Doshisha University

Graduate School of Brain Science

- Division of Molecular and Cellular Neurosciences
- Division of Systems Neuroscience
- Division of Brain Pathology

The Graduate School of Brain Science Training next

The Graduate School of Brain Science at Doshisha University offers a five-year doctoral program.

Research in brain science and neuroscience is considered one of the frontiers of the life sciences, and numerous studies are being conducted around the world. As research into higher brain functions, such as learning, memory, and decision-making as well as neurodegenerative and psychiatric disorders, is gaining attention, it is essential to further strengthen basic research on neurons and neural circuitry that underpin these functions.

The relationship between basic research and applied research is similar to that of a bulb and a flower; in the bulbous state, there is no telling which flowers will bloom in the future.

Even if the flower called "applied research" blooms, it will die if the bulb is removed. We, the Graduate School of Brain Science, are committed to promoting basic research that may bloom in the future.

We hope that you will acquire "genuine skills" to become an independent researcher in the future through this five-year course.

■ Faculty

Molecular and Cellular Neurosciences

Molecular mechanisms underlying neural and brain functions

Laboratory of Molecular Synaptic Function

SAKABA Takeshi, Ph.D.

- Synaptic plasticity: Underlying mechanisms and their functional implications in neural circuits

Laboratory of Neural Membrane Biology

TAKAMORI Shigeo, Ph.D., D.V.M

- Bioenergetics of neurotransmitter uptake into synaptic vesicles
- Molecular mechanism for synaptic vesicle acidification
- Molecular anatomy of neuronal large dense core vesicles
- Molecular basis for neurite, synapse, and SV formation

Laboratory of Developmental Neurobiology

MOTOYAMA Jun, Ph.D.

- Understanding the molecular mechanisms that control neural stem cell development
- Effect of maternal separation stress on hippocampal development in neonates
- Spontaneous fluctuation of intracellular Ca^{2+} concentration during mammalian neural stem cell development

Systems Neuroscience

Mechanisms operating to establish and maintain neural networks

Laboratory of Neural Information

SAKURAI Yoshio, Ph.D.

- Dynamics of cell assemblies underlying coding and modification of various information
- Neuronal mechanisms in olfactory memory formation and odor-evoked motivational behaviors
- Roles and mechanisms of the frontal-subcortical circuits in adaptive behaviors

Laboratory of Cognitive and Behavioral Neuroscience

TAKAHASHI Susumu, Ph.D.

- Neural substrates of episodic memory encoding and retrieval
- Neuronal mechanisms underlying spatial navigation

Brain Pathology

Mechanisms underlying disorders of the nervous system

Laboratory of Structural Neuropathology

NUKINA Nobuyuki, Ph.D., M.D.

- The mechanism of aggregation formation of misfolded proteins
- Protein quality control in cells
- Physiological and pathological roles of unmyelinated fibers in the central nervous systems

Laboratory of Ion Channel Pathophysiology

MISONO Hiroaki, Ph.D.

- Molecular mechanisms of vesicular trafficking of ion channels in neurons (live-cell imaging of protein trafficking)
- Kv channels in the regulation of sleep (EEG recording in gene knockout mice)
- Homeostatic regulation of neuronal excitability by Kv channel conductance in health and disease (patch-clamp recording and slice electrophysiology)
- Cellular and molecular understanding of the pathological accumulation of tau protein in Alzheimer's disease

-generation scientists in the field of neuroscience.

[Highlights]

1 Five-year integrated doctoral program

Concentrated and comprehensive training facilitates students obtaining essential skills and knowledge to carry out cutting-edge brain research.

2 Customized training program by internationally renowned program faculty

The ratio of students to faculty is 50 : 7

Hands-on research training provided by two research staff members per laboratory

Advisor system

Each student will have an academic advisor to consult on curriculum selection, thesis research, and career decisions.

3 Total tuition remission

Students under 32 years of age (34 for transfer students) at the time of admission are provided with a five-year (three years for transfer students) scholarship covering tuition.

4 Education centered on self-study with tutorials and class discussions

5 Global-standard education

English is the primary language of teaching materials, presentations, and class discussions.

6 Training in a wide range of research methodologies in brain science

Laboratory rotations and active collaborations in the department offer opportunities for students to learn a variety of techniques used in the field.

7 Training for real world skills

We offer practical training that will hone students' abilities and skills, such as goal setting, self-study, professional communication, diversity appreciation, and presentation.

8 Career support

We encourage students to appreciate diverse opportunities for their career development by inviting speakers from abroad, sending students to summer training courses and scientific meetings, and offering internships in affiliated biomedical companies.

Interviews with faculty members

The Graduate School of Brain Science has seven laboratories across three divisions of molecular and cellular neurosciences, systems neuroscience, and brain pathology, and faculty members provide high-quality education and research mentoring.

Here, two faculty members of the Graduate School of Brain Science introduce their research and their views on graduate education.

Systems Neuroscience

Laboratory of Cognitive and Behavioral Neuroscience, Division of Systems Neuroscience

Professor TAKAHASHI Susumu

Research interests shift from artificial intelligence to learning and memory in the hippocampus

I majored in computer science from the Department of Electrical Engineering, Faculty of Science and Technology, Keio University because I was interested in artificial intelligence (AI). However, while studying AI research, I realized that not much is known about the brain itself before venturing into artificial intelligence. Therefore, I decided to study brain science under Professor ANZAI Yuichiro, a leading expert in cognitive science. While I was a graduate student at Keio University, I attended the Tamagawa University Brain Science Research Institute, where I monitored neuronal activity by inserting electrodes into the brains of rats. I was interested in how the brain responds to sound, so I studied the auditory system in the brain, but gradually became interested in learning and memory. During my doctoral program, I moved to Kyoto to study learning and memory in the hippocampus under Professor SAKURAI Yoshio at Kyoto University (now Professor at Doshisha University Graduate School of Brain Science).

In 2008, I became an assistant professor at Kyoto Sangyo University, where I focused my studies on episodic memory in the hippocampus.

Discovery of replays representing episodic memory

When the Doshisha University Graduate School of Brain Science was established in 2012, I was invited to serve as an Associate Professor in the Laboratory of Neural Circuitry in the Division of Systems Neuroscience. The research for the 2014 Nobel Prize in Physiology or Medicine, awarded to Dr. John O'Keefe, Dr. Edvard Moser, and Dr. MayBritt Moser, has revealed how space is perceived in our brains and the underlying neural substrates. These place-specific firing neurons have been named "place cells," but we now know that they are not just place-related cells, but also have temporal information about the past, present, and future. The discovery of place cells opens the door to understanding the secrets of the navigation system in the brain, including how our brain generates spatial maps as a global positioning system (GPS). Because place cell activities allow us to visualize how an animal grasps spatial information in the brain, the place cell study was very attractive to me. A particular focus of my research on place cells has been the study of a phenomenon called "replay." Several previous studies have reported that when rats pause in the maze and cannot decide whether to go right or left, their place cells start to fire about 10 times faster than in the running period. This suggests that the rat was replaying the spatial memory of successfully reaching the goal. We demonstrated that replay is related to episodic memory.

A breakthrough in understanding the learning and memory systems

Place cells are involved in the brain's navigation system as well as in episodic memory. Research is also underway on how impaired navigation functions mediated by place cells may be responsible for wandering, in patients with dementia. Place cell research may reveal the symptoms of Alzheimer's disease because the patients sometimes lose track of where they are or where they are about to go. Place cells are like a scope for how we perceive and remember the outside world. I believe that our research has the potential to result in a breakthrough in understanding learning and memory in the brain, which is yet to be captured in its entirety.

Molecular and Cellular Neurosciences

Laboratory of Developmental Neurobiology, Division of Molecular and Cellular Neurosciences

Professor MOTOYAMA Jun

Let's understand how the brain develops!

I am studying the mechanism of brain development, which is not only controlled by genetic programs, but also influenced by environmental factors. For example, in an experiment using mice, we found that when a baby was separated from its parents, the isolation stress affected its brain development. By presenting concrete evidence, we believe we can provide a deeper understanding of the importance of parent–child physical interactions and strategies to deal with child neglect.

Currently, we are focusing on the molecular mechanisms that control the development of neural stem cells. Neural stem cells proliferate early in the fetal period and eventually give rise to neurons, and later, glial cells. A better understanding of the process of differentiation of neural stem cells and physiological conditions in each type of cell may provide useful information for developing future regenerative medicine. The major problem in doing so has been the technical difficulties in studying neural stem cells in living embryos, but we are trying to establish a method to investigate living neural stem cells and determine their developmental fate. By doing this, our research has significantly progressed in recent years.

The advancement of stem cell biology, including induced pluripotent stem cells and embryonic stem cells, is so remarkable that some students visit the laboratory to become medical technicians. However, I would like students to spend more time observing nature and finding their own research interests, and developing their own research projects. Within the framework of brain science, there are various research themes, such as mechanisms of memory and learning, and mechanisms of brain development and maturation. In any field of natural science, it is important to approach the research subject by following one's own curiosity. This is a special process that one can only experience through research activities.

Let's acquire a broad perspective!

After working at research institutes in Japan and overseas, I worked as a unit leader at the RIKEN Brain Science Institute from 1999. In 2009, I became a professor at the Faculty of Life and Medical Sciences at Doshisha University. In 2012, at the same time as the establishment of the Graduate School of Brain Science, I was appointed as the principal investigator of the Laboratory of Neurodevelopmental Molecular Functions in the division of Molecular and Cellular Brain Science. Although the research environments of research institutes and universities are different, and both have their own advantages and disadvantages, I think universities offer excellent environments for researchers in that they provide opportunities to interact with experts in other fields and broaden their horizons. When you become too specialized in a particular research field, you may be able to see only a very limited aspect of the nature. However, nature is not so simple, and if you change your perspective, you will be able to see the multifaceted picture. There is a lot of unknown information from other research fields that can help you realize that something you thought was irrelevant to your research is actually relevant. Therefore, it is important to not only develop your current expertise, but to also learn diverse perspectives and approaches from others.

Also, I can highly recommend studying abroad to broaden your horizons. While Japanese researchers tend to deepen their knowledge by interacting with other experts within a particular field of research, foreign researchers prefer to cross academic borders and try to approach a problem from a new angle by working with people in different fields. This would be a very stimulating experience.

Let's image of research life in graduate school through a research internship!

The Graduate School of Brain Science has a unique program called the Research Internship Program, which allows undergraduate students to experience activities in the laboratories. Last year, a student from the Department of Psychology came to my laboratory to participate in a mother and child separation experiment. I hope that we can add her name to our research paper as one of the authors. Many students used this program and decided to join graduate school. What you learn at graduate school is completely different from that from lectures and practical training at the undergraduate level. Therefore, this program will provide a clear image of what you would actually experience in molecular and cellular level research in graduate school. The opportunity to pursue scientific questions and curiosity is limited. Graduate school provides such rare opportunities, and is therefore, truly a valuable place in that sense. If you decide to pursue this avenue, you should first visit the laboratory you are interested in and see for yourself what kind of experiments you can do. This would help you to have a satisfactory graduate school life.

Interviews with graduate students

PUTU ADI ANDHIKA
Laboratory of Developmental Neurobiology
「Understanding the mechanism of selfrenewal in neural stem cells」

MIYANO Rinako
Laboratory of Molecular Synaptic Function
「Understanding the mechanism of synaptic plasticity」

TANISUMI Yuta
Laboratory of Neural Information
「Understanding the neural mechanism underlying the perception of smell」

At the Graduate School of Brain Science in Doshisha University, graduate students are engaged in research from various angles on the theme of brain science.
We asked three graduate students to talk about their motivation to enter the Graduate School of Brain Science and the appeal of brain science research.

Why did you choose the Graduate School of Brain Science? What motivated you to do this?

MIYANO: I went on to the Graduate School of Brain Science from the Faculty of Life and Medical Sciences, Doshisha University. I attended a lecture called "Introduction to Neuroscience" by Prof. Sakaba when I was an undergraduate. The first thing I experienced was the fascination for the study of the mechanism of information transfer between neurons, memory, and behavior. However, I was even more strongly attracted to Prof. Sakaba's human appeal. In the Graduate School of Brain Science, I would like to follow Prof. Sakaba.

TANISUMI: I was also a graduate student from the Faculty of Life and Medical Sciences. While I studied at the Department of Biomedical Information as an undergraduate student, I wanted to elucidate the neural circuit mechanisms of mental states and emotions. The Graduate School of Brain Science provides a research internship program in which undergraduate students can try to conduct the research program. I started attending the Laboratory of Neural Information in my third year of undergraduate study, and I felt something fateful.

PUTU: I am an international student from Indonesia and graduated from the Medical School of Udayana University in Bali. Based on my experiences in the medical field, I believe that the role of neural stem cells, with both self-renewal and differentiation potential, is expected to increase in the future. I believe the demand will be as high as pharmaceutical medication and surgical treatments. Through the research internship program at the Graduate School of Brain Science, I was interested in the detection method of neural stem cells developed by Prof. Motoyama and experienced excellent research infrastructure that is not available at Udayana University. I decided to study abroad because I wanted to study neural stem cells in such outstanding research environments.

What kind of research are you currently involved in?

MIYANO: My research focuses on synapses, which are the sites of information transfer between neurons. The change in the efficiency of information transfer is called synaptic

plasticity. It is an important function that allows the brain to process information flexibly, but the mechanism of synaptic plasticity remains elusive. I routinely perform experiments to elucidate the mechanism of plasticity using electrophysiological methods.

TANISUMI: To understand the neural mechanisms underlying the perception of smell, one of the five senses, I record the electrical activities of neurons. Specifically, I record neuronal activities during odor behavioral task performance of rats and analyze the correlation between neuronal activity and the retrieved odor memory. The laboratory is an open environment where you can go whenever you want and return whenever you want. I go to the lab six days a week, except Saturdays, to conduct research activities, mainly experiments.

PUTU: I am studying the mechanism wherein the ability of self-renewal in neural stem cells is weakened. Neural stem cells are cells before they become neurons, and when they are immature, they have the ability to self-renew and give rise to other neural stem cells, although this ability is progressively weakened. By elucidating the control mechanism, I hope to find a way to artificially control the ability of neural stem cells to self-renew. In addition to its therapeutic benefits for spinal cord injuries, I believe that this method can contribute to aging research. I take holidays on Saturdays and Sundays, but on weekdays, I work all day long, mainly carrying out experiments.

How do you plan to make use of the experiences of your studies in graduate school in the future?

MIYANO: I would like to remain in academics and continue my basic research after

receiving my Ph.D. I am inclined to join a public research institute or university for employment. After graduation, I would like to expand the scope of my research further; for this, I would like to acquire a firm grasp of electrophysiology methods as the foundation of my research activities as a graduate student.

TANISUMI: I would like to be a professor or researcher at a university. I am hoping to get a solid foundation during graduate school and find a research position in a laboratory in Japan or abroad. I believe that there are many ways to do so, such as recommendations from my mentor, Prof. Sakurai, or faculty members in our lab, or introductions from researchers whom I met at international conferences. I hope to contribute to society by clarifying the relationship between Alzheimer's disease and olfactory impairment.

PUTU: After completing my Ph.D., I plan to acquire more advanced skills and experience at a Japanese research institute before returning to Indonesia. First, I would like to share my research results in brain science with my juniors in my country, and would like to contribute to the enrichment and development of the brain science research foundation in Indonesia. In the future, I would like to engage in educational activities as a university faculty member while devoting myself to anti-aging research and improving treatment techniques using stem cells.

What is the appeal of the Graduate School of Brain Science, and what is your message to prospective students?

TANISUMI: I recommend the Graduate School of Brain Science to anyone who wants to become a researcher because it provides an environment where you can pursue your research consistently for five years, and with a full scholarship system, you can focus on your studies without any financial constraints. As long as you are clear about what you want to do and have a clear goal, I think you can learn any method you want.

PUTU: If you are interested in brain science and the functioning of neurons and neural stem cells, you can feel free to discuss with researchers in a variety of research fields, not just specialized ones. Additionally, you can share information and research results with students in various research fields and spend valuable time there. I can recommend this program to junior students because of the scholarship that provides five years of tuition, resulting in a low financial burden on students.

MIYANO: I would like to tell my prospective students to do what they enjoy first. I attended Sakaba Laboratory as a research intern when I was an undergraduate student and thought it would be interesting, so I went on to the Graduate School of Brain Science and spent a very fulfilling research life there. If you feel like doing something, do it without hesitation. All you need is the perseverance to complete your research over the course of five years.

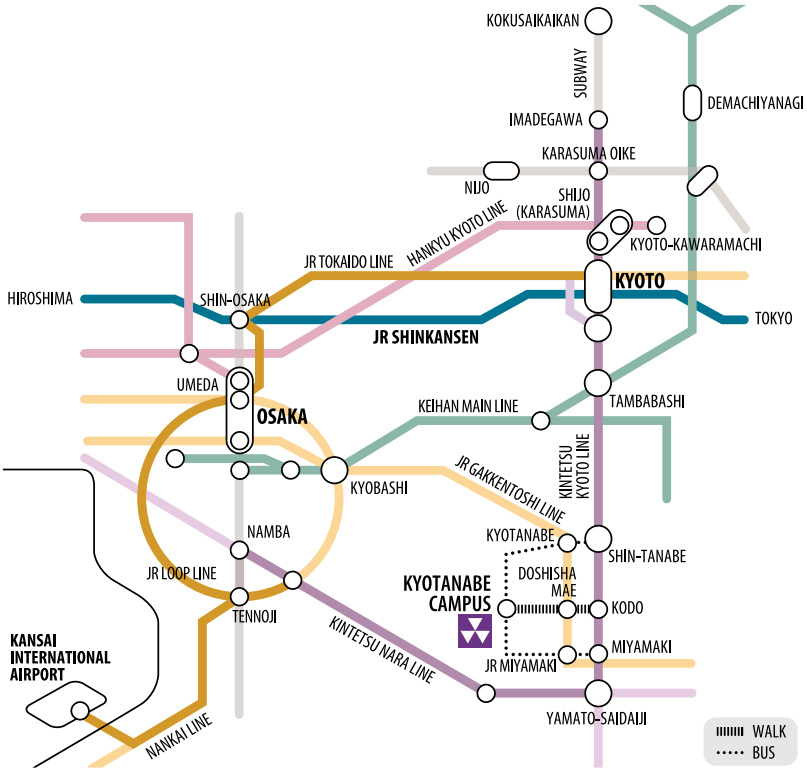
■ What is a five year (three years for transfer students) scholarship covering tuition?

It is a scholarship in which students under 32 years of age (34 for transfer students) at the time of admission are provided with a five-year (three years for transfer students) scholarship covering tuition.

Access map

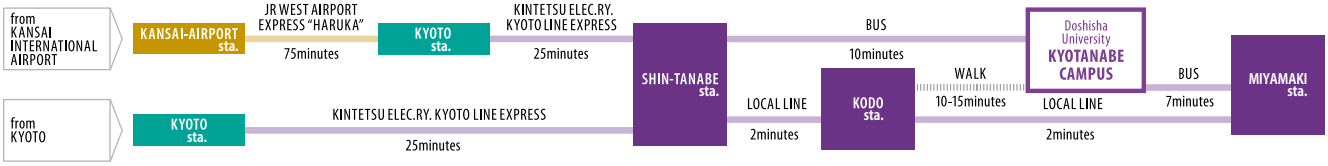
https://www.doshisha.ac.jp/en/information/campus/access/kyotanabe.html

KYOTANABE CAMPUS



Hochikan Building (Graduate School of Brain Science) on the Kyotanabe Campus of Doshisha University

To Kyotanabe Campus



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