1．Outline of Research and Education Center for Brain Science

（1）Introductory Outline of Research and Education Center for Brain Science

The Research and Education Center for Brain Science (RECBS) was established in 2003 as a cross-departmental center, a kind of organization that is not very common in universities nationwide. At the RECBS, interdisciplinary studies are conducted in the three research areas of critical periods, communication and advanced measurement. The RECBS also provides a systematic program of eduction to master's and doctoral students majoring in developmental brain science at the RECBS virtual graduate school.

All activities related to research and teaching at the RECBS are carried out by a staff of about 30 key teachers from 14 departments on campus, including from the Graduate School of Medicine, the Graduate School of Letters and the Faculty of Health Sciences.Researchers specializing in brain science at various faculties, graduate schools and institutes of Hokkaido University have been exchanging information with each other since before the RECBS was established.

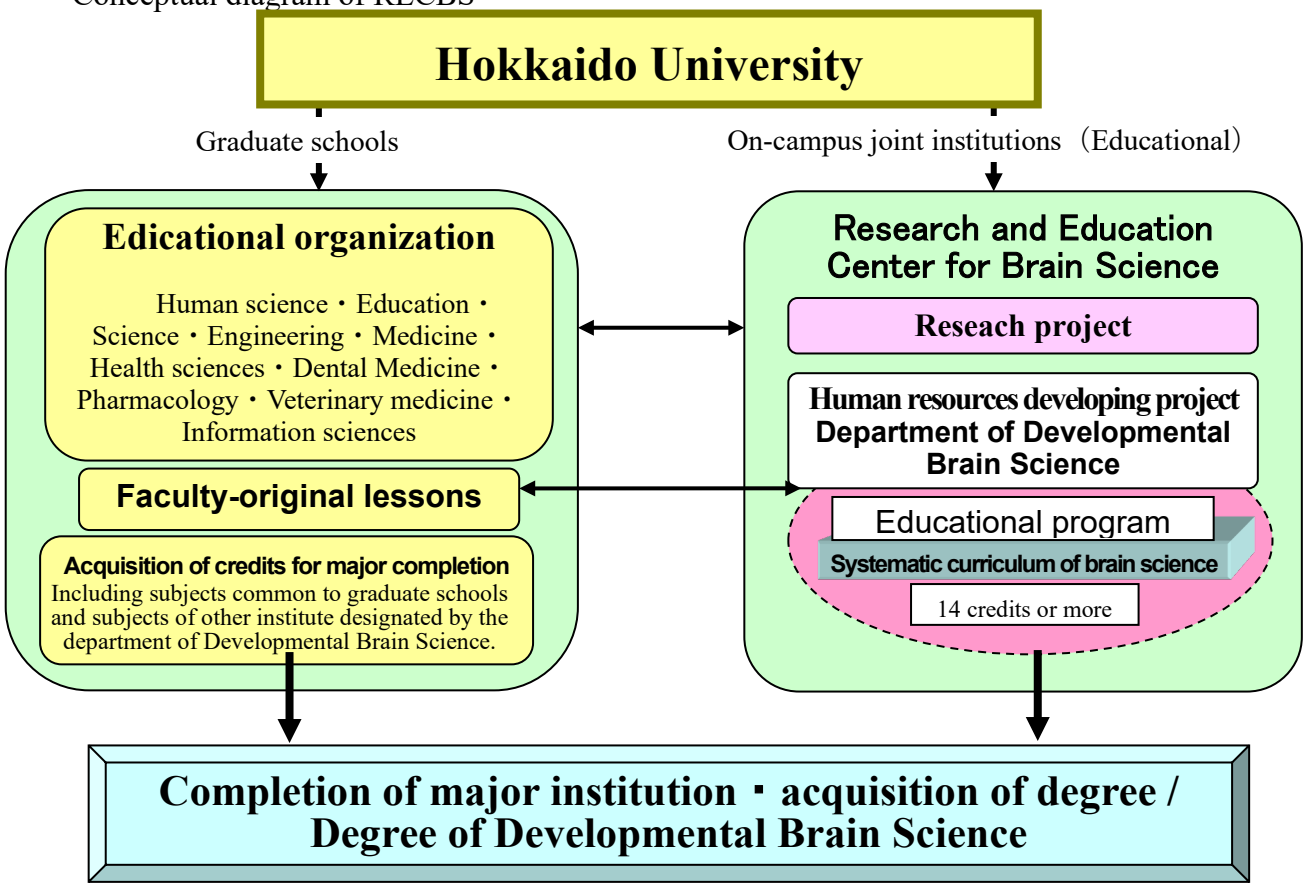
The exchanges among the researchers became more active when regular meetings on neuroscience were started by researchers from various departments in the School of Medicine in 1992. Gradually, researchers from other schools, faculties and institutes on campus began to attend the meetings. In 1997, an interdisciplinary research project titled Toward Comprehensive Enhancement of Brain Science Education at Hokkaido University was established with Discretionary Funds of the President. Under the project, a periodic symposium on brain science and a course for all graduate schools on campus, The Development of Brain Sciences, were launched.

The core course focuses on brain science methodology. It is taught to graduate students in lectures and laboratory work. For this course, the textbook Laboratory Manual on Brain Sciences was compiled by Ken-ichi Honma and Kikuro Fukushima and published by Hokkaido University Press. The interdisciplinary research project was continued with Discretionary Funds of the President and was supported by Research Revolution 2002 (RR2002) of the Ministry of Education, Culture, Sports and Technology (MEXT). The project bore fruit in the form of the Research and Education Center for Brain Science.

At the RECBS, integrated learning opportunities are provided to graduate students majoring in developmental brain science. Specifically, graduate students learn through lectures, lab work, workshops and study camps in which they confer with teaching staff. Additionally, each graduate student has a deputy adviser from a different academic field who assesses the completion of the student's doctoral or master's program together with a thesis adviser. Those who have completed their doctoral or master's program are well-trained in brain science, being active now as researchers of brain science or as professionals in other fields.

Research on Depression conducted by researchers at the RECBS has been supported by MEXT under the framework of its Strategic Research Program for Brain Sciences since 2011.

・Conceptual diagram of RECBS



（２）The Research and Education Center for Brain Science

The Research and Education Center for Brain Science at Hokkaido University was established in September, 2003, for the purpose of

1. promoting studies in a broad range of academic fields related to brain science,
2. developing human resources with an extensive knowledge of brain science and

with the support of Research Revolution 2002, a national policy for promoting science.

To understand how the human brain works, both microscopic and macroscopic perspectives are necessary. From the microscopic perspective, biological studies are conducted toward understanding the biological characteristics of nerve cells, the developmental mechanisms of nerve cell networks and the like. Macroscopic studies focus on the human mechanisms of learning, thinking and memory, the processes of audiovisual cognition, the language acquisition process, clinical conditions of emotional disorders and the like.We will be able to understand how the human brain works only after integrating the results of microscopic studies with those of macroscopic studies.

In view of this specific requirement of brain science, the RECBS has built a cross-departmental research system to facilitate integration of research results from the humanities, the sciences and medicine. This research system brings together brain scientists from the natural sciences (i.e., researchers at the Graduate School of Medicine, the Graduate School of Dental Medicine, the Faculty of Pharmaceutical Sciences, the Faculty of Science, the Faculty of Engineering, the Graduate School of Information Science and Technology, and the Research Institute for Electronic Science) and researchers specializing in humanities, such as in education, psychology and linguistics, at the Faculty of Education, the Graduate School of Letters and the Research Faculty of Media and Communication.

1）Research groups

① Group for Research on the Development of Brain Functions in Critical Periods

Regulation of the expression of genetic information carried by DNA governs the first synapse formation that is species-wide and species-specific. However, the first synapses include redundant or entangled ones, and they are functionally immature.

Mammals have a highly evolved cerebral cortex. The structural maturation of the mammalian brain, particularly of the human brain, requires exposure to adequate experience and environmental stimuli in the early postnatal period, which is also called the critical period, during which the brain is highly sensitive. It also requires reorganization of synaptic connections in response to experience and stimuli. In the reorganization process, activated (frequently used) synapses gain strong connections and rarely used synapses are pruned. Consequently, the brain is highly evolved, and distinct brain mechanisms undergo maturation.

This research group studies the developmental mechanisms of brain function during critical periods at the molecular, circuit, system and life levels from the viewpoint of gene regulation and environmental modifiers.

Major research topics include the following:

- The molecular basis of cerebellar synapse formation
- The development of biological clocks: Their plasticity and critical periods
- Emotional stress and behavioral changes in critical periods
- Behavioral sensitization induced by methamphetamine

② Group for Research on the Development of Communication

Verbal communication ability acquired during the growth process is specific to humans. The acquisition of this ability is closely related to the non-verbal communication that precedes language acquisition and to the development of basic cognitive processes. As the brain evolves, it learns how to interact with others, and it gradually becomes capable of communicating well with others. Communication is obviously a process of the brain; thus, knowledge about communication leads to understanding about the development of the brain's intellectual abilities.

This research group consists of researchers from academic fields such as education, psychology, linguistics and information science. They aim at deepening their understanding of the development of communication by integrating the results of diverse research methods that include psychological experiments, the measurement of brain waves and other brain activity by means of event-related potential, near-infrared spectroscopy and fMRI, mathematical data analysis, the development of computational models of brain phenomena, and simulations using neural computational models.

Major research topics include:

- The integration of functional brain modules, and interactions between them
- The development of a computational model of "other."
- Cognitive and emotional processes in the brain during infancy

③ Group for Research on Advanced Measurement

- **MEG Subgroup**

The Superconducting Quantum Interference Device (SQUID) is an unparalleled supersensitive magnetic sensor that utilizes superconducting quantum interference, a phenomenon unique to superconducting electrons. The extreme sensitivity of SQUID pushes the limits on the measurement of quantum-mechanical fluctuations. SQUID makes measurements from the surface of the head, noninvasively detecting the weak magnetic fields generated by brain neural activity. Additionally, inverse estimation of the source of the measured magnetic fields in the brain makes it possible to visualize spatio-temporal features of brain activity. The MEG Subgroup has been conducting research on noninvasive measurement and analysis of brain function with a focus on SQUID.

- **Optical Measurement Subgroup**

In studying cell function, the Optical Measurement Subgroup has been focusing on optics, using genetically modified animals and cultivated cells. Genes that encode bioluminescent enzymes or fluorescent proteins are inserted into these animals. The biological clock maintains stable circadian rhythms, cycles of about 24 hours. Of the various functions of the brain, this clock is an excellent experimental system. It can be used for consecutive analysis from the level of the molecule to the level of the individual person. In a biological clock, clock gene proteins interact with each other, forming feedback loops of transcriptional regulation. In this way, oscillations, or rhythms, are generated. The Optical Measurement Subgroup has been working on biological clocks as experimental models, toward elucidating how the brain tells time.

- **fMRI Subgroup**

The fMRI Subgroup has been conducting research that focuses on the functional development of the frontal lobes. The research uses a technique called functional magnetic resonance imaging (fMRI). It uses oxygen metabolism, which correlates with brain activity, to visualize brain function.The frontal lobe, the frontal association area in particular, is regarded as playing a central role in working memory, or temporary retention, of information necessary for goal-oriented behavior as well as playing a role in higher mental functions (i.e., higher brain functions), such as flexible modifications to rules for behavior in response to environmental changes. Much attention is being given to the frontal association area from the viewpoint of brain science, education and development.

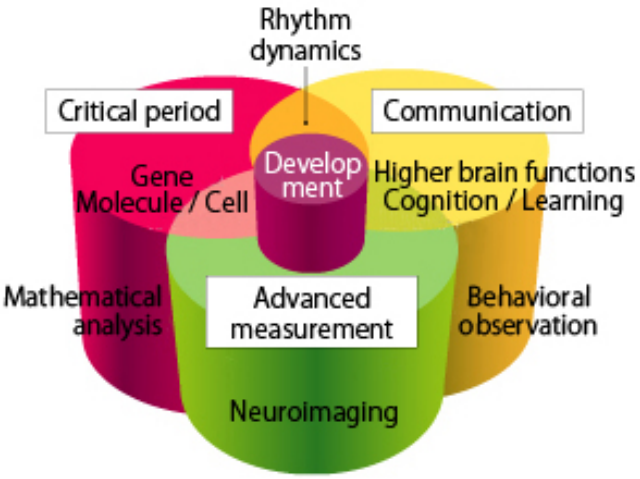
2）Researchers in each Reseach Group

Three research groups are organized by the following members and are conducting fusion researches.

(April 1, 2022)○: Group leader

1. Group for Research on the Development of Brain Functions in Critical Periods

○Haruyuki Kamiya（Faculty of Medicine）
Masahiko Watanabe（Faculty of Medicine）
Ichiro Kusumi（Faculty of Medicine）
Fumino Fujiyama（Faculty of Medicine）
Ichiro Yabe（Faculty of Medicine）
Miwako Yamasaki（Faculty of Medicine）
Yu Ohmura（Faculty of Medicine）
Kazuhiro Wada（Faculty of Science）
Masabumi Minami（Faculty of Pharmaceutical Sciences）
Taisuke Miyazaki（Faculty of Health Sciences）
（10 members）



Research Group Diagram

2. Group for Research on the Development of Communication

○Hiromi Wada（Faculty of of Humanities and Human Science）
Yasuhiro Kawabata（Faculty of of Humanities and Science）
Mayumi Adachi（Faculty of of Humanities and Human Science）
Jun-ichiro Kawahara（Faculty of of Humanities and Human Science）
Kenji Ogawa（Faculty of of Humanities and Human Science）
Taiki Takahashi（Faculty of of Humanities and Human Science）
Sae Kaneko（Faculty of of Humanities and Human Science
Tetsuko Kasai（Faculty of Education）
Ayumi Seki（Faculty of Education）
Masaki Abe（Faculty of Education）
Mika Otsuki（Faculty of Health Sciences）
Kazuki Yoshida（Faculty of Health Sciences）
Taisuke Sawamura（Faculty of Health Sciences）
Fumihito Ikeda（Institute for the Advancement of Higher Education）Kenji Ogawa
（14 members）

3. Group for Research on Advanced Measurement

Masaki Tanaka（Faculty of Medicine）
Hiroaki Norimoto（Faculty of Medicine）
Masaaki Satou（Faculty of Medicine）
Makoto Funahashi（Faculty of Dental Medicine）
○Hiroto Ogawa（Faculty of Science）
Akira Kitamura（Faculty of Advanced Life Science）
Yujiro Yamanaka（Faculty of Education）
Koichi Yokosawa（Faculty of Health Sciences）
Hiroyuki Sugimori（Faculty of Health Sciences）
Takashi Tateno（Faculty of Information Science and Technology）
Hideaki Shiraishi（Hokkaido University Hospital）
（11members）

２．Overview of Developmental Brain Science Course

The Developmental Brain Science Course has been set up to continuously develop human resources in Brain Science with reflecting the integrative research promoted by RECBS. The course is set up under RECBS rather than the original graduate schools to achieve systematic education of Integrated Brain Sciences. The purpose of the program is to organize the educational contents with large flexibility and to promote characteristic Brain Science researches for the institutions to which the students belong (referred to as "host institutes").

Students of the Developmental Brain Science Course are also required to take the postgraduate master's or doctoral course (including the doctoral course at the Schools of Medicine, Dentistry, and Veterinary Medicine) in the graduate school where the core RECBS members serve as thesis advisers. The students must take the program of the Developmental Brain Science Course in addition to the original programs provided by the host institute. The credits earned in the Developmental Brain Science Course can be included in the requirements for completion of the host institute under the rules of the relevant graduate school. In addition to the superivision at the host institute, the students also receive the research guidance from the members of the Developmental Brain Science Course, and will complete their dissertation in the field of Integrated Brain Sciences.

（１）Contents of Educational Program

The contents of the educational program of the Developmental Brain Science Course are organized with the aim to develop human resources who have a broad perspective on Brain Sciences and the ability to search and solve problems with flexible ideas (interdisciplinary) and challenging spilits (creativity).

- Beyond the exsisting academic fields, the researchers involved in natural sciences (medicine, pharmacy, science, engineering, information science, etc.) and humanities/social sciences (education, psychology, linguistics, etc.) share the concept, and build a novel postgraduate education system. Students learn the subjects (14 credits or more) specified by the Developmental Brain Science Course in parallel with the subjects offered by the host institute (major subjects).
- By taking the Developmental Brain Science Course, students can learn that there are both the innate/fixed elements and the acquired/variable elements in the brain function, and will understand that most of diversity in the psychosomatic functions are derived from the adaptation processes during developments.
- Through this course, students acquire cross-sectional knowledge related to "knowing the brain", "protecting the brain", "creating the brain", and "nurturing the brain", and apply it to their own researches to complete the dissertation at the host institutes.

（２）How to take the educational programs

１）Requirements for qualification in 2022

Students taking the Developmental Brain Science Course must meet all of the following requirements:

① Their research theme is in a field of Integrative Brain Science.

② Applicants must obtain approval from their supervisor in the host institute.

③ Applicants must be enrolled in or advanced to the graduate school of Hokkaido University in April 2022.

２）Number of recruitments

The recruitment capacity of the Developmental Brain Science Course is as follows.

・Master’s program: 10 students

・Doctoral program: 10 students

３）Permission of enrollment

The students may apply for the Developmental Brain Science Course only if they have been admitted to enter the graduate school and have obtained the approval from their supervisor.

The applicants have to submit the application form prescribed by the RECBS by the deadline. For the application, the students need to obtain a recommendation form signed by their supervisor, notify the department head of the host institute (via the department office), and submit an application form to the office of RECBS. The Center conducts a selection examination (interview test) for applicants, and those who pass it are permitted to take the course.

If the registration is permitted, RECBS will notify it to the host institute.

４）How to take subjects and recognition of credits

The educational programs organized by the Developmental Brain Science Course are shown in the appended table of the bylaws of the program (related to Article 3). Subjects are designated as either the "common subjects for all graduate courses" ot the "subjects for specific graduate course". The former can be registered as the "common subjects " and the latter as the "subjects offered by other graduate schools" at the host graduate school. Although the registration of the "common subjects" is directed by the "Guidebook of the common subjects to graduate schools" (Academic Affairs Department of Hokkaido University), the registration of the "subjects offered by other graduate schools" is not specifically mentioned in the guidebook.

Therefore, in registering the “subjects offered by other graduate schools”, students must contact the academic affairs office of the host institute and notify them that these subjects are registered as a part of the Developmental Brain Science Course (otherwise the acquired credits may not be registered to the host institute). In addition, students must submit a confirmation slip for subject registeration to the RECBS office for sure. Note that this is not the registration form for the subjects offered by other institutions.

Credits required for completion of the Developmental Brain Science Course are confirmed by the transcript issued by the host institute. Therefore, if there is a defect in the registration process at the host institute, the results may not be transfered. RECBS does not grant credits. All acquired credits and grades should be notified to the host institute. RECBS only judges whether the credits acquired by the host institute meet the requirements for completion of the course.

Since the subjects designated by the Developmental Brain Science Course cover more than one graduate schools, the RECBS offce may not be able to respond to sudden changes in class schedules.

Therefore, students are encouraged to actively gather information about the class schdule from the relevant school. In addition, students should submit the designated Class Enrollment Check Sheet to the RECBS office for each semester by the deadline. Based on this sheet, RECBS will check the status of registeration.

We have no bulletin board for students of the Developmental Brain Science Course. All notices will be announced by e-mail. Students should obtain the e-mail address issued by the university as soon as possible and send it to the following address.
brain@med.hokudai.ac.jp

5） Designated subjects

The subjects designated for the Developmental Brain Science Course in 2022 are shown in the "Guides of Education Program for Developmental Brain Science Course, RECBS, Hokkaido University", which are listed on the following page.

6） Completion requirements and certificates

To complete the course, students must acquire 14 or more credits from the designated subjects in accordance with the prescribed course category. They also need to pass the review of their completion thesis by the core RECBS members, and meet the completion requirements of the host institute.

<table>
<tr><td colspan="3">14 or more credits must be acquired, including 8 credits from the compulsory elective subjects.</td></tr>
<tr><td>Compulsory Elective Subjectse</td><td>Basic Brain Science Ⅰ～Ⅷ
Brain science Ⅰ～Ⅳ</td><td rowspan="2">14 or more credits must be acquired, including 8 credits from compulsory elective subjects.</td></tr>
<tr><td>Elective Subjects</td><td>Behavioral Theories
(Others omitted. Refer to the "Appended Table" in the course guide)</td></tr>
</table>

The completion thesis for the Developmental Brain Science Course can be same as the one for the host institute, and it is not necessary to write another thesis. The final thesis will be reviewed by multiple core members of RECBS as to whether the thesis contains research in the fusion fields of Brain Science. Therefore, if your thesis contains materials only in a single diciplinary, it is possible that you are unable to graduate the educational program even though you complete the course at the host institution. Please prepare your thesis according to the research guidance of the core RECBS members (the thesis adviser is usually a member of RECBS).

Briefly, the completion requirements are the following three points.

(1) To acquire 14 or more credits from the prescribed subjects.
(2) To pass the review of the completed thesis.
(3) To complete the graduate course at the host institute.

Students who meet the above requirements will be awarded a certificate of completion of the Education Program of the Developmental Bran Science Course.

With regard to (1), credits acquired prior to admission to the Developmental Brain Science Course can be included in the requirements for completion. For details on how to register and so on, please contact the RECBS office (brain@med.hokudai.ac.jp).

7） Career path after completion

The advantage of education in the Developmental Brain Science Course is that it will foster specialists of various academic fields with knowledge of brain development who can adapt a wide range of fields in the society. Graduates with extensive knowledge and experience in Brain Sciences are expected to play an active role not only in research but also in education and medical care as highly specialized experts. For example, teachers of special education with knowledge of brain development and disability processes can develop more effective educational methods. In the fields of psychotherapy, speech therapy, and art therapy, the educational clinicians can also develop effective treatments by applying the knowledge of Brain Sciences learned in the course. In addition, in the field of welfare, human resources not only caring for people with disabilities and diseases but also having knowledge about the underlying mechanisms are expected to have a potential to bring new perspectives and technologies to the field.

Graduates of the Developmental Brain Science Course have knowledge and experience in human developments of communication, which leads to the understanding of human mind when using new devices. Consequently, these human resourses are needed and expected to be active in various companies related to human interfaces. For example, manufacturers of home appliance seek human resources who can deeply understand other's minds, and expect that they join the designing and planning novel home appliances and softwares. In addition, the knowledge of the movement of human mind is extremely important for automobile manufacturers which are particularly in need in current information-oriented society. Thus, the graduates of the Developmental Brain Science Course are expected to play important roles in a variety of fields in the society.

９） The faculty members of Department of Developmental Brain Science in 2022

（35 members as of April 1,2022）

Schools / Centers	Departments / Courses	Position	Name	EXT
Faculty of Humanities and Human Science	Division of Human Science	Specially Appointed Professor	Hiromi Wada	3321
		Professor	Yasuhiro Kawabata	4014
		Professor	Mayumi Adachi	4168
		Professor	Junichiro Kawahara	4154
		Associate Professor	Kenji Ogawa	4093
		Associate Professor	Taiki Takahashi	3008
		Associate Professor	Sae Kaneko	4155
Faculty of Medicine	Division of Medicine	Professor	Masahiko Watanabe	5032
		Professor	Haruyuki Kamiya	5027
		Professor	Masaki Tanaka	5039
		Professor	Ichiro Kusumi	5969
		Professor	Fumino Fujiyama	5033
		Professor	Ichiro Yabe	6028
		Associate Professor	Miwako Yamasaki	5030
		Associate Professor	Hiroaki Norimoto	6919
		Lecturer	Yu Ohmura	5058
		Lecturer	Masaaki Sato	5058
Faculty of Dental Medicine	Division of Oral Functional Science	Professor	Makoto Funahashi	4230
Faculty of Science	Biosystems Science Course, Graduate School of Life Science	Professor	Hiroto Ogawa	3525
		Professor	Kazuhiro Wada	4443
Faculty of Pharmaceutical Sciences	Biomedical and Pharmaceutical Science Course , Graduate School of Life Science	Professor	Masabumi Minami	3246
Faculty of Advanced Life Science	Transdisciplinary Life Science Course , Graduate School of Life Science	Lecturer	Akira Kitamura	9006
Faculty of Education	Division of Education	Professor	Tetsuko Kasai	3108
		Professor	Ayumi Seki	2608
		Associate Professor	Masaki Abe	5442
		Associate Professor	Yujiro Yamanaka	3077
Faculty of Health Sciences	Division of Health Sciences	Professor	Koichi Yokosawa	2828
		Associate Professor	Mika Otsuki	3376
		Associate Professor	Hiroyuki Sugimori	3410
		Associate Professor	Taisuke Miyazaki	3330
		Lecturer	Kazuki Yoshida	3414
		Lecturer	Taisuke Sawamura	3387
Faculty of Information Science and Technology	Division of Information Science and Technology	Professor	Takashi Tateno	6763
Hokkaido University Hospital	Pediatrics	Clinical Associate Professor	Hideaki Shiraishi	5954
Institute for the Advancement of Higher Education	Department of Natural History Sciences Graduate School of Science	Professor	Fumihito Ikeda	7489