## RIKEN CBS



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**RIKEN** Center for Brain Science







RIKEN Center for Brain Science (CBS) is a core research center that investigates the human brain as the foundation of the human mind.

The brain is the last frontier in natural science. The mission of CBS is to probe this frontier with thoughtful and diverse methods at the cellular, individual, and social levels, to produce results with societal impact.



Rapidly aging populations in Japan and elsewhere are facing unprecedented challenges, in particular from dementia and other neuropsychiatric diseases that are already disrupting the foundations of society. In addition, overcoming mental health issues is a pressing matter for our modern society. The brain is the foundation of the mind and enables us to live as human beings, and mental health instability is caused by dysfunction in the brain. The human brain is capable of learning and memory, as well as decision-making and creative activities based on experience. Discovering the principles of these brain activities is essential to understanding the basis of the mind and overcoming mental health challenges.

RIKEN CBS was established in 2018 as a core center for brain science research in Japan. We have been conducting basic research and developing innovative technologies for the brain and mind across multiple levels, including genes, cells, individuals, and social systems, based on interdisciplinary and integrated academic fields such as medical science, biology, chemistry, engineering, information and mathematical sciences, and psychology.

In addition, by working hand-in-hand with domestic and international research institutes, universities, and inter-university research institutions, we are realizing our role as a core center for the Japanese national project Brain/MINDS 2.0 (Multidisciplinary Frontier Brain and Neuroscience Discoveries). By fostering collaboration with industry, we are furthering our goal of serving as a hub for industry-academia-government networks in brain science. Through such research and development, we aim to meet the expectations of society, contribute to discovering the full range of brain functions and overcome neuropsychiatric disorders. We invite you to join the research journey, and thank you for supporting RIKEN CBS.



### <u>Four Keys to</u> Unravelling the Brain



## Understand what is unique about the human brain

The brain and mind remain shrouded in mystery. How do people understand themselves and others and how do they form relationships? We will elucidate the brain's highly-developed cognitive functions such as language and emotion.



## Learn from the brains of other species

Looking at the brains of other species offers multiple comparative insights at the molecular, cellular or neural network levels. We will work out universal principles that link the brain and body across species.



## Analyze the brain with big data

Information science and new technologies are crucial to advancing brain science. Analyzing already-collected data and examining the brain from new angles will allow researchers to reveal the internal computational principles, which can lead to a new generation of artificial intelligence.



## Improve quality of life by studying the brain

People face an array of social problems and physical disorders. Many are caused by the deep involvement of the brain. Brain science can clarify the causes of mental and neurological disorders, leading to possible solutions for social problems.



#### **Principal Investigators**



Joshua Johansen Laboratory for Neural Circuitry of Learning and Memory

We study how aversive experiences trigger alterations in brain circuits and neural coding resulting in emotional memory formation.



Kazuhisa Shibata Laboratory for Human Cognition and Learning We clarify brain mechanisms of human cognition by psychophysics, neuroimaging, and machine learning.



Lukas Ian Schmitt Laboratory for Distributed Cognitive Processing We investigate how selective, short-term maintenance of information allows brain networks to produce continuous, connected perception based on noisy, disconnected inputs.



Hakwan Lau Laboratory for Consciousness

We study how the brain generates visual experiences in the absence of external input.



Kentaro Miyamoto

Laboratory for Imagination and Executive Functions Our goal is to reveal how our brain enables imaginations for future and others.



Shigeyoshi Fujisawa Laboratory for Systems Neurophysiology

Our goal is to elucidate the neuronal and network mechanisms underlying cognitive functions such as episodic memory and decision making.





Hiroyuki Kamiguchi Laboratory for Neural Cell Dynamics

Understanding cellular mechanisms that control nervous system formation and repair.



Hokto Kazama Laboratory for Circuit Mechanisms of Sensory Perception

Our goal is to understand the computations and neural circuit mechanisms underlying sensory-guided behavior.



Thomas McHugh Laboratory for Circuit and Behavioral Physiology

Our goal is to understand the neural circuits that allow the brain to encode, consolidate and recall memories.



Adrian Moore Laboratory for Neurodiversity

Our lab asks: how does a neuron grow up to be different; how are differentiation pathways initiated and directed to create diversity in neuron form and function?



Tomomi Shimogori

Laboratory for Molecular Mechanisms of Brain Development

Revealing molecular mechanisms that control experiencedependent plasticity.



Yoshihiro Yoshihara Laboratory for Systems Molecular Ethology

We aim to elucidate molecular, cellular and neural circuit mechanisms underlying various olfactory behaviors.

#### **Principal Investigators**



Ryoichiro Kageyama Laboratory for Neural Stem Cell Research

We aim to enhance adult neurogenesis, thereby improving cognitive function.



Aya Takeoka Laboratory for Motor Circuit Plasticity We study how motor experience and training trigger plasticity of brain and spinal circuits to regulate the encoding of motor learning and consolidate and recall motor memories.



Atsushi Miyawaki Laboratory for Cell Function Dynamics Our primary goal is to better understand how biological molecules behave in space and time.



Masanori Murayama Laboratory for Haptic Perception and Cognitive Physiology We observe the living brain and clarify the relationship between perceptual behavior and neural activity at the single-cell and network level.



Fumi Kubo Laboratory for Sensorimotor Integration We aim to understand neural mechanisms for sensory perception and behavior at cellular and network levels.



Hiroyuki Nakahara Laboratory for Integrated Theoretical Neuroscience

Uncovering brain functions and computations for learning, decision making and social intelligence.





Taro Toyoizumi Laboratory for Neural Computation and Adaptation

Exploring the principles behind learning in the brain by computational approaches.



Takuya Isomura Brain Intelligence Theory Unit We aim to mathematically express universal characterization of the brain intelligence.



Louis Kang Neural Circuits and Computations Unit We study how computations in neural circuits produce memory and other mental capabilities.



Takaomi Saido Laboratory for Proteolytic Neuroscience We aim to elucidate and to regulate the mechanism of brain aging that leads to the onset of Alzheimer's Disease.



Motomasa Tanaka Laboratory for Protein Conformation Diseases Our goal is to elucidate molecular mechanisms of protein aggregation and its physiological consequences in neuropsychiatric diseases.



Akiko Hayashi-Takagi Laboratory for Multi-scale Biological Psychiatry We aim to causally identify the contributory factors for psychiatric disorders, which could provide the knowledge necessary to establish circuit-centric therapeutics as well as molecular-based drug designs.

#### **Principal Investigators**



Atsushi Takata Laboratory for Molecular Pathology of Psychiatric Disorders

Deciphering the biological basis of psychiatric disorders in order to transform clinical psychiatry.



Jun Nagai Laboratory for Glia-Neuron Circuit Dynamics

Exploring contributions of glial cells to brain circuits and adaptive/maladaptive behavior.



Aya Ito-Ishida Laboratory for Brain Development and Disorders

We aim to clarify the mechanism for brain development and find a solution for developmental disorders.



Asuka Takeishi Neural Circuit of Multisensory Integration RIKEN Hakubi Research Team

Exploring the neural and molecular mechanisms of behavior choice in *C. elegans.* 



Masako Tamaki Cognitive Somnology RIKEN Hakubi Research Team

Elucidating the roles of the sleeping brain in cognition and behavior in humans.



Terufumi Fujiwara Adaptive Motor Control RIKEN Hakubi Research Team

We aim to reveal neural mechanisms of how animals adaptively control movements upon environmental and body state changes.





Toshitake Asabuki Hierarchical Neural Computation RIKEN ECL Research Unit

Exploring the neural circuit mechanisms of hierarchical learning.



Hiroki Sasaguri Dementia Pathophysiology Collaboration Unit Elucidating the pathophysiology of dementia through generation and analyses of disease animal models.



Dai Yanagihara Cognition and Behavior Joint Research Laboratory

#### Multidisciplinary Frontier Brain and Neuroscience Discoveries (Brain/MINDS 2.0)



Brain/MINDS 2.0 is a national flagship project aimed at innovative technology development and elucidation of higher brain functions and disease mechanisms. This project establishes a research platform for a mathematical model called the Digital Brain, promoting diagnosis and treatment methods for neurological and mental disorders, including dementia, as well as research and development in drug discovery. CBS, as the core organization of Brain/MINDS 2.0, plays a role in promoting and overseeing this large-scale research program by facilitating collaboration between basic and clinical research and strengthening cooperation with academia and industry.



Hideyuki Okano Laboratory for Marmoset Models of Brain Diseases We aim to develop therapeutics for neurological disorders by utilizing transgenic marmosets.

#### Collaborations with Universities and Research Institutes

CBS has established two collaborative divisions promoting inter-organizational communication with universities and research institutes.

#### Integrative Computational Brain Science Collaboration Division

The Integrative Computational Brain Science Collaboration Division develops technologies to analyze big data and works together with the Graduate School of Information Science and Technology at the University of Tokyo. A unit specializing in data science promotes data-driven explorations of the field.





Taro Toyoizumi Integrative Computational Brain Science Collaboration Division



Tomomi Shimogori Neuroinformatics Unit



Fumiyasu Komaki Mathematical Informatics Collaboration Unit



Henrik Skibbe Brain Image Analysis Unit



Takeru Matsuda Statistical Mathematics Collaboration Unit



#### Brain Medical Science Collaboration Division

The Brain Medical Science Collaboration Division promotes academic exchange with university medical schools and research institutes. Professors from the University of Tokyo, Juntendo University and Kyorin University head collaboration laboratories at CBS and conduct medical research.





Shigeo Okabe Brain Medical Science Collaboration Division



Masanori Matsuzaki Brain Functional Dynamics Collaboration Laboratory

The goal of our laboratory is to elucidate the prefrontal neural dynamics relevant to cognition and behavior by studying the common marmoset.



Hirofumi Nakatomi

Biomedical Neural Dynamics Collaboration Laboratory Analyzing the genomics from brain tissue, and investigating the pathophysiology of cerebrovascular diseases and epilepsy.



Nobutaka Hattori Neurodegenerative Disorders Collaboration Laboratory

Deciphering the underlying mechanism of neurodegenerative diseases for the development of theranostics.

#### Industrial Collaborations

CBS has established two industrial collaboration centers with the aim of ensuring our research outcomes have social benefit.

#### **RIKEN CBS – EVIDENT Open Collaboration Center (BOCC)**

#### E<sup>♥</sup>IDENT

Established in June 2007

Linking more than 20 years of brain science expertise of CBS with the optical know-how of Evident, this center develops and harnesses fundamental bio-imaging technologies and instruments. The center also disseminates bio-imaging technology and knowledge through the technical support of researchers. Operational logs of microscopes at BOCC are used to improve bio-imaging products.

Image taken with FV3000 microscope Confocal Laser Microscope FV3000





#### RIKEN CBS – TOYOTA Collaboration Center (BTCC)

Established in November 2007

This research organization was set up under a comprehensive agreement with Toyota Motor Corporation to pursue socially-relevant innovation and explore the potential of merging brain science and technology. The center puts up a theme called "Well-being Dynamics of Individuals and Groups", addressed by an integrated endeavor by the three



ΤΟΥΟΤΑ



Yasuo Kuniyoshi RIKEN CBS-TOYOTA Collaboration Center Strategic Collaboration Unit



Rei Akaishi Social Value Decision Making Collaboration Unit



Wataru Toyokawa Computational Group Dynamics Collaboration Unit



Takahiko Koike Inter-Individual Brain Dynamics Collaboration Unit

## Research Resources Division (RRD)

Research resources and research technologies are crucial for brain science. RRD provides technological support such as bio-material analysis and electron microscopy, and maintains shared research equipment facilities for animal experimentation and human MRI,

#### Support Unit for Animal Resources Development



Brain science has accelerated through the use of laboratory animals. This unit maintains large-scale animal experimentation facilities, supplying highquality laboratory animals. The unit provides relevant technological support, such as the production of mutant mice by genome editing and mouse embryo manipulation. The unit also offers administrative support, for example animal health certificates.



Kimie Niimi Unit Leader

#### Support Unit for Bio-Material Analysis



Researchers in bioscience including brain science require a variety of scientific technologies. This unit provides essential technical support and experimental environments to RIKEN members. The skillful staff carry out commissioned analyses on nucleic acids, proteins, amino acids, synthesis of peptides, and more. The unit maintains research equipment in shared experimental areas and also gives technological advice. Educational seminars and exhibitions of research instruments are held as required.



Nobuhiko Miyasaka <sup>Unit Leader</sup>

for example. RRD also provides support for researchers to use these resources. The division has specialized technical staff who offer guidance on experimental technologies to research teams.



Hiroyuki Kamiguchi Director

#### Support Unit for Functional Magnetic Resonance Imaging



One of the ultimate goals of brain science is to understand human brain functions. This unit provides technical support for experiments that use non-invasive measurements, though magnetic resonance imaging (MRI), of the structure and activities of brains in humans and other species. The unit has been equipped with a 3 Tesla human MRI scanner for a while, and a 7 Tesla human MRI scanner has been in operation since FY2022. Experiments with DTI, MRA, MRS and fMRI can be supported. The unit also develops its own technologies for imaging and data analysis.



Tomohisa Okada <sup>Unit Leader</sup>

#### Support Unit for Electron Microscopy Techniques



Our brain is composed of neural circuits. Analysis of synaptic connections is important to understand the neural circuit architecture. Electron microscopy is an excellent tool to study synaptic connection. The Unit for Electron Microscopy Techniques provides a research environment to support research on synaptic connections, fine structures of intracellular organelles and so on. Our staff supports processing of brain tissue for EM, imaging with FIB-SEM (Focus Ion Beam - Scanning Electron Microscope) or FE-SEM (Field Emission Scanning Electron Microscope), and developing technologies of related tools.



Yoshiyuki Kubota <sup>Unit Leader</sup>

#### Human Resource Development



#### **CBS Summer Program**

This program began in 1999 with the aim of training junior brain scientists, mainly those currently in graduate school. About 50 students from around the world are selected each year through a rigorous application. The program offers a two-month laboratory internship and a one-week intensive lecture course with domestic and overseas experts in cutting-edge research areas. The entire program, including exchange meetings, is delivered in English.



#### **Brain Science Training Program**

BSTP is a one-year program for fostering young researchers, directed mainly at first-year Master's students. Systematic exposure is given to acquire comprehensive as well as specialized knowledge of brain science. Instruction is in English. Many alumni have gone on to become successful researchers at overseas institutions.

# **CBS Young Talent Training Program**



#### Young Investigators' Seminar

This seminar is mainly for young researchers to introduce their research to CBS members. They receive questions and feedback from team leaders, other teams, and colleagues. It is an excellent opportunity for presenters and participants to interact with each other. The seminar also sometimes provides an opportunity to do collaborative research. The seminar is held over lunch so that more researchers can participate.



#### UCSF-CBS Young Investigator Exchange Travel Award Program

This collaborative program between the University of California, San Francisco (UCSF) and CBS provides an opportunity for CBS trainees to meet new colleagues, set up international collaborations, and bolster international scientific exchange. CBS trainees attend the UCSF retreat and present a poster or talk followed by a visit to the UCSF campus. Reciprocally, participants host UCSF trainees at the CBS retreat.



#### Retreat

The annual off-site retreat is an opportunity for exchange of ideas among researchers in different branches of brain science. Free discussion is encouraged across specialized fields. The retreat program has lectures, workshops, poster presentations and roundtables for researchers who might not normally interact to meet and exchange ideas. A lecturer from UCSF is invited every year.

#### PDFA (Postdoctoral Fellow Association)

PDFA is a self-governing organization within CBS. It was formed by young researchers who organize workshops and forums for career development, scientific discussion and advancement of diversity. Members volunteer at the CBS Summer Program to interact with and assist invited junior researchers from across the globe.



#### Collaboration with Domestic and Overseas Universities

Collaborations have been established to promote developments in the field of brain science. CBS team leaders may be appointed as visiting professors, while Ph.D. students from collaborating universities are able to visit and undertake research.

#### Public Relations and Outreach

CBS places great importance on outreach activities. We use social media to deliver press releases and research news to wide audiences. CBS welcomes some 1,000 visitors every year and holds an annual RIKEN Open Day with lectures and demonstrations for adults and children. As part of World Brain Awareness Week (an international awareness campaign for brain science), CBS holds a popular summer science class for high school students that is known for its clear lectures and hands-on research experience opportunities.

In addition, based on the concept of "Bringing researchers closer to the public", we distribute "CBS MAGAZINE", which is published twice a year, at bookstores and other places in an effort to make neuroscience more widely known to the general public.





#### **Researchers / Technical staff**

Full time only





#### Foreign Staff by Region

Including researchers in management

				<sup>Total</sup> 70
Asia <b>51%</b> (36)	Europe 20% (14)	North America 20% (14)	Oceania <b>9%</b> (6)	

As of April 1, 2024

#### **Bio-resources**

295 model mice with Alzheimer's disease, developed by Laboratory for Proteolytic Neuroscience and 104 DNA clones from the Laboratory for Cell Function Dynamics have been supplied to domestic and overseas research institutions (FY2023). Other CBS research teams accept inquiries concerning bio-resources from all over the world. Genetically modified zebrafish, for example, have been provided by CBS.



#### RIKEN Center for Brain Science

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cbs.riken.jp/en











#### Cover Images provided by:

- 1 Laboratory for Cell Function Dynamics
- 2 Brain Image Analysis Unit
  - 3 Laboratory for Systems Molecular Ethology





