recover the global environment by 2050.

Program Director (PD) **YAMAJI Kenji** President, Research Institute of Innovative Technology for the Earth (RITE)

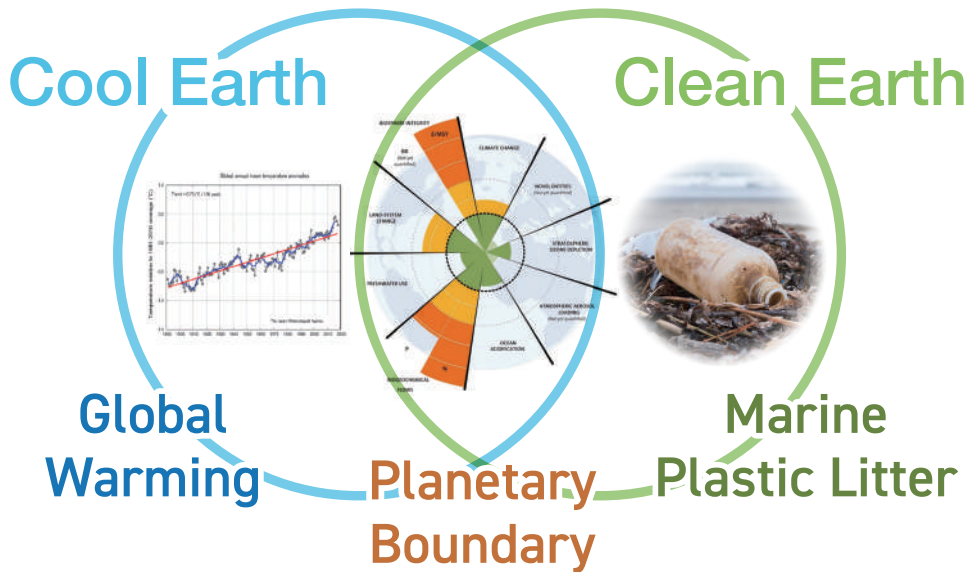
Outline

We must take measures to prevent the circulation of substances that cause global environmental problems. These include greenhouse gases (GHGs) responsible for global warming, nitrogen compounds in a high-risk state that exceed the threshold determined by the planetary boundary concept^{*1}, and marine plastic litter that disturbs marine ecosystems and can affect humans through the food chain. To restore the global environment, this R&D program aims to contribute to solving the global warming problem (Cool Earth) and the environmental pollution problem (Clean Earth) while accounting for continued industrial and consumer activity. Under this program, NEDO is engaged in ambitious R&D activities to realize a new form of resource circulation that reduces environmental pollutants such as GHGs, nitrogen compounds, and marine plastic litter.

^{*1}: Under this concept, thresholds have been established in nine areas of the global environment to ensure the sustainable development of human society. Exceeding these thresholds will cause irreversible changes to the natural resources upon which humans depend.

Message from PD

Moonshot R&D is characterized by its more ambitious and unconventional approach. For GHGs, the program is targeting an innovative technology known as Direct Air Capture (DAC), which directly captures CO₂ that has already been released into the atmosphere and utilizes it effectively. For nitrogen, we aim to detoxify nitrogen compounds discharged into the environment and convert them into valuable materials. As for marine plastic litter, a growing concern in recent years, we aim to design degradation initiation switches for biodegradable plastics that are functional yet safe for the environment.



R&D Projects

Development of Highly Efficient Direct Air Capture (DAC) and Carbon Recycling Technologies

Project Manager **KODAMA Akio**
Professor, Institute for Frontier Science Initiative, Kanazawa University

Outline
-Development of innovative amine-loaded CO₂ solid sorbent
-CO₂ capture and enrichment process using less energy than conventional technologies

Integrated Electrochemical Systems for Large-Scale CO₂ Recycling

Project Manager **SUGIYAMA Masakazu**
The director and a professor, Research Center for Advanced Science and Technology (RCAST), The University of Tokyo.

Outline
-CO₂ enrichment process at medium and low temperatures by physical absorption/desorption and electrochemistry
-Creation of a system for CO₂ enrichment and reduction to chemical feed stocks by electro-chemical processes using renewable electricity
-Flexible system that allows for small-scale distributed deployment

Research and Development on Direct Air Capture With Available Cold Energy

Project Manager **NORINAGA Koyo**
Professor, Institutes of Innovation for Future Society, Director of Research Center for Net Zero Carbon Society, Nagoya University

Outline
-Direct capture of atmospheric CO₂ by employing unused cold energy from liquefied natural gas (LNG)
-Pressure swing recovery of CO₂ by the CO₂ sublimation while operating both absorber and desorber at room temperature
-Output high-purity and pressurized CO₂ ready for storage and utilization process

Development of a CO₂ Recycling System for a Beyond-Zero Society

Project Manager **FUJIKAWA Shigenori**
Distinguished Professor, International Institute for Carbon-Neutral Energy Research, Director of Research Center for Negative Emission Technology, Kyushu University

Outline
-Development of CO₂ capture unit using innovative separation nano-membranes with unparalleled CO₂ permeability
-Development of conversion unit that converts CO₂ into carbon fuel with high efficiency
-Scalable system for use in small-sized homes and medium-sized buildings

Research and Development of Passive DAC Technologies

Project Manager **YAMAZOE Seiji**
Professor, Department of Chemistry, Graduate School of Science, Tokyo Metropolitan University

Outline
-Development an innovative passive DAC system that minimizes the air-flow energy during CO₂ absorption and CO₂ desorption energy and enables storage and transportation of absorbed CO₂
-Realizing a carbon resource circulation system based on highly efficient and low-cost CO₂ capture

A-ERW Combines Technology and Site Characteristics

Project Manager **NAKAGAKI Takao**
Professor, Faculty of Science and Engineering, Waseda University

Outline
-Accelerating artificial weathering and CO₂ mineralization utilizing characteristics of Japanese rocks and application sites
-Evaluating pretreatment energy, modelling CO₂ absorption rate and sequestration, and predicting co-benefits for industrial and agricultural applications
-Consolidating information database of accurate carbon accounting toward international standards

Redesign of Macroalgae for Highly Efficient CO₂ Fixation by Functional Modifications and Their Product Generation

Project Manager **UEDA Mitsuyoshi**
Professor, Special Appointed Professor, IAC (Office of Institutional Advancement and Communications), Kyoto University

Outline
-Breeding of macroalgae by redesign for highly efficient CO₂ fixation including genome editing technology
-Enlargement of marine field for macroalgae
-Production of functional bio-products from macroalgae

Mitigation of Greenhouse Gas Emission from Agricultural Lands by Optimizing Nitrogen and Carbon Cycles

Project Manager **MINAMISAWA Kiwamu**
Specially Appointed Professor, Graduate School of Life Sciences, Tohoku University

Outline
-Focusing on agricultural lands as major sources of nitrous oxide emissions
-Activation of N and C cycling in soil micro-organisms induces reduction of nitrous oxide emissions
-Design of soil microbial community could provide the establishment and functional expression of inoculated microorganisms

Nitrogen Recycling Technology Can Keep Us Within Our Planetary Boundary

Project Manager **KAWAMOTO Tohru**
Principal Researcher, Research Institute of Core Technology for Materials Innovation National Institute of Advanced Industrial Science and Technology (AIST)

Outline

- Development of technology to transform nitrogen oxides in exhaust gas into ammonia, a useful material
- Conversion and recovery of ammonia from toxic nitrogen compounds in wastewater

Multi-Lock Biopolymers Made From Biomass Break Down in the Ocean

Project Manager **ITO Kohzo**
University Professor, Graduate School of Frontier Sciences, The University of Tokyo

Outline

- Breaking through trade-off between polymer degradability and durability /toughness
- Multi-lock mechanism^{*3} provides high durability during use and on-demand degradation when accidentally released into ocean-Produced from non-food biomasses

*3: A mechanism that requires multiple stimuli such as light, heat, oxygen, water, enzymes, microorganisms, and catalysts at the same time for degradation

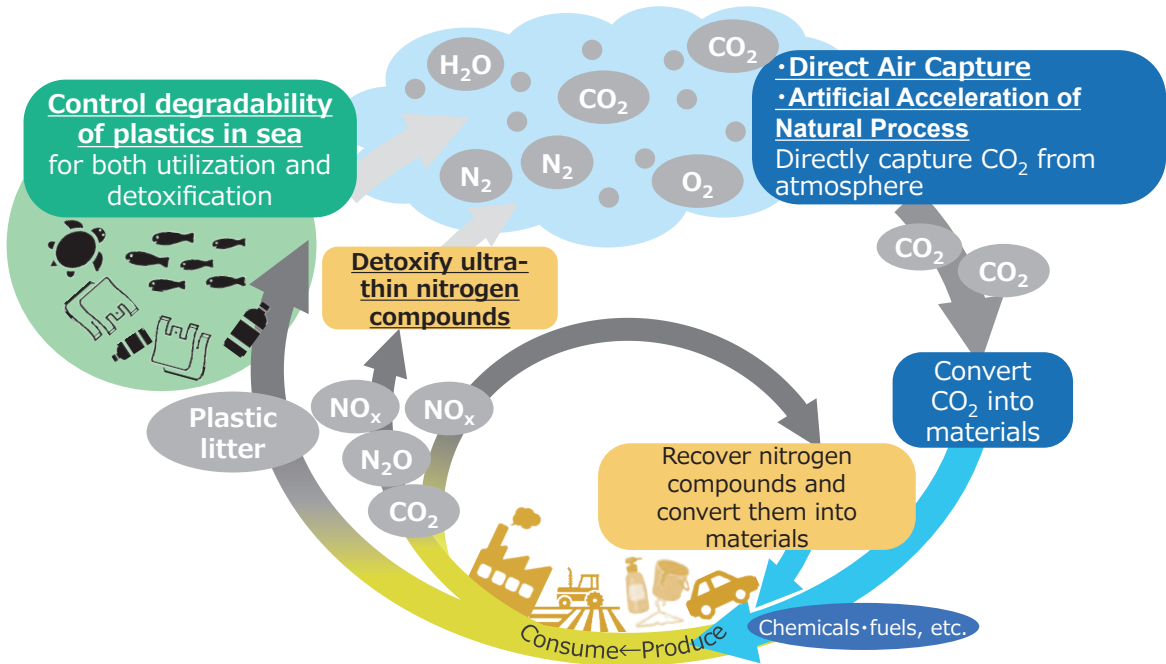
Research and Development into Marine Biodegradable Plastics With a Degradation Initiation Switch

Project Manager **KASUYA Ken-ichi**
Dean, Graduate School of Food and Population health Sciences, Gunma University

Outline

- Development of technology to control timing and speed of degradation
- Marine biodegradability (90% in 6 months in seawater at 30°C) verified in ocean
- Creation of marine biodegradable polymers based on biomass and CO₂

Moonshot Goal 4 Cool Earth & Clean Earth



KODAMA Akio



SUGIYAMA Masakazu



NORINAGA Koyo



FUJIKAWA Shigenori



YAMAZOE Seiji



NAKAGAKI Takao



UEDA Mitsuyoshi



MINAMISAWA Kiwamu



KAWAMOTO Tohru



ITO Kohzo



KASUYA Ken-ichi



https://www.nedo.go.jp/english/news/ZZCA_100007.html

Program Director
YAMAJI Kenji

Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050.

Program Director (PD) **YOSHIZAWA Fumiaki** Executive Director and Vice-President, Utsunomiya University

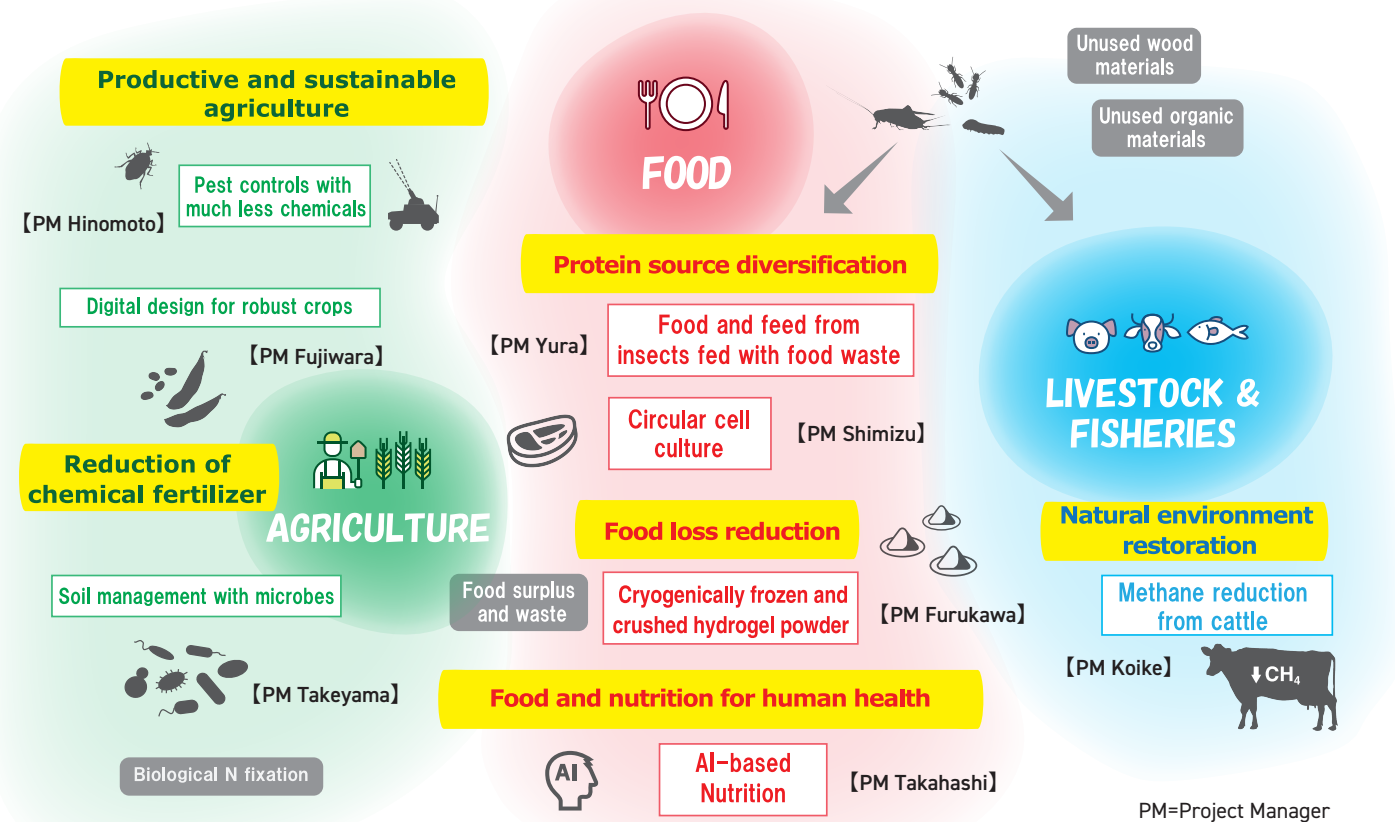
Outline

The global demand for food is estimated to increase 70% by 2050. Since excessive focus on production efficiency would hamper the cyclical function of the earth, it is essential to establish a food production system friendly to the global environment while increasing the food supply. Moonshot Goal 5 aims to address the issue with eight R&D projects, which are promoted by the Bio-oriented Technology Research Advancement Institution.

Message from PD

While with the formation of agrarian societies, humankind has acquired a stable method of sustainable food supply, with the dramatic expansion of human activities in recent years, the sustainable supply of food forces a serious situation where there is no longer any prospect for the immediate future. Overcoming this difficulty is not only a great responsibility we have for the future, but also an intellectual challenge with unparalleled problems. To address these global-scale challenges, it is necessary to unite innovative ideas that are not bound by existing concepts with the ability to realize them, and to act decisively. I believe that our country, which possesses a technological system capable of achieving world-class quality and precise management even on a small scale, has a mission to lead the realization of a sustainable society and to guide the world.

Sustainable food supply for 9 billion people



PM=Project Manager



FUJIWARA Toru



TAKEYAMA Haruko



SHIMIZU Tatsuya



HINOMOTO Norihide



KOIKE Satoshi



YURA Kei



TAKAHASHI Shin-Ichiro



FURUKAWA Hidemitsu



Bio-oriented Technology Research Advancement Institution

R&D Projects

Food Production

Developing environmentally robust crops based on a new design approach

Project Manager **FUJIWARA Toru**
Professor, The University of Tokyo

Outline The breeding process will be substantially faster with digital designing technology to develop crops which can be grown in extreme environments.

Enhancing soil microbial functions based on detailed understandings of soil ecology

Project Manager **TAKEYAMA Haruko**
Professor, Waseda University

Outline The complex interaction of soil microbiology will be analyzed in detail and controlled to allow optimal crop and soil management.

Sustainable circular food production system driven by animal cells and algae

Project Manager **SHIMIZU Tatsuya**
Director and Professor, Tokyo Women's Medical University

Outline Sustainable food will be produced through a circular animal cell culture system using algae as nutrients and recycling waste culture fluid.

Developing non chemical pest controls

Project Manager **HINOMOTO Norihide**
Professor, Kyoto University

Outline Insect pests will be managed through a combination of non chemical methods such as blue laser rays, new natural enemy strains and microbiological techniques.

Raising cows with less methane emission

Project Manager **KOIKE Satoshi**
Professor, Hokkaido University

Outline Methane emission will be substantially reduced by controlling microorganisms in cows' rumens.

Food Consumption

Producing food and feed from insects fed with food wastes

Project Manager **YURA Kei**
Professor, Waseda University

Outline Food and feed will be produced from unused resources such as food waste, with the efficient metabolism of insects such as crickets, black soldier flies and termites.

Developing food through an AI nutrition system

Project Manager **TAKAHASHI Shin-Ichiro**
Project Professor, The University of Tokyo

Outline Food and nutrition suggestion will be made with AI technology to meet personal needs and conditions.

Reducing Food Loss with "Unused Foodstuffs" × "Cold Energy of LNG"

Project Manager **FURUKAWA Hidemitsu**
Professor, Yamagata University

Outline We will manufacture hydrogel powder using unused foodstuffs and LNG cryogenic energy (cold energy generated when liquid natural gas vaporizes), establish long-term storage technology in ultra-low temperature warehouses to create added value for unused foodstuffs, and aim to build a social system that promotes ethical consumption.



https://www.naro.go.jp/laboratory/brain/english/moon_shot/

Program Director

YOSHIZAWA Fumiaki



Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050.

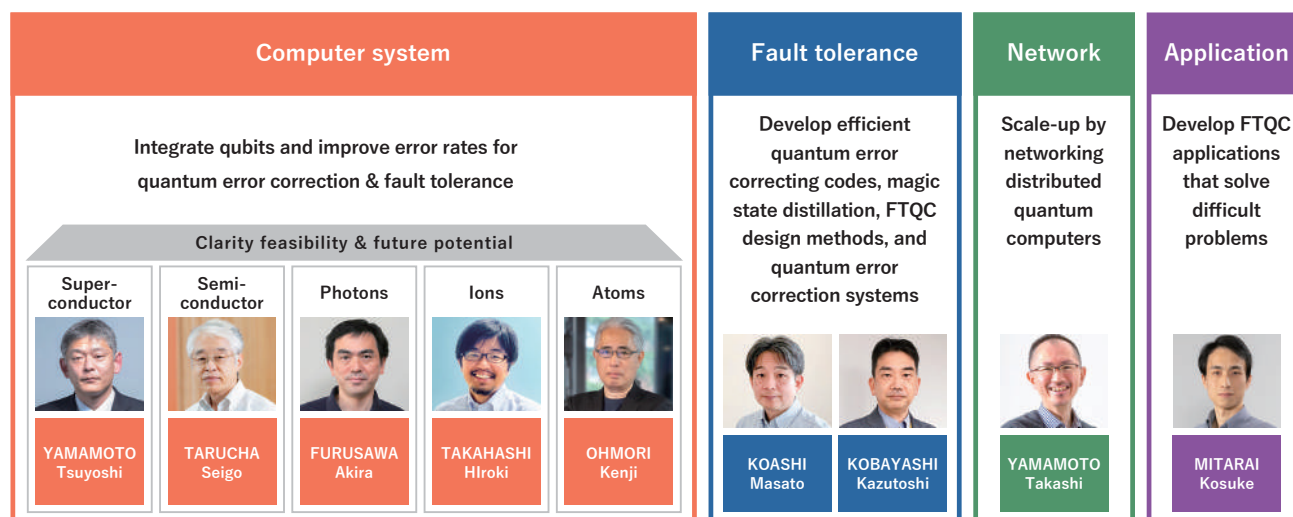
Program Director (PD) **KITAGAWA Masahiro** Director, Center for Quantum Information and Quantum Biology, The University of Osaka

Outline

While it is said that the progress of conventional computers is reaching its limits, it is important to be able to respond to the explosion of information processing demands. If we want quantum computing to rapidly solve our numerous and complex social problems, we need a fault-tolerant universal quantum computer that can perform precise computation while correcting quantum errors. In order to realize such a fault-tolerant universal quantum computer we are conducting R&D into the relevant hardware, software, networks, and related quantum technologies.

Message from PD

In order to realize a fault-tolerant universal quantum computer, it is necessary to integrate a huge number of qubits, provide redundancy using quantum error correcting codes, and reduce the physically arising quantum error to below the fault-tolerant threshold. Therefore, we aim to develop a certain scale of quantum computers and demonstrate the effectiveness of quantum error correction. Considering the possibility of massively integrated quantum computers through quantum communication, R&D projects will be implemented in four categories: 1) quantum computer system, 2) error correction theory, 3) communication networks, and 4) application. Specifically we would like R&D projects in each category to compete for feasibility, collaborate across categories, and conduct R&D to achieve the Moonshot Goal.



R&D Projects

Neutral Atom-Based Fault-Tolerant Quantum Computer

Project Manager **OHMORI Kenji**
Professor/Chairman, Institute for Molecular Science, National Institutes of Natural Sciences

Outline: Neutral-atom quantum computers use the arrays of ultracold atoms assembled with optical tweezers, in which each single atom serves as a high-quality qubit, whereas the whole system operates at room temperatures. We develop, operate, and upgrade neutral atom-based fault-tolerant quantum-computer systems, where we will fully utilize our various core competencies in qubit control / manipulation, scalability, ultrafast laser technologies, and system engineering, etc. Tight industry-academia collaborations will lead to all the components modularized and packaged, achieving unprecedented levels of stability and usability.

Research and Development of Theory and Software for Fault-tolerant Quantum Computers

Project Manager **KOASHI Masato**
Professor, School of Engineering, the University of Tokyo

Outline: This project develops and expands a co-design model for fault-tolerant quantum computers, encompassing all technological layers. This model is used to integrate various innovative approaches conceived by our diverse team of researchers in quantum information, computer architecture, and various physical systems, aiming to realize a large-scale quantum computer by 2050.

Development of a Scalable, Highly Integrated Quantum Error Correction System

Project Manager **KOBAYASHI Kazutoshi**
Professor, Department of Electronic, Kyoto Institute of Technology

Outline: The mission of this research and development project is to agilely adapt to a wide variety of qubit modalities, ranging from superconducting to neutral atoms, and to realize error correction systems as well as compact, low-power qubit control devices. To achieve this, we will undertake research and development using superconducting qubits. We will also extend the results to other quantum bit schemes.

Fault-tolerant Quantum Computing with Scalable Integrated Ion Traps and Multiplexed Photonic Interconnects

Project Manager **TAKAHASHI Hiroki**
Assistant Professor, OIST

Outline: This project aims to realize a photonic-interconnected, fault-tolerant quantum computer based on ion-trap technology. By 2030, we will build a 100-qubit system, demonstrate quantum error correction and logical operations, and establish key technologies such as the universal unit cell (UUC) scalable beyond 1,000 qubits and multiplexed photonic interconnects. Building on these advances, by 2050 we target a million-qubit-class quantum supercomputer composed of multiple linked QPUs, creating a transformative computational platform for materials discovery, drug development, and energy optimization.

Development of Fault-Tolerant Silicon Quantum Computing Technologies

Project Manager **TARUCHA Seigo**
Group Director, RIKEN Center for Emergent Matter Science /Team Director, RIKEN Center for Quantum Computing

Outline: This project aims to develop scalable multi-qubit devices with error correction toward realization of fault-tolerant silicon quantum computers. We will apply qubit integration and qubit-shuttling technology to implement a unit structure of qubits and scale up the qubit devices by integrating the unit structures. We will establish technology bases appropriate to implement large-scale quantum computers by 2030, and expand them in cooperation with the semiconductor industry to realize fault-tolerant large-scale quantum computers by 2050.

Development of fault-tolerant all-optical quantum computers

Project Manager **FURUSAWA Akira**
Professor, School of Engineering, The University of Tokyo/Deputy Director, Riken Center for Quantum Computing, RIKEN/Director, OptQC Corp

Outline: We develop our own quantum lookup table method to realize large-scale fault-tolerant quantum operations. By 2050, we aim to realize a large-scale optical quantum computer that can operate at room temperature.

Application R&D for Fault-Tolerant Quantum Computers

Project Manager **MITARAI Kosuke**
Associate Professor, Center for Quantum Information and Quantum Biology, The University of Osaka

Outline: We will promote application R&D for fault-tolerant quantum computers with a focus on computer-aided engineering (CAE) and computational materials science. We will also conduct exploratory research toward new applications such as machine learning. Beyond theoretical study, we will integrate algorithm design, compiler development, and implementation evaluation to quantify quantum advantage in the end-to-end applications required by users.

Fault-Tolerant Networked Quantum Computer

Project Manager **YAMAMOTO Takashi**
Professor, Graduate School of Engineering Science, The University of Osaka/
Deputy Director, Center for Quantum Information and Quantum Biology, The University of Osaka

Outline: This R&D project aims to realize a large-scale "Fault-Tolerant Networked Quantum Computer" by developing networking technologies that establish quantum interconnects between multiple small/medium-scale quantum processors.

Development of Superconducting Fault-Tolerant Quantum Computer Systems

Project Manager **YAMAMOTO Tsuyoshi**
Joint Appointed Fellow, National Institute of Advanced Industrial Science and Technology

Outline: To realize a practical fault-tolerant quantum computer, the number of physical qubits must be scaled up to roughly ten thousand times the current level. However, today's superconducting quantum computers have poor scalability to large systems, which has become a truly critical issue. To drastically reduce the number of coaxial cables and maintain scalability that seems impossible through mere extensions of existing superconducting quantum-computer development, we propose a new architecture.



<https://www.jst.go.jp/moonshot/en/program/goal6/>

Program Director
KITAGAWA Masahiro



7

Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one's life with relief and release from health concerns until 100 years old.

Program Director (PD) **HIRANO Toshio** Professor Emeritus, The University of Osaka / President, Osaka International Cancer Treatment Foundation

Outline

In recent years, diseases that are caused by a combination of environmental and genetic factors, such as so-called lifestyle-related diseases and diseases associated with aging, have come to have a significant impact on people in Japan, and this trend is expected to continue in the future. As the average life expectancy is increasing, the importance of prevention in addition to diagnosis and treatment will increase as we face the challenge of dealing with such diseases in order to further extend healthy life expectancy. The key is to live with as few limitations as possible even after suffering from a disease. For this reason, this R&D program will promote research and development in order to achieve the goal by 2040.

Message from PD

In order to realize a healthy society with a long life expectancy, it is important to provide medical care that maintains QoL (quality of life, that is, people feel comfortable), and does not just treat diseases in the past. Medical care includes treatment, prevention, rehabilitation, etc., and also a daily life after receiving medical care. We believe that QoL is an important perspective in the provision of medical care itself and in all the aspects of life after medical care. Cancer, brain disease, cardiovascular disease, etc., which are major diseases in a healthy and long-lived society, are considered to be lifestyle-related diseases rooted in genetic factors, lifestyle habits from infancy such as diet, exercise, and rest, and aging (life course). The most fundamental keyword for these diseases is chronic inflammation (It is a condition in which inflammatory reactions are mild but persist for a long time and become chronic. When such an inflammation persists, abnormalities in the function and structure of biological tissues occur, leading to various diseases.). We will continue our research and development projects based on this perspective of chronic inflammation.



Control of Mitochondria
ABE Takaaki



Control of Inflammation anywhere
NANGAKU Masaomi



Prevention of Carcinogenesis
Cancer Immunoregulation
NISHIKAWA Hiroyoshi



The regulation of Senoinflammation
HIGUCHI Makoto



Control of Microinflammation
MURAKAMI Masaaki



Control of Sleep/Wake
YANAGISAWA Masashi



Microbiome regulation
HONDA Kenya



Normalization of cancer cells
KOSEKI Haruhiko



The regulation of cognitive function in the brain by improving sleep
FS HAYASHI Yu



The regulation of brain reservoir function
FS ISA Tadashi

Control of Chronic Inflammation
Basis for Realization of a Healthy and long-lived society

FS Feasibility Study

R&D Projects

Mitochondrial Medicine

Project Manager **ABE Takaaki**
Professor, Graduate School of Biomedical Engineering, Tohoku University

Outline To perform a comprehensive and integrated analysis of the "mitochondrial-gut flora association" to clarify which mitochondria and gut microbiota regulate the host, and develop non-invasive diagnostic methods and new therapeutic agents. We aim to achieve healthy longevity by detecting mitochondrial dysfunction at an early stage by intervening and treating it by 2040.

Regulating microinflammation: Preventing disease through quantum and neuromodulation technologies

Project Manager **MURAKAMI Masaaki**
Professor, Institute for Genetic Medicine, Hokkaido University

Outline Tissue-specific disease-related microinflammation develops around blood vessels during presymptomatic disease. Currently, there is no method to detect and eliminate this microinflammation. In this proposal, we aim to establish two novel technologies to reset the presymptomatic disease state to the healthy state: quantum measurements and AI-based information integration analysis. First, we will detect a weak but minimal level of IL-6 amplifier activation that leads to the development of tissue-specific microinflammation. Then, we will establish neuromodulation technologies to eliminate the microinflammation via specific neural circuits including gateway reflexes.

Deciphering and Engineering Sleep and Hibernation -- The Future of Medical Care

Project Manager **YANAGISAWA Masashi**
Director/Professor, International Institute for Integrative Sleep Medicine, University of Tsukuba

Outline Through elucidating the neurophysiological roles and regulatory mechanisms for two immobile modes of animal behavior, sleep and hibernation, we will develop technologies to control sleep and induce hibernation in humans, transforming the future medicine. Induced hibernation will be a step forward to space expedition, a dream of humankind.

Bring hospital into home toward controlling inflammation at home

Project Manager **NANGAKU Masaomi**
Professor, Graduate School of Medicine, The University of Tokyo

Outline We will establish technologies analyzing gases emitted from human skin to monitor health condition, will research and develop technology that produces exercise-like effects (exercise substituting therapy and exercise mimicking drugs). By building a medical network that connects wearable sensors and hospitals to enable home diagnosis, we aim to realize a healthy longevity society.

Understanding and harnessing the role of the gut microbiome in healthy longevity

Project Manager **HONDA Kenya**
Professor, School of Medicine, Keio University

Outline We will illuminate the structure of metabolites produced by intestinal microbiota, which are currently poorly defined, and understand their operating principles as well as their effects on the nervous and immune systems. Through these studies, we aim to conquer Alzheimer's disease, Parkinson's disease, and chronic inflammation, realizing the unprecedented prevention and treatment methods.

A world of zero cancer risk created by rejuvenation using cell lineage conversion

Project Manager **KOSEKI Haruhiko**
Deputy Director, RIKEN Center for Integrative Medical Sciences

Outline Chronic inflammation, which causes aging and cancer, can be a "double-edged sword" because it has the potential to cause "cell lineage conversion" such as cell rejuvenation. By applying the mechanism of the reprogramming in the cells of regenerative medicine, We will develop a technology to "reverse cancer tissues to normal tissues" via cell lineage conversion. Our interdisciplinary approach involves a multi-racial, large-scale clinical studies based on the Japan / US cooperation.

Actualization of a cancer-free society through regulation of chronic inflammation

Project Manager **NISHIKAWA Hiroyoshi**
Professor, Graduate School of Medicine, Kyoto University

Outline We will elucidate the mechanism of the inflammation-precancerous state-carcinogenesis transition and establish novel technologies to detect cancer-initiating cells at an ultra-early stage based on immune-genomic analysis. We will also work on preventive medicine and new drug discovery / development using wearable devices, etc. The Japan-U.S. team will strongly pursue this program to realize a "society with zero incidence of cancer".

Study of reservoir functions that support resilience* of the brain and its enhancement to overcome dementia
*resilience : ability to overcome difficulties flexibly and recover

Project Manager **ISA Tadashi**
Director General, National Institute for Physiological Sciences, National Institutes of Natural Sciences

Outline We will develop methods to enhance cognitive function by promoting the reservoir function, which involves inducing the activation and plasticity of intact neurons, in addition to traditional methods that prevent Alzheimer's disease pathology. Through this, we aim to realize a society where people can maintain a healthy brain up to the age of 100.

Life course approaches through sleep to protect, nurture, and activate the brain

Project Manager **HAYASHI Yu**
Professor, Graduate School of Science, The University of Tokyo

Outline In dementia, sleep disorders often appear earlier than cognitive decline and are the most frequent peripheral symptoms, often being the primary reason for patients requiring institutional care. We aim to unravel the mechanisms by which sleep protects, nurtures, and activates the brain, focusing on the regulation of cognitive functions. By harnessing the power of sleep, which everyone experiences daily, we strive to create a society where dementia can be prevented and overcome.

Early detection and modulation of the dementia pathogenesis based on the concept evolving from glial pathology to senoinflammation

Project Manager **HIGUCHI Makoto**
Director, Advanced Neuroimaging Center, National Institutes for Quantum Science and Technology

Outline We hypothesized that the fundamental basis of dementia lies in the transformation of brain "guardians," such as glial cells, into "destroyers" through a process called "senoinflammation," which involves the interaction between inflammation and cellular senescence. This transformation leads to pathological protein aggregation and neurodegeneration. Our goal is to identify key molecules that influence this "senoinflammation" in the brain at a very early stage and to develop a next-generation dementia diagnostic workflow that allows us to monitor and control these key molecules.



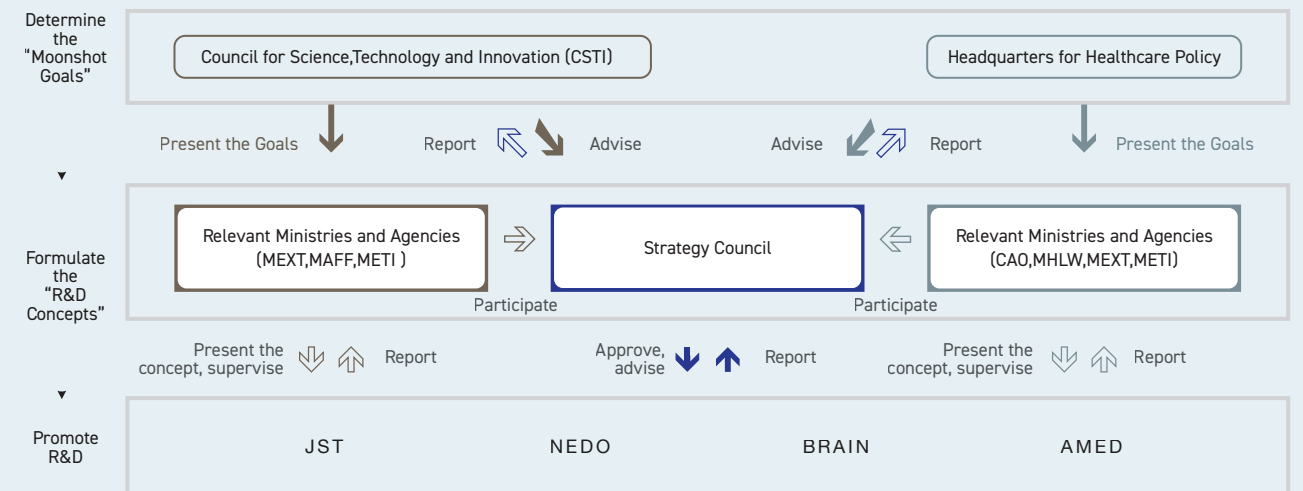
Program Director
HIRANO Toshio



<https://www.amed.go.jp/en/program/list/18/03/001.html>

Moonshot R&D Promotion System and History

〈Promotion System〉



〈History〉

- 2018.06 The 39th Council for Science, Technology and Innovation (CSTI)
 - ▶ CSTI executive members highlighted necessity for Moonshot type R&D.
- 2019.03 Goal-setting Visionary Council established.
 - ▶ Council members discussed potential Moonshot Goals.
 - ▶ Ideas welcomed from the general public regarding most important issues to be solved, and visions for an ideal future society.
- 2019.12 The Moonshot International Symposium
 - ▶ Various stakeholders from around the world discussed future of the program and its goals.
- 2020.01 The 48th Council for Science, Technology and Innovation (CSTI)
 - ▶ MS Goal 1 to 6 decided
- 2020.07 The 30th Headquarters for Healthcare Policy
 - ▶ MS Goal 7 decided
- 2021.01 Researchers selected to create new MS Goals.
 - ▶ Teams of ambitious young researchers brainstormed additional goals appropriate for the 'new normal' economy and society transformed by COVID-19.
- 2021.09 The 57th Council for Science, Technology and Innovation (CSTI)
 - ▶ MS Goal 8 and 9 decided
- 2023.12 The 70th Council for Science, Technology and Innovation (CSTI)
 - ▶ MS Goal 10 decided
- 2024.06 The 73rd Council for Science, Technology and Innovation (CSTI)
 - ▶ MS Goal 4 and 5 continued
- 2025.11 The 80th Council for Science, Technology and Innovation (CSTI)
 - ▶ MS Goal 1, 2, 3 and 6 continued
- The 54th Headquarters for Healthcare Policy
 - ▶ MS Goal 7 continued

Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050.

Program Director (PD) **MIYOSHI Takemasa** Team Principal, Center for Computational Science, Data Assimilation Research Team, RIKEN

Outline

Global warming means that wind and flood damage caused by extreme weather events such as typhoons and torrential rains are becoming more severe and frequent. If it is possible to change the intensity, timing, and/or location of extreme weather events that lead to disasters, it may be possible to avoid or dramatically reduce the resulting damage. In this program, we will conduct R&D aimed at: gaining a deeper understanding of extreme weather, which is essential for the development of weather control theory; improving weather forecasting technology such as weather modeling, data assimilation and ensemble methods; and realizing weather control technology that is socially, technically, and economically feasible.

Message from PD

Our goal is to significantly reduce the damage caused by extreme windstorms and floods, which are becoming more severe due to global warming and other factors, by developing weather control technology to change the intensity, timing, and location of typhoons and torrential rains. In our R&D we will combine control theory using numerical simulations, control technology that applies artificial disturbances to the atmosphere, and elements related to fundamental mathematics and ELSI. Weather control has long been a dream of humanity, and through my leadership as PD I hope to realize it as an open technology.

Goal
8

Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050

3 Targets

Demonstration of the effectiveness of weather control using **numerical simulation**

Establishment of weather control technologies in the real world based on **observations and outdoor experiments**

Rule-making and building public consensus for implementing weather control

R&D Projects Targeting Typhoon



SAWADA Yohei
The University of Tokyo

Control Theory of Weather-Society Coupling Systems for Supporting Social Decision-Making



FUDEYASU Hironori
Yokohama National University

Typhoon control research aiming for a safe and prosperous society

R&D Projects Targeting Heavy Rain



YAMAGUCHI Kosei
Kyoto University

Heavy Rainfall Control for Living Together with Isolated-Convective Rainstorms and Line-Shaped Rainbands



KOTSUKI Shunji
Chiba University

Artificial generation of upstream maritime heavy rains to govern intense-rain-induced disasters over land

R&D Projects

Control Theory of Weather-Society Coupling Systems for Supporting Social Decision-Making

Project Manager **SAWADA Yohei**
Associate Professor, Graduate School of Engineering, The University of Tokyo

Outline This project aims to develop meteorological control theory that will enable small external forces to significantly change the weather. In addition, we also pursue the ability to precisely forecast a wide variety of impacts of meteorological disasters on society, which is necessary for social decision-making regarding weather control. By 2050, we aim to be able to control weather-society coupling systems based on democratic social decision-making processes in order to free the world from the fear of meteorological disasters.

Typhoon Control Research Aiming for a Safe and Prosperous Society

Project Manager **FUDEYASU Hironori**
Director, Typhoon Science and Technology Research Center, Institute for Multidisciplinary Sciences, Yokohama National University/Professor, Faculty of Education, Yokohama National University

Outline This project aims to develop principles and fundamental techniques to diminish typhoons, which are expected to become increasingly severe with climate change, to the level that disaster prevention infrastructure becomes effective. To this end, we will establish typhoon control theory through high-precision observations by aircraft, ships and satellites, and the development of numerical models that reproduce the inner workings of typhoons. Furthermore, we will conduct disaster forecasting and impact assessment, and tackle the issues of social acceptability and consensus-building for typhoon control. By 2050, we will realize a society of safety and that is free from the threat of typhoons.

Heavy Rainfall Control for Living Together with Isolated-Convective Rainstorms and Line-Shaped Rainbands

Project Manager **YAMAGUCHI Kosei**
Professor, Disaster Prevention Research Institute, Kyoto University

Outline This project aims to control the intensity of "guerrilla heavy rainfall" and "line-shaped convective heavy rainfall". Based on numerical meteorological models, field observations, and laboratory experiments, we will develop multiple control devices. We will construct a control system that considers the impact assessment and social accountability of heavy rainfall control, by using those devices at multiple points in time and in multiple phases. By 2050, we will contribute to the formation of a future society in which heavy rainfall control technologies integrate with nature and human society.

Artificial Generation of Upstream Maritime Heavy Rains to Govern Intense-Rain-Induced Disasters Over Land

Project Manager **KOTSUKI Shunji**
Professor, Institute for Advanced Academic Research / Center for Environmental Remote Sensing, Chiba University

Outline This project aims to develop a weather control technology that mitigates heavy-rainfall-induced economic damages by artificially generating heavy rain over the upstream ocean. Given the limitations of directly altering the atmosphere, we explore a weather control method for intentional generation of heavy rains with optimization of manipulations. We will also promote social science research on legal issues and environmental risk assessments in order to accelerate the practical application of our results. By 2050, we aim to establish a weather control technology that society can accept.



<https://www.jst.go.jp/moonshot/en/program/goal8/>

Program Director

MIYOSHI Takemasa



Realization of a mentally healthy and dynamic society by increasing peace of mind and vitality by 2050.

Program Director (PD) **KUMAGAI Seiji** Professor, Institute for the Future of Human Society, Kyoto University

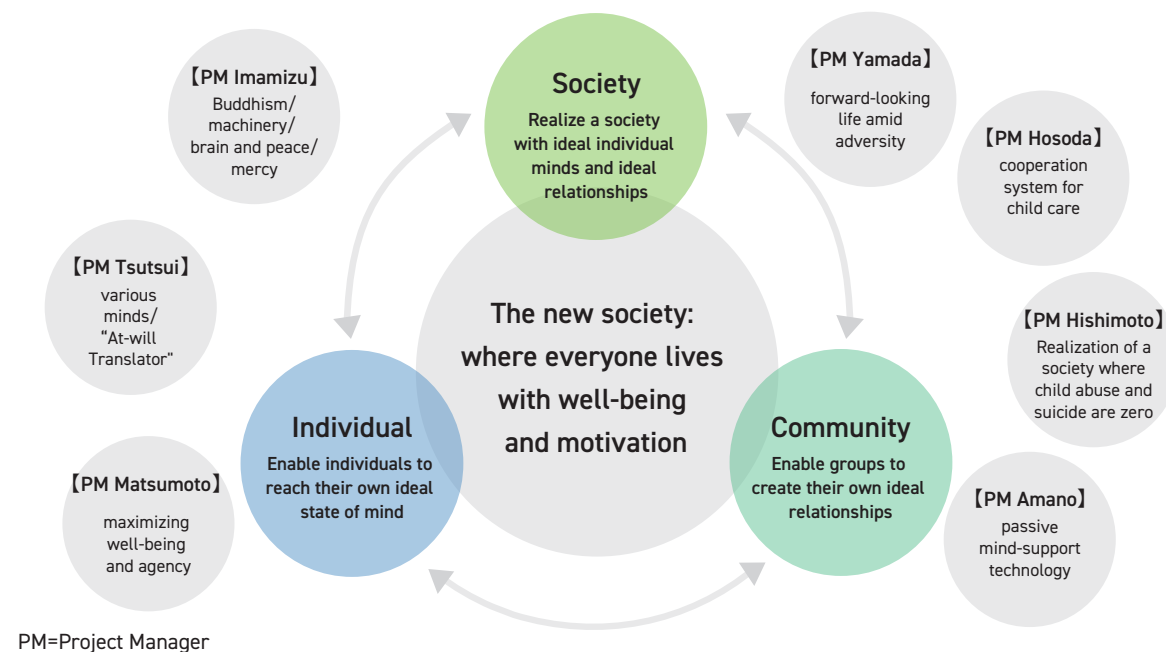
Outline

In recent years, social issues related to our mental states have become increasingly severe. The key to creating a mentally healthy and dynamic society is to develop a comprehensive understanding of mental states, and kind interpersonal and intergroup communication that will lead us in a more mutually beneficial direction.

Our R&D program aims to realize increased peace of mind and vitality by creating technology to realize "understanding of individual mental states and transitions" and "mental health support in terms of interpersonal and intergroup communication" so as to increase peace of mind and vitality.

Message from PD

We aim to realize a mentally healthy and dynamic society through development of technology that provides peace of mind and vitality. I believe it is necessary to discover the mechanisms behind our mental states, and use this practical knowledge for technology that will generate positive mental state transitions for users based on individual preferences. We will promote R&D using comprehensive knowledge gained by the fusion of different fields such as natural sciences, social sciences and humanities. Applying the expertise of enthusiastic researchers gathered from all over the world, together we will achieve our Moonshot Goal.



R&D Projects

Asian humanities and brain informatics to enhance peace and compassion of the mind

Project Manager **IMAMIZU Hiroshi**
Director, Cognitive Mechanisms Laboratories, ATR Brain Information Communication Research Laboratory Group

Outline This project aims to investigate the dynamics of the human mind based on knowledge of Asian humanities, represented by Buddhism, and brain informatics and apply our investigations to society. We will construct models of mental-state personalities from large-scale surveys and detailed examinations of small groups, and develop technologies that accurately estimate and visualize brain dynamics. Our models and technologies will contribute to the development of meditation methods and their social applications that will enable people to understand themselves deeply, enhance the peace and vitality of their minds, and achieve a society which has compassion towards others as one of its most cherished values.

Development of "Jizai Hon-yaku-ki (At-will Translator)" connecting various minds based on brain and body functions

Project Manager **TSUTSUI Ken-Ichiro**
Professor, Graduate School of Life Sciences, Tohoku University

Outline This project aims to develop a "Jizai Hon-yaku-ki (At-will Translator)" supporting people's communications in various situations, which may be useful in realizing an inclusive society. Neuroscientists, molecular biologists, and VR/AR and robotics engineers will collaborate to develop technologies to quantify states of mind, and methods for perceptual, cognitive and motor interventions. The Jizai Hon-yaku-ki will be produced by combining these technologies and methods, and facilitate the communication of individuals and small groups.

Maximizing well-being and agency on the basis of interpersonal comparison of brain indicators

Project Manager **MATSUMOTO Kenji**
Professor, Brain Science Institute, Tamagawa University

Outline This project aims not only to improve "happiness" at the level of individuals, but also to achieve aggregation and equality at the level of society. To this end, we will provide innovative technology to measure interpersonally comparable indicators of "happiness" from brain/neural activity. "Happiness" is enhanced not only by the experience of "well-being," which benefits each person's life, but also by the recognition of "agency," a way of life that each person has individually decided. We will study "well-being" and "agency" in future society using humanities and social science methods and virtual reality technology. Moreover, we will also achieve individual comparison of well-being and agency by elucidating brain indicators of subjective feelings "pleasure" and "aspiration". In doing so we will bridge neuroscience studies and real-world activities, such as evaluating mobility policies in smart cities.

Realization of a society where people can live a Maemuki (forward-looking) life in the face of adversity.

Project Manager **YAMADA Makiko**
Group Leader, Institute for Quantum Medical Science, National Institutes for Quantum Science and Technology

Outline This project aims to realize a society in which people can live "forward-looking" lives even in the midst of adversity. To this end, we will clarify the diverse and multifaceted components of "positivity," calculate positivity indices by measuring physical posture and brain/physiological reactions, and establish technologies to assist, train, and educate people on positivity factors tailored to their individual situations through positivity support technologies.

Child Care Commons 2.0: Building Children's Social Capital and Creating Social Value for Co-Nurturing

Project Manager **HOSODA Chihiro**
Associate professor, Graduate school of information science, Tohoku university

Outline As urbanization and nuclear families increase child-rearing burdens and Japan's birthrate declines, the concept of socializing child-rearing—distributing child-rearing responsibilities across society—has become critical. The "Child Care Commons 2.0" project addresses this by building social capital that includes children and enabling trusted third parties to participate in caregiving. Integrating insights from sociology, psychology, neuroscience, education, information science, medicine, and robotics, it designs environments and technologies that foster diverse relationships. Through this, the project aims to create a sustainable environment where children grow with rich social capital, ultimately enhancing well-being in an age of declining birthrates.

Realization of a society where child abuse, depression, and suicide are zero

Project Manager **HISHIMOTO Akitoyo**
Professor, Kobe University Graduate School of Medicine

Outline By using our proprietary data resource for the biological aging of abused children and young suicide decedents, as well as novel AMPA receptor recognition technology for human brain and information presentation technologies, we aim to: 1) develop biological indicators that visualize child and young people's abuse, depression, and suicide risks, as well as their recovery; 2) elucidate the biological mechanisms that determine stress and resilience caused by adverse experiences; 3) develop intervention and support systems that adjust mental problems in children and young people to healthy-positive states based on scientific evidence and indicators; and 4) precisely depict the ethical, legal, and social barriers to implementing cutting-edge technology in society, and finally contribute to the realization of a society with zero child abuse, depression, and suicide.

Development of Sensory-Stimulation Technology to Modulate Reciprocal Altruism

Project Manager **AMANO Kaoru**
Professor, Graduate School of Information Science and Technology, The University of Tokyo

Outline We aim to realize a society where sensory stimulation enhances cooperation, trust, and altruism among people. By applying visual and auditory stimuli to gently activate brain reward and empathy systems, we will examine changes in cooperative behavior through small-scale and online experiments. Based on these findings, we aim to design and socially deploy a "passive mind-support technology" that can be used broadly in schools, communities, workplaces, and other everyday settings.



<https://www.jst.go.jp/moonshot/en/program/goal9/>

Program Director
KUMAGAI Seiji



Realization of a dynamic society in harmony with the global environment and free from resource constraints, through diverse applications of fusion energy, by 2050.

Program Director (PD) **YOSHIDA Zensho**

Project Professor, Graduate School of Mathematical Sciences, The University of Tokyo

Outline

In order to put fusion energy (energy produced by nuclear fusion reactions) to practical use, innovation that realizes stable energy generation systems and building scientific knowledge that can accurately predict the complex phenomena involved is essential.

This R&D program will cast back from society in 2050, where fusion energy is implemented into various applied technologies, to identify key issues that would have to be faced before implementation and to conduct R&D to find solutions to those issues. Furthermore, we aim to create disruptive innovations that implement fusion energy into society by collaborating across a wide range of scientific and technological fields.

Message from PD

Goal 10 has been formulated to create a vibrant society in 2050 that lives harmoniously with Earth's environment by developing new fusion energy technologies. Researchers and engineers worldwide have been collectively working towards the ambitious dream of achieving practical applications of fusion energy for over 70 years. As the realization of this dream becomes more urgent, this R&D program seeks to play a key role in generating innovative technologies that can accelerate the research and development of fusion energy. To carry out this important mission, we have launched a R&D project that brings together researchers and engineers from a wide range of specialized fields to realize a society where fusion energy is used in power generation and various other scenes by 2050.

Innovative RF Accelerator
OKUNO Hiroki

HTS Superconducting Coil
KISS Takanobu

Fusion Digital Platform
HOSHI Takeo

Semiconductor Laser
MORI Yoshitaka

OEC Laser for Nuclear Fusion
FUJIOKA Shinsuke

Innovative Blanket
TANIGAWA Hiroyasu

Innovative Isotope Separation
TANAKA Hideki

Muon-Catalyzed Fusion
OKADA Shinji

Mathematical Model
OZAWA Tohru

Dipole Fusion
SAITOH Haruhiko

Diverse applications of fusion energy

R&D Projects

Development of High Intensity Neutron Source and Advanced Fusion System by Innovative Acceleration Technology

Project Manager	OKUNO Hiroki Group Director, Nuclear Transmutation Technology Group, Nishina Center for Accelerator-Based Science, RIKEN
Outline	This project aims to revolutionize fusion energy development by introducing innovative accelerator technologies. By establishing high-energy, high-output ampere-class beam accelerator technology, we enable the generation of large quantities of neutrons, thereby accelerating the development of fusion reactor materials. Additionally, by using automated cyclotron resonance accelerators for ion injection and heating, we will verify the feasibility of small-scale fusion reactors. This will help us aim for a future with a self-sustaining fuel society, one that does not increase high-level radioactive waste, a society coexisting with fusion energy, and a future supporting activities in uncharted spaces such as deep-sea and interplanetary travel.

Fundamental Superconducting Technology to Realize Various Innovative Fusion Reactor Concepts

Project Manager	KISS Takanobu Director, Research Institute of Superconductor Science and Systems, Kyushu University
Outline	This project aims to realize the early application of high-temperature superconductors to fusion reactors by establishing innovative mass production technologies for high-temperature superconducting wires and superconducting magnet technology that is resistant to neutron irradiation, stable against disturbances, and does not require liquid helium for operation. This will contribute to achieve the miniaturization and improved economic viability of fusion reactors. To this end, we will demonstrate 40-tesla-class high-temperature superconducting coils and high-capacity conductors. Furthermore, we will promote spillover effects in fields other than fusion, such as medical and mobility sectors, thereby realizing Japan's international superiority in superconducting technology and fostering talent.

Backcasting Digital Systems by Super Dimensional State Engineering

Project Manager	HOSHI Takeo Professor, National Institute for Fusion Science, National Institutes of Natural Sciences
Outline	This project aims to build a digital platform and virtual laboratories that will enable, in a digital space, the design and performance test of the fusion energy systems. To achieve this, we will utilize innovative AI and data-driven scientific technologies to develop computational methods that can accurately reproduce complex states such as plasma, where physical quantities are intricately intertwined, in a digital space. This will significantly reduce the time and cost required for the development and performance testing of prototypes, thereby aiming for cost reduction and early realization of diverse fusion energy systems.

Innovative Muon-Catalyzed Fusion Technology for Practical Applications

Project Manager	OKADA Shinji Professor, College of Science and Engineering, Chubu University
Outline	This project aims to establish the scientific foundation for highly efficient muon-catalyzed fusion by dramatically increasing the number of fusion reactions induced by a single muon. Muon-catalyzed fusion is a technique that enables nuclear fusion reactions using an elementary particle known as a muon. Unlike conventional fusion approaches, it does not require the extreme temperature and pressure conditions of a reactor core and is highly compatible with existing technologies. Through this project, we will achieve a positive energy balance in muon-catalyzed fusion. By 2050, we aim to contribute to a sustainable society in harmony with the global environment through diverse applications such as distributed power sources and neutron sources.

Innovation in the Formulation and Solution Methods of Mathematical Models to Transform the Paradigm of Fusion Research

Project Manager	OZAWA Tohru Professor, School of Advanced Science and Engineering, Waseda University
Outline	This project aims to create new mathematical concepts and methodologies for the fusion energy field by fostering collaboration between mathematical sciences and plasma physics, grounded in the challenges of fusion research as well as its abundant experimental data and numerical simulations. To understand the complex phenomena of ultra-high-temperature plasmas and the systems that generate and sustain them, we will begin by mathematically formulating the core issues in fusion science. Through redefining key concepts and achieving disruptive innovation in methodology, this project will contribute to the early realization of fusion energy and to enhancing the performance and safety of future fusion devices.

Interdisciplinary Development of Advanced Fusion and Antimatter Science Using Superconducting Dipole Fields

Project Manager	SAITOH Haruhiko Associate Professor, Graduate School of Frontier Sciences, The University of Tokyo
Outline	This project aims to realize a neutron source based on a dipole magnetic field, a configuration analogous to planetary magnetospheres that can be formed and sustained stably with a relatively simple device configuration. We will extend this concept to apply interdisciplinary developments in antimatter science. To achieve this goal, we will use a high-field superconducting dipole device to demonstrate ion heating and neutron production, thereby establishing the engineering foundation for a fusion-based neutron source. Through these initiatives, the project will contribute to the broader utilization of fusion energy and to the realization of advanced fusion systems in the future.

Development of Innovative Isotope Separation System for the Realization of Compact Fusion Fuel Cycle

Project Manager	TANAKA Hideki Professor, Institute for Aqua Regeneration, Shinshu University
Outline	This project aims to establish high-efficiency, low-cost isotope separation technologies to realize domestic production and a stable supply of fusion fuels. To achieve this, we will develop adsorbents and ion-exchange materials capable of sensitively recognizing the minute quantum effects that arise between isotopic molecules and ions, and pursue the creation of an innovative isotope separation system utilizing these materials. This will not only accelerate the social implementation of fusion energy as a baseload power source, but also contribute to the application of deuterium to high value-added materials and to the realization of a resource-circulating society for lithium-ion batteries.

Development of Autonomous Breeding Blanket for Compact Fusion Reactors

Project Manager	TANIGAWA Hiroyasu Deputy Director, Department of Blanket Systems Research, Rokkasho Institute for Fusion Energy, National Institutes for Quantum Science and Technology
Outline	The aim of this project is to develop a compact and innovative fuel breeding blanket that will ensure the sufficient plasma volume essential for achieving the required fusion power output, even as the fusion reactor itself becomes more compact. This will enable ITER-size reactors to achieve the fusion power and stability required for commercial operation while reducing the plant's overall tritium inventory. By establishing this design as the global standard for fuel breeding blankets, the project will contribute to accelerating the worldwide deployment of fusion energy on a global scale.

Fusion Reactor Using Optical Enhancement Cavity Laser

Project Manager	FUJIOKA Shinsuke Professor, High Energy Density Science Research Division, Institute of Laser Engineering, The University of Osaka/Director, Blue Laser Fusion Energy Collaborative Research Institute
Outline	This project aims to develop a new type of power laser called the "OEC laser," which stores optical energy in space. It focuses on achieving high-repetition-rate operation for practical use of laser fusion as an energy source and on establishing an autonomous research system called "OASIS," which integrates laser irradiation, fuel delivery, diagnostics, analysis, and simulation. By leveraging OASIS, we will rapidly optimize the conditions for fusion ignition, systematically accumulate technologies and knowledge, and thereby contribute to the realization of laser fusion.

Development of Inertial Fusion Modules Powered by Blue-Violet Semiconductor Lasers

Project Manager	MORI Yoshitaka Founding Board Director, EX-Fusion Inc.
Outline	This project aims to apply blue-violet semiconductor laser technology to establish a highly efficient laser driver for the realization of inertial fusion. The project will pursue the short-pulse operation and high-power performance of blue-violet semiconductor lasers, which are expected to achieve device level continuous wave efficiencies exceeding 50%. This high efficiency will significantly reduce the electrical power required to generate the high-intensity laser pulses needed to compress fusion fuel. Through this approach, the project aims to reduce the energy gain requirement for inertial fusion from the conventional level of around 100 to approximately 20, thereby advancing the realization of inertial fusion energy plants.

<https://www.jst.go.jp/moonshot/en/program/goal10/index.html>Program Director
YOSHIDA Zensho