Attached Table 2 Research Outline of Research Areas Showed on Attached Table 1

When applying for Publicly Offered Research, the applicant should note the following points.

- Research period is 2 years (Application of research period other than this period is not subject to screening).

- The Principal Investigator cannot set up a team of project members together with a Co-Investigator. (However, Research Collaborator is allowed to participate in research project when necessary.)

- Please be aware that the maximum application amount listed is not the total amount for the research period (two years) but the amount equal to a single fiscal year.

- Please note that in principle, the allotted amount is in units of 100,000 yen.

- It is possible to apply and receive grants for up to 2 projects in Transformative Research Areas (A) (Publicly Offered Research) at the same time.
  For example, in case that grants have been received for 1 project continuation of which will be in FY2026 in Transformative Research Areas (A) (Publicly Offered Research), it is possible to apply for only 1 project in Transformative Research Areas (A) (Publicly Offered Research) for FY2026.

- Please refer to the website of each research area for the details of application contents.

Research Outline of Research Areas

Qualia Structure: Bridging a gap between subjective conscious experience and scientific objectivity by establishing a super interdisciplinary research program
https://sites.google.com/monash.edu/a2023-2027/home_english

Number of Research Area	:	23A101	Term of Project :	FY2023-2027
Head Investigator	:	TSUCHIYA Naotsugu		
Research Institution	:	Advanced Advanced Telecommunications Research Institutes International		

1. Details of Research Area

Do subjective consciousness and the brain as objective matter belong to completely different domains? How are qualia, the contents of consciousness, related to the brain? The question of consciousness and the brain is not only of scientific interest. It is also directly related to everyday situations associated with difficulties in understanding feelings in others. Quality of experience, or qualia, is difficult to verbalize. To avoid this difficulty, conventional studies of consciousness have focused on the experimental paradigms, where experience can be reducible to a binary judgment (e.g., seeing vs. not seeing) by fixing perceptual stimuli, then they tried to isolate the neural correlates of consciousness. Recently, we have established a new paradigm to characterize Qualia Structures: by measuring a massive number of similarity judgements between a range of visual qualia. From there, we are to reveal their neural correlates and their information structures. This Research Area will expand the Qualia Structure paradigm by adding phenomenological studies, cognitive development, and constructivist approaches. By targeting perceptual and emotional qualia, this Research Area aims to establish the Qualia Structure paradigm. The outcome of this Research Area includes a better understanding of the consciousness of others, including animals and artifacts, aiming to address the issues that matter in real society.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

The overall aim of this Research Area is to understand the relationship between the structure of qualia and the structure of information obtained from brain information. Towards this aim, this Research Area takes the following basic strategy: 1) to focus on perception and emotional qualia, 2) to employ various theoretical and empirical methods, which generates synergy between them. However, with this limited strategy, it is difficult to arrive at our ultimate goal of a better understanding of the consciousness of others in a way that tackles the issues in real society. Thus, we invite Publicly Offered Research to collaborate with our Planned Research. In particular, those research that 1) deals with **research topics or employing methods, which are not employed by Planned Research**, 2) deals with **qualia with a structural approach,** 3) without focusing on a particular type of qualia, deals with **the relationship between the unconscious and consciousness**, **self-consciousness, changes of qualia structures associated with changes in levels of consciousness** (e.g., dreams, sleep, anesthesia, etc.). Those Publicly Offered Research will be overseen by relevant Planned Research to enable effective collaboration. We hope to attract those represented less in the field (e.g., young, female, or non-Japanese researchers) to participate, either individually or in teams with collaborators. To promote diverse participants, meetings in Research Areas will be recorded via web conferencing as much as possible, and consideration will be given to researchers of child-rearing age. The selected researchers will be expected to actively participate in the research activities of this Research Area, such as public relations through YouTube and SNS, the Qualia Summer School (from 2024~) to promote this Research Area to be recognized at the international level. The following summarizes some example projects. See our website for details.

In this second call, we hope to intensify participation from researchers in the humanities and social sciences (e.g., ethical, legal, and social issues that may arise in consciousness research that may be relevant to qualia structure, linguistics, religious studies, cultural anthropology, linguistics, art, etc.). With the aim of increasing the number of applications from this field, we have added an additional 10 slots of 1.5 million yen per year.

A01: Using large-scale online experiments, try to deal with qualia for value, beauty, and free will. Approaches from ethics, aesthetics, and religious studies are welcomed. Similarities and other methods can be used to visualize their qualia structures. Mathematical approach such as quantum cognition, topological data analysis.
A02: Philosophy, religious studies, aesthetics. Dealing with the relationship between embodiment, culture, and qualia.
A03: Human infants and mammals: comparative cognitive-behavioral research in atypical development (other than autism). Qualia structure approach from cultural psychology, evolutionary studies, etc.
B01: Qualia structure research by brain measurement and manipulation.
C01: Qualia structure research using information structure and model research and real neuronal data.
C02: Constructivism research using AI and robots (natural language processing, cognitive robotics, etc.). Also, research related to symbol emergence and consciousness in linguistics, sociology, cultural anthropology, etc.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Experimental psychology and mathematics of qualia structures		
A02	Phenomenological studies of qualia structures		
A03	Typical/atypical development of qualia structures		
B01	Measuring/manipulating brain activity related to qualia structures	5	7
C01	Correspondence between informational structures and qualia structures	3 1.5	10 10
C02	Symbol emergence from qualia structures		
D01	Unconsciousness, self, levels of consciousness and qualia structures		

Research Outline of Research Areas

Integrative bioarchaeological studies on human prehistory in the Japanese archipelago
https://i-bioarchaeology.org

Number of Research Area : 23A102 Term of Project : FY2023-2027
Head Investigator : YAMADA Yasuhiro
Research Institution : Tokyo Metropolitan University, graduate school of Humanities

1. Details of Research Area

Prehistoric archaeology is currently at a major turning point. It is clear that the results of many conventional, pure archaeological research methods, are forced to be revised due to recent results of natural scientific analyses.
Today, it is no longer possible to understand the real picture of the past using purely traditional archaeological methods. In order to escape from this crisis, archeology itself needs to shift from the traditional humanities academic field and be reborn as a new academic field.
Therefore, we advocate for the construction of a new form of integrative bioarchaeology, a comprehensive academic field that takes bioarchaeology and other current archaeological methods mainly focusing on excavated materials such as human bones, animal and plant remains, etc. in Japan and interweaves them with natural scientific methods such as radiocarbon dating, isotope analysis, and genomic analysis.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

The research area of this project consists of the following 11 Planned Research.
A01: Research on the social structure of prehistoric humans using archaeological methods,
A02: Research on the relationships among prehistoric peoples using genomic data and osteological features,
A03: Research on age, dietary restoration, and migration through the isotopic analysis of prehistoric bone,
B01: Dispersal of modern homo sapiens in the Japanese archipelago during the last glacial,
B02: Establishment of prehistoric humans and culture in Hokkaido,
B03: Establishment of prehistoric humans and culture in the Ryukyu Islands,
B04: Establishment of prehistoric humans and culture in the Honshu, Shikoku, and Kyushu regions,
B05: Research on the population dynamics of prehistoric humans,
C01: Research on paleoenvironmental changes in the Japanese archipelago,
C02: Research on artificial environment formation (fauna) by prehistoric humans,
C03: Research on artificial environment formation (flora) by prehistoric humans.
The aim of this project is to improve the quality of research and help advance the field in this Research Area, to further the broaden the scope of research in this entire field, and to recruit for focus areas not currently covered. If possible, we expect research application to cover multiple Research Groups. Please refer to the homepage of the relevant research area for details of the contents of recruitment for each Research Group. In addition, we welcome active applications from female and early career researchers to help further the goal of fostering and supporting female and young researchers and their research pursuits.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Research on Yayoi period tomb systems and social structure in Eastern Japan	2 5	10 6
A02	Research on the environmental conditions and kinship structures at archaeological sites using osteological features and genomic data		
A03	Research on improving the accuracy of dating and isotope ratios measurements on bone materials		
B01	Research on a high-resolution reconstruction of coastline changes in the Japanese archipelago in the late Pleistocene		
B02	Group Formation Theory, Ethnicity/Racial Theory, Multispecies Research, Environmental Change Research		
B03	Research on the movement and exchange of people, material goods, and culture in the Nansei Islands and Kyushu		
B04	Research on human migration and inter-regional networks in the Jomon, Yayoi, and Kofun periods		
B05	Research on population dynamics in the Yayoi and Zoku-Jomon periods		
C01	Environmental archaeological research on prehistoric human migration and population change based on high-precision climate change data		
C02	Research on the relationship between humans and animals in the Japanese archipelago using archaeological and genomic analyses		
C03	Research on the relationship between humans and plants in the Japanese archipelago using archaeological and genomic analyses		

Research Outline of Research Areas

Establishing the Field of "Dignity Studies": Toward an Interdisciplinary Paradigm of Social Integration Based on the Concept of Dignity

https://songengaku.jp/

Number of Research Area : 23A103 Term of Project : FY2023-2027
Head Investigator : KATO Yasushi
Research Institution : Sugiyama Jogakuen University, School of Foreign Studies

1. Details of Research Area

The concept of dignity originated with Cicero's translation of Plato's "axia" (the internal value of human beings) as "dignitas". In England, dignity became associated with social position or status and was characterized as a value that could fluctuate or disappear. In contrast, Kant characterized it as an "internal absolute value," a normative concept that could not fluctuate or disappear. This concept emerged as an ideal that supported the post-World War II international and social order, and it became an object of legal protection, being emphasized in documents like the Convention on the Elimination of All Forms of Discrimination against Women and the Convention on the Rights of Persons with Disabilities. In bioethics, dignity has been an important concept for questions of brain death, organ transplantation, genome editing, and "death with dignity." Dignity also offers a helpful ethical perspective for examining phenomena like A.I. (especially chatbots like ChatGPT), robots, and big data. The "basic guidelines" related to the Animal Welfare and Management Law also apply dignity to animals.

In this way, the concept of dignity was incorporated into the foundations of the international and social order. However, when "human dignity" was introduced into the E.U. constitution, differences in content between Germany's "Menschenwürde" and the U.K.'s "human dignity" were pointed out, with the former implying objective, absolute value and the latter subjective, relative value. While "dignity" has been applied to social issues, it lacks an all-inclusive definition. Hence, we synthesize research on dignity from various academic fields, including the sciences, discussing the concept comprehensively while also establishing "Dignity Studies" as a field that deals with the resolution of issues of clinical application and social implementation.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

This research area is made up of a mutual collaboration between "theoretical and conceptual historical research" (A01-04) and "clinical applied research" (B01-05), as well as "social implementation" (C01) based on both of them. We will examine the justification of "dignity" in terms of values, and construct a conceptual history that includes the non-Western world, taking into account both "the dignity of creatures" and "the dignity of life." Based on the results of this research, we will analyze the clinical application of advanced science and technology and advanced medical technology from the perspective of dignity. Moreover, we will deal with the "social implementation" of dignity by applying it to various educational settings. In this way, we will refine the concept of dignity. While the open call for publicly offered research proposals seeks research that will complement the above plan, we are also open to proposals that provide a broad understanding of our themes. We welcome proposals that offer perspectives and arguments that were not anticipated by our contributors, as well as proposals that offer a critical perspective on our research, including, for example, proposals that argue that the concept of dignity is unnecessary.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Animal Rights and Animal Dignity	1.1	1
	Gender and Dignity	0.9	1
A02	History of the Concept of Dignity (Ancient and Medieval Western Philosophy)	1	1
A03	A Study on Views of Humanity in Traditional Cultures of Non-Western Regions	1	1
B01	Dignity Provisions in the Constitutions of Asian Countries and their Interpretations	0.9	1
	The Concept of Dignity in Social Security (right to life) and Labor Rights	1.1	1
B02	The Atomic Bomb (Atomic Bomb Victims) and Dignity	1	1
B03	Nursing Ethics and Dignity	1	2
B04	Dignity in the Use of Care and Nursing Robots	1.1	1
	Dignity of Avatars in Digital Space	0.9	1
B05	Reproductive Genomics and Ethics	0.9	1
	Advanced Biotechnology and Human Dignity	1.1	1
C01	Disaster Prevention (Catastrophe) Policy and the Dignity of Disaster Victims	1.1	2
	Research and Development of the Educational, Medical and Caregiving System through the Introduction of the Concept of Dignity	0.8	1

Research Outline of Research Areas

1000-Tesla Chemical Catastrophe : Science of Chemical Bonding under Non-perturbative Magnetic Fields

https://1000tesla.issp.u-tokyo.ac.jp/

Number of Research Area : 23A201 Term of Project : FY2023-2027
Head Investigator : MATSUDA Yasuhiro
Research Institution : University of Tokyo, Institute for Solid State Physics

1. Details of Research Area

Magnetic fields are essential to the formation of nature, but on the Earth, their effects are generally weak and perturbative. On the other hand, the strong magnetic field in space, which is 16 orders of magnitude larger than the Earth's magnetic field, gives non-perturbative magnetic field effects. In this research area, we use the recently developed 1000 T ultrahigh magnetic field to clarify the non-perturbative magnetic field effects in the nature on the Earth. The 1000-T magnetic field gives electron spins an energy change of 1350 K in terms of thermal energy, which exceeds the Curie temperature of the iron and the melting point of gold. The phenomenon of Chemical catastrophe, which is a destructive effect on chemical bonds, is expected to be realized in solids. From solids to molecules, biomolecules, elementary particles, and plasma, innovative phenomena such as the creation of new crystals by magnetic fields will allow us to explore the essence of the mechanisms that shape the natural world.

There are six Research Groups in the Planned Research: A01 Molecular Orbital Catastrophe, A02 Spin Catastrophe, A03 Band Electron Catastrophe, A04 Chemical Reaction Catastrophe, A05 Elementary Particle Universe Catastrophe, and A06 Magnetic Field Catastrophe Theory, each with one Planned Research project.

A01 to A03 are on solid-state physics. One of the chemical catastrophe phenomena is crystal deformation due to a magnetic field. Through the wave function shape, Zeeman effect, Landau quantization, etc., the crystal structure is optimized in a magnetic field, which makes it possible to create new crystals in a magnetic field that cannot be realized in a low magnetic field. Solid oxygen, which undergoes a phase transition from monoclinic to cubic at 120 T by reconfiguration of molecular steric configuration, is one of the typical examples, but the research objectives of the field are to expand the research to a wider range of target materials and to understand the phase transition mechanism quantum mechanically. In A04, the main research target is non-perturbative magnetic field effects on photochemical reactions in molecules and polymers. Non-perturbative effects of magnetic fields, including photoexcited states, on chemical reaction processes through the Zeeman effect and Lorentz force will be the subject of research. The correlation between chirality and spin currents and magnetic fields will also be utilized to create new molecules in high magnetic fields and to understand their formation mechanisms. A05 studies non-perturbative magnetic field effects on plasma and elementary particle phenomena. The following phenomena are studied: production, scattering, and decay reactions of dark matter and dark energy, birefringence and anomalous synchrotron radiation in a quantized vacuum, and shock waves, jet collimation, and magnetic reconnection in magnetized plasmas, which are expected to occur when catastrophic phenomena in outer space are reproduced. We will conduct ultrahigh magnetic field experiments using a variety of quantum beams. We will elucidate the mechanisms at the microscopic level of elementary particles and plasmas, and clarify the role of magnetic fields in extreme space environments. A06 aims to theoretically elucidate the non-perturbative magnetic field effects of ultrahigh magnetic fields of up to 1000 T in molecules, polymers, plasmas, and elementary particles, with a focus on solids.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

As Research Group B01, we invite applications for experimental and theoretical studies of catastrophic phenomena induced by non-perturbative magnetic field effects in solids. The research topics include crystal deformations induced by magnetic field control of the spatial extent of wavefunctions, violation of the effective mass approximation due to interference with the crystal period, structural phase transitions caused by competitions of the magnetic energy and several excitations, nonperturbative magnetic field effects on phonons, and so on. We expect proposals beyond the framework of conventional magnetic field research. Plans to complement the target material groups in Planned Researches A01-A03 are also welcome. Research Group B02 invites experimental and theoretical studies of nonperturbative magnetic field effects on chemical reactions of molecules and macromolecules, and biological phenomena. Proposals for target molecules, macromolecules, and biological materials that complement Planned Research A04, and studies of magnetic field effects on catalysis and artificial photosynthesis are expected. For Research Group B03, we expect experimental or theoretical studies that pioneer non-perturbative magnetic field phenomena in astrophysics and particle physics. Hadron physics, solar physics, and other research topics that are related to Planned Research A05 are also open to applications. Researchers with no previous experience in high magnetic field experiments are also eligible to apply, as technical guidance will be provided after the proposal is accepted. (It is expected that high magnetic field experiments will be conducted using the shared use system of domestic magnetic field facilities and the portable pulsed magnetic field equipments developed in this research area.)

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
B01	Non-perturbative magnetic field catastrophe in solids	Experiment 2.5 Theory 1.5	8 4
B02	Non-perturbative magnetic field catastrophe to chemical reactions	Experiment 2.5 Theory 1.5	3 3
B03	Non-perturbative magnetic field catastrophe to particles and space	Experiment 2.5 Theory 1.5	3 3

Research Outline of Research Areas

Unveiling, Design, and Development of Asymmetric Quantum Matters

https://asymmetry.hiroshima-u.ac.jp

Number of Research Area	:	23A202	Term of Project : FY2023-2027
Head Investigator	:	ONIMARU Takahiro	
Research Institution	:	Hiroshima University, Graduate School of Advanced Science and Engineering	

1. Details of Research Area

In this research area, we transcend the understanding of electromagnetic effects such as cross-correlation response and non-reciprocal conduction that arise from the asymmetric electronic states in solids by employing the multipole concepts and develop innovative functions. Recent developments of quantum beam and physical properties measurements in high resolution facilitate the visualization of the orders of multipoles and the quantification of the susceptibility to the external fields. We construct a theoretical model describing the cross-correlation mechanism based on the obtained knowledge and it helps us to design new asymmetric quantum matters. We apply this model to molecular clusters, artificial materials, and broader target, to lead the evolution of next-generation material science and to frame the "asymmetronics". In planned research A01, we conduct microscopic analysis using quantum beams, and in A02, we develop new functions by combining microfabrication technology and various macroscopic measurements in high resolution. The theory group B01 constructs basic theoretical models that incorporate many-body effects and designs new materials. In C01, solid crystals are synthesized to develop new asymmetric quantum matters, and in C02, the strategy is to expand the material scales in wider range.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In publicly offered research, promotion of strong research collaboration in the research area is highly expected. Research that advances complementary with the planned research and that expands this research area are expected. The former involves various measurements of polarized quantum beams, precise macroscopic measurements using microfabricated samples, and research using advanced many-body numerical calculation techniques. The latter includes research that expand the concept of asymmetric quantum matters to softer and broader materials such as organic compounds and molecular clusters, as well as artificial substances. We welcome themes that utilize shared equipment, such as a cryogen-free low-temperature automatic measurement system and a focused ion beam processing equipment, or themes related to sophistication of the equipment. We expect applications from young researchers working on ambitious themes.

A01: Researches using advanced quantum beam analysis techniques to investigate the electronic states of asymmetric quantum matters and the order parameters of multipoles. For example, they include resonant inelastic X-ray scattering (RIXS), neutron PDF analysis, μSR, and fluorescent X-ray holography to clarify the electronic states.

A02: Experimental researches that will lead to technological innovation, such as providing new functions of matters and realizing a huge response by microfabrication and the practical application of anisotropic superconductivity. The concept is widely applied to organic chemistry and metamaterials to detect electrical, magnetic, thermal, and elastic cross-correlation responses and control them using various external fields.

B01: Theoretical researches that construct basic theories based on multipoles and promote its application. For example, theory to evaluate responses to external fields, elucidation of mechanisms of multipole order, applications to mesoscales, and development of new asymmetric quantum matters using first-principles calculations and materials informatics.

D01: Experimental researches that can collaborate with C01 and C02, with sufficient prospects for development of new materials, novelty of synthetic methods, and development and control of functional properties. A wide range of materials are objects based on a scale-seamless perspective, e.g., not only crystals without inversion symmetry, but also molecular clusters, metal complexes, organic compounds, and artificial materials such as metamaterials.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Probing Microscopic Properties of Asymmetric Quantum Matters through Quantum Beam Analysis	Theoretical: 1.0 Experimental: 2.5	10 28
A02	Exploring Novel Functionalities in Asymmetric Quantum Matters through Precise Measurements		
B01	Fundamental Theories and Theoretical Design of Asymmetric Quantum Matters		
D01	Development of Asymmetric Quantum Matters		

Research Outline of Research Areas

Materials Science of Meso-Hierarchy
https://mesohierarchy.jp/en/

Number of Research Area	:	23A203	Term of Project :	FY2023-2027
Head Investigator	:	YAGAI Shiki		
Research Institution	:	Chiba University, Graduate School of Engineering		

1. Details of Research Area

Conventional bulk materials, including crystalline solids, liquid crystals, and polymers, are typically formed through the self-assembly or self-organization of synthesized molecules or inorganic substances. However, the structures of such materials often consist merely of nanoscale periodic or aggregated arrangements that extend directly to the macroscale, and thus lack any discernible hierarchy within the mesoscale domain bridging the nano and macro dimensions. This is in stark contrast to biological tissues, which exhibit intricately hierarchical structures and functions from the molecular to the cellular level. This research area aims to uncover novel functionalities that emerge from hierarchically organized structures formed through self-assembly and self-organization in the unexplored mesoscale regime, thereby pioneering an innovative field in materials science. Achieving this goal requires not only the advanced nanostructure construction techniques that have been vigorously studied to date, but also the development of a new theoretical framework for extending and organizing these structures into higher-order hierarchies. For instance, by controlling non-linear structure formation processes such as nucleation during self-assembly and secondary nucleation induced by pre-existing structures, it is anticipated that unprecedented functional mesoscopic architectures can be created. In this context, we define materials possessing hierarchically organized structures at the mesoscale as "mesohierarchical materials." The research area will promote interdisciplinary studies centered on the following topics: (1) supramolecular self-assembly chemistry at the mesoscale, (2) design and construction methodologies for mesohierarchical structures and their theoretical modeling, (3) visualization and quantification techniques for observing such structures, (4) energy manipulation technologies leveraging light–matter interactions at the nanoscale, and (5) evaluation of novel mechanical properties exhibited by mesohierarchical architectures. Through the collaboration of researchers from diverse fields working on these themes, we aim to build a comprehensive understanding of mesoscale hierarchical structures and establish a new academic domain—"Mesohierarchical Materials Science"—to drive a paradigm shift in materials development. The research will be structured around four major research components: A01 (“Morphology” and “Visualization”), A02 (“Photo-functional Science” and “Optical Measurement”), A03 (“Stimuli-responsive Materials” and “Nonlinear Responses”), and B01 (“Theoretical Computation”). Additionally, we will invite proposals for Publicly Offered Research to complement these core initiatives or to explore novel ideas unbound by existing frameworks.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

C01 Synthesis and Characterization of Meso-Hierarchical Structures: Proposals are sought for the hierarchical self-assembly of organic, inorganic, or hybrid materials in the mesoscale domain. π-Conjugated systems, functional dyes, metal clusters, and quantum dots are especially encouraged. Studies leveraging secondary nucleation or novel analytical methods are particularly welcome. → Linked to Planned Research A01

C02 We invite research exploring unique properties of mesohierarchical structures, such as long-range exciton transport, mechanical responses, and energy manipulation via light–matter interactions. Application-oriented studies and measurement innovations are also encouraged. → Linked to Planned Research A03

C03 Theoretical Analysis of Meso-Hierarchy: We seek proposals that elucidate the formation, stability, and properties of mesohierarchical structures using methods such as quantum chemistry (first-principles) calculations and (coarse-grained) molecular dynamics. Contributions from researchers in soft matter physics and (secondary) nucleation theory are highly valued. → Linked to Planned Research B01

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
C01	Synthesis and Characterization of Meso-Hierarchical Structures, Meso-Hierarchy Synthesis and structural analysis of structures	3.5	12
C02	Analysis and Utilization of Photophysical/Mechanical Properties of Meso-Hierarchical Structures	3	6
C03	Theoretical Analysis of Meso- Hierarchy	2	5

Research Outline of Research Areas

Latent Chemical Space Based on Diverse Natural Products for Bio-active Molecular Design
https://latent.chemical.space

Number of Research Area	:	23A204	Term of Project :	FY2023-2027
Head Investigator	:	KIKUCHI Kazuya		
Research Institution	:	Osaka University, Graduate School of Engineering		

1. Details of Research Area

The discovery and identification of biologically active molecules using two typical compound resources, natural products (first) and synthetic compound libraries (second), has been a driving force in promoting chemical biology research, a field that integrates chemistry and biology. In this research area, we propose a third resource to follow these two. This third resource is virtually generated from the Latent Chemical Space, which is constructed by deep learning technology based on bioactivity data of natural products, and is realized in real space using robust organic synthesis. The Latent Chemical Space created by the fusion of natural products and informatics research will bring about a paradigm shift in data-driven chemical biology research and revolutionize the design of biologically active molecules. To realize this, we will launch the "Cyber Bioactive Molecule Design Lab" consisting of three groups: Chemical Biology, Informatics, and Organic Synthesis. The goal is to establish a new science of bioactive molecule design that can develop innovative molecules that lead to the clarification of new biological functions and to the seeds for pharmaceuticals and agrochemicals, starting from the compounds created from this third resource.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

We invite applications for research members to add depth and breadth to our research perspectives and backgrounds, and to strengthen our research system to achieve the goals of this research area, which aims to create new scientific principles for designing biologically active molecules by integrating chemical biology, informatics, and synthetic organic chemistry research. The goal is to create a new science of biologically active molecular design method. In order to achieve research objective, it is necessary to recruit a wide range of research topics that share the same sense of purpose and to accumulate successful research examples. In order to lay the foundation for the future development of the research field, we expect active applications from active female and young researchers who share the same vector of research goals. The following are the main points of the research topics for which applications are solicited.

For research item A01 (Chemical Biology Group), it is necessary to increase the variation of evaluation methods, and we invite applications from researchers who can strongly promote activity evaluation methods from unique viewpoints. In order to construct a high-quality compound potential space, a more comprehensive activity evaluation is desirable. For this purpose, we envision the adoption of group members specializing in bio-related chemistry and structural biology, which provide excellent activity evaluation methods and structural biological basis. Furthermore, we expect to receive applications from researchers specializing in natural product chemistry who are updating the first resource using original evaluation methods.

For research item B01 (Informatics Group), we are seeking researchers who can further expand the chemical latent space, which is constructed based on a deep learning method originally developed by the planned research members of this research area, from the knowledge of computer science. Specifically, we are widely inviting proposals for research on the application of latent spaces to virtual screening and chemoinformatics, the development of novel machine learning methods, and the learning and application of language models (not limited to natural language). Researchers specializing in deep learning, data mining, and graph information processing are also welcome, as this research area will collect various labeled data on compounds and organize them in graph data structures. Even if they have no previous experience in chemistry or biology, we expect applications from researchers who develop and apply excellent algorithms and methods in the fields of computer science and artificial intelligence.

In research item C01 (Organic Synthesis Group), the following two points will be pursued in parallel: (1) synthesis of novel bioactive candidate molecules derived from compound potential space, and (2) construction and expansion of a library of novel synthetic compounds based on bioactive molecules. In order to respond to the structural diversity of new molecules proposed by information analysis, it is important to advance and diversify the synthetic technologies possessed by this research area. Therefore, we expect applications from researchers who possess original technologies and high synthetic capabilities useful for the synthesis of complex molecules, and who can actively contribute to the deepening of the chemical space by working on the above items (1) and (2) through further advancement of these technologies.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Chemical Biology: Collection of bioactivity data from diverse compounds	3	7
B01	Informatics: Construction and application of latent chemical space		7
C01	Organic Synthesis: Construction of synthetic compounds for evaluation of biological activity		7

Research Outline of Research Areas

The creation of multi-messenger astrophysics -- The unified picture of dynamical universe driven by births of black holes
https://multimessenger.jp

Number of Research Area	:	23A205	Term of Project :	FY2023-2027
Head Investigator	:	YOSHIDA Shigeru		
Research Institution	:	International Center for Hadron Astrphysics		

1. Details of Research Area

The gravitational energy produced by the mighty gravity of black holes has been the primary energy source of the universe since the Big Bang, and is the source of the diversity of the universe, driving the growth of black holes, the synthesis of elements that are the origin of matter, and the creation of ultra-high energy cosmic ray nuclei with enormous energy that has never been explored by humans. However, the origin of these extreme cosmic phenomena is a great mystery, as the sites are hidden by the surrounding high-density matter. In this research area, we will promote multi-messenger observations that combine neutrino and gravitational wave cosmology observations with traditional electromagnetic wave observations, which have made overwhelming progress in recent years, in order to unify our understanding of the final fate of gravitational energy, from the growth process of ultra-dense fireball plasma produced by the strong gravitational field to elemental synthesis and high-energy radiation. The final fate of gravitational energy, from the growth process of ultra-dense fireball plasma produced by a strong gravitational field to elemental synthesis and high-energy radiation, will be understood in a unified manner. The new research field by a diverse group of researchers with different professional backgrounds will reveal why the universe is so diverse and dynamic.

This research area consists of three research groups: Group A, which is a planned research group to dramatically advance observational research in multi-messenger astrophysics by strengthening the observational experiments and facilities currently in operation; Group B, which conducts future-oriented development research; and Group C, which promotes theoretical research. Each of these research groups is as follows Cosmic neutrinos (IceCube - A01), gravitational waves (LIGO - A02), visible, near-infrared and radio waves (A03), X-rays (A04), gamma rays (CTA - A05), multi-particle space observation technology (B01), multi–Messenger Observation Satellite (B02), Neutrino Astrophysical Theory (C01), and Strong Gravity Research (C02). Five fusion research themes with neutrino, gravitational wave, and electromagnetic wave observations designed to make the most of the observational experiments and projects participating in the area have been established, and each planned research in group A will be promoted in cooperation with each other. The mission of the group C project is to provide guidance for this fusion research and to decipher the observational data to understand in a unified manner the processes leading to the emission of neutrinos, gravitational waves, and electromagnetic waves, starting from the accumulation and release of gravitational energy. In order to sustainably develop this fusion research in the future, B01, which focuses on the development of detectors, especially in the wavelength and energy bands for which advanced observation sensitivity is required, and B02 , which conducts the basic design and development of the HiZ-GUNDAM satellite led by Japan, will play the role of sowing seeds of growth.

Multi-messenger astrophysics is a nascent interdisciplinary field that requires the formation of a new community of researchers with expertise in different space observation techniques. The ultimate goal of this research area is to create a multi-messenger astrophysics expert group consisting of a diverse group of researchers, with Japan leading the way in the fierce international competition.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Multimessenger astrophysics, by its very nature, is related to a wide range of astronomical, space, and particle physics research fields. Although each planned research item in the field integrates various specialized research fields by setting up top-down issues, there are many research themes and projects that cannot be covered by this approach. We expect bottom-up research proposals that broaden the base of interdisciplinary research in the open call for research. We welcome observation research proposals that are not part of the top-down fusion research agenda, such as observation research using balloons and other flying objects, survey observation specializing in a certain wavelength band, and cosmic particle observation research using ground-based detectors, as well as proposals for detector development based on novel ideas. We also expect seed research proposals that will develop fusion research, such as research on methods for integrating and analyzing data of different quality, and theoretical research proposals on cosmology, particle theory, gravity theory, etc., which will form the basis of the framework of multi-messenger astrophysics.

In addition, in order to promote relatively large-scale observation and development research, we invite truly pioneering research with a maximum application amount of 5 million yen per single year .

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
E01	Multi-messenger Astrophysics Observation and Development Large scale Research	5	2
E02	Multi-messenger astrophysics observation, numerical simulation and development research	3	8
E03	Multi-messenger astrophysics theory research	1	8

Research Outline of Research Areas

Green Catalysis Science for Renovating Transformation of Carbon-Based Resources
https://greencatalysis.jp/

Number of Research Area	:	23A206	Term of Project : FY2023-2027
Head Investigator	:	OOI Takashi	
Research Institution	:	Institute of Transformative Bio-Molecules (WPI-ITbM), Nagoya University	

1. Details of Research Area

Considering the sustainable development of society, organic synthesis must evolve into an environmentally benign technology that can efficiently convert any molecule for providing value-added organic molecules. In other words, there is an urgent need for a transformative shift toward greener organic synthesis in view of effective utilization of ubiquitous carbon resources, molecular transformations using renewable energy, and minimization of waste. However, achieving this goal within the framework of conventional organic synthesis is extremely challenging. This is mainly because most of the existing synthetic methods rely on ionic reactions using thermal energy, which require functional groups as a handle for executing precise transformations of starting materials. On the other hand, radical reactions are not dependent on functional groups and hold significant potential for implementing truly sustainable chemical synthesis with a wide range of carbon resources. However, it is very difficult to tame short-lived, highly reactive radicals, and no guiding principle has been established for the development of radical-mediated selective organic transformations. The research area "Green Catalysis Science" aims to realize precise control of radical reactions by the development of catalysts capable of harnessing light and/or electric energy based on the integration of inorganic coordination chemistry, solid surface chemistry, and organic chemistry, leading to transform organic synthesis into a form suitable for a sustainable society. Specifically, we will pursue the design of inorganic complexes and solid-state catalysts with the ability to generate radicals at targeted positions in starting materials through light excitation or electron transfer with electric energy. Meanwhile, organic molecular and metal catalysts will also be rationally designed for rigorous control of the subsequent bond-forming processes of radicals. These catalysts will be exploited in developing molecular transformations to assemble high value-added molecules, which were previously considered nearly impossible to synthesize, from small molecules such as methane and hexane, polymers, and biomass, which have been difficult to use as starting materials, in the shortest possible steps. This will revolutionize methods for the transformation of carbon resources, establishing the next-generation organic synthesis that embodies greenness and is independent of the structure of molecules.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In this research area, research is conducted through the organization of three groups: Research Group A01 (Control of Radical Generation), Research Group A02 (Control of Radical Reactions), and Research Group A03 (Expansion of Synthetic Processes). To achieve the goal of the area, a fusion of a wide range of fields is essential. Particularly, collaborative research based on understanding and controlling radical species through photo- and electrochemical approaches, advanced measurement science, theoretical and computational science, and broad catalysis science creates a basis for exploring methodologies for the transformation of carbon resources. The content expected for publicly offered research in each research group is as follows:

In **Research Group A01**, the focus is on controlling radical generation and developing methodologies to generate radicals from a wide range of carbon resources, such as small molecules like CO_2 and methane, biomass, and polymers, for use as starting materials. Therefore, proposals related to the exploration of catalytic methods for radical generation are expected with an emphasis on the activation of molecules that have been difficult to use as starting materials in conventional organic synthesis.

In **Research Group A02**, the focus is on catalytic control of selectivity associated with radical-mediated bond formations. Proposals for catalyst development based on various approaches, such as enzymatic and supramolecular catalysis, are expected. Proposals related to molecular design and methodology development for the application of inorganic complexes and solid-state catalysts to the control of radical reactions are also welcome.

In **Research Group A03**, the focus is on expanding synthetic processes by radical reactions. This includes not only the development of new reactions with organic small molecules but also novel methods effective for natural product synthesis, polymer synthesis, and even the development of photo- and electrochemical reactions with polymers. Proposals to merge catalytic radical reactions utilizing light and electric energy with process chemistry and flow synthesis are also encouraged.

For each of the research group, proposals that contribute to the "understanding" to control radicals and develop new reactions are welcomed from theoretical science and advanced measurement science. As diversity is the foundation of interdisciplinary collaboration, applications from young and female researchers with diverse backgrounds are especially encouraged.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Control of radical generation	3	20
A02	Control of radical reactions		
A03	Expansion of synthetic processes		

Research Outline of Research Areas

Shin-biology regulated by protein lifetime
https://www.proteinlifetime.jp

Number of Research Area	:	23A301	Term of Project :	FY2023-2027
Head Investigator	:	MURATA Shigeo		
Research Institution	:	The University of Tokyo, Graduate School of Pharmaceutical Sciences		

1. Details of Research Area

Proteins are vital to living organisms, and the functions of cells and tissues are determined by the proteome, which consists of thousands of different proteins. Protein synthesis follows genetic information, but the correlation between mRNA, translation, and protein levels is weak. Post-translational regulation, especially proteolysis, plays a critical role. Proteins vary in lifetime, from minutes to years. Existing laws explain some protein lifetimes, but most remain elusive. The regulation of individual protein lifetime is extensively studied in key biological events, but only limited aspects of protein dynamics are observed. During major functional transformations, protein composition undergoes significant reconfiguration, affecting degradation and synthesis. The mechanisms behind selective and large-scale proteolysis in biological and pathological contexts are unknown. To unravel these mysteries, we'll explore new principles of protein lifetime regulation, establish techniques for in-depth lifetime measurements, and elucidate regulatory mechanisms that drive compositional changes. We'll integrate sequence, modification, and 3D structure information to study protein lifetime regulation factors. We'll also develop technologies for precise protein lifetime control and methods to manipulate cellular and tissue functions. This interdisciplinary research aims to understand, measure, and manipulate protein lifetime mechanisms to achieve a deep understanding of biological phenomena and pathological conditions.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Research Group A01 seeks a new understanding of life phenomena through the comprehensive measurement of protein lifetime and the investigation of regulatory mechanisms. While the planned research will focus on cellular senescence, neural stem cell differentiation, and Moyamoya disease, publicly offered research is encouraged to address other life phenomena and disease mechanisms involving protein lifetime regulation. This research area will study the large-scale regulation of protein populations rather than individual proteins. Research Group A02 aims to uncover novel molecular mechanisms that determine protein lifetime. The planned research will focus on the ubiquitin-proteasome and autophagy-lysosome systems in eukaryotic cells, particularly on branched ubiquitin chains, ubiquitin chain discrimination, and the enhancement of degradation by liquid-liquid phase separation. Publicly offered research is not limited to these systems but should investigate diverse substrates and lifetime determination mechanisms that involve significant changes in protein composition rather than a regulatory system for a specific substrate. Research Group A03 aims to develop tools for in-depth measurement and computational analysis of protein half-lives and for controlling the lifetimes of target proteins. The planned research includes the establishment of high-resolution measurement techniques, the analysis of the correlation between lifetime and proteoforms, and the further development of techniques such as auxin-degron and PROTACs for protein lifetime control. Proposals should introduce new methods and tools for measurement, control, information analysis, and mathematical analysis of protein lifetimes, using diverse approaches such as synthetic biology, analytical chemistry, informatics, organic chemistry, and computational science. Administrative Group has established mass spectrometry and information analysis teams. We invite publicly offered research that synergizes with planned research and contributes to the development of this research area. Diverse and highly original research by young and female investigators is encouraged.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Biology of Protein Lifetime Dynamics	4	5
A02	Mechanisms of Protein Lifetime Determination	4	9
A03	Measurement and Control of Protein Lifetime	4	3

Research Outline of Research Areas

Integration of extracellular information by multimodal ECM activity
https://www.multimodal-ecm.com

Number of Research Area	:	23A302	Term of Project :	FY2023-2027
Head Investigator	:	FUJIWARA Hironobu		
Research Institution	:	RIKEN Center for Biosystems Dynamics Research		

1. Details of Research Area

The structure and function of multicellular organisms emerge from complex yet coordinated interactions between cells and the extracellular matrix (ECM). While biological research has long focused on cellular mechanisms, the ECM has often been regarded as merely a 'passive scaffold'. However, recent advancements in imaging, measurement and manipulation techniques have begun to unveil that the ECM is a dynamic structure, rich in diverse biochemical (e.g., molecular composition, adhesive and soluble signals) and physical (e.g., adhesion, viscoelasticity, geometry) information. These spatiotemporally distributed cues constitute 'multimodal information' that underlies the self-organisation and morphogenesis of multicellular systems. This research area aims to bring together experimental biologists, polymer materials scientists, and mathematical/data scientists to develop a comprehensive understanding of the dynamic and multimodal properties of the ECM. By elucidating how the ECM regulates multicellular behaviours across scales, we aim to transform the traditionally cell-centric perspective of biology.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Despite recent progress, it remains challenging to fully visualise ECM dynamics or disentangle and manipulate the diverse parameters it comprises. To address this, we have defined three core research groups: A01, which investigates the operating principles of the ECM–multicellular dynamic unit; A02, which aims to manipulate extracellular information by developing designer matrices; and A03, which applies mathematical and data science to analyse ECM–multicellular interactions. We invite proposals for Publicly Offered Research that aligns with the aims of the area, including those that complement or expand the planned research, promote collaboration across research groups, or challenge existing paradigms with novel approaches. In this second phase of the project, we especially welcome interdisciplinary proposals that integrate perspectives from experimental biology, materials engineering, and mathematical/data sciences. For example, proposals may include efforts to manipulate cell behaviour through engineered ECM environments, or to link experimental observations with theoretical models to better predict and understand complex phenomena. We plan to select 12 experimental research projects, each with a funding limit of 4 million yen per year, and 4 theoretical research projects, each with a funding limit of 3 million yen per year. Young and female researchers are especially encouraged to apply.

Research Group A01 calls for studies that investigate how ECM spatiotemporal dynamics influence multicellular systems. We prioritise studies that extend beyond static analysis of specific ECM molecules and instead seek to quantitatively analyse their interactions with cells in a dynamic, spatially and temporally resolved manner. Topics may include the ECM's role in morphogenesis, tissue regeneration, fibrosis, cancer, and evolution, as well as its cross-scale dynamics and interactions with soluble factors.

Research Group A02 supports the development of designer matrices, such as reconstituted ECMs, artificial matrices, and synthetic polymer hydrogels, capable of decoupling, integrating, and manipulating individual ECM parameters. Proposals that combine such matrices with biological experimental systems, including cell-, tissue-, or organism-level models (e.g. organoids), to explore emergent cell behaviours and functions are especially encouraged. Projects focused on measuring, visualising or manipulating the physical properties or molecular organisation of the ECM are also welcome.

Research Group A03 seeks proposals grounded in mathematical or data science approaches. These may involve the integration of multidimensional datasets (e.g. gene expression, spatial distribution, live imaging, proteomics and mechanical properties), or the development of innovative mathematical models and simulations that capture the dynamics of ECM–multicellular interactions.

The above examples are illustrative. We welcome all proposals that align with the research area's objectives.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Operating principles of the ECM-multicellular dynamic unit	Experimental research: 4 Theoretical research: 3	12 4
A02	Manipulation of extracellular information by designer matrices		
A03	Mathematical and data science for ECM-multicellular systems		

Research Outline of Research Areas

Hibernation biology 2.0: understanding regulated hypometabolism and its function
https://hibernationbiology.jp

Number of Research Area	:	23A303	Term of Project :	FY2023-2027
Head Investigator	:	YAMAGUCHI Yoshifumi		
Research Institution	:	Institute of Low Temperature Science, Hokkaido University		

1. Details of Research Area

Most mammals are homeotherms that keep their core body temperature within a narrow body temperature range of 37°C. If the core body temperature continues to deviate from the range, a breakdown of systemic homeostasis occurs, leading to death. On the other hand, some mammals called hibernators can achieve hibernation, during which basal metabolisms and core body temperature become very low under conditions such as cold or starvation when a food, a source of body heat production, is insufficient. During hibernation and torpor, animals can maintain homeostasis and survive for a long period of time. Elucidating the mechanism of hibernation will lead to the clarification of the mechanism of whole-body homeostasis under extreme hypothermia, which could not be approached in non-hibernators such as humans, and has the potential to expand and spread to various fields. Recently, hibernation research is entering a new stage with the spread of genetic modification techniques in mammalian hibernators and the identification of neurons that induce a hibernation-like hypometabolic state in non-hibernators. This research area aims to take advantage of these breakthroughs and elucidate the mechanisms of induction and adaptation of "hibernation/torpor " and to derive new knowledge on the mechanism of "extended homeostasis," the mechanism by which homeostasis is maintained despite extreme low core body temperature.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

A wide range of research to deepen our understanding of the principles of hibernation and torpor in mammals is invited in each research category from A01 to A03. In addition to research that uses mammalian hibernators (e.g., hamsters and chipmunks), we are also seeking research that draws a picture of the essence of hibernation by comparing hibernation diversity, and research on the mechanisms that induce hibernation-like low metabolism and hypothermia in mice a hibernation-like hypometabolism (e.g. QIH: Q neurons-Induced Hypometabolism and hypothermia). Research that contributes to an understanding of the extended homeostasis observed during hibernation and torpor, not only with regard to central regulation, but also with regard to the nature of peripheral organs and the systemic organ connections with the central nervous system, is also welcome. Proposals from young and female researchers are also welcome in order to promote the future development of research in this area and to encourage research from diverse perspectives.

A01 Molecular and Neural Basis for Hibernation: Proposals are invited to examine the functions of genes, molecules, and neural circuits predicted to be involved in the control of hibernation and torpor. Although hamsters will be used as a model hibernator in this area, interspecies comparisons will be an important element in understanding the principles of hibernation. We welcome studies on torpor and hibernation-like low metabolism models in mice, as well as proposals related to the control and significance of hibernation and torpor in poikilotherms, which should contribute to our understanding of homeostasis mechanisms in mammals through comparative verification.
A02 Biological Responses Induced by Hibernation: Proposals are invited to elucidate the responses to the biological environment such as hypometabolism and hypothermia induced by hibernation and torpor, and their mechanisms at the cellular, tissue, or individual level using techniques from molecular biology, biochemistry, or neuroscience. Research that pursues not only the response in mammalian hibernators, but also the low temperature response and its mechanisms in non-hibernators such as mice and humans, as well as in organisms for which comparative physiological verification is possible, is included in this section.
A03: Elemental Technologies for Hibernation Research: Proposals are invited to introduce or propose emerging technologies and methods necessary to elucidate the mechanisms of hypometabolism induction, low temperature response, and stress tolerance that occur during hibernation and torpor. We also welcome research proposals that appropriately address problem setting in hibernation research, even for existing experimental techniques and methodologies that have not been addressed in hibernation research due to difficulties in their application at low temperatures or in mammalian hibernators.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Molecular and Neural Basis for Hibernation	4.3	7
A02	Biological Responses Induced by Hibernation	4.3	7
A03	Elemental Technologies for Hibernation Research	4.3	2

Research Outline of Research Areas

Dynamic reproductive lifespan: Life-long changes and fluctuations in germ cell function and risk for next generation
https://reproductivelifespan.jp

Number of Research Area	:	23A304	Term of Project :	FY2023-2027
Head Investigator	:	KITAJIMA Tomoya		
Research Institution	:	RIKEN Center for Biosystems Dynamics Research		

1. Details of Research Area

This research area aims to elucidate the dynamic nature of the reproductive lifespan by clarifying the changes and fluctuations of germ cell functions and properties across the lifespan. Traditionally, the reproductive lifespan has been defined as a period during which an individual has the ability to produce the next generation. This is based on a qualitative view in which an individual's reproductive capacity is turned on and off in a binary manner at physiological turning points. However, as recent technological innovations have quantitatively analyzed germ cell functions and properties at the cellular level, it has become clear that they can change and fluctuate throughout life in terms of reproductive capacity and risk to the next generation. In this research area, we will quantitatively characterize such changes and fluctuations in germ cells across the entire lifespan and elucidate their underlying mechanisms.

Our particular interest includes changes and fluctuations in germ cell function and the risk to the next generation throughout the adult stage. For example, in mammalian females, oocytes enter a dormant state after production and remain non-proliferative throughout the adult stage. However, as life progresses, functions such as chromosome segregation deteriorate, leading to infertility and miscarriage, and increasing the risk of aneuploidies in the next generation. In males, however, sperm stem cells acquire the ability to suppress genomic mutations, continue to proliferate, and produce numerous sperm throughout the adult stage. However, the risk of transmitting mutations to the next generation increases with age. Not limited to these examples, germ cell function and risks to the next generation change and fluctuate from various perspectives, and these changes and fluctuations shape a dynamic reproductive lifespan with the processes of "acquisition, maintenance, adjustment, and deterioration" in life. This research area brings together research and technological development focusing on "acquisition" during the developmental and juvenile stages, "maintenance and adjustment" during the adult stages, and "deterioration" during the aging stages, to conduct germ cell research throughout the entire life span, with the goal of elucidating the dynamic reproductive life span.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Researches that focus on changes and fluctuations in germ cell function (A01) and risk to the next generation (A02) across the lifespan, as well as the development of technologies to facilitate these researches (A03), are eligible. We welcome research proposals that bring new approaches and perspectives not found in existing germ cell research, as well as research that takes advantage of technologies that have been developed in the field of germ cell research to date. While this research area is a group that gathers to elucidate the dynamic reproductive lifespan, it is intended to be a place where outstanding individual research can be enhanced through effective collaboration within the research area, and proposals based on open ideas that contribute to this concept are encouraged. In addition, as this research area seeks to promote diversity in human resources, proposals from young scientists and women scientists are strongly encouraged.

The following is a list of examples of research that we expect to see, but proposals are not limited to these, as long as a proposal contributes to the goals of this research area.

- Research to elucidate the dynamic changes and fluctuations in germ cells by taking advantage of mammalian or non-mammalian animal models.
- Research to elucidate cellular changes and mechanisms using techniques such as *in vitro* germ cell reconstitution and live imaging.
- Research that focuses on the fundamental processes of the reproductive cycle, such as germ cell differentiation, meiosis, and fertilization.
- Research to develop or utilize techniques such as micromanipulation or optical or magnetic tweezers to measure mechanical properties inside or outside of germ cells.
- Research focusing on the dynamics of long-term turnover of molecules and cells during the reproductive lifespan.
- Research that focuses on the effects of external factors, such as nutrition, on germ cell function and risk to the next generation.
- Research to elucidate mechanisms underlying reproductive lifespan by exploiting large-scale datasets such as genome cohorts related to reproductive aging.
- Research that develops or utilizes engineering and informatics technologies such as device fabrication and artificial intelligence, as well as original technologies.
- Research that theoretically elucidates the reproductive lifespan using quantitative data at the cellular level.
- Research to elucidate basic germ cell functions related to the reproductive lifespan of primates, including humans.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Reproductive lifespan by germ cell function	4	15
A02	Reproductive lifespan for next generation		
A03	Technology development for reproductive lifespan research		

Research Outline of Research Areas

Photosynthesis ubiquity: Supramolecular complexes and their regulations to enable photosynthesis all around the globe
https://www.photosynthesis-ubiquity.jp/en/

Number of Research Area	:	23A305	Term of Project :	FY2023-2027
Head Investigator	:	KURISU Genji		
Research Institution	:	The University of Osaka, Institute for Protein Research		

1. Details of Research Area

Photosynthesis is one of the most important topics in plant science, as it is an excellent light-driven chemical reaction in very diverse conditions from the tropics to the poles. Photosynthetic organisms cover the globe overcoming not only high or low light, but also dynamically changing light conditions, which embodies the concept of "photosynthesis everywhere". Thus, if we can address how photosynthetic organisms have adapted to diverse light conditions and understand and verify the principle of photosynthetic adaptation to diverse light environments, not only high academic impact but also pervasive social effects, such as the potential application to global warming or climate changes, will be expected.

The latest scientific research in plant biochemistry, plant physiology, and structural biology, elucidated that photosynthetic organisms have evolved specific proteins or the combination to adapt to their environments by diversifying light-harvesting antenna and its regulation system, without changing the core molecular apparatuses on the thylakoid membrane. Furthermore, these adaptations are thought to be strengthened by optimizing the regulation of gene expression, thylakoid membrane structure, and electron transfer activity. In other words, it is now becoming clear that it is important to understand environmental adaptation in photosynthesis based on the functional analysis and structural studies of various types of supramolecular protein complexes. However, it has not yet been accomplished to link the supramolecular complex structures, which are dynamically formed on the thylakoid membranes in response to environmental changes, and the physiology of various photosynthetic organisms. In this Research Area, leading scientists in structural biology, plant physiology, and biochemistry, team up with researchers in information science to tackle how the supramolecular complexes express their structural and functional features to accomplish the ubiquitous photosynthesis.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

For Publicly Offered Research, we seek for research proposals that cover biological diversity of environmental responses using non-model organisms (Research Group B01) and that pursue unique measurement techniques such as the development of new structural and functional analysis methods (Research Group B02) to fill the gaps in Planned Research Groups.

In Research Group B01, we will actively select research proposals using species that are not be covered by the Planned Research but expected to serve as important keystones in studying the principle of photosynthetic adaptation to diverse light environments. The strength of photosynthesis and plant/algal research in our country lies in the wealth of human resources who work with a wide range of photosynthetic organisms and make use of each characteristic to achieve high-quality results. Unfortunately, however, there are many researchers who are not sufficiently well funded despite their high-quality research. Therefore, in Research Group B01, we would like to encourage the participation of researchers who work with characteristic materials in a wide range of lineages, such as "Cyanobacteria in extreme environments", "Glaucophyta, one of the earliest divergent eukaryotic algal lineages without light-harvesting antennae of LHC", "Bangiophyceae, red algae with a hybrid light-harvesting antennae of LHC and PBS", and "Prasinophytes and streptophyte algae known for their characteristic physiological functions", which are important for investigating the principle of photosynthetic adaptation.

In Research Group B02, we will actively pursue research proposals that address the development of new methods for analyzing supramolecular functions based on the emerging atomic-level information. For example, vibrational spectroscopy such as Raman/IR or ultrafast spectroscopy, as well as new method development for molecular simulation using computational chemistry are expected to be applied.

In addition, we especially expect young researchers in Category II to actively apply for the program, since it is important for this Research Area to provide an appropriate environment of which they can take advantage for networking in early stages of their careers. In both B01 and B02, we expect active applications from young and female researchers.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
B01	Structural and environmental adaptation of supramolecules	Category I: 5 Category II: 3	10
B02	New techniques to analyze structures/functions of supramolecules		10

Research Outline of Research Areas

Plant Climate Feedbacks
https://www.plant-climate-feedback.com/

Number of Research Area	:	23A401	Term of Project :	FY2023-2027
Head Investigator	:	SATAKE Akiko		
Research Institution	:	Kyushu Univ.		

1. Details of Research Area

Volatile organic compounds (BVOCs) emitted by plant leaves and flowers play diverse roles in the Earth system. They contribute to forest scents, influence solar radiation and rainfall through aerosol formation, and drive ozone production in the troposphere. BVOC emissions vary both diurnally and seasonally, making them a phenological trait of growing importance for predicting future climate dynamics. Yet, understanding the complex interplay between plant seasonal activity and atmospheric processes remains challenging due to limited data and uncertainties in BVOC–climate interactions. To address this, we aim to establish a new interdisciplinary field, plant–climate feedback, linking genetic regulation of plant phenology with atmospheric and climate responses. Our research group is organized into two sections: Regulatory Mechanisms and Feedback. The former explores the genetic and molecular bases of BVOC emission, flowering, and leaf development, and builds models to predict plant responses to climate change. The latter focuses on developing observational tools and climate models to scale insights from individual plants to ecosystems. To integrate these efforts, we are launching the Plant Climate Integration Center, which will support advanced measurement technologies, modeling, and fieldwork. This center serves as a collaborative hub to unify expertise across plant biology, ecology, atmospheric chemistry, and climate science.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

The research scope of this field spans multiple biological and environmental levels, from genes to ecosystems and climate. To effectively analyze the resulting multilevel data, a multidimensional and integrative approach is essential. Accordingly, it is important to strengthen research areas beyond the capacity of the Core Research and Project Research Teams by engaging publicly solicited projects. Collaborations with the Planning Research Group are expected to generate strong synergistic effects. Examples of projects currently open for proposal include the following:

A01: Experimental and Monitoring Research (Biological Systems)

This category focuses on plant phenological responses and stress tolerance under climate change, aiming to elucidate underlying regulatory mechanisms. It welcomes studies on the biosynthesis of BVOCs, as well as the molecular mechanisms controlling the accumulation and release of BVOCs, including methane. Projects that examine organism–ecosystem interactions with a focus on dynamic gene expression changes are highly encouraged. Additionally, proposals integrating phytoclimatic feedback perspectives into paleoclimate and paleontology research are also invited.

B01: Experimental and Monitoring Research (Ecosystems, Atmospheric Science, Climate)

This category seeks six proposals that investigate phytoclimatic feedbacks driven by compounds other than BVOCs. It also encourages research using innovative technologies, such as automated remote systems for species identification, biomass and phenology monitoring, and the development of advanced instrumentation for measuring BVOCs and aerosols.

C01: Data Analysis and Modeling

This category, which emphasizes data science, will support five proposals focused on developing new methods for analyzing large-scale, multilevel, and high-dimensional data. It also promotes the creation of biodiversity models that incorporate genetic diversity, as well as theoretical studies that mathematically model plant–climate feedbacks for future projections. As this category does not involve experimental costs, the maximum funding per project is capped at 2 million yen, lower than in the experimental categories. All categories welcome research that extends beyond BVOCs to include other molecular systems, diverse plant species, and various geographical regions.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Experiment and monitoring (Biological systems)	4	7
B01	Experiment and monitoring (Ecosystem, Atmospheric Science, Climate)		6
C01	Data analyses and modeling	2	5

Research Outline of Research Areas

Extension and validation of unified theories of prediction and action
https://unifiedtheory.jp/en/

Number of Research Area	:	23A402	Term of Project :	FY2023-2027
Head Investigator	:	ISOMURA Takuya		
Research Institution	:	RIKEN Center for Brain Science		

1. Details of Research Area

Elucidating the computational principle of the brain and implementing it in artificial intelligence (AI) remains the greatest frontier of natural and computational sciences. Although AI has achieved great success by gaining inspiration from neuroscience, a significant gap still exists between human intelligence and AI.

The brain constructs a 'generative model' that expresses the dynamics of external states to enable prediction and action to minimise future risks. The Bayesian brain hypothesis and the free-energy principle have been proposed to account for the perception, learning, and action of biological organisms. However, the neuronal bases underlying these theories are yet to be elucidated. Recent developments in experimental techniques have enabled the identification of cell types and the acquisition of high-precision, large-scale data covering multiple layers and regions. Furthermore, reverse engineering of generative models has enabled the mapping of neural circuit quantities to quantities in generative models. These developments have made it practical to identify generative models from experimental data, facilitating an understanding of the brain and mind.

Thus, this project aims to use state-of-the-art techniques to measure highly accurate, large-scale neuronal activity data from the brains of various animals and reverse engineer generative models from these data, to develop a unified theory of the brain and empirically test its validity. We will measure the neural activity related to the prediction of the external world and behaviour in various species—including fish, rodents, monkeys, and humans—and test whether empirical generative models can predict brain activity, behaviour, and learning in animals. By integrating theoretical and experimental research, this project will develop a unified theory of the brain that explains perceptual prediction and action optimisation, paving the way for the development of AI with human-like thinking and early diagnostic methods for psychiatric disorders.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

To combine innovative ideas from diverse perspectives with original techniques and theories in a complementary manner, research proposals will be recruited from a wide range of fields. Emphasis will be placed on proposals that involve the necessary data science to link theory and experiments, and on the magnitude of the synergistic effect of collaborations between Publicly Offered and Planned Research. For example, we encourage applications from theoretical researchers who are willing to test their original theory empirically with data from the Planned Research, and experimental researchers who deal with functions and measurement scales—or who have unique measuring and controlling technologies—that are not handled in the Planned Research. We believe that Publicly Offered research conducted by multitalented researchers will play an extremely important role in the development of this research area. We expect active applications from young and female researchers with flexible and new perspectives. Research proposals of up to JPY 10, 5, and 3 million per year are invited. If your proposal spans both theory and experiment, please select the research group C01 or C02 that is more relevant.

C01: Theoretical research on unified theory—We invite proposals that will lead to the construction of a unified theory of the brain, proposals for theories with an original perspective targeting specific brain functions related to prediction and action, and proposals that will 'test theories by analysing data' measured by this research area and utilizing existing databases. We also emphasise AI applications and invite proposals that include ideas that could lead to the development of next-generation AI; for example, implementing energy-efficient computation using spiking neural networks.

C02: Experimental research on unification theory—We invite proposals with highly original measurement techniques and analysis methods to acquire highly accurate, large-scale neural activity in the brain related to prediction and behaviour in animals or humans. A specialised biological background is not a requirement for applicants. Proposals involving a variety of animal species will be obtained. Proposals focusing on the control and manipulation of biological information to verify theoretical predictions by examining causal relationships will also be invited.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
C01	Theoretical research on unified theory	10 5 3	1 4 3
C02	Experimental research on unified theory	10 5 3	3 3 2

Research Outline of Research Areas

Face-body design: Deepening and Sublimating Face-Body Based on Practical, Empirical and Constructive Research
https://face-body-design.tamacc.chuo-u.ac.jp/

Number of Research Area : 25A101 Term of Project : FY2025-2029
Head Investigator : YAMAGUCHI K. Masami
Research Institution : Chuo University

1. Details of Research Area

We aim to design the face and body of the future by expanding, deviating from, deepening, and sublimating traditional face-body studies. This effort is grounded in three key approach fields. We introduce [Practice], which integrates the face and body through artistic and performative expressions, encouraging exploration beyond conventional frameworks (expansion/deviation), and propose [Demonstrative Research], focusing on the analysis and theorization of interoception and deep bodily sensations for emotional connections among individuals (deepening/sublimation), and adopt a constructive approach [Designing] using body science and robotics to design the face and body of future humans and artificial entities (sublimation/evolution). We move beyond existing academic boundaries and establish a new interdisciplinary framework encompassing these three fields. We consider the rapid transformation of real face-body relationships driven by technological advancements and aim to foresee and support future forms of interpersonal interaction that transcend biological limitations by observing diverse face-body relationships across regions, age groups, and people with disabilities. Our ambition is to design a future society where the face and body are not sources of discrimination or suffering, but rather mediums for inclusive and empathetic expression. By simulating interoception as a body-brain network underpinning deep sensation, we explore new configurations of face-body interactions that merge biological and artificial perspectives. Ultimately, this project seeks to eliminate the distortions imposed on faces and bodies in contemporary society—such as prejudice, pain, and exclusion—by proposing a new vision of co-existence between humans and artificial entities toward a future in which the face-body serves as a platform for ethical development and inclusive education. Through this, we hope to foster a society that acknowledges embodied diversity, removes discriminatory structures, and reduces individual suffering, particularly by leveraging the transformative potential of arts and performance.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

We are accepting applications on the theme of "face and body" from various academic disciplines, including but not limited to philosophy, anthropology, psychology, cognitive science, engineering, and information science. We especially encourage applications from early-career researchers to support the development of future academic leaders by providing opportunities for cross-disciplinary and integrated collaborative research. We are particularly interested in proposals that explore areas not covered by the planned research, as well as in cross-sectional research in the three fields mentioned above. The number of cases and budget are shown in the table below. Each planned research group will provide opportunities for cross-disciplinary collaboration, shared use of equipment, access to regional surveys and performances. Research groups A and B: Various research including face and body practices such as video and theater, disability and performance, art, education and welfare, virtual reality and avatars, makeup, beauty, and body modification, etc. Research groups C, D, E: Research on AI, computer graphics, posthumous technologies including VR, unique facial features, and avatars, also including historical and sociological studies of faces and bodies. Empirical and design-oriented research is also encouraged, such as aging-related changes, bodily transformation and learning through technology, robotics, facial and bodily aesthetics, design engineering, and mathematical models of interaction, etc.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Joining bodies / Intercorporeal phenomenology of art	1	5
B01	Transformative face-body/ Field practice of embodied transformation	2	4
B02	Analyzing bodily habits and awareness / Ethics of face-body studies	4	1
C01	The body in death / The body in non-existence		
C02	Bodies in imagination: Between lived and symbolic embodiment		
D01	Encumbered body: Deep perception of body	1	3
D02	The face & body in the future / Habits and learning of face & body	2	10
E01	Designing artificial face & body with functional expression structure	4	4
E02	Interacting bodies: Elucidating emotion transmission processes and designing artistic performance		

Research Outline of Research Areas

Establishing the Digital History
https://dighis.rekihaku.ac.jp

Number of Research Area	:	25A102	Term of Project :	FY2025-2029
Head Investigator	:	GOTO Makoto		
Research Institution	:	National Institutes for the Humanities, National Museum of Japanese History		

1. Details of Research Area

This research project proposes Digital History as a new paradigm in historical studies. Positioned within the Digital Humanities, it seeks to establish a field that integrates advanced informatics—including AI—and data infrastructure to achieve both the deepening of disciplinary expertise (vertical development; Component B) and the opening of historical knowledge to broader publics and fields (horizontal development; Component A).

Component A promotes the dissemination and democratization of historical knowledge. Through technologies such as data accumulation, open access, visualization, and crowdsourcing, it transforms historical research from an individual endeavor into a collaborative, interdisciplinary practice.

Component B aims to externalize interpretive processes traditionally performed by historians. By applying natural language processing, machine learning, and knowledge representation, it seeks a quantitative, reproducible historical methodology. Efforts include OCR for handwritten modern sources and automated extraction of named entities, enhancing both research scalability and human–machine collaboration.

By integrating Components A and B, the project theorizes a comprehensive approach to Digital History, reexamining its epistemological foundations while fostering wider participation. This integrated model—Historian in the Loop—offers a new research paradigm where human expertise and computational methods advance historical inquiry together.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

This research program aims to promote a collaborative practice of history that involves both computational approaches and participation by non-specialists. Through such collaboration, the project seeks to reconsider the essence of historical scholarship conducted by experts, while also exploring new, inclusive research frameworks that co-operate historians, computers, and broader communities. Accordingly, proposals that take distinct approaches or focus on different targets from the main planned research are welcome. Non-Japanese case studies are welcome where relevant to the project's aims.

A02 encourages studies that investigate the provenance and metadata of historical materials in relation to specific sources. Rather than merely producing catalogues, proposals should examine the transmission and transformation of historical documents from multiple perspectives. Collaborative approaches involving information scientists and archival scholars are particularly encouraged, especially those aiming to build knowledge infrastructures.

A03 focuses on the practical application of digital infrastructures to address urgent social issues in contemporary Japanese society, such as depopulation and natural disasters. It emphasizes collaborative historical practices and cultural heritage initiatives involving local communities. Proposals should consider the methodologies, ethics, and potential forms of "history as a team-based practice," engaging both experts and non-experts.

B01 seeks research that explores how computational methods, including current AI technologies, can transform specific aspects of historical methodology—such as transcription, language conversion, knowledge extraction, and visualization. Preference is given to approaches distinct from the core planned projects. Both (1) technically oriented studies developing algorithms and tools for historical source analysis, and (2) historically grounded research leveraging AI to propose new methods, are welcomed. All projects should include plans for communication with historians within and beyond the domain.

B03 invites proposals that embed scholarly knowledge into data to enhance the openness, reusability, and interpretative potential of historical datasets. The focus is not on conventional digital editions or database construction, but on innovative approaches such as: (1) encoding human reading practices into data to enable deeper computational analysis, or (2) embedding knowledge within data structures to generate new pathways for historical interpretation.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A02	Advancing the methods for documentation of history information	2	4
A03	Collaborative Public Engagement for Sharing Historical Scholarship	1.5	12
B01	Advanced Information Extraction and Analysis of Historical Materials	4	7
B03	Creating Advanced Historical Texts through TEI Markup	2.5	2

Research Outline of Research Areas

Exploring quantum emergence through correlation design science
https://cds.phys.s.u-tokyo.ac.jp/

Number of Research Area	:	25A201	Term of Project :	FY2025-2029
Head Investigator	:	ARITA Ryotaro		
Research Institution	:	University of Tokyo, Graduate School of Science		

1. Details of Research Area

Emergent quantum phenomena arise from correlations among quantum degrees of freedom, such as charge, spin, orbital, and lattice, often exhibiting properties that surpass intuitive expectations. The complexity of these interactions cannot be fully explored through serendipitous discoveries alone. We aim to develop an integrated design science that spans phenomenological modeling, first-principles calculations, material synthesis, and measurement. Specifically, we focus on developing materials that demonstrate robust quantum properties under extreme conditions, exhibit extraordinary responses, and potentially serve as the foundation for discovering new fundamental laws and phenomena.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

The research teams are organized into the following six groups, with specific research objectives as follows:

Team A01 will conduct research on magnetic materials, focusing on the exploration of new quantum phases in frustrated magnets. Their work will include studying electron correlations and spin moiré engineering in topological magnetic structures, as well as investigating new systems such as altermagnets and multipolar ordered systems.

Team A02 will conduct research on novel quantum metals, focusing on the exploration of new quantum phases in materials such as kagome superconductors, multilayer graphene, cuprates, nickelates, and iron-based high-temperature superconductors. Specifically, they will focus on odd-parity orders, strong correlation-driven topological phase transitions, electron pair density waves, and quasicrystal superconductivity.

Team A03 will establish control and probing methods for exotic superconductors and explore new functionalities, particularly targeting spin-triplet superconductors, parity-lacking superconductors, and two-dimensional heterostructures.

Team B01 will design and explore novel topological materials and states by leveraging correlations in materials. Specifically, they will explore magnetic Weyl semimetals, propose and design spin devices, establish new methods for identifying symmetries in unconventional superconductors and elucidate new functionalities.

Team B02 will explore new non-equilibrium quantum phases that are not seen in equilibrium states, especially aiming for theoretical proposals and experimental observations of new electronic states on ultrafast timescales of picoseconds or less.

Team B03 will develop methodologies and construct databases fundamental to theory-driven materials development. They will also develop efficient strongly-correlated first-principles calculation methods.

As Publicly Offered Research, we envision projects that can synergize with the above plans, involving a significant expansion of research subjects. This will include the participation of surface science experts skilled in surface modification and atomic manipulation, along with specialists in crystal structure prediction and high-pressure synthesis above 20GPa. Researchers focusing on molecular solids and soft matter are also expected to join, potentially broadening the scope for new material development. We anticipate collaborating on research aimed at practical applications, such as spintronics. Furthermore, we plan to cooperate with experts who are developing foundational databases for generative AI and actively using quantum computers in theoretical research.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Emergent phenomena arising from spin correlations	3.5 1.5	9 8
A02	Correlation design in emergent phenomena of quantum metals		
A03	Correlation design in exotic superconductors		
B01	Design and development of topological materials		
B02	Emergent properties driven by non-equilibrium and nonlinear dynamics		
B03	Advancing materials design through data-driven and computational sciences		

Research Outline of Research Areas

The Pursuit of Functionality Woven by π-Molecular Complexity
https://pi-molecular-complexity.jp

Number of Research Area	:	25A202	Term of Project : FY2025-2029
Head Investigator	:	YAMAGUCHI Shigehiro	
Research Institution	:	Nagoya University, Institute of Transformative Bio-Molecules	

1. Details of Research Area

The exploration of molecular photo- and electronic functions not only offers solutions to current energy and environmental issues, through the development of technologies such as thin-film solar cells, but also drives advances in biology and medicinal science through the progress of fluorescence imaging technologies. Thus, the chemistry of designing sophisticated π-conjugated molecules stands at the heart of functional molecular science. However, the creation of scientifically intriguing π-skeletons does not necessarily lead directly to the development of epoch-making materials. Bridging this gap, transforming novel molecular architectures into functional materials that address real-world societal challenges, remains a major issue in the field. In this project, we tackle this challenge by focusing on "π-molecular complexity" as a key concept for achieving outstanding molecular functionalities. Through a hierarchical approach, we aim to explore the elements of complexity in a synergistic manner. Specifically, by combining "structural complexity," which generates new classes of molecules, with "state complexity," which brings about exceptional physical properties and responsiveness, we seek to create superb π-conjugated molecules that forge new frontiers in science. Furthermore, by incorporating "functional-field complexity" optimized for these molecules, we will elaborate sophisticated π-electron systems, paving the way toward a diverse array of functional molecular science. By integrating quantum chemical understanding with advanced exploration methodologies, we aspire to establish a new integrated design principle for weaving π-molecular complexity.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

This research area consists of four groups, A01–A04, and invites cutting-edge research proposals for each as outlined below.

A01 Exploration of Structural Complexity: We invite researchers aiming to create unprecedented classes of π-skeletons through diverse approaches, such as incorporating antiaromatic or nonbenzenoid frameworks, introducing novel bonding modes or unsaturated bonds involving heavier main-group elements, and fusing two- and three-dimensional structures. Practical-scale synthesis of target molecules is also crucial. Thus, we encourage participation by those developing efficient synthetic routes to π-skeletons with high structural complexity.

A02 Control of State Complexity: This group seeks to realize distinctive physical properties by implementing strategies such as designing molecular systems with charges or spins, precisely managing excited states, and enabling reversible switching between states via molecular flexibility. "State complexity" encompasses phenomena like upconversion, reverse intersystem crossing between singlet and triplet states, and photochromism. We invite researchers focused on manipulating such states to achieve novel functionalities. In addition, given the importance of understanding molecular dynamics in complex environments, particularly in collaboration with Group A03, we also seek experts in advanced measurement and analysis techniques.

A03 Creation of Molecular Systems Incorporating Functional Field Complexity: This group aims to develop innovative molecular functions and technologies by comprehending and optimizing molecular behavior under specific conditions. The targeted functional fields include not only device and biological settings but also complex environments such as interfaces between different materials or phases. We welcome proposals with clear molecular design strategies tailored to specific functional fields, and encourage close collaboration with synthesis teams.

A04 Quantum Chemical Understanding and Exploration: This group advances the understanding of molecular behavior, such as excited-state dynamics and responses in complex environments, through high-precision quantum chemical calculations. By integrating these insights with computational exploration of chemical space, we aim to systematize essential knowledge for molecular design and materials discovery. We welcome researchers focused on enhancing high-accuracy quantum chemical methods in collaboration with experimentalists, as well as those skilled in *in-silico* screening of π-conjugated molecules.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Exploration of Structural Complexity	3	4
A02	Control of State Complexity	3	5
A03	Creation of Molecular Systems Incorporating Functional Field Complexity	3.1	6
A04	Quantum Chemical Understanding and Exploration	3	4

Research Outline of Research Areas

Quantum Matter Science in the Universe Opened Up by Precise Numerical Calculations
https://qm-science.org/

Number of Research Area : 25A203 Term of Project : FY2025-2029
Head Investigator : HIYAMA Emiko
Research Institution : Tohoku University, Graduate School of Science

1. Details of Research Area

We aim to construct a "unified platform for finite quantum many-body computation" based on the infinitesimally shifted Gaussian Lobe expansion method (GEM) proposed and developed by the project leader, and to describe the formation and evolution of matter in the universe from the fundamental particle level by using this platform. The goal is to obtain precise solutions for quantum many-body systems ranging from 3 to 100 particles by unifying GEM and other computational methods. Using this platform, we try to elucidate the internal materials of neutron stars and the interstellar molecular evolution process. We work on these issues in collaboration with experiments using the J-PARC accelerator and other facilities and with ultra-precise molecular spectroscopy experiments to determine heavy particle interactions and to verify the accuracy of calculations in order to improve the predictive power of calculations. We also collaborate with experiments on heavy-element nuclei to elucidate the heavy-element synthesis process in space. In addition, as a social contribution use of the unified platform, we support the development of RIKEN's compact neutron source (RAMS).

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Group A is mainly engaged in the development of GEM, and the unification of GEM with the shell model (LSM) and density functional theory (DFT), which have been used in nuclear physics over a wide range of particle numbers, to create a unified platform for high-precision quantum many-body calculations for particle numbers ranging from 3 to 100. Group B is mainly composed of experimental groups and promotes research on quantum matter in the universe. In order to achieve these goals, the theoretical groups A01, A02, and A03 will establish research items C01 and C02, which will establish calculation methods for small- to many-body systems and nuclear structure and reactions related to groups A01 and A02, and apply these calculation methods to the research to be conducted by group B. In C02, research that specializes in computational science related to the research of Group A03 is to be submitted. Details are described below.

C01: Resonant states from a rigorous few-many system viewpoint, research on solutions to quantum few-many system problems, research on the structure of hypernuclei, research on nuclear reaction calculations, research on low-density and high-density asymmetric nuclear matter, research on chiral effective theories of effective nuclear force and nuclear force, construction of energy density functional, research on nuclear response and nuclear reaction rate, calculation of heavy-element synthesis processes calculations, development of full-degree-of-freedom finite many-body quantum chemistry not based on the adiabatic approximation (BO approximation), development of multi-scale calculation methods, and theoretical studies related to B01, B02, B03, and B04.

C02: Porting and optimization of precise quantum many-body computation programs for different computational architectures such as GPUs

B01: Precision spectroscopy of interstellar molecules and other materials using optical combs and cooled molecules, precision spectroscopy to elucidate chemical reaction processes, and devices and catalysts using nuclear quantum effects.

B02: production, structure, and decay of hypernuclei, exotic hadronic many-body systems,baryon-baryon interactions taking particle correlations, etc, Baryon-baryon forces using experimental and lattice QCD data,structure of hypernuclei and high-density objects including hyperons, hadron EOS.

B03: Delayed fission in actinide regions using multi-nucleon transfer reactions, decay experiments in excited states using nuclear reactions, equation of state in dense matter by heavy ion collisions, isotope analysis in meteorites, observations of kilonovae after binary neutron star mergers, and component analysis of heavy element synthesis in metal-poor stars.

B04: Neutron reaction data observation, neutron utilization research, basic neutron physics experiments.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
B01	Optical Comb Precision Molecular Spectroscopy	5 2.5	10 9
B02	Baryon-Baryon interaction and hypernuclei		
B03	Heavy neutron-rich nuclei for study of heavy element synthesis		
B04	Advanced compact Neutron Sources		
C01	Theoretical Study of Finite Quantum many body system	1.5	15
C02	Theoretical study related computing science		

Research Outline of Research Areas

Drug development through data-driven evolutionary engineering of precision polymers
https://polymer-shinka.org/

Number of Research Area	:	25A204	Term of Project :	FY2025-2029
Head Investigator	:	HOSHINO Yu		
Research Institution	:	Department of Applied Chemistry, Kyushu University		

1. Details of Research Area

Synthetic polymers are promising as an inexpensive and stable next-generation drug discovery modality, since it is easy to construct a polymer library with infinite diversity by copolymerizing designed monomers. Recently, rapid progress in polymer synthesis and purification technologies has made it possible to synthesize "precision polymers" with completely defined molecular weights and monomer sequences. The precision polymers are capable of recognizing specific antigens.

In this research area, we aim to create a new interdisciplinary research area by integrating expertise from the rapidly evolving fields of precision polymer synthesis, interaction analysis, and structural analysis with data science—including computational chemistry, machine learning, and bioinformatics—and materials informatics platforms. In addition, we will work closely with researchers in pharmaceutical development–such as those specializing in chemical biology and directed molecular evolution– to integrate these approaches. Concurrently, we will conduct proof-of-concept studies using animal models in collaboration with researchers involved in pharmaceutical development and clinical practice, ultimately constructing a platform capable of continuously generating precision polymer-based therapeutics.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

This research area aims to establish a novel drug discovery modality using precision polymers through collaboration with this research area. The precision polymers are defined as "non-natural polymers consisting of repeating monomer structures with completely defined molecular weights and sequences". In addition to individual research proposals, we strongly encourage collaborative research in the area. Proposals based on the assumption that precision polymers will be supplied by Research group A are also acceptable. Studies that deal only with heterogeneous polymers are not eligible. Precision polymers include oligomers from dimers and medium-sized molecules. However, research consisting only of natural biopolymers such as nucleic acids and peptides is not eligible. At C04, we will accept research that includes only biopolymers on the premise that the research targets precision polymers.

A05 calls for technologies for creating precision polymers with defined structures. This is not limited to polyacrylics and polyolefins, but also includes polysiloxanes, polyesters, polythiophenes, peptoids, etc. Research on controlling the arrangement, conformation, topology (asymmetric synthesis, cyclization, template/template polymerization, side-chain transformation, and ligation reactions), isolation, and purification of precision polymers is also eligible. Nanoparticles, clusters, supramolecules, and complexes whose structures are precisely controlled at the atomic level are also eligible.

B04 focuses on advancing the structure and function of precision polymers in a data-driven manner. The aim is to develop precision polymer-based therapeutics that interact with target molecules with high affinity by utilizing data science technologies such as structure prediction using deep learning models and physics-based docking simulations. B04 also includes the methods to analyze the structure of precision polymers using structural analysis experiments such as NMR, chromatography, mass spectrometry, and VCD. Creating databases and combining machine learning and computational science are also eligible.

C04 calls for evolving precision polymers through evolutionary molecular engineering. developing highly functional precision polymers by applying various pharmaceutical and drug discovery technologies to synthetic polymers, realizing an unprecedented function of precision polymer through conjugation with biomacromolecules, and creating unique experimental libraries for evolutionary molecular engineering are acceptable. The development of binders (antibodies, peptides, or nucleic acids) that exhibit high affinity for precision polymers for their application as experimental tags are also acceptable.

D05 calls for pharmaceutical applications of precision polymers. Specifically, eligible research includes the development of technologies to facilitate the in vivo functionality of precision polymers, the creation of novel therapeutic strategies using precision polymers, and the evaluation and resolution of anticipated future barriers (immunogenicity, pharmacokinetics, safety) for the practical application of precision polymers.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A05	Creation of precision polymers	3.5	4
B04	Data-driven evolution of precision polymers	3.5	4
C04	Co-evolving systems of precision polymers	3.5	4
D05	Pharmaceutical applications of precision polymers	3.5	4

Research Outline of Research Areas

Multi Scale Muon Imaging : From Signs to Discovery
https://msmi.jp/

Number of Research Area	:	25A205	Term of Project :	FY2025-2029
Head Investigator	:	MORISHIMA Kunihiro		
Research Institution	:	Graduate School of Science, Nagoya University		

1. Details of Research Area

Japan has long led international research on the muon, a third fundamental particle after the photon and electron. Recently, muons have gained attention beyond academia, particularly as a novel quantum probe for imaging in industry. The aim of this research area is to establish the scientific and technological foundations of Multi Scale Muon Imaging (MSMI) by harnessing the exceptional penetrating power of the fundamental particle known as the muon, and by integrating and advancing a wide range of muon measurement techniques with information science, in order to overcome the limitations of conventional measurement methods. Research Group A01–A04 will develop innovative technologies to enable new ways of visualizing diverse phenomena. B01 will demonstrate new imaging methods using accelerators, while C01 will integrate measurement techniques with mathematical and data processing tools to enhance imaging accuracy and utility. Through these efforts, we aim to accelerate and refine imaging technologies and deepen academic understanding across disciplines. MSMI will allow visualization over vast scales—from attometers to cosmic distances—revealing elementary particle phenomena, material functions, and the interiors of levees, pyramids, volcanoes, as well as atmospheric and space environments. These advances will drive a paradigm shift in imaging, fostering interdisciplinary innovation and contributing to a more prosperous future society.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

This research area promotes the advancement of muon imaging technologies and their application across a broad range of spatial and disciplinary scales. To this end, we have organized a set of Research Groups spanning particle physics, astrophysics, accelerator science, materials science, civil engineering, earth and planetary sciences, and signal processing. We are establishing the "MSMI Technology Platform" as a foundation for technical integration across these projects, to ensure that the entire research area progresses in a coordinated and synergistic manner. These Research Groups are designed to play complementary roles both in terms of technical focus and target scale. However, given the wide-ranging nature of muon imaging technologies and their applications, the Research Group alone cannot fully cover the potential of this field. Therefore, for the FY2026–2027 open call for proposals, we seek the following types of research that contribute to expanding the scope of the field beyond the current framework, while maintaining collaboration with the existing Research Groups. Integration with methods from other fields: We welcome collaborative proposals that combine approaches from this research area with different measurement principles or techniques, especially from researchers who possess unique technologies or valuable data. Novel approaches to muon generation, acceleration, detection, and imaging: Proposals introducing innovative methods not currently covered in this research area are also welcome. While they may initially be independent, we expect them to evolve through collaboration with the MSMI Technology Platform and the Research Groups. We also encourage bold and original ideas that contribute to the development of the field, even if they fall outside the standard categories. Applicants should select the most relevant research topic number from the existing Research Groups when submitting proposals. If the proposal relates to multiple topics, please indicate this clearly in the application. After selection, coordination with one of the Research Groups will be arranged by the program committee. The research proposal should clearly describe how the applicant's technologies or ideas will contribute to the goals of this research area, and provide concrete plans for potential collaboration or joint research with Research Groups. With a funding cap of 7 million yen per proposal, the call is designed to support relatively large-scale equipment development or experimental studies. Ambitious proposals from researchers with no prior experience in muon research are also welcome.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Imaging Phenomena	7 3	2 14
A02	Imaging Functions		
A03	Imaging Interiors		
A04	Imaging Environments		
B01	Expanding Imaging		
C01	Refining Imaging		

Research Outline of Research Areas

Biodiversity driven by mobile DNA elements and hosts : host response and trans-generation
https://mobilegenome.k.u-tokyo.ac.jp/

Number of Research Area : 25A301 Term of Project : FY2025-2029
Head Investigator : ISHIGURO Kei-ichiro
Research Institution : Kumamoto University, Institute of Molecular Embryology and Genetics,

1. Details of Research Area

In the human genome, only about 2% of the genetic material codes for proteins, while the remaining 98% is largely composed of transposons, endogenous retroviruses, or fragmented DNA sequences derived from them—collectively referred to as mobile DNA elements. Most organisms' genomes contain a substantial amount of mobile DNA elements. Due to their ability to transpose and amplify, mobile DNA elements have often been regarded from a negative perspective, as they introduce mutations into the host genome, potentially leading to diseases or even species collapse. However, recent research has revealed that they also contribute to genomic sequence variation and higher-order genome structural changes, facilitating the acquisition of novel genetic functions and phenotypic diversification. This suggests that mobile DNA elements are not merely harmful to their hosts but can also exert positive effects.

To fully understand the processes of phenotypic diversification, speciation, and evolution across various species, it is crucial to deepen our understanding of the positive roles of mobile DNA elements. This research area, therefore, aims to investigate past and present host–mobile DNA element interactions, exploring their potential contributions to novel trait acquisition, speciation, and evolution. While somatic mutations caused by mobile DNA elements are limited to individual lifetimes, their impact on speciation requires an understanding of how genomic structural changes—including those not involving direct sequence alterations—can be transmitted through the germline and persist across generations. Until recently, short-read sequencing technology has made it difficult to accurately annotate mobile DNA elements, preventing a comprehensive understanding of their role across nearly all species. Furthermore, experimentally reconstructing the evolutionary process poses significant challenges. However, the increasing adoption of long-read sequencing technologies has created new opportunities to explore the positive effects of mobile DNA elements in greater depth.

This research area is structured into two core research projects: A01: "Host Response" and A02: "Transgenerational Transmission". By integrating experimental biology with genomic informatics, this initiative aims to: 1. Develop experimental methodologies that compress natural evolutionary timescales to address questions that cannot be resolved by interspecies comparative orthology. 2. Establish collaborative research frameworks that incorporate the latest technologies and focus on a diverse range of organisms.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Proposals involving diverse species or novel analytical techniques not covered by the core research teams are strongly encouraged. In particular, experimental research proposals that integrate with the mobile DNA element analysis support team are highly welcomed. To ensure the sustainable development of this field, applications from early-career and female researchers are also strongly encouraged.

A01: "Host Response – Mechanisms of Host-Element Interactions Induced by Internal and External Factors"

This research theme focuses on understanding the mechanisms by which various internal and external stressors—such as rising temperatures or viral infections—activate mobile DNA elements. It also explores how interactions between mobile DNA elements and endogenous systems influence host chromatin, gene expression, and phenotypic outcomes, particularly in the F1 generation. Proposals should consider the regulation of mobile DNA elements and their contribution to phenotypic variation, while clearly distinguishing this research from general chromatin or epigenetics studies.

A02: "Transgenerational Transmission – Functional Roles of Host-Element Interactions in Reproductive Cycles and Their Transmission Across Generations".

To understand how host responses to mobile DNA elements contribute to species diversification, this research theme investigates the transmission mechanisms of mobile DNA elements during reproductive cycles, including horizontal and transgenerational transmission. This project aims to determine how they contribute to individual variation, diversification, speciation, and ultimately, evolution.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Host Response	4.5	7
A02	Transgenerational Transmission	4.5	7

Research Outline of Research Areas

Integrated understanding of RNA-induced perturbations in living systems and their adaptive mechanisms
https://perturb-rna.m.chiba-u.ac.jp/

Number of Research Area	:	25A302	Term of Project :	FY2025-2029
Head Investigator	:	KAWAHARA Yukio		
Research Institution	:	The University of Osaka Graduate School of Medicine		

1. Details of Research Area

Organisms have adapted to invasive RNAs or the expression of RNAs that perturb their own systems over a long period of time by developing mechanisms to eliminate or suppress them, and sometimes by co-opting them. However, with the frequent emerging of viral infections in recent years and the practical application of artificial mRNAs, the opportunities to accept RNAs whose medium- to long-term effects are unclear are rapidly increasing. To address these pressing issues, we define perturbing RNAs (perRNAs) as a group of RNAs that perturb living systems, whether exogenous or endogenous, and aim to characterize them by bringing together researchers from different fields to comprehensively understand the regulatory mechanisms of perRNAs and their roles in disease and adaptation to environmental changes. These perRNAs include exogenous perRNA derived from viruses and other sources, and endogenous perRNA such as retrotransposon-derived RNA and endogenous double-stranded RNA with potential risk of perturbing living systems. Our attempt to reconsider RNA from the viewpoint of negative functions will bring about a paradigm shift from preconceived notions about RNA. The results of this research area will be widely disseminated as a "perRNA database" to share the novel concept of perRNA with researchers in Japan and overseas. This will make it possible to elucidate perRNAs associated with a wide range of species, diseases, and environmental changes, and to predict their physiological effects with a high degree of accuracy. As a result, physiological phenomena, causes of diseases, and adaptation mechanisms to environmental changes will be clarified, leading to the development of new disease treatments and RNA medicines with fewer adverse reactions.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In Research Group A01, a group of perRNA candidates will be extracted from public databases and experimental data obtained by each research group based on their specific ability of perturbations in living systems, and characterized in terms of sequence, structure, and dynamics, using bioinformatics analysis that incorporates machine learning. Note that perturbations by proteins translated from mRNAs with aberrant splicing or mutations is, in principle, outside the scope of this research area due to the definition of perRNA. In Research Group A02, we aim to comprehensively understand the mechanisms that eliminate or suppress perRNAs and the co-opting mechanism that enables coexistence of perRNAs in the host. To achieve this goal, we call for publicly offered research proposals focusing on the following themes and promote collaboration with planned research groups to further broaden the scope of the field. In addition, this field offers a variety of technical support, including bioinformatics analysis, full-length RNA library production, cryo-electron microscopy analysis, and genome-edited mouse production, which are expected to be actively utilized.

1. Research to elucidate the characteristics of perRNAs in various viruses and organisms and the molecular mechanisms that control them (A01, A02): Proposals on viruses and organisms, especially bacteria, yeast and plants, are welcome, as they are important for gaining an overall picture of perRNAs through collaboration with the planned research groups. Research proposals that offer an adaptive model for perRNAs that perturb living systems in specific environments are also important. Exploratory research proposals on novel perRNAs that are not involved in existing RNA categories are also highly welcome.
2. Research on diseases and physiological functions involving perRNAs (A01, A02): since endogenous perRNAs that are suppressed in developmental and aging processes, and various types of cancer are expected to be expressed and play a significant role in metabolism and pathological conditions, we expect proposals focusing on certain perRNAs related to diverse physiological phenomena and diseases. We also welcome research on perRNA-mediated regulatory mechanisms in intractable diseases such as autoimmune and neurodegenerative diseases, as well as research that proposes therapeutic modalities targeting these diseases.
3. Research on extraction of perRNAs from public transcriptome database (A01, A02): research on comprehensive search and characterization of perRNAs from public transcriptome database for a wide range of virus species and diseases is welcome, as it will provide fundamental information to improve the accuracy of predicting physiological effect of perRNAs. Research proposals for development of original algorithms to enable prediction of physiological effects of perRNAs are also welcome.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Identification and characterization of perRNAs	4	20
A02	Elucidation of molecular mechanisms that manipulate perRNAs		

Research Outline of Research Areas

Autophagy expanded: decoding membrane interface biology
https://makukaimen.umin.jp/

Number of Research Area	:	25A303	Term of Project :	FY2025-2029
Head Investigator	:	NODA Nobuo		
Research Institution	:	Institute for Genetic Medicine, Hokkaido University		

1. Details of Research Area

It has become evident that proteins and lipids, which are the principal constituents of life, exhibit collective behavior that transcends molecular species at membrane interfaces. This molecular cooperation occurring at membrane interfaces has also been found to play a role in an extraordinarily diverse array of biological phenomena, including autophagy, in eukaryotic cells that possess a highly developed and complex intracellular membrane system. In this research area, researchers applying advanced methodologies to investigate various membrane interface phenomena are coming together to elucidate the diverse functions of membrane interface molecular cooperation and, by identifying the conserved mechanisms, to establish fundamental principles that will give rise to membrane interface biology. Furthermore, by clarifying the relationship between abnormalities in membrane interface phenomena and diseases, as well as advancing the development of artificial control methods, this endeavor seeks to lay the groundwork for pharmaceutical applications aimed at disease prevention and treatment.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In this research area, we bring together researchers from biochemistry, cell biology, structural biology, physical theory, computational science, chemical biology, and other fields, with the aim of establishing "membrane interface biology." Our goals include understanding the mechanisms and physiological functions of molecular cooperation at membrane interfaces, particularly in autophagy and a variety of other life phenomena involving lipid membranes, and envisioning pharmaceutical and medical applications by artificially controlling this membrane interface molecular cooperation. Consequently, we are widely seeking research proposals in the publicly offered category that align with these objectives and address a breadth of topics not covered by the planned research projects. In this research area, it is crucial that researchers working on diverse life phenomena and methodologies gather and actively engage in collaborative research. We also welcome bold proposals from young researchers who represent the next generation.

A01 Membrane interface biology of autophagy

This category focuses on research aiming to elucidate the membrane interface molecular cooperation that underpins complex membrane dynamics in multimode autophagy and organelle membrane morphology control in selective autophagy. Research on autophagy that does not address membrane interface molecular cooperation is not eligible. We particularly encourage proposals that are not covered by the planned research, including those on membrane dynamics in microautophagy, the selective autophagy of various organelles, autophagy in a wide range of model organisms, and investigations that seek to clarify the operational principles of autophagy membrane dynamics.

A02 Expanding membrane interface biology

This category addresses research aimed at elucidating membrane interface phenomena that support various life processes other than autophagy, focusing on studies not covered by the planned research. The research must deal with membrane interface molecular cooperation. We especially invite unique proposals that will contribute to expanding and advancing membrane interface biology, such as studies related to diseases or phenomena that extend beyond a single cell.

A03 Analytical and control methods in membrane interface biology

This category focuses on research aimed at developing and applying analytical and control technologies that will propel the advancement of membrane interface biology. Relevant projects include those not covered by the planned research, such as special or advanced methods for analyzing membrane interface molecular cooperation, as well as proposals for the development of diverse approaches to artificially control membrane interface molecular cooperation.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Membrane interface biology of autophagy	4	6
A02	Expanding membrane interface biology	4	6
A03	Analytical and control methods in membrane interface biology	4	4

Research Outline of Research Areas

Establishment of pH Biology
https://phbiology.rcast.u-tokyo.ac.jp/

Number of Research Area	:	25A304	Term of Project : FY2025-2029
Head Investigator	:	OGINUMA Masayuki	
Research Institution	:	RIKEN Pioneering Research Institute (PRI) / RIKEN Center for Biosystems Dynamics Research (BDR)	

1. Details of Research Area

This research area explores the fundamental mechanisms by which living organisms respond to fluctuations in pH—one of the most essential chemical parameters of life. Historically, the prevailing belief has been that cytoplasmic pH remains constant and stable, a misconception that has limited global research into how organisms truly sense and adapt to pH changes. Our project challenges this outdated view by proposing a new paradigm: that organisms have evolved core mechanisms to cope with pH fluctuations ("pH stress response") and have further developed sophisticated systems to utilize pH changes as biological signals ("pH signaling"). Through an interdisciplinary and integrative approach—encompassing a wide diversity of species and leveraging cutting-edge technologies for pH visualization and manipulation—we aim to uncover the fundamental principles underlying these processes. In doing so, we seek to fundamentally redefine the role of pH in biology and establish a new academic field: pH-responsive biology

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

To deepen our understanding of how organisms sense and respond to pH dynamics and to advance technologies for pH visualization and manipulation—the planned projects in this research area are conducting broad analyses across diverse organisms. Complementing these efforts, Publicly Offered Research projects will address fundamental biological questions beyond the scope of the planned projects, delving into the core of pH biology. These studies will explore the diverse roles of pH across the life course—from fertilization to aging—revealing how pH dynamics shape biological processes. We also encourage the integration of physical, chemical, and mathematical approaches, including simulations of pH-dependent changes in protein structure, biochemical reactions, and inorganic systems. Through such interdisciplinary efforts, we aim to further develop the emerging field of pH-responsive biology.

A01: Mechanisms of pH Stress Response: Publicly Offered Research projects are encouraged to explore physiological and pathophysiological mechanisms of pH stress responses that are not covered by the planned projects—for example, respiratory or renal functions, among others. We particularly welcome proposals focusing on organisms adapted to harsh pH environments, including freshwater and brackish-water species, as well as bacteria and archaea. These studies should aim to uncover molecular-level mechanisms by which organisms sense and respond to pH stress, and how disruptions in these responses may contribute to disease.

A02: Mechanisms of pH Signaling: Research on pH signaling remains a largely uncharted frontier. We therefore encourage proposals that offer novel perspectives and interdisciplinary approaches. In particular, we welcome studies that aim to elucidate pH-based or pH-associated chemical signaling mechanisms throughout the entire life course—from fertilization and embryonic development to growth and aging. We also invite investigations into unique pH-dependent phenomena across a broad spectrum of organisms, including unicellular species.

A03: Development of pH Visualization and Manipulation Technologies : Publicly Offered Research projects are also expected to propose innovative technologies for the quantitative analysis of pH responses, especially those that surpass current capabilities. This includes the development of real-time pH imaging techniques—using novel probes and techniques—at subcellular or whole-organism scales. We also welcome simulations that model how pH fluctuations affect protein structures, biochemical pathways, or inorganic systems. In particular, we encourage participation from researchers in AI and mathematical modeling, whose expertise can significantly enhance the overall progress of the program.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Mechanisms of pH Stress Response	4.2	16
A02	Mechanisms of pH Signaling		
A03	Development of pH Visualization and Manipulation Technologies		

Research Outline of Research Areas

Symplast; intercellular communication mechanism in plants under environmental changes
https://plant-symplast.jp

Number of Research Area	:	25A305	Term of Project :	FY2025-2029
Head Investigator	:	NOTAGUCHI Michitaka		
Research Institution	:	Kyoto University, Graduate School of Science		

1. Details of Research Area

Individual plant cells are not completely independent, but are connected by plasmodesmata that penetrate the cell walls of neighboring cells and connect protoplasms. The protoplasmic space continuously shared throughout the body via plasmodesmata and phloem sieve tubes is called symplast. The symplast pathway has been thought to be used for translocation of nutrients such as sugars and amino acids. However, recent studies have revealed that the symplast is a site of signal transduction, and that plant development and environmental responses are regulated by the sharing of various signaling molecules between cells and tissues. This research project will seek to elucidate the nature of plant growth regulation and environmental adaptation mechanisms under environmental fluctuations by reconsidering intercellular and systemic signal transduction from the viewpoint of the symplast.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

Researchers engaging in the Publicly Offered Research are expected to work toward the goal of this Research Area, which is to elucidate molecular mechanisms of plant growth regulation and environmental adaptation through the symplast, and to promote the research through active discussion and joint research with the Planned Research Group.

Superior research proposals are desired that fully reflect the target direction of the aforementioned Research Area, and take a bold approach to elucidating the regulatory mechanisms of symplast formation and function during various environmental responses and in individual developmental events. It is encouraged that proposals will embody diverse points of departure that leverage the strengths of each applicant, such as by complementing the goals of the Planned Research, or adopting a perspective that differs from that of the Planned Research. In addition, proposals are encouraged that address evolutionary aspects of symplast formation and functional patterns in the developmental processes of individual plants. As long as proposals seek ambitiously to elucidate growth regulation and environmental response mechanisms with a basis of symplast function, specific previous research achievement with respect to plasmodesmata and symplast is not necessarily required, but proposals are expected to encompass molecular mechanisms that involve in symplast systems.

With respect to research implementation of the Publicly Offered Research, the Research Support Center established in this Research Area (Imaging Section, Electron Microscopy Imaging Section, Next-generation Sequencing Section, Mass Spectrometry Section, Comprehensive Protein Interaction Analysis Section, and Evolutional Analysis Section) may be utilized. Furthermore, proposals for the Publicly Offered Research that involve extensive use of new research technologies complementing those of the Research Support Center, are encouraged. Innovative, interdisciplinary, and ambitious proposals capable of making major contributions to the symplast research from a broad plant science perspective are encouraged.

With respect to the three core research perspectives of this Research Area (symplast formation mechanism; intercellular and systemic mobile molecules; and plant growth regulation and environmental adaptation through the symplast), the objective is that each Research Group, while having its respective major research focus, will promote mutually cooperative, organically collaborative research; and to encourage achievement of this objective, Research Groups shall not be strictly divided. As such, all applications for the Publicly Offered Research shall be attached to Research Group A01.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Symplast; intercellular communication mechanism in plants under environmental changes	3.5	16

Research Outline of Research Areas

Next-Generation Developmental Engineering
https://nextdevbio.cira.kyoto-u.ac.jp

Number of Research Area	:	25A306	Term of Project :	FY2025-2029
Head Investigator	:	TAKASHIMA Yasuhiro		
Research Institution	:	Center for iPS Cell Research and Application (CiRA), Kyoto University		

1. Details of Research Area

The fundamental question of how an apparently simple cluster of cells develops into a living organism remains unresolved. In recent years, it has become possible to generate reconstructed embryos—referred to as stem cell-based embryo models (in vitro embryo models)—that mimic early pre- and post-implantation development using only stem cells in vitro. This breakthrough opens new avenues for investigating early human embryogenesis, which has long been challenging due to ethical and technical limitations.

However, all in vitro embryo models reported to date arrest shortly after implantation and fail to undergo organogenesis. This suggests that current in vitro embryo models lack the developmental robustness inherent to in vivo embryos generated by normal fertilization.

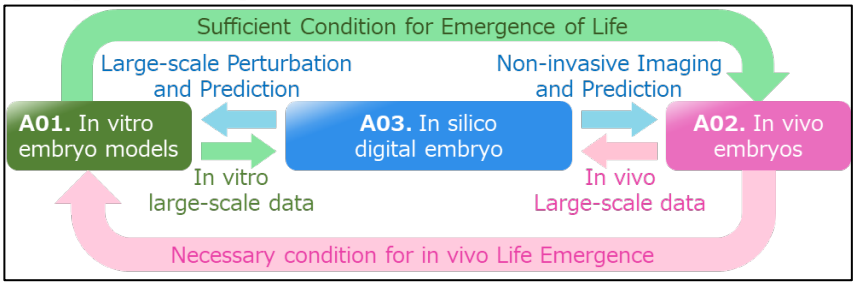
This research area aims to utilize in vitro embryo models to constructively elucidate the principles of the emergence of life, wherein a collective of cells functions and develops as a living entity. To systematically understand both the emergence of life and embryonic integrity control systems, we will employ cutting-edge technologies—such as omics-based analyses of intercellular interactions and transcription factor networks, single-cell profiling, and advanced optical measurements—to perform multidimensional and large-scale analyses. Based on the acquired data, we will construct digital embryo models to predicting the key factors driving the emergence of life by in silico simulations.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In this research area, we aim to transform conventional developmental bioengineering—traditionally centered on the manipulation of In vivo embryos and whole organisms—into next-generation life engineering by integrating emerging technologies such as In vitro embryo models and In silico digital embryo models. The ultimate goal is to constructively understand and control the molecular mechanisms through which cellular assemblies give rise to life.

In Research Group A01, we will develop the foundational stem cells and construct In vitro embryo models that encompass implantation, organogenesis, and organismal formation. In Research Group A02, we will use In vivo embryos to elucidate the mechanisms ensuring embryonic development, through the analysis of maternal and paternal factors, transcriptional programs, epigenomic states, and advanced embryological manipulations.

To integrate these two contrasting approaches, Research Group A03 will apply the latest digital science methodologies to measure and predict the principles underlying life phenomena. Specifically, A03 will consolidate multimodal datasets acquired in A01 and A02 using cutting-edge measurement technologies, and construct a unified digital embryo models for In silico prediction. The three projects will operate in concert, forming a feedback loop of data acquisition, interpretation, and prediction to unravel the mysteries of the emergence of life and embryonic integrity control systems (see figure).



Publicly Offered Research is expected to contribute to the overall goals of the project by offering perspectives not covered by the Planned Research, and to complement and collaborate bidirectionally with A01–A03. Possible examples include studies using imaging, metabolism analysis, or AI to measure parameters of In vitro and In vivo embryos, as well as ex vivo embryo culture studies. Rather than modeling each component separately, it is crucial to build an integrated digital twin of the embryo. To this end, the development of novel algorithms such as multimodal foundation models that integrate multiple biological features is essential for In silico simulations, and proposals in this direction are highly encouraged. Beyond these examples, we welcome diverse and ambitious research proposals aligned with the goals of this research area.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	In vitro embryo models	4.5	5
A02	In vivo embryos	4.5	4
A03	In silico digital embryos	4.5	5

Research Outline of Research Areas

EPIC assembly: emergence of novel functional assembly by Evo-Physico Information Coupling
https://epic-assembly.crmind.net/

Number of Research Area	:	25A401	Term of Project :	FY2025-2029
Head Investigator	:	KOBAYASHI Tetsuya J.		
Research Institution	:	The University of Tokyo , Institute of Industrial Science		

1. Details of Research Area

Our project seeks to elucidate the principles that govern the emergence and subsequent refinement of novel biological functions.
We tackle this question through the lens of assemblies—architectures constructed from heterotypic biological components. Proteins are molecular assemblies of amino-acid residues; intracellular reaction networks and neural circuits constitute circuit assemblies of chemicals or neurons; and multicellular organisms can be regarded as cellular assemblies. Because assemblies are intrinsically combinatorial, they furnish a structural framework through which evolution can explore an open-ended landscape of functional diversity and complexity. Most biological assemblies operate far from thermodynamic equilibrium, underscoring the need to understand how nonequilibrium physics and evolutionary dynamics are coupled to shape function. Leveraging state-of-the-art imaging and sequencing technologies, we will acquire quantitative data on molecular, circuit, and cellular assemblies, construct mathematical models, and develop informatic methods that seamlessly integrate experiment with theory. Drawing on nonequilibrium statistical physics, information theory, and large-deviation theory, we aim to reveal the universal and intertwined roles of energy dissipation, evolutionary processes, and information flow in the emergence of biological functionality. The experimental, computational, and theoretical technologies advanced in this project are expected to find broad application in biomimetics, bioengineering, and artificial intelligence.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In this research area, we call for publicly offered research proposals for the three research groups, each of which aims to
(C01) broaden the range of systems covered in this area by linking biological function and its evolution across a wide spectrum of biological assemblies.
(C02) establish the technical foundation of the field by constructing the theories, informatics tools, and measurement or engineering technologies required to unravel the coupling of biological function and its evolution for diverse assemblies.
(C03) extend the area's impact by applying its findings to other disciplines—such as bioengineering and information science.
We strongly encourage applications from early-career researchers who can drive their own projects, as well as from scientists with a variety of research backgrounds. We especially welcome proposals offering distinctive experimental platforms, theoretical frameworks, or informatics technologies—and capable of advancing the research area in close collaboration with the planned research groups and with other publicly offered teams. While proposals integrating experiment and theory are highly desirable, we also invite (i) experimental studies on function and evolution of biological assemblies, which can be advanced by the aid of the theories or informatics methods developed in this research area, and (ii) theoretical models, computational analyses, or measurement/engineering techniques, which align with the experimental phenomena targeted by this area.
Other biological assemblies than molecular, circuit, and cellular ones also fall within the scope of this call, provided that the relationship between their function and evolution will be addressed. The term "informatics" encompasses bioinformatics, model inference, deep learning, and related methodologies. We also recognize the importance of general mathematical and information-engineering techniques that, even without direct link to assemblies, enable the prediction or exploration of exceptional events such as emergence and attainment of new function. Finally, while nonequilibrium processes are a central theme of the area, some equilibrium phenomena—such as protein folding—can also be pivotal for function and evolution; proposals therefore need not be restricted to nonequilibrium systems.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
C01	Experimental investigation of assembly phenomena	Experimental proposal: 5 Theoretical informatic proposal : 2.5	10
C02	Development of methodologies for analyzing assemblies		10
C03	Exploration of informatic and engineering applications of assemblies		

Research Outline of Research Areas

Life in Space: the Exploration of Environmental Responses and Robustness of Biological Systems to Predict the Future of Life on and Beyond Earth

https://www.life-in-space.org/home-en

Number of Research Area	:	25A402	Term of Project :	FY2025-2029
Head Investigator	:	MURATANI Masafumi		
Research Institution	:	University of Tsukuba		

1. Details of Research Area

In order to support humanity's long-term expansion into space, it is essential to develop novel approaches to health management and food production. This endeavor requires a deeper understanding of the diverse biological responses embedded within living organisms. Predicting the future of life as it ventures into space—after having evolved on Earth over the past 4 billion years—can also offer a new perspective for interpreting functions acquired by terrestrial life in response to ancient environmental changes. Biological experiments conducted in the microgravity environment aboard the International Space Station (ISS) have begun to reveal unique traits of life that are not readily observed under Earth conditions. Although such experiments are still limited in number, comparisons with well-established terrestrial life science data have uncovered previously hidden biological behaviors. The studies conducted in ISS have revealed that microgravity not only impairs the anti-gravitational functions of bones and muscles that support posture and movement in vertebrates but also causes broader physiological changes. Intriguingly, some of these changes appear to reflect a regression toward ancestral traits that were once acquired during the evolutionary transition from sea to land. In other words, physiological mechanisms and differentiated cellular states that are normally maintained to preserve homeostasis seem to revert to a state resembling ancestral characteristics in space—a phenomenon of great scientific interest.

This research area conceptualizes these changes as "space-induced atavistic phenotypes" and hypothesizes that traits previously considered evolutionarily fixed may in fact represent ongoing physiological adaptations to Earth's environment. Studies involving mice in space have also indicated the presence of transgenerational effects, suggesting that life, even over a few generations, might undergo profound transformations under low-gravity conditions like those on the Moon (1/6 G) or Mars (3/8 G), potentially giving rise to entirely novel biological states.

This area seeks to elucidate the robustness of regulatory systems that maintain homeostasis and cellular differentiation on Earth, as well as the plasticity that permits re-expression of ancestral traits under microgravity. We will investigate these opposing characteristics through the analysis of genome and epigenome regulation, as well as transgenerational effects. Moreover, methods to artificially induce latent physiological functions adapted to Earth's environment may lead to rediscovery of unknown genomic functions and open new avenues for their application in health care, food production, environmental sciences, and biomimetics—both on Earth and in space.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

In the A01 group, we welcome researchers with unique experimental systems capable of investigating how environmental or physical stimuli influence the homeostatic maintenance of tissues and organs from developmental, anatomical, or physiological perspectives. In A02 group, we invite research on environmental stress responses and transgenerational effects using unicellular or multicellular organisms, as well as cell culture models. Studies addressing extreme environmental conditions—such as temperature, pressure, desiccation, and radiation—within the realm of astrobiology are also within scope. A03 group and its associated studies aim to develop a transdisciplinary field that integrates theoretical frameworks and experimental systems across a wide variety of organisms, from microbes to humans, extrapolating findings from A01 and A02. These efforts will contribute to understanding and predicting the past and future of life on a cosmic scale. The establishment of novel experimental platforms for post-ISS space biology is also encouraged.

We particularly encourage proposals that aim to understand gravity response and mechanosensory systems through comparative biology of terrestrialization in plants and animals, with an emphasis on evolutionary diversity and phylogenetic breadth. For transgenerational research, we welcome approaches not only from the biological sciences but also from psychiatry, social sciences, and data science to explore phenomena potentially relevant to planetary migration.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Cellular differentiation and homeostasis of tissues and organs	5	6
A02	Environmental stress response and transgenerational effects	3	12
A03	Unique experimental systems across microorganisms, model and non-model animals, photosynthetic organisms, and humans		