(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.

- It is possible to receive grants for up to 2 projects in Publicly Offered Research.
  In case that there are no projects of Publicly Offered Research for which grants has currently been received, it is possible to apply and receive grants for new 2 projects. However, it is not possible to apply and receive grants for 2 projects in the same research area.
  In case that grants have been received for 2 projects continuation of which will be in FY2021 in Publicly Offered Research, it is not possible to apply for another project.

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

1 The Essence of Urban Civilization: An Interdisciplinary Study of the Origin and Transformation of Ancient West Asian Cities

http://rcwasia.hass.tsukuba.ac.jp/city_EN/

Number of Research Area	:	5001	Term of Project :	FY2018-2022
Head Investigator	:	YAMADA, Shigeo		
Research Institution	:	University of Tsukuba, Faculty of Humanities and Social Sciences		

Urban society emerged for the first time in human history in ancient West Asia, forming a social structure around centralized cities, which determined in turn the characteristics of each region. The remains of the cities of West Asia aid in our understanding of the birth of urban culture and its transformation during ancient times, providing key evidence in the form of abundant archeological records and numerous cuneiform texts written on clay tablets. This project aims to study the process by which these ancient cities emerged; the development of their diverse landscapes and social structures; and the interactive relationships between urban societies and the natural environment. It intends to clarify the essential aspects of ancient West Asian cities through interdisciplinary study linking archeology, philology, and the natural sciences. This project critically considers the question "What is a city?" while examining regions adjoining West Asia and West Asian cities from ancient to modern periods. In doing so, it will clarify the uniqueness of ancient West Asian cities, examine their influence on later ages, and present a theory of civilization that will be of use in achieving a sustainable future for modern urban civilization.

This project is comprised of four Research Groups—A01: First Signs of Urban Civilization, which conducts archaeological research of the prehistoric period; A02: Landscape and Structure of Ancient West Asian Cities, which studies urban civilization in ancient West Asia and ancient Egypt through collaboration between philological and archaeological methodologies; B01: Environment and Resources of West Asia, which elucidates the interactions between cities and the environment in ancient West Asia from the perspectives of earth science and materials science; and C01: West Asian Cities from Medieval to Modern Times, which examines medieval to modern, including present-day, West Asian cities through literature research and fieldwork. Finally, X00: A Discourse on Urban Civilization in West Asia, summarizes the above research projects and acts as the collaborative hub for all research groups. The teams as a whole consider the interrelationships of cities, human societies, and their respective environments, to construct a vision which contributes to a sustainable future of human society and the global environment. We invite research projects that support the project in critical ways, such as: (1) research that deals with various urban issues of regions and periods which are not included in the project's core, (2) research focused on urban studies and theory as applied to ancient cities (3) natural science research that reinforces research in the materials science field, and (4) practical studies which contribute to the solving of modern urban issues.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Research on urbanization in prehistoric West Asia and its surrounding regions		
A02 Research on urbanization in ancient West Asia and its surrounding regions during early historical times (e.g., urban landscape, cultural tradition, social and political functions)		
B01 Research on mineral deposits and the environment in West Asia and its surroundings, environmental fluctuations in the Quaternary period, and geomorphic developments		
C01 Research on cities in West Asia and its surroundings from Medieval to Modern periods	2	9
・Historical research on cities in West Asia and its surrounding regions ・Comparative research on the structure and socio-cultural functions of cities (comparative history of urban planning, comparative urban typology, urban theory, etc.) ・Various urban issues (e.g., social and environmental issues of modern cities; disaster, epidemic and the city; management of historical cities; urban conservation and recovery; conservation of cultural heritage and cultural traditions., etc.)	1	8

2 HYDROGENOMICS: Creation of Innovative Materials, Devices, and Reaction Processes using Higher-Order Hydrogen Functions

https://hydrogenomics.jp/indexE.html

Number of Research Area	:	6001	Term of Project :	FY2018-2022
Head Investigator	:	ORIMO, Shin-ichi		
Research Institution	:	Tohoku University, Advanced Institute for Materials Research		

Hydrogen is a flexible element. It exists in materials in a wide concentration range, and exhibits high mobility and quantum property, and various reactivity with other elements. Depending on the surrounding environments, it also becomes an atomic, covalent, ionic state (both of proton and hydride-ion), and an intermediate state between them; and then, even the size of hydrogen itself in each state is drastically changed.

In this research area, we will construct a new materials science of hydrogen and hydrides (hereafter referred to as "HYDROGENOMICS", i.e., hydrogen-omics) as a guiding principle to "fully utilize" the diverse functionalities of hydrogen in materials. Toward this end, we will induce various "higher-order hydrogen functions (synergistic effects of multiple hydrogen functions)" through collaboration among researchers across disciplines such as engineering, chemistry, physics, and biology; and then, practically create innovative materials, devices, and reaction processes.

New calls of Publicly Offered Research for "HYDROGENOMICS" are as follows:

・Research Group B01 "Hydrogen Densification/Localization" which focuses on "High Densification Ability (Planned Research A01)" and "Interfacial Localizability (A02)", toward the synthesis of new hydrides and the induction of new material properties and functionalities.

・Research Group B02 "Hydrogen Migration/Coupling/Reaction" which focuses on "Fast Migration Ability (A03)" and "High Activation Ability (A04)", for designing new devices and reaction processes using various hydrogen-electron coupling.

・Research Group A05 "Advanced Analysis and Simulation Techniques", in order to effectively and continuously promote the activities of these research groups.

We are widely calling for proposals related to hydrogen science toward the construction of "HYDOGENOMICS"; especially on researches that cooperate with multiple groups, and on data-driven researches that cooperate with researchers inside and outside of this area. We also welcome the creative and challenging proposals from young researchers.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
B01 Hydrogen Densification/Localization	2 (experimental researches) 1.5 (computational/theoretical/ mathematical researches)	12 (experimental researches) 3 (computational/theoretical/ mathematical researches)
B02 Hydrogen Migration/Coupling/Reaction		
A05 Advanced Analysis and Simulation Techniques		

3 A Paradigm Shift by a New Integrated Theory of Star Formation: Exploring the Expanding Frontier of Habitable Planetary Systems in Our Galaxy

http://star-planet.jp/en/

Number of Research Area	:	6002	Term of Project :	FY2018-2022
Head Investigator	:	INUTSUKA, Shu-ichiro		
Research Institution	:	Nagoya University, Department of Physics		

Stars form continuously in our Milky Way Galaxy. Heavy atomic elements, such as metals, are created inside stars and blown out into the interstellar space of the Galaxy. This process has provided atomic elements heavier than hydrogen and helium, such as carbon and oxygen, which are critically important for the existence of living creatures in the universe. In our Milky Way Galaxy, the enrichment of heavy elements started in the inner Galactic regions and has gradually expanded toward the outer regions of the Galactic disk. This implies that the environment for forming habitable planets and biological entities are developed inside-out in the Galactic Disk over a timescale of the age of the universe. Understanding the origin and evolution of our solar system requires the comprehension of the environment of the birth place of the solar system about 4.6 billion years ago that is expected to be different from its current location in the Galaxy. This requires our understanding of the evolution of our Galaxy itself, over the timescale comparable to the age of the universe. We will try to understand this by extending the recently developed theories of star formation and by describing the formation of star clusters. In addition, we will develop planet formation theories and try to solve multiple puzzling questions regarding the origin of the solar system. This will be done by collaborations among all the relevant researchers in Japan, leading a paradigm shift in the investigation of the origin of our solar system. We encourage (but not restrict) the applicants to study a wide variety of subjects such as (a) stellar metallicity in the Galactic disk utilizing Gaia data, (b) galaxy evolution with metallicity distribution essential for the evolution of habitable zones, (c) theory and observation of star/planet formation in unexplored environments such as in the regions far away from spiral arms or in extraordinary star clusters.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Theory for the Formation of Star Clusters and the Evolution of Our Galaxy	4	4
A02 Theory for the Formation of Planetary Systems from Diverse Protoplanetary Disks	2	12
A03 Theoretical and Observational Studies of the Formation and Evolution of Diverse Planetary Atmospheres	1	13
B01 Observational Studies on the Formation of Star Clusters in Giant Molecular Clouds		
B02 Observational Studies on the Evolution of Protoplanetary Disks in Diverse Environments		
B03 Innovation of Infrared Observations of Young Planets and Habitable Planets		

4 Exploration of Particle Physics and Cosmology with Neutrinos

https://www-he.scphys.kyoto-u.ac.jp/nucosmos/en/

Number of Research Area	:	6003	Term of Project：	FY2018-2022
Head Investigator	:	NAKAYA, Tsuyoshi		
Research Institution	:	Kyoto University, Graduate School of Science		

Neutrino physics aims to elucidate not only the fundamental properties of elementary particles, the origin of mass, and the unified theory of matter and force, but also the origin of matter-antimatter asymmetry and the structure formation in the Universe, among many other phenomena.

The focus of this research area is on neutrino oscillation, violation of particle-antiparticle symmetry (CP symmetry), and neutrino astronomy, by utilizing the world's most advanced neutrino experiments (Super-Kamiokande, T2K, and IceCube).Furthermore, to explore the unified theory of elementary particle physics and that of the very early universe, we challenge more fundamental questions, such as the search for proton decay, neutrino mass measurements and verification of inflation (primordial gravitational waves) by observing the cosmic microwave background (Simons Array/GroundBIRD experiment), and verification of the Majorana-nature of the neutrino. Our goal is to create a "new perspective of particle physics and cosmology" for the 21st century by combining the research field on elementary particles, nuclei, cosmic rays, and the universe, with neutrinos as the centerpiece.

This publicly offered research expects collaboration with the planned research and research that strengthens and complements the cooperation between the planned research. We also welcome exploratory experimental and theoretical ideas that are not in our field and cross-disciplinary research. Among the following research topics, D01 is for the world's leading neutrino experiments and research and development of their critical experimental technologies (related to the planned research A01, A02, B01, and B02). D02 is for research on natural observations with neutrinos (related to the planned research A01, A03, and A04), D03 is for theoretical study on neutrinos (related to the planned research C01 and C02). If the study spans more than one research group, the most relevant research group should be selected.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
D01 Experimental research on neutrinos (including experimental technology development research)	3 2 1	2 3 2
D02 Research on natural (earth, space, etc.) observation with neutrinos	2 1	2 2
D03 Theoretical study on neutrinos	2 1	2 6

5 Materials Science on mille-feuille structure -Development of next-generation structural materials guided by a new strengthen principle

https://www.mfs-materials.jp/en/

Number of Research Area	:	6004	Term of Project :	FY2018-2022
Head Investigator	:	ABE, Eiji		
Research Institution	:	The University of Tokyo, Graduate School of Engineering		

The "mille-feuille structure" constructed by microscopic stack of hard and soft layers is able to provide excellent mechanical properties through the kink formation, and therefore universal understanding of kink phenomena will lead to further development of lightweight structural materials. In this research area, by aiming at the elucidation of kink strengthening mechanism and the construction of the new kink theory, we have organized a research group extended across the different fields of materials, mechanics, structural science, physics, chemistry, and mathematics, in order to consolidate and combine knowledges for the birth of a new leading academic field "Kink strengthening of mille-feuille structures". We then apply the kink strengthening theory to develop new next-generation structural materials by extending into three major materials; metals, ceramics and polymers.

There are four research groups in the research area. In the research group A01, design new Mg alloys having various mille-feuille structures along with the extended concepts of long-period stacking/order (LPSO) structure-type Mg alloys. In the planned research A02, we conducted mechanical experiments, state-of-the-art structural measurements, and modeling (calculations) in order to elucidate the kink strengthening mechanism. In the research group A03, a kink theory will be constructed by the effective collaborations between materials, mechanics, physics, and mathematics. In the research group A04, we attempt to apply the kink strengthening theory to develop new metal and polymer mille-feuille structured materials.

We seek for the publicly offered researches on the subjects which have not been well covered in the planned researches, targeting on those for developments of new kink-strengthened materials, experimental/computational methods and basic theories; the 20 proposals are expected in total, including 13 for the experimental studies, and 7 for the theoretical/computational studies. For the materials creation researches, we set up "Experimental Research I" to invite challenging studies on new mille-feuille materials that can be strengthened by kinks. For the issues on "Mechanism elucidation and theory construction", we expect both the experimental and theoretical/computational studies, including quantitative evaluations of disclinations by diffraction methods, and fractal-base modeling of spontaneous mille-feuille organizations as a priority issue (Theory・Computation System I). We welcome enthusiastic applications from various fields including diffraction science and applied mathematics. We also welcome the active applications of young researchers.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Creation of new Mg alloy with various mille-feuille structures	Experimental Research I : 5	2
A02 Elucidation of kink mechanism of mille-feuille structures	Experimental Research II : 3	11
A03 Construction of kink theory of mille-feuille structures	Theory・Computations I : 3	2
A04 Creation of new metal/polymer materials based on kink theory	Theory・Computations II : 2	5

6 Clustering as a window on the hierarchical structure of quantum systems

http://be.nucl.ap.titech.ac.jp/cluster/eng/

Number of Research Area	:	6005	Term of Project :	FY2018-2022
Head Investigator	:	NAKAMURA, Takashi		
Research Institution	:	Tokyo Institute of Technology, School of Science		

What makes our material world hierarchical; quarks, hadrons, nuclei, atoms, and molecules? This is a fundamental question yet to be understood in science. The research area, "Clustering as a window on the hierarchical structure," aims to understand the formation mechanism of the hierarchical structure of the quantum particles. We thus integrate our research activities on hadron-, nuclear-, atomic physics, and molecular science, where Japan has played leading roles, and establish a research consortium to fill the large gaps among the conventional research fields. A variety of novel clustering phenomena will be the primary targets of the research, which would clarify not only universal phenomena but also characteristic features of each hierarchy. Accordingly, we open a new research field to investigate the origin of the hierarchical structure of matter.

We call for publicly offered researches for this research area. Each research subject is recommended to be complementary, or fit to the planned researches in Group A01, A02 (Quark and hadron hierarchies), B01, B02 (Nuclear hierarchies), C01, C02 (Atomic and molecular hierarchies), or D01 (Theories to connect these hierarchies) (See Table below, and the web page shown above). Each applicant should specify in the application which group A01-D01 the research will be relevant to. We have three budget schemes, as shown in the Table.

Examples of complementary researches are as follows: A01: Precise measurements of vector mesons mass state modifications, exotic hadron productions, viscosity measurements and perfect fluidity of QGP; A02: Exotic hadrons, exotic bound states involving vector mesons, pseudo-scaler mesons in nuclei; B01: Scattering experiments, hyper-nuclei, hyperon-nucleon interactions (including three-baryonic force, medium effect), nuclei including K- and Λ*; B02: Clustering phenomena in exotic nuclei, three-nucleon force, α clusters, multi-nucleon correlations; C01: Theories on the relation between ultra-cold atomic system composed of gases with large mass ratio and atomic nuclei, on the analogy between SU(4)-system in the optical lattice and α cluster in nuclei, on three-body forces in different hierarchies; C02: Equation of states of strongly-correlated quantum particles, experiments on fluid properties and non-equilibrium dynamics, dipole excitation and spectroscopy of hadron molecules, nuclei, and molecules, formation and disintegration of composite particles; D01: Phase transition from quarks to hadrons, origin of hadron resonances, nucleon-nucleon correlation, three nucleon force, role of α cluster in nuclei, universality in ultra-cold atoms, Efimov physics, electron-electron correlations, ab-initio calculations. Besides these examples, we also expect other related subjects.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Dynamics to bridge quark and hadron hierarchies	Experimental Researches 3.5 2.5 Theoretical Researches 1	3 9 10
A02 Elucidation of hierarchical structure between quark and hadron phases by means of quark clusters		
B01 Clusters of strange hadrons for investigating hierarchical structure of matter		
B02 Exotic nuclei for investigating hierarchical structure of matter		
C01 Ultracold atom study of exotic phenomena bridging different hierarchies		
C02 Universal physics of quantum matter at the change of the hierarchy and the state		
D01 Emergence mechanism of hierarchical structure of matter studied by ab-initio calculations		

7 High Entropy Alloys - Science of New Class of Materials Based on Elemental Multiplicity and Heterogeneity

https://highentropy.mtl.kyoto-u.ac.jp/en

Number of Research Area	:	6006	Term of Project :	FY2018-2022
Head Investigator	:	INUI, Haruyuki		
Research Institution	:	Kyoto University, Faculty of Engineering		

'High-entropy alloy (HEA)' is defined in a narrow sense as a single-phase equiatomic solid-solution consisting of more than five elements, but the research area related to HEAs is recently expanding to deal with multi-component and multi-phase concentrated alloys with chemical compositions not necessarily being equiatomic but in the vicinity of the central composition of the multi-component phase diagram. Many HEAs defined in the latter broad sense are reported to exhibit unusually excellent materials properties that is believed to arise from the so-called 'cocktail' effects resulting from non-linear interactions among the constituent elements, which cannot be described by a simple rule of mixture among them. The present research area aims at establishing science of new-class of materials that exhibit peculiar physical properties due to non-linear interactions among constituent elements by elucidating mechanisms behind unusual and peculiar physical properties of HEAs through intensive interdisciplinary cooperative research among top researchers in various research fields. In addition to planned research in the three research groups listed below, we call for research in the related areas in these three research groups to advance research on HEAs.

New areas and aspects that are not covered by planned research are expected to be proposed in publicly offered research. Applicants in publicly offered research do not necessarily have to have experience in the past to work on HEAs, and when started, they can conduct research in cooperation with researchers of planned research and also they can receive HEA specimens and so on from those of planned research. The subjects of publicly offered research are not restricted to mechanical properties but can be extended to cover new and peculiar functional properties of HEAs. Proposals for a wide range of materials including metallic, ceramics and organic materials by experiment and theoretical calculation and simulation will be welcome. In particular, proposals from various areas such as physics and chemistry and also those from young and active scientists will be very welcome. Details of the research contexts of the present research area can be found in the home page (https://highentropy.mtl.kyoto-u.ac.jp/en).

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Synthesis and mechanisms of new materials and functions	4 (experimental work)	8
A02 Modelling of physical properties expression and alloy design	2.5 (computational work)	4
A03 Phase stability and nano-microstructure control	2 (computational work)	4

8 Toward new frontiers : Encounter and synergy of state-of-the-art astronomical detectors and exotic quantum beams

https://member.ipmu.jp/SpaceTech_to_QuantumBeam/index_e.html

Number of Research Area	:	6007	Term of Project :	FY2018-2022
Head Investigator	:	TAKAHASHI, Tadayuki		
Research Institution	:	The University of Tokyo, Kavli Institute for the Physics and Mathematics of the Universe		

In this research area, we will link the state-of-the-art detector technology for space X-ray, gamma-ray observations and three "exotic" quantum beams: negative muon, high energy photon and RI-beams, on which Japan is the current leader in these fields, and extend research using new perspectives and methods.

We will extend research in fundamental physics as well as explore and develop novel methods that can advance the applications such as "negative muon non-destructive element analysis", "new muon catalyzed fusion scheme" and "materials science research by ultra-sensitive NMR method."

We aim at early realization of novel highly sensitive hard X-ray / gamma-ray imaging detectors for cancer research by pursuing the development of cross-field technology such as R&D of state-of-the-art detectors and ultra-low energy negative muon microbeams. To explore new research fields through the cooperation between research disciplines, we will perform the following seven research groups categorized into A. fundamental science, B. applied experimental science, and C. cross-field technology development, as shown in the following table.

For details on the planned research projects, please refer to the research-field web page. We call for publicly offered research, not only experimental and theoretical research corresponding to the above research groups, but also research that crosses the field or research from a different field application using outputs of our programs (research group D01). In addition, we conduct a theoretical study in association with any of A01 to C02 (research group E01).

[D. Cross-Field Research, Different Field Applications] D01: Cross-field research or novel applications using various technical seeds and quantum beams that the above research projects are performed with.

[E. Theoretical study] E01: Theoretical study in association with any of A01 to C02 projects or common platform for the research field.

We especially encourage active applications from young researchers to the publicly offered research. In the theoretical study E01, please clarify which research group is the closest to your research interest considering possible collaboration with any of A01 to C02.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 High-precision experiments in atomic and molecular physics using a negative muon beam and their astrophysical application	2	6
A02 Investigation of deep inside of nuclei and neutron stars with high energy photons	3	4
B01 Development of non-destructive elemental analysis method using negative muon beam	5	4
B02 Creation of in-flight muon catalyzed fusion in the Mach shockwave interference region		
B03 Highly spin-polarized RI beam and its application to nuclear physics and materials science		
C01 Novel and interdisciplinary application of hard X-ray and gamma-ray detectors		
C02 Advanced negative muon beam development		
D01 Cross-disciplinary study or explore a new application		
E01 Theoretical study with a relation to research groups A01-C02	1	4

9 Constructive understanding of multi-scale dynamism of neuropsychiatric disorders

http://multiscale-brain.umin.ne.jp/en/

Number of Research Area	:	7001	Term of Project :	FY2018-2022
Head Investigator	:	HAYASHI-TAKAGI, Akiko		
Research Institution	:	RIKEN, Center for Brain Science		

Despite extensive recent efforts, the pathogenesis of psychiatric disorders remains poorly understood, mainly because their pathophysiology is a synergistic interaction between multiple genes variants and environmental factors. Thus, what we recently know as contributory factors for the diseases is the susceptible gene variants (Molecular layer), synaptopathy (Subcellular and Cell layer), alteration in neuronal circuits (Circuit layer), conceivably resulting in the behavioral manifestations (Individual layer). However, the understanding of each layer has been limited within a single layer, which hinders the integrative and causal mechanistic understanding of behaviors. Each layer can probably affect one another, macroscale to the mesoscale, and then to the microscale layer or vice versa. Thus, we deal with phenomena of the intricate complexity of psychiatric disorders that are governed by various mechanisms integrated across multiscale layers.

For this goal, we aim at a constructive understanding of the multiscale hierarchical nature of psychiatric disorders with the use of recently available state-of-art techniques: hypothesis-free and comprehensive data sampling, which can handle big data from multiscale layers ranging from molecules/synapses/neurons/circuit (A01: Data-driven approach). Second, big data from the A01 team will be analyzed and subject to the construction of mathematical models (A02: Abduction approach) to identify the candidate for responsible molecules or mechanisms. The abducted hypothesis by A02 will be examined through manipulative experiments (A03: Hypothesis-driven approach). Besides, by using induced pluripotent stem (iPS) cells derived from patients with psychiatric disorders, neural cells and cerebral organoids will be generated, and cellular pathology underlying mental disorders will be reconstructed. For "Publicly Offered Research," the proposal designed as a collective research effort through collaboration with "Planned Research" with a different approach from your proposal is encouraged. For example, if researchers apply to A01, a rational and feasible collaborated proposal with A02 or A03 group would be appreciated so that all teams in our field are mutually beneficial. This grant aims to generate a synergistic driving force by a group of diverse researchers, which will develop and lead to the upgrading and enhancement of basic psychiatric research.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Data driven approach	3	9
A02 Abduction approach	3	9
A03 Verifying a hypothesis approach	3	9

10 Ensuring integrity in gametogenesis

https://www.gamete-integrity.com/english/

Number of Research Area	:	7002	Term of Project :	FY2018-2022
Head Investigator	:	HAYASHI, Katsuhiko		
Research Institution	:	Kyushu University, Graduate School of Medical Sciences		

The aim of this research area is to understand how the functionality of gametes, named "gamete integrity", is established during gametogenesis *in vivo*. Based on this knowledge, this research area also aims to reconstitute the process *in vitro*.

Gametes are highly specialized cells for the creation of new individuals. Quality of germ cell lineage closely relates to viability of embryos and individuals. This research area will try to understand molecular mechanisms and biological processes for construction of gamete integrity *in vivo*. This research area includes technological development of non-invasive systems to evaluate gametes, and establishment of in vitro gametogenesis that can firmly reconstitute gamete integrity.

This research area is composed of three research groups (A01-A03): A01 is to develop the culture system to reconstitute gamete integrity in vitro. A02 is to innovate non-invasive systems to predict the developmental competence of the gamete. A03 is to understand biological processes needed for selection of the developmentally competent gametes.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Reconstitution of Gamete Integrity *in vitro*	6	3
A02 Innovation of Non-invasive Systems to Predict the Developmental Competence of the Gamete	4	8
A03 Understanding of Biological Processes *in vivo* for Gamete Integrity		

11 Chromatin potential for gene regulation

http://www.nibb.ac.jp/potentia/

Number of Research Area	:	7003	Term of Project :	FY2018-2022
Head Investigator	:	KIMURA, Hiroshi		
Research Institution	:	Tokyo Institute of Technology, Institute of Innovative Research		

In eukaryote cells, genomic DNA is packed in the nucleus as chromatin, which controls gene expression, a fundamental process to regulate the life of an organism. The state of chromatin is controlled in various hierarchies such as histone modification, condensation state, intranuclear localization, and interaction with nuclear structure, but how these factors regulate the potency of transcription in living cells has not been solved. The purpose of this research area is to understand the mechanism of gene expression control through chromatin by introducing a new concept "chromatin potential". Focusing on biological events, such as early embryonic development and stem cell differentiation, in which dynamic changes of chromatin state and gene expression pattern occur, we analyze chromatin potential by using state-of-art technologies, such as in vivo fluorescence imaging, omics analysis, reconstitution assays, genome and epigenome editing, and theoretical modeling. By stimulating collaborations among different groups in the research area, we aim to present a universal concept of chromatin potential for gene regulation.

For the applicants of the Publicly Offered Research ("Koubo Kenkyu"), we expect proposals that contain originalities over the preexisting chromatin researches and that can be further developed by collaboration with the other groups in the area, sharing the purpose of this research. In particular, we welcome theoretical studies based on mathematical modeling and simulation, and studies on statistics and informatics handling the large-scale time series and omics data. In addition, we expect researches that reinforce or complement the Planned Research ("Keikaku Kenkyu") projects in terms of methods (e.g., advanced biological imaging, novel chromatin manipulation technologies, nucleic acid chemistry, genome synthesis, etc.), objects (e.g., plants, non-model organisms, etc.), and biological phenomena (regeneration, higher order biological function, etc.). We encourage young and/or female scientists who can become new leaders in the future of the research area to apply.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Chromatin potential for gene regulation	4	12

12 New frontier for ubiquitin biology driven by chemo-technologies

http://www.ubiquitin.jp/

Number of Research Area	:	8001	Term of Project :	FY2018-2022
Head Investigator	:	SAEKI, Yasushi		
Research Institution	:	Tokyo Metropolitan Institute of Medical Science		

Protein ubiquitylation is a posttranslational modification that controls various cellular functions by regulating the protein life cycle, subcellular protein localization, and protein–protein interactions. The variety of ubiquitin's functions can be attributed to the structural diversity of ubiquitin modification, called the 'ubiquitin code'. However, due to the complexity and dynamics of ubiquitin signaling, the overall principles of ubiquitin codes are still unknown.

In this research area, we aim to: i) decipher the ubiquitin code by developing and utilizing new chemically based analytical platforms, and ii) create new methodologies for regulating cellular functions exploiting protein ubiquitylation. To achieve these goals, the research area includes two major fields of study; the researches to elucidate how protein ubiquitylation mediates biological processes (Research group A01), and the researches to develop new chemo-technologies for analyzing the ubiquitin-mediated processes (Research group A02).

In the publicly offered researches, we will broadly call for challenging proposals that can be synergistically developed with the planned researches and contribute to this research area. Research in A01 will focus on cellular pathways in which ubiquitylation plays a critical role, particularly in those pathways where the molecular mechanisms of ubiquitin involvement have been or are being clarified. Interested researchers are encouraged to propose chemical technology–based topics that will advance the understanding of ubiquitylation or help explore the possibility of ubiquitin-related drug discovery. Research in A02 will focus on developing new ubiquitin analytical techniques, primarily from the standpoint of organic chemistry. For example, this includes research to develop chemical probes for ubiquitin chains and chemical inhibitors for ubiquitylating enzymes. It also includes research on the regulation of cell function by forced ubiquitylation using chimeric compounds.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Elucidation of ubiquitin functions by chemo-technologies	3	12
A02 Development of ubiquitin chemo-technologies	2	12

13 Chronogenesis: how the mind generates time

http://www.chronogenesis.org/en/

Number of Research Area	:	8002	Term of Project :	FY2018-2022
Head Investigator	:	KITAZAWA, Shigeru		
Research Institution	:	Osaka University, Graduate School of Frontier Biosciences		

In this research area, we aim at elucidating how the mind generates our conscious experience of time that has evolved to the most advanced stage in human beings. In our preceding area, "The Science of Mental Time" (FY2013-2017), we achieved major goals such as drawing a map of mental time over the medial surface of the cerebral cortex through the inter-disciplinary studies across linguistics, neuroscience, and clinical medicine. In this research area, we construct an artificial neural network that yields mental time information in response to natural sentences (research group A01), and use it as a control to be compared with the brain. Through the comparison, we elucidate how a sense of continuous "flow of time" emerges (B01), how rhythmic brain activities are related with our awareness of time (C01), how we "acquire" time through development and evolution (D01), and how we "lose" our time in neurological and mental diseases (E01), down to the level of neural circuits.

We will accept two research proposals, which would complement our programmed researches, for each of the five research groups: A01 "generate", B02 "flow", C01 "tick", D01 "acquire", and E01 "lose". We raise some examples but we welcome proposals other than these. Research group A01: typology of linguistic-time, research on mental-time and linguistic-time, B01: research from the view-point of the integrated information theory, neural bases of the A-series (past, present, and future) of time, C01: experimental research on time perception in humans and animals, and development of interventional techniques using electromagnetic stimulation to manipulate our temporal experience, D01: comparative studies targeting variety of animal species, and investigation of speech in human children with respect to time expression, E01: neuroscientific research on generation and destruction of time processing and its subjective value, and clinical research on time agnosia and time illusion.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 "Generate". Linguistic Chronogenesis	2.7	2
B01 "Flow". Neural bases for the flow of time	2.7	2
C01 "Tick". Mechanism and manipulation of mental time associated with perception and action	2.7	2
D01 "Acquire". Ontogeny and phylogeny of the acquisition of time	2.7	2
E01 "Lose". Generation and collapse of time processing and its emotional value	2.7	2

14 Science of Soft Robot: interdisciplinary integration of mechatronics, material science, and bio-computing

http://softrobot.jp/en/

Number of Research Area	:	8003	Term of Project :	FY2018-2022
Head Investigator	:	SUZUMORI, Koichi		
Research Institution	:	Tokyo Institute of Technology, School of Engineering		

In recent years, in various fields including machinery, electronics, computers, and material science, new sciences aimed at "softness" have appeared simultaneously. In this Research Area, the seeds of these new sciences have been merged with the goal of creating a "system of knowledge concerning soft and independent artifacts" based on the values of a biological system, which differ sharply from the "hard" values and methodologies of past artifacts and machines. In this area, three Research Groups, "A01: soft body," "A02: soft motion," and "A03: soft knowledge" have been set for Planned Researches, and extensive researches are underway to merge these different fields.

We are calling for proposals of Publicly Offered Research that can supplement the content of these Research Groups and Planned Researches and contribute to link and cooperatively study with them. Specifically, we are calling for research proposals concerning two Research Groups, "B01: Sprouting of soft sciences" and "B02: Introducing soft robots throughout society."

Regarding B01, we look forward to participation in the creation of a new science aiming for "softness." We anticipate challenges such as the soft form and knowledge of living organisms, soft sensors, actuators and robots, soft functional materials or organic materials, information processing for flexible robot intelligence, or the simulation and control of dynamic systems consisting of soft material objects, and others, which will become the driving force behind the advance of this Research Area. Regarding B02, we are calling for research challenges aimed at the introduction of soft robots throughout society. We will, for example, welcome applied research that can greatly impact a super-aged society with a declining population and initiatives from the humanities and social sciences to facilitate its introduction throughout society.

In this Research Area, we are eager to advance research and academic systematization by blending research challenges and are looking forward to proposals that will vigorously advance joint research within the research area.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
B01 Sprouting of soft sciences	5	6
B02 Introducing soft robots throughout society	5	6

15 Deciphering Origin and Establishment of Japonesians mainly based on genome sequence data

http://yaponesian.org/

Number of Research Area	:	8004	Term of Project :	FY2018-2022
Head Investigator	:	SAITOU, Naruya		
Research Institution	:	National Institute of Genetics, Division of Population Genetics		

Main questions of this research area are origin and formation of people who live on Japanese Archipelago (Yaponesia). Predetermined research groups A01-A03 are determining genome sequences of several hundred modern individuals and more than 100 ancient individuals as well as those of animals and plants moved to Yaponesia with humans. We try to decipher genomic history of people on Yaponesia through analyses of these newly determined genome sequences with other available ones. Predetermined research groups B01-B03 are conducting archeological studies focused on scientific dating, linguistic studies involving dialects of Japanese and Ryukyuan languages, and studies on demographic changes through genome data collaborated with A01-A03 groups. We aim to establish new research area by integrating biological studies and humanity/social science studies. Please visit our Project Homepage for details.

We welcome proposals of new interdisciplinary studies not necessarily related to topics of predetermined research groups for advertised studies. Because determination of many genome sequences for modern human, ancient human, non-human animals and plants, as well as collection of massive data may need large amounts of budgets, we set the upper limit of this type of study (A04) as 4 million yen per year. However, grant applications including interdisciplinary studies are favored. We also set another type of research plan (B04) that does not include large scale study such as genome sequencing, and its upper limit is 2 million yen per year. We welcome applications such as ancient history, ethnology, folklore, or AI-assisted data analyses which are not covered by study plans of predetermined research groups.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A04 Unraveling origin and formation of Yaponesian mainly using genome data	4	10
B04 Unraveling origin and formation of Yaponesian through interdisciplinary studies	2	10

16 Elucidation of the strategies of mechanical optimization in plants toward the establishment of the bases for sustainable structure system

https://www.plant-structure-opt.org/home/

Number of Research Area	:	8005	Term of Project :	FY2018-2022
Head Investigator	:	DEMURA, Taku		
Research Institution	:	Nara Institute of Science and Technology, Graduate School of Science and Technology		

As environmental and population issues are worsening at the global level, efforts to build up a sustainable society are accelerating. The creation of a sustainable living space, in harmony with the surrounding environment, is one of society's most important endeavors, even in the fields of manufacturing, architectural design, and urban planning. In recent years, approaches in engineering using biomimetics have been pursued. Additionally, studies on plant cell walls have demonstrated that plants are excellent structural systems that autonomously optimize their mechanical properties in response to various environmental factors and stresses. Based on the above background, this research area aims to understand the mechanical optimization of plants on a multi-scale (molecular, cellular, tissue, and individual) level. Also, we aim to sublimate the mechanical optimization strategy of plants into new energy-saving / material-saving building designs, new material models, and to create a base for the next-generation of sustainable structural systems.

To achieve these objectives, currently three research groups are set to take on the different goals of the project. Group A01 "System" will aim to understand the mechanical phenomenon at the organ-individual scale (e.g. posture control during gravitropism, morphogenesis in response to environmental changes, etc.) and will develop and propose new "building systems". Group A02 "Module" will elucidate the mechanical phenomenon on the cell-tissue scale (e.g. partial strengthening of cell walls, mechanical stability by cellular arrangement, etc.) and will develop new module designs (e.g. blocks for laminated construction method, etc.). Group A03 "Unit" will analyze the mechanical properties on the subcellular scale (e.g. cell wall, vacuole, cytoskeleton, membrane structure, etc.) and will develop improved units (e.g. building materials, etc.) in construction. We seek attractive proposals based on the physiological phenomena, methodologies, and points of view, that are not covered by the Planned Research groups. We especially welcome aggressive, multidisciplinary research proposals such as those focusing on the social implementation of construction design and material development inspired by plant systems and those emphasizing theoretical aspects including mathematical modeling.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 System	Experimental: 4 Theoretical: 2	10
A02 Module		4
A03 Unit		

17 Molecular Engine: Design of Autonomous Functions through Energy Conversion

http://www.molecular-engine.bio.titech.ac.jp/eng/

Number of Research Area	:	8006	Term of Project :	FY2018-2022
Head Investigator	:	KINBARA, Kazushi		
Research Institution	:	Tokyo Institute of Technology, School of Life Science and Technology		

In this research area, we define a molecule, that transforms a certain form of energy to the other form through a mechanical structural change, as a "molecular engine". This area aims at establishing a fundamental principle toward construction of molecular engines. For this purpose, a cross-sectoral research collaborations among experts of synthetic chemistry, molecular biology, biophysics, soft matter physics, computational science, etc., were organized. Through these collaborations, we aim to construct a molecular system autonomously and efficiently converting various energies. Publicly offered researches related to the following research groups are invited.

The research group A01 aims to develop molecules that interconvert various energies such as light, chemical, heat, kinetic, electric energies, etc. through mechanical motions. This group covers researches on artificial molecules, biomolecules and hybrid molecules. In addition, studies on the "field" for energy conversion by molecular engines (e.g. anisotropic field such as bilayer membranes). The research group B01 aims to construct condensed systems and molecular assemblies with synthetic, biological, and hybrid molecular engines, so as to realize interconversion of energy and information, substance transport, and so on. The research group C01 covers the precise analysis and measurement of molecular engines. In addition to single molecule and multimolecule measurement, evaluation of molecular engines by structural analysis, spectroscopic and mechanical analyses for evaluation of molecular assemblies are also targeted. The research group C02 aims at theoretical analyses of molecular engines including de novo design, all atom/coarse-grained molecular dynamics calculation, quantum chemical calculation, hydration calculation (RISM / 3D-RISM etc.), data assimilation method, artificial intelligence, and structure prediction using bioinformatics: analysis of artificial, biological, hybrid type molecular engines by computational science are targeted. In addition, soft active matters, theoretical studies of molecular engines and their energy conversion mechanisms by non-equilibrium statistical mechanics, and integrated researches of theory and experiments are also covered.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Design of molecular engines	3	20
B01 Design of molecular-assembly motions for energy conversion		
C01 Precise analysis of molecular engines		
C02 Theory and calculation of molecular engines		

18 Singularity biology

http://singularity-bio.jp/eng/

Number of Research Area	:	8007	Term of Project :	FY2018-2022
Head Investigator	:	NAGAI, Takeharu		
Research Institution	:	Osaka University, The Institute of Scientific and Industrial Research		

There exist critical moments, such as the Big Bang, where something is created from nothing, or potential moments in the future when artificial intelligence outperforms human intelligence. These moments are called singularities. Singularity events have a major feature where a small number of rare events would become the trigger to cause drastic and irreversible changes (singularity phenomenon) throughout the manybody complex system. Even in life phenomena, it is known that a relatively small number of cells (singularity cell) can become the core to trigger drastic change of the entire multi-cellular system, the mechanisms by which these phenomena occur are largely unknown. In this research area, in order to approach the biological singularity phenomenon, the research team will construct and improve the trans-scale-scope AMATERAS, which is compatible with ultra-wide field of view, high spatial resolution, high speed and long term imaging, so that singularity cells are not overlooked. In addition, two research groups: Group A01 “Development of technologies to measure and control singularity cells”, and Group A02 “Development of mathematical and information technologies to analyze singularity phenomena" are organized, and the technologies developed are fed back to AMATERAS as needed. Moreover, Group A03 “Elucidation of the biological significance of singularity phenomena" is also organized to promote highly interactive collaborative research in measurement science, mathematical and information science, and biology. We expect research proposals that will supplement and contribute to the elucidation of various biological singularity phenomena, and promote highly-interdisciplinary joint research with us by using AMATERAS.

Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01 Development of technologies to measure and control singularity cells	4 2.5	5 22
A02 Development of mathematical and information technologies to analyze singularity phenomena		
A03 Elucidation of the biological significance of singularity phenomena		