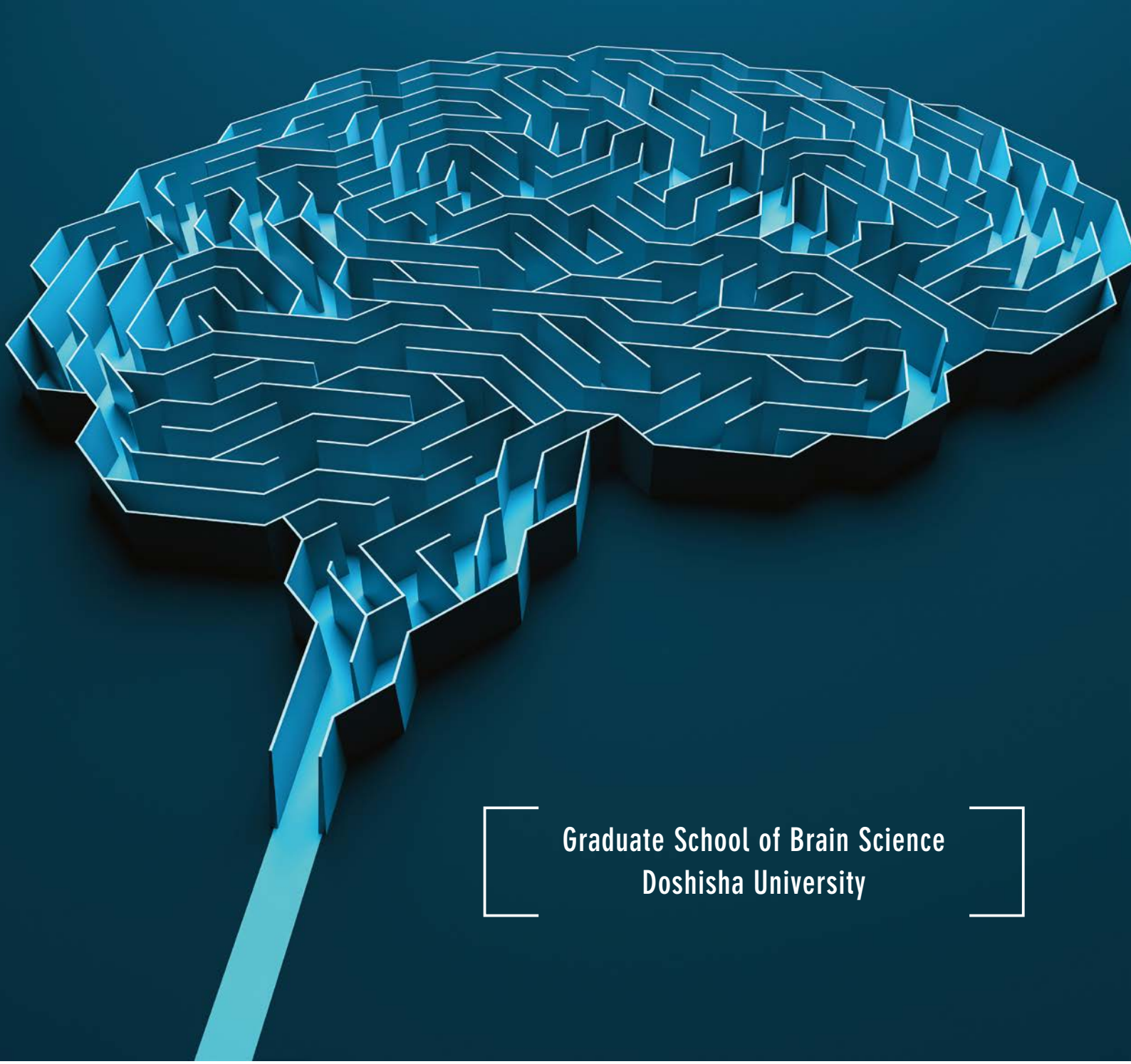


Doshisha University

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

Laboratory of Functional Brain Circuit Construction

MASAMIZU Yoshito, Ph.D.

- Development of techniques to produce a neuronal fiber
- Development of techniques to construct novel brain's neural circuits
- Recovery of brain functions with novel neural circuits
- Extension of brain functions with novel neural circuits

Brain Pathology

Mechanisms underlying disorders of the nervous system

Laboratory of Neuronal Regeneration

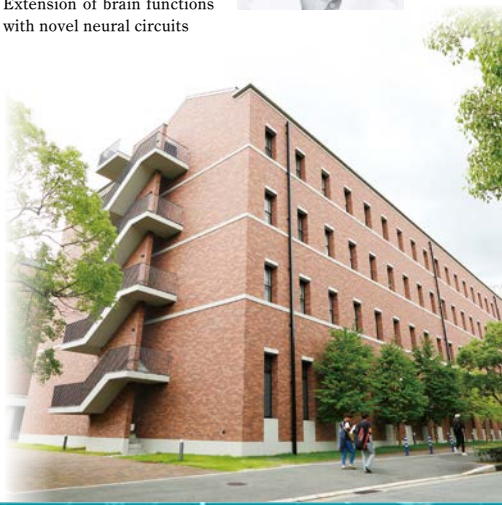
KANEKO Naoko, Ph.D., M.D.

- Elucidating the nature and role of newborn neurons in adult
- Adult-born neurons in neuronal regeneration after brain injury
- Development of interventions to promote adult neurogenesis

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 : 8

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.

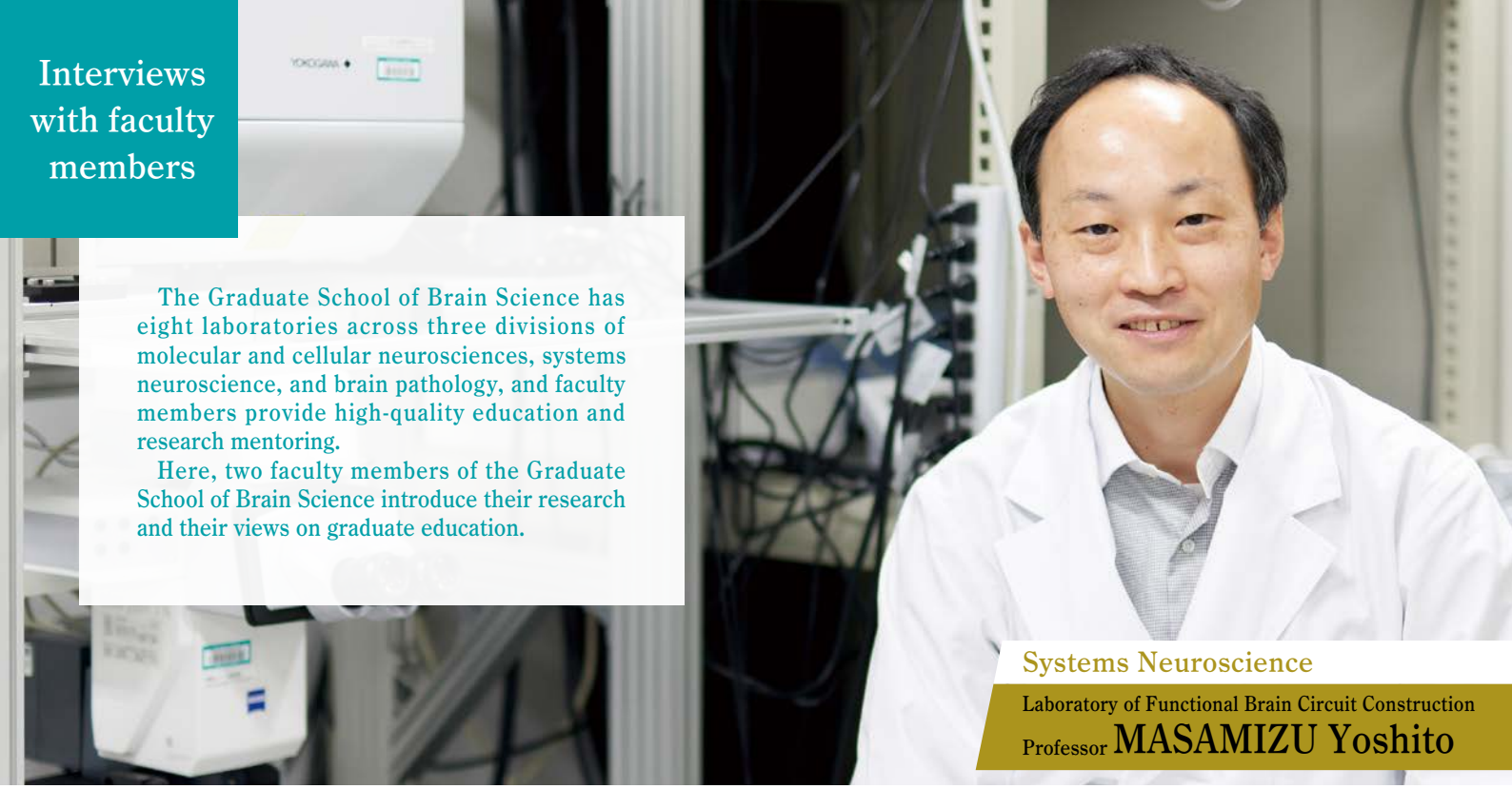
7 Training for real world skills

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 eight 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 Functional Brain Circuit Construction

Professor **MASAMIZU Yoshito**

Success! Development of techniques to produce a neuronal fiber that needs to create novel neural circuits into the brain

In our brain, neurons in different brain regions make local and inter-regional connections and form the functional brain network. In neurological disorders, for example, in Parkinson's disease, dopamine neurons in the substantia nigra par compacta innervating to the striatum die, and therefore dopamine released into the striatum is reduced. This in turn impairs the function of the striatum and impairs motor functions to control bodily movements. Neuronal loss due to brain injuries such as strokes and trauma also results in the loss of brain functions. Other than the loss of neurons in specific brain areas, the loss of the connections among brain regions also impacts the brain functions important for physiological regulations and cognition.

To ameliorate such damage on inter-neuronal connections, the development of neuronal fibers in culture has been considered as a candidate intervention. My research goal has been to establish methods to create neuronal fibers, which are competent for transplant into the brain, using my bioengineering expertise. After a long effort, I have been able to establish a method to create a fiber which consists of neuronal spheroid and axons.

My research career at various research institutes fostering my current research in brain neurons

My research started in the graduate school of Kyoto University. My initial interest was how neurons are generated in embryonic and newborn brains. From 2008, I became a researcher in the National Center for Neurology and Psychiatry and studied cognitive neuroscience in human and primates. From 2010, I conducted neurophysiological research using mice at the National Institute for Basic Biology, and then from 2016 at the University of Tokyo in the laboratory of Cellular and Molecular Physiology. From 2019 to 2021, I served as a deputy team leader of the Brain Functional Dynamics Collaboration Laboratory at RIKEN Center for Brain Science. I was also a JST Sakigake investigator in the"Optical control of biological functions for the elucidation of biological systems" area.

While I went through my career at different places, I initiated my original research to generate neuronal fibers since 2018. Then, in 2021, I have been appointed as professor at the Graduate School of Brain Science in Doshisha University. My lab aims to establish methods to transplant neuronal fibers into mouse brain to construct novel brain's neural circuits. Currently, we are verifying whether the transplanted fibers can properly transmit information between the brain regions connected by the fibers, using genetic labeling, fluorescent calcium sensors, and a wide-field-of-view multi-scanning confocal microscope to examine this functional innervation.

We hope that these methods can be used to regenerate damaged neuronal circuits. Also, we may be able to create a bypass: For example, given a network from region A to region C via region B, when the region B is damaged, a bypass from the region A to C could route the damaged region and restore the function. Furthermore, we hope to deepen our understanding of the primate brain by copy-pasting a primate-specific circuit into a rodent brain using our neuronal fiber implant.

Research with information technology students: Prospective students favoring original ideas

At the moment, we have two graduate students. They are from the Department of Biomedical Engineering of Doshisha University. We also have an undergraduate student as an intern from the Department of Biomedical Sciences and Informatics. Since my research is related to bioengineering and regenerative medicine and also to information processing in the brain, it seems to attract students from information technology. I myself am from the pharmacy background and would like to have students in diverse backgrounds.

My research is really pioneering new areas of brain research. The useful outcome for human therapeutics or enhancement probably will come 20 or more years later. It would take a while to be paid, but the return would be promising. I would like to continue my research with staff and students, who can enjoy pioneering new research areas with trial-and-errors or failures.

Brain Pathology

Laboratory of Neuronal Regeneration

Professor **KANEKO Naoko**

Realization of the importance in understanding the root cause of brain disorders as a clinical psychiatrist

In 2007, I obtained my degree at the Integrated Graduate School of Medicine and Engineering of University of Yamanashi. I then continued my research in regenerative medicine at Nagoya City University and came to the Graduate School of Brain Science in Doshisha University as a professor in 2022. I have also practiced clinical psychiatry while doing basic research on brain cells. What I realized through my career as a clinical psychiatrist is that there have not been virtually no groundbreaking discoveries, innovations, or major breakthroughs in medical research in mental/neurological disorders in the past 20 years. The jobs of a clinician are to provide pharmacological treatments and psychotherapy. However, these practices rarely help us understand the actual cause of mental disorders. For this reason, I became more focused on basic research of the brain under physiological and pathological conditions tackling the nature of these disorders.

The nature and role of adult neurogenesis

My research interest focuses on neurons, which form neural circuits and underlie brain computation. Until recently, it had been believed that neurons are generated during embryogenesis but not in the adulthood. Therefore, when neurons are lost due to disorders or injuries, they would not be replaced by new neurons. This should make the regenerative ability of the brain quite low. In other words, a person must live the 80 years-long life with the neurons made before his/her birth.

There is a region called subventricular zone around the lateral ventricle. Recent studies using various mammalian species have revealed that neurogenesis occurs in the adult brain particularly in this region. Interestingly, neurons generated in the subventricular zone actively migrate in the adult brain and modify existing neuronal circuits. Also, newborn neurons seem to migrate to damaged brain areas and contribute to regeneration. My research has focused on the nature of these adult-born neurons.

Neurogenesis in the human subventricular zone greatly declines in the first one and half year after birth. However, studies reported that, when analyzing the brain of a patient died of a stroke, there were a significant number of newborn neurons. These reports made researchers aware that active neurogenesis may occur in some special conditions such as brain disorders and injuries in adult human brain. Unfortunately, these newborn neurons do not have enough power to recover the lost function completely. The goal of my research is to understand the role and mechanism of adult neurogenesis and to use this knowledge to control the number, differentiation, and migration of newborn neurons. By establishing these methods, we can develop new therapeutic treatments for brain disorders and injuries, for which clinical intervention is limited.

Fostering young scientists who can dive into the joy of research

In my lab, we use mice to analyze the behavior of newborn neurons in adult brains in the presence of strokes or injuries employing live-cell imaging, histology, and behavioral tests. We hope to understand how these neurons migrate and take posts, and how they interact with existing neuronal circuits. We will then develop means to accelerate neurogenesis and to control their behavior with the potential and limitation of the regenerative ability of adult neurogenesis in mind. If we can control newborn neurons to situate them in damaged brain areas effectively, we can also adopt the methods to improve the regenerative capacity of transplanted neurons and functional recovery of the brain by them.

This is my first time to carry out research in a university without a medical school. In the previous institutes, students I trained for research mostly chose clinical jobs afterward. At Doshisha University, one of my goals is to train outstanding and enthusiastic young scientists. As I myself migrated from clinical to basic science and became immersed into the excitement of research, I hope to continue my research with people who also wholeheartedly enjoy and devote themselves to basic research.

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.

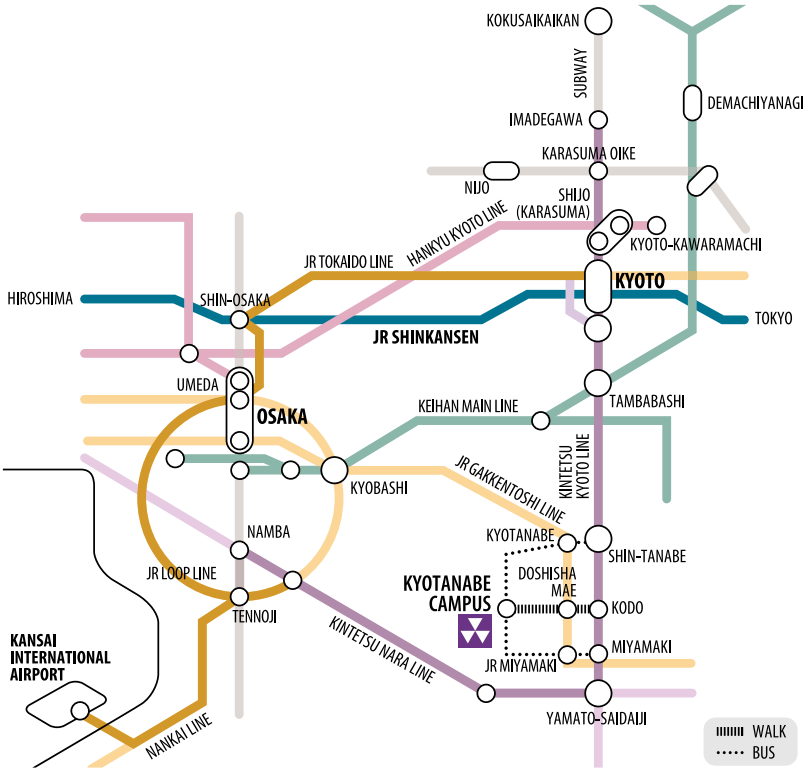
■ What is a five year (three years for transfer students) scholarship covering tuition?

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

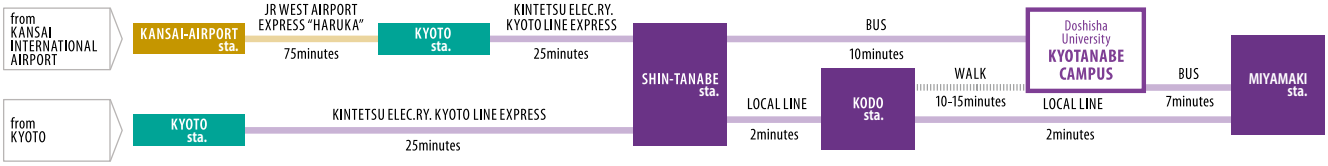
https://www.doshisha.ac.jp/en/information/campus/access/kyotanabe.html

KYOTANABE CAMPUS



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

To Kyotanabe Campus



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