大学共同利用機関法人
自然科学研究機構
基礎生物学研究所

Inter-University Research Institute Corporation
National Institutes of Natural Sciences

National Institute for Basic Biology

www.nibb.ac.jp/en

“Welcome to the world of basic biology”

Director General of
the National Institute for Basic Biology

Masayuki Yamamoto

What do you think of when you hear the term ‘Basic Biology’? Maybe the phrase brings to mind words like DNA, genes, genome, and images of the complicated research they entail? Or perhaps the phrase makes you think of the wings of a glittering butterfly, of strange creatures dwelling in the deep darkness of the ocean, of orchids blooming in lush rainforests, and of the simple joy we can find just in observing nature in all its beauty. Some people may even imagine the long history of life that can be seen from the record left behind by ancient fossil remains.

Humans, as living creatures ourselves, have long pondered the questions: “What is life?” and “Why are we here?” Every living creature shares certain traits: they take in materials from their surroundings, build their bodies, prepare for the birthing of the next generation, leave behind offspring, and pass on. But why have we come to be so? For both plants and animals, closely related organisms share many traits, and yet also possess distinct characteristics that define and set them apart. Across the earth in places of extreme heat, extreme cold, having high levels of salt, where the light of the sun cannot reach, and in even more alien and inhospitable places we can find life flourishing, adapted to its environment. How could such a great variety of life forms have sprung up? It seems as though you could ponder the mysteries of life on earth for an eternity, and just have scratched the surface.

There was a time when we believed that living things were governed by different physical laws than non-living things. However, as research has advanced, we have come to see that the mechanisms of life ultimately can be understood through the same laws as those governing physics or chemistry. However living things, even micro-organisms too small for the eye to see, have extremely intricate structures, with the chemical reactions occurring within them of a complexity to match. Meanwhile, from bacteria to insects, to mammals and plants, every living thing carries genes made up of DNA, with the sum of those genes, that is to say their genome, acting to provide each creature with the qualities that define it. Through research of genomes it has become clear that life as we know it is much more closely related than our outward differences might suggest. Indeed, looking back along the paths of genes, we have come to understand that all life shares one ancestor far in the ancient past.

At NIBB, we use cutting edge technology and analysis techniques in order to answer why life takes the form it takes, with the various traits and behaviors it displays. Deepening the understanding of life and the organisms it includes is our mission. Though research that leads to specific ends, such as a new way to cure a disease, or creating a new form of crop useful in agriculture is important, we at NIBB are not performing research with the objective of some direct application. Within the history of natural science there have been many cases where, by solving and clarifying a fundamental process that as yet had remained unclear, the doors were opened and a road map was laid out for subsequent research into techniques and products that had previously not even been thought of as possible. We call this a “breakthrough.” A researcher must put his whole energy towards searching for new understanding and the solving of mysteries before he can hope to come to the revolutionary conclusions a breakthrough entails. Furthermore, though not directly applicable to new products or technology, I believe that research into deepening our basic understanding of life helps to enrich us intellectually, and add flavor and wonder into our lives; I wonder if you too, have begun to feel the same.

Taking the advancement of research as its greatest mission, and as a member of the Graduate University for Advanced Studies (SOKENDAI), NIBB is endeavoring to educate and raise up graduate students who will become the next generation of researchers. In addition, as an Inter-university Research Institute, we are working hard to advance the collaborative research of universities throughout Japan, by providing our specialist knowledge and facilities with DNA analysis and microscope technology to our partner organizations.

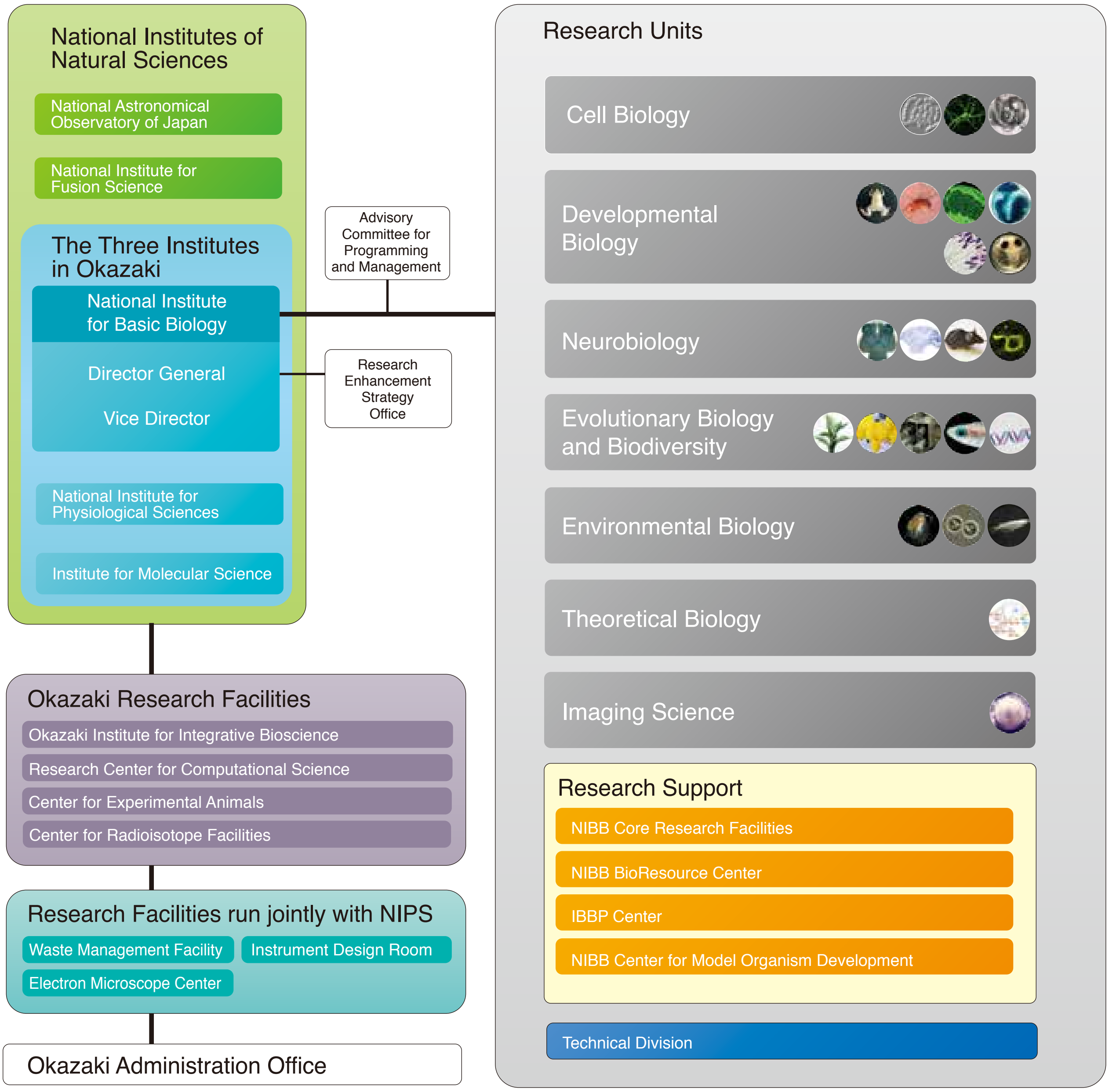
As a research institute on the front lines of human understanding, we feel that informing people about the sort of questions we are researching and why, and what we have gained from this research, in a simple and easy to understand manner, is one of our most important duties. This pamphlet was created as a part of that goal. Because the understanding and encouragement of NIBB's research by people such as yourself is one of our most important assets, we hope for your cooperation and support continuing forward.

History

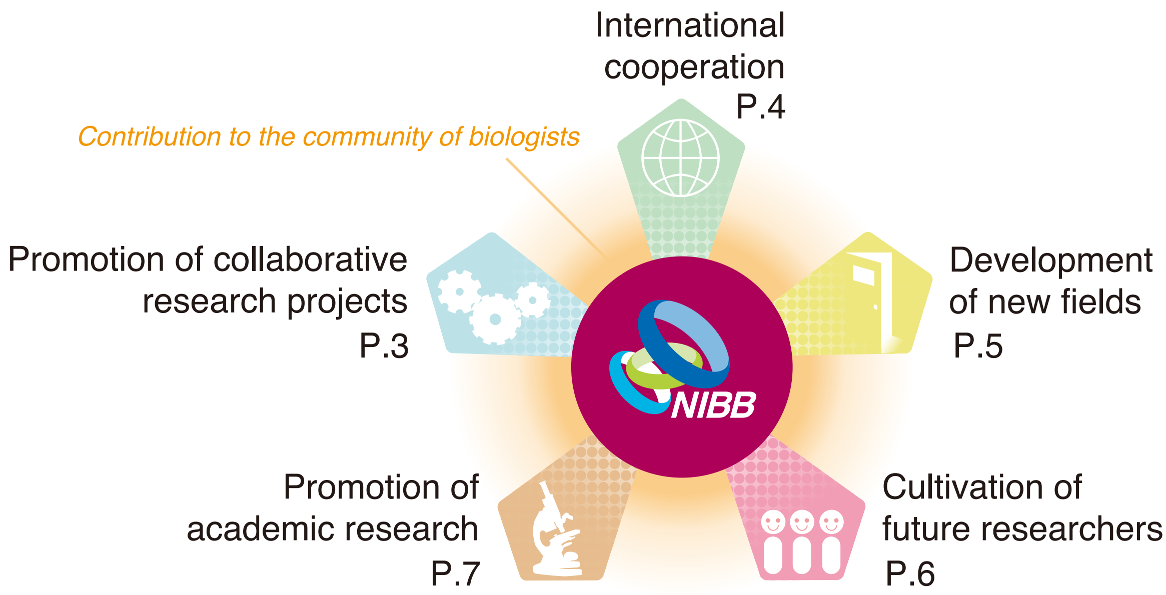
The National Institute for Basic Biology (NIBB) was established in the Myodaiji area of the city of Okazaki in 1977 along with the National Institute for Physiological Sciences (NIPS). Since 1981, NIBB and NIPS have constituted the Okazaki National Research Institutes with the previously established Institute for Molecular Science. As a leading research institute for basic biology in Japan, NIBB, since its establishment, has accepted many joint researchers from Japan and abroad, and its achievements, as products of "OKAZAKI," are highly praised in treatises and at international conferences. Research also commenced in the Yamate area in 2002. Since 2004, the National Astronomical Observatory of Japan, the National Institute for Fusion Science, and the three institutes in Okazaki have been conducting research under a new framework called the National Institutes of Natural Sciences.

Myodaiji area

Yamate area



Goals of NIBB



A center of excellence for biological research

Collaborative research projects

Inter-University Research Institutes

An inter-university research institute is a "research institute operated by the research community", a type of world-class organization unique to Japan. The inter-university institutes were organized as a core base to provide a place for joint research and extramural use by researchers across Japan. The inter-university research institutes not only promote pioneering studies on important research issues, but also provide opportunities for cutting-edge researchers throughout Japan to gather and engage in activities aimed at exploring future academic fields and creating new principles.

While maintaining its uniqueness and diversity, each institution makes a great contribution in the development of academic research in Japan as a Center of Excellence (COE) in each research field. Together, they also serve as an international core base to promote cooperation and exchange with research institutes and researchers abroad.

Collaborative research projects

Research projects envisioned as collaborations with NIBB's divisions/laboratories as well as research activities to be conducted using facilities in NIBB are solicited from external researchers at other universities and institutes. In addition to our standard "individual collaborative research projects", "collaborative experiments using the Large Spectrograph", and "NIBB workshops", we also carry out one to three year "Priority collaborative research projects" as group research by internal and external researchers with the purpose of developing pioneering research fields in biology. We also conduct "model organism development collaborative research projects" to further the establishment and development of new model organisms. Furthermore we have begun taking applications for collaborative experiments using DSLM microscopes and next-generation DNA sequencers. In the belief that the methods of conducting collaborative research projects must be constantly modified according to the demands of the age and the biology community, NIBB has always encouraged discussion on such projects.

Collaborative research projects by year

year	2010	2011	2012
Priority collaborative research projects	4	6	5
Collaborative research projects for model organisms/technology development	2	2	3
Individual collaborative research projects	67	82	89
NIBB workshops	3	6	6
Collaborative experiments using the Large Spectrograph	8	9	14
Collaborative experiments using the DSLM	7	8	5
Collaborative experiments using next generation DNA sequencers	11	45	47
Training Courses	1	0	2
Emergency collaborative research projects for researchers disrupted by the Great East Japan Earthquake	—	6	—
total	103	164	171

NIBB Core Research Facilities

The NIBB Core Research Facilities was founded in 2010 with the goal of supporting and developing new technologies for comprehensive gene expression analysis and the effective use of optics as an analytical tool. In addition to the researchers of NIBB we also support national and international researchers with equipment such as the Okazaki Large Spectrograph (OLS) and next-generation sequencers.

NIBB BioResource Center

The NIBB BioResource Center was established in 2010 to facilitate progress and development of new technologies in model organism research. The center consists of the Model Animal Research Facility (Mammalian Biology Unit, Animal Research Unit, Small Fish Biology Unit, Medaka BioResource Unit), Cell Biology Research Facility, Model Plant Research Facility, Marmoset Research Facility, and the Morning glory BioResource Unit.

A portal connecting international researchers

International cooperation

NIBB Conference

The NIBB Conference is an international conference organized by NIBB's researchers with the participation of guest lecturers from abroad. Since the first conference in 1977 (the year NIBB was founded), the NIBB Conference has provided researchers in basic biology with valuable opportunities for international exchange.

Recent NIBB Conferences

59th	Neocortical Organization	Mar. 2012
58th/60th	Germline -Specification, Sex, and Stem Cells-	Aug. 2012
61st	Cellular Community in Mammalian Embryogenesis	Jul. 2013

The 61st NIBB conference

International academic exchange with EMBL

The European Molecular Biology Laboratory (EMBL) is a research institute funded by 18 European states and was established in 1974. It conducts comprehensive, high-level basic research programs, leading the world in the field of molecular biology. NIBB takes the leading role in collaborative research programs between EMBL and the National Institutes of Natural Sciences (NINS), which were launched in 2005, and promotes personal and technological exchange through symposia, exchanges between researchers and graduate students, and the introduction of experimental equipment.

Recent NIBB-EMBL Joint Symposia

8th Evolution: Genomes, Cell Types and Shapes
Nov. 2008 Heidelberg (Germany)

9th Functional Imaging from Atoms to Organisms
Apr. 2009 Okazaki (Japan)

10th Quantitative Bioimaging
Mar. 2013 Okazaki (Japan)

Participants of the 1st symposium

Academic exchange at EMBL

International academic exchange with the Max Planck Institute for Plant Breeding Research

In April of 2009 NIBB joined hands with the Max Planck Institute for Plant Breeding Research (MPIPZ) in an academic exchange agreement aimed at stimulating research in the field of plant sciences. After holding our first joint symposium, "Japanese-German Symposium on Evolution and Development" in August of 2009 in Cologne Germany, we have continued to hold joint symposia on a regular basis in order to deepen the academic exchange.

International academic exchange with the Temasek Life Sciences Laboratory

In August of 2010, NIBB signed an academic exchange agreement with Temasek Life Sciences Laboratory, (TLL) of Singapore. In addition to holding joint symposia on a regular basis, we are promoting cooperative activities such as holding the joint training course for researchers "Genetics, Genomics and Imaging in Medaka & Zebrafish" in 2012.

International Practical Course

With the cooperation of researchers from Japan and abroad, the NIBB international practical course is given at a dedicated laboratory specifically prepared for the course in NIBB. Previous themes, such as: "Developmental Genetics of Zebrafish and Medaka," and "Laboratory Course and Workshops on *Physcomitrella patens*" have given graduate students from various nations and areas (including America, Germany, Finland, and Asia) valuable training in state-of-the-art research techniques.

Practical training at the dedicated laboratory

Micro-manipulation of embryos

Bioresources

The National BioResource Project (NBRP) is a national project for the systematic accumulation, storage, and supply of nationally recognized bioresources (experimental animals and plants, cells, DNA, and other genetic resources), which are widely used as materials in life science research. To promote this national project, NIBB has been appointed as a research center for research on "Medaka (*Oryzias latipes*)" whose usefulness as a vertebrate model was first demonstrated in Japan. The usability of Medaka as a research material in biology has drawn increasing attention since its full genome sequence recently became available. NIBB also works as a sub-center for this national project for research on Japanese morning glory. In addition, NIBB provides databases containing research data on *Physcomitrella patens* (moss), *Daphnia, Xenopus laevis*, plant cell organelles, bacterial genomes, and gene expression in the brain.

Top: Inbred Hd-rR strain of Medaka with the full genome sequence determined, Middle: Transgenic Medaka with red fluorescence emerging from the whole body, Bottom: Quintet strain of Medaka with transparent body.

A center for developing new fields of biology

Development of new fields

Bioimaging

Recently, the capability of optical microscopes has greatly improved, and biophotonic probes have also been developed. The combination of these technologies allows us to use living samples and observe biological phenomena in real time, which, in the past, could only be estimated based on fragmentary information from fixed samples. NIBB aims to maximize the application of these techniques for visualizing biological phenomena (bioimaging) in biological research and to develop new imaging techniques.

1) *Imaging Science Laboratories*

NIBB aims to be a center for developing microscopes and biophotonic probes.

2) *Bioimaging Forum*

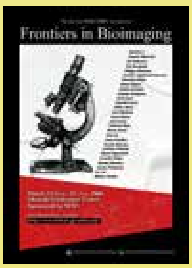
This Forum provides an opportunity for researchers in NIBB, and company engineers to frankly discuss practical difficulties and needs regarding imaging.

3) *Introduction of DSLM (Digital Scanned laser Light sheet Microscope)*

As part of our collaborative work with EMBL, NIBB introduced DSLM, which is effective for the three-dimensional observation of living samples, first in Japan.

4) *Bioimaging Symposium*

This Symposium provides an opportunity for academic exchanges with overseas cutting-edge researchers in the imaging field, mainly from EMBL.



Participants of symposium and a poster

Okazaki Biology Conferences

NIBB holds Okazaki Biology Conferences (OBC) that, under the endorsement of the Union of Japanese Societies for Biological Science, support the formation of international communities in future biological research fields with the goal of identifying new research issues in biology. Dozens of top-level researchers from Japan and abroad spend about one week together in exhaustive discussions seeking strategies for addressing future critical issues in biology. The past conferences have promoted the formation of international researcher communities.

Past OBCs

OBC1	The Biology of Extinction	Jan. 2004
OBC2	Terra Microbiology	Sep. 2004
OBC3	The Biology of Extinction 2	Mar. 2006
OBC4	Terra Microbiology 2	Sep. 2006
OBC5	Speciation and Adaptation	Mar. 2007
OBC6	Marine Biology	Dec. 2007
OBC7	The Evolution of Symbiotic Systems	Jan. 2010
OBC8	Speciation and Adaptation II	
	- Environment and Epigenetics -	Mar. 2012
OBC9	Marine Biology II	Oct. 2012

Participants of OBC9

Poster session (OBC2)

Oral session (OBC4)

General Discussion (OBC5)

Facilities tour (OBC6)

The cultivation of future researchers in biology

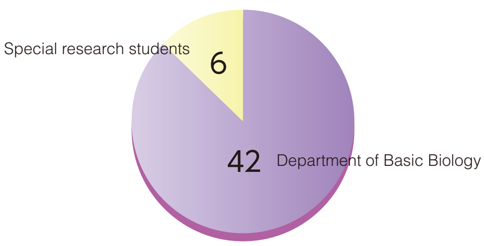
Admission of graduate students: SOKENDAI and other universities

As a center of biological research in Japan, NIBB has cutting-edge facilities and equipment. It also retains excellent faculty members who have continuously produced outstanding creative research results; the number of citations of their published papers is at the very highest level in Japan and worldwide. NIBB offers advanced graduate education in this excellent research environment with the goal of cultivating future leaders in biology.

Education of graduate students in NIBB

Admission of graduate students

One way to enter NIBB is to enroll in the Department of Basic Biology in the School of Life Science of the Graduate University for Advanced Studies (SOKENDAI), which is affiliated with NIBB. Another way for graduate students already enrolled in the graduate schools of other universities is to become a "special research student" under collaborative research projects. To become a special research student, graduate students must apply for enrollment in NIBB and undergo an assessment each year. In both cases above, graduate students can live an academic life and receive financial support from NIBB based on the research assistant (RA) system.



Graduate students in NIBB

About SOKENDAI

SOKENDAI was established in 1988 as a university without undergraduate courses that provides graduate education with a view to the comprehensive development of basic academic fields. It has headquarters in Hayama, Kanagawa Prefecture, offering graduate education with students separately assigned to 18 Inter-University Research Institutes (national institutes). Its School of Life Science consists of three departments: Department of Basic Biology, Department of Physiological Sciences (National Institute for Physiological Sciences), and Department of Genetics (National Institute of Genetics in Mishima, Shizuoka Prefecture). The Department of Basic Biology provides advanced research training courses in which fundamental and higher-order biological phenomena related to plants and animals are studied at the molecular level. There are two courses available: a three-year doctoral course for graduate students with master's degrees and a five-year course for university graduates. For both courses, students are admitted in April and October every year.

A "Life Science Retreat" is held every year for students and faculty members in the School of Life Science to gather and present research results.

Graduate education with a high ratio of staff to students

In most universities, the number of faculty members is small in relation to that of graduate students (approximately 0.16 per graduate student for national universities). In contrast, SOKENDAI has a significantly higher ratio of faculty members to graduate students (approximately 1.8 per graduate student); there is no concern about lack of student mentoring. Currently, the Department of Basic Biology has 42 SOKENDAI students and 69 faculty members, meaning that we are able to provide the ideal "one-to-one" education.

In "Life Science Progress Report" sessions, students report the progress of research activities and, in turn, receive advice from many faculty members.

High-quality seminars

NIBB holds many seminars with external distinguished guests as lecturers. It also hosts conferences, most of which students in NIBB can attend. These seminars and conferences offer good opportunities for future researchers to widen their vision.

Exchange seminar with graduate students as part of collaborative work with EMBL.

High rate of students becoming researchers

The Department of Basic Biology is engaged in the cultivation of advanced researchers. In the last five years, over 90% of those who finished the courses became researchers, including assistant professors and postdoctoral researchers.

How to enroll in SOKENDAI

Detailed information is available in the "PhD Program" section of NIBB's homepage. In addition, several admission information sessions are held in Tokyo and Okazaki every year. The NIBB Internship Program is also available, which allows students to experience actual academic life in NIBB while taking part in important research (support for transportation and accommodation costs is available).

The promotion of cutting-edge biological research

Academic Research

Cell Biology

Laboratory of Cell Responses

Director General
Masayuki Yamamoto

Specially Appointed Associate Professor
Akira Yamashita

Laboratory of Neuronal Cell Biology

Associate Professor
Nobuyuki Shiina

Laboratory of Cell Sociology

Assistant Professor
Yoshio Hamada

Developmental Biology

Division of Morphogenesis

Professor
Naoto Ueno

Associate Professor
Noriyuki Kinoshita

Division of Developmental Genetics

Professor
Satoru Kobayashi

Division of Molecular and Developmental Biology

Professor
Shinji Takada

Division of Embryology

Professor
Toshihiko Fujimori

Division of Germ Cell Biology

Professor
Shosei Yoshida

Laboratory of Molecular Genetics for Reproduction

Associate Professor
Minoru Tanaka

Environmental Biology

Division of Molecular Environmental Endocrinology

Professor
Taisen Iguchi

Division of Environmental Photobiology

Professor
Jun Minagawa

Division of Seasonal Biology

Visiting Professor
Takashi Yoshimura

Evolutionary Biology and Biodiversity

Division of Evolutionary Biology

Professor
Mitsuyasu Hasebe

Associate Professor
Takashi Murata

Division of Symbiotic Systems

Professor
Masayoshi Kawaguchi

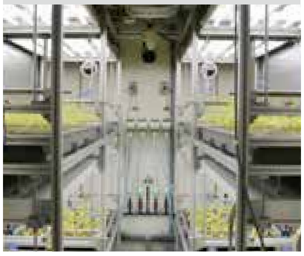
Laboratory of Morphodiversity

Associate Professor
Ryuji Kodama

Laboratory of BioResources

Associate Professor
Kiyoshi Naruse

Laboratory of Biological Diversity



Theoretical Biology

Laboratory of Genome Informatics

Assistant Professor
Ikuo Uchiyama

Neurobiology

Division of Molecular Neurobiology

Professor
Masaharu Noda

Associate Professor
Takafumi Shintani

Division of Brain Circuits

Professor
Masanori Matsuzaki

Division of Brain Biology

Professor
Tetsuo Yamamori

Associate Professor
Akiya Watakabe

Laboratory of Neurophysiology

Associate Professor
Eiji Watanabe

Imaging Science

Laboratory for Spatiotemporal Regulations

Associate Professor
Shigenori Nonaka

NIBB Core Research Facilities

Functional Genomics Facility

Specially Appointed Associate Professor
Shuji Shigenobu

Spectrography and Bioimaging Facility

Specially Appointed Associate Professor
Yasuhiro Kamei

Data Integration and Analysis Facility

Interuniversity Bio-Backup Project for Basic Biology

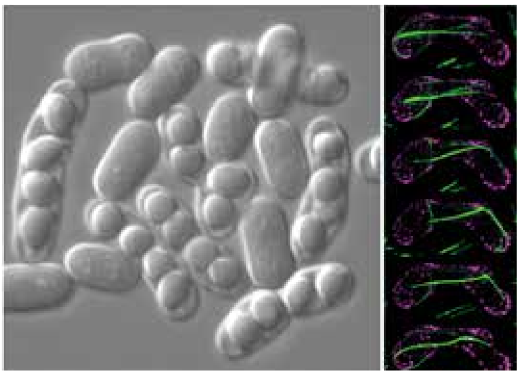
Living unit: the cell

All organisms are made up of a basic unit called the cell. Within each cell there are various small organs known as organelles. Organelles change their form and function dynamically and the life of a cell depends on the integrative function of the organelles. We are attempting to elucidate the mechanism behind the dynamic changes of cells.

How cells switch activities

Laboratory of Cell Responses (Director General Masayuki Yamamoto)

Cells sense the environment around them, for example the amount of nutrients and hormones, as well as the temperature and pressure, and decide what kind activities to undertake using that information. In particular, the germ cells that produce sperm and eggs begin halving their number of chromosomes during a special kind of cell division called meiosis, in response to ambient conditions. In our laboratory we use yeast, the simplest organism that performs meiosis, to examine the mechanism by which cells, according to the ambient conditions, switch from continuing to increase using the kind of cell division that divides cells equally to create two identical cells (called mitosis) to begin the process of meiosis, which is essential for bringing forth future genetically diverse generations.



The fission yeast *Schizosaccharomyces pombe*

The tie between mother and child

Laboratory of Cell Sociology (Assistant Professor Yoshio Hamada)

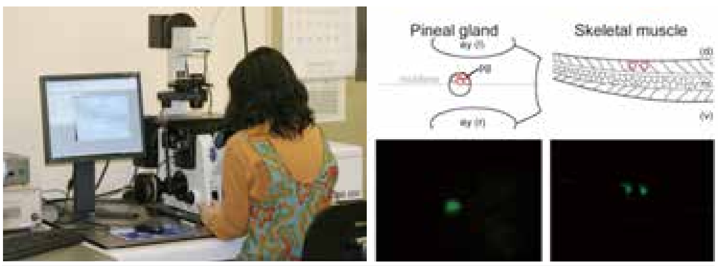
All animals except mammals start eating food immediately after they hatch. Mammals have little nourishment within the egg and, as soon as they are hatched in the early stages of the formation of the body, mammalian embryos become parasitic to the maternal body in order to intake the nourishment necessary for continued growth. The placenta is an organ through which the embryo receives nourishment and oxygen from the mother and returns wastes and carbon dioxide back to the maternal body. As a necessary consequence of their parasitic growth process, mammalian children continue to receive nourishment from their mothers in the form of breast milk. The placenta is an organ made up of the cells of the embryo, but its organogenesis is considered to be heavily dependent on interaction with the mother-derived cells. Our laboratory studies the cellular interaction between mother and child.

Mouse embryo (left) and placenta (right, dark pink). The light pink membrane surrounding the placenta (the decidua) is the tissue derived from the mother and surrounds the entire embryo and the placenta when intact.

Manipulating cell behavior using infrared laser mediated gene expression

Spectrography and bioimaging facility (Specially appointed Associate Professor Yasuhiro Kamei)

We have developed a novel microscopic method for controlling gene expression at the single-cell level using an irradiating infrared laser; infrared laser-evoked gene operator (IR-LEGO). Also, NIBB is designated as the core center for medaka of the National BioResource Project, and various information and resources are accumulated here. We are now establishing a system which finely controls spatiotemporal gene expression in medaka for revealing the function of each gene *in vivo*. We are also contributing to research communities from basic biology to medical science by supplying platforms consisting of various resource and new technology.



Production version of IR-LEGO microscope system for *in vivo* single-cell/local gene induction (left) and examples for induced gene (GFP) expression in medaka pineal gland and skeletal muscle (right). The IR-LEGO microscope is also used for the NIBB cooperative research program.

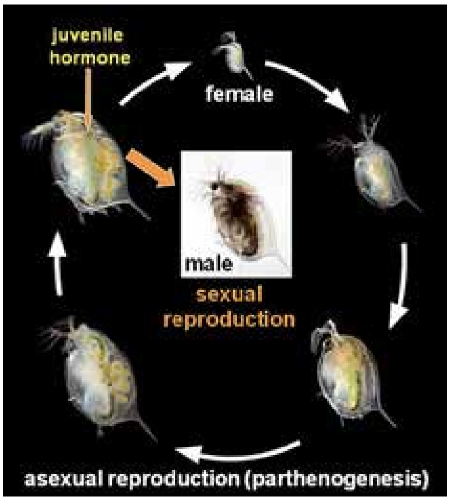
Methods for adapting to a changing environment

Organisms have the ability to sense changes in their surroundings and take appropriate actions in response to the new environment. But how do they sense these changes? Also, what changes occur within organisms as they undergo adaptations? We are researching the sensing mechanisms and methods of environmental adaptation possessed by living things.

Sex hormones and endocrine disruptors

Division of Molecular Environmental Endocrinology (Professor Taisen Iguchi)

Various man-made chemicals are being released into the environment. Some of these chemicals, known as endocrine disruptors, have the ability to behave similarly to natural sex hormones and alternately some have the ability to hinder the normal functioning of naturally occurring hormones. Our research group uses various model organisms to study the effects of naturally occurring sex hormones, the endocrine disruptors that inundate the environment, and temperature, etc., from the time an organism emerges from the egg until adulthood.



This image depicts the process by which *Daphnia magna*, an exemplary example of parthenogenesis, by which females gives birth to all female young un-fertilized by a male, will suddenly convert to sexual reproduction and produce male young when introduced with a juvenile hormone analogue. Through conducting research of this kind, we hope to understand the relationships between life-forms and their environment and develop proposals for the better preservation of our own environment.

Investigating Photosynthesis Using Microalga

Division of Environmental Photobiology (Professor Jun Minagawa)

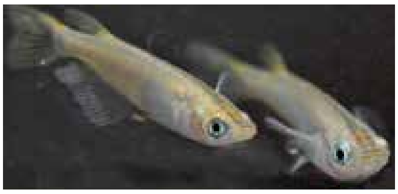
Photosynthesis allows plants to take energy from the sunlight that continually pours down upon the earth and convert it into energy that they can use. We use single celled microalga (such as *Chlamydomonas*) as model organisms, along with molecular genetics, biochemistry, and spectroscopic techniques, to research the fundamentals and efficiency of light harvesting "antenna" molecules for photosynthesis. In addition, based on the fundamental knowledge obtained we aim to gain a better understanding of the eco-physiology of environmentally important photosynthetic organisms from North Pacific diatoms, and the symbiotic *zooxanthellae* in coral, to Antarctic green alga.

Chlamydomonas during conjugation (10μm diameter)

Exploring how animals sense the seasons

Division of Seasonal Biology (Visiting Professor Takashi Yoshimura)

Animals living outside the tropics adapt various physiology and behavior to seasonal changes in the environment. As animals use changes in day length and temperature as seasonal cues, these phenomena are referred to as photoperiodism and thermoperiodism, respectively. Medaka provides an excellent model to study these mechanisms because of their robust seasonal responses. In addition, genomic sequences and transgenic approaches are available in this species. In this division, we are trying to uncover the underlying mechanisms of seasonal adaptation using Medaka fish.



Left: Breeding medaka male (left) and female (right). Right: Collection of wild medaka (Tsugaru City, Aomori Prefecture).

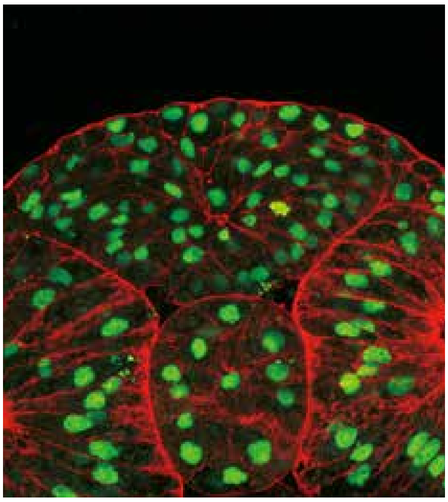
Formation of the shape of living organisms

Living organisms, both animals and plants, have various shapes that differ from species to species. How are living things formed? We are endeavoring to discover the mechanisms of morphogenesis by searching for the genes controlling shape formation and studying their function, as well as by analyzing morphogenetic processes using mathematical models.

From a round egg to an adult body

Division of Morphogenesis (Professor Naoto Ueno)

Most animal eggs begin as a spherical-shaped cell. During the developmental process the embryo changes dramatically as it elongates lengthwise. As the embryo changes shape, the various organs, such as the heart and brain etc., begin to form. How are the characteristic shapes of organisms, and the shapes of their organs, formed? Is there some kind of blueprint? To answer these questions we are looking at the morphogenesis of organs and embryos through analysis of gene function and cell behavior. The results of these studies are expected to contribute to the understanding of human congenital disorders.



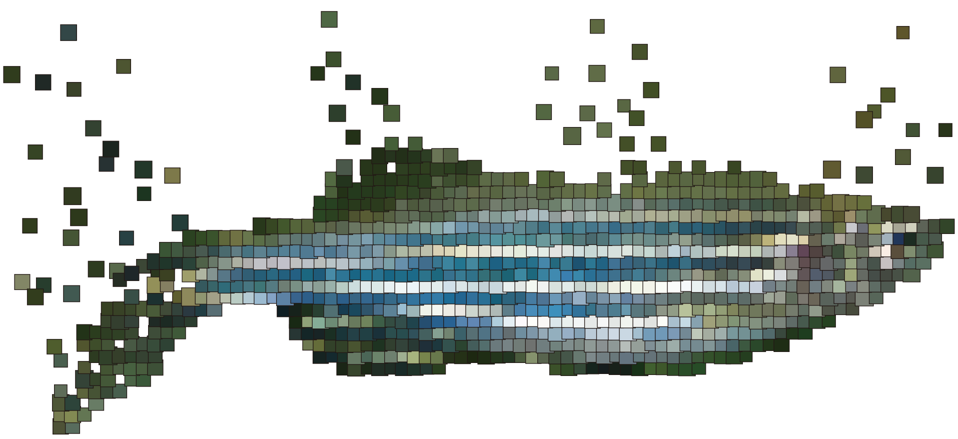
Cross-section of the *Xenopus* embryo. The fan-like structure at the top center is the neural tube that will become the brain and spinal cord. (Red areas are the cell membranes, green areas are nuclei)

Repetition in the bodies of animals

Division of Molecular and Developmental Biology (Professor Shinji Takada)

Probably, many people do not realize, but there are repeating structures in the embryos of animals, including humans. These structures, known as somites, are the source of the cells that become parts of our bodies such as vertebrae. As one can see, the repetitive patterns seen in our spine originate as somites. In spite of the precise formation of this fantastic repeating structure being an indispensable aspect of the formation of our bodies it is not well understood. By elucidating the function of genes related to the creation of somites we hope to better understand the system by which they are formed. We use small fish, such as zebrafish, and mice as model organisms to analyze the functions of these genes.

A zebrafish embryo 16 hours after fertilization.

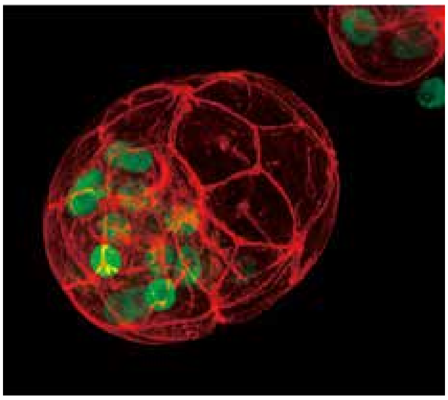


Formation of the shape of living organisms

How does the formation of a mammal's body begin?

Division of Embryology (Professor Toshihiko Fujimori)

The first stages of mammalian embryonic development occur within the oviducts and uterus of their mothers, which makes studying them during these stages difficult. Within the same species of nematode and similar organisms at any particular point in the embryo the progression of the developmental systems of ontology that control cell division, arrangement, and specialization, are quite consistent. On the other hand during mammalian development at any particular area an abundant variety of ontological patterns of cell division and arrangement can be seen. However even if it seems at first glance that these individual cells are each behaving freely, each mammalian embryo develops into a body with almost the exact same shape irrespective of the particular areas. Using mice, we are analyzing behaviors of the individual cells and genes of embryos, focusing specifically on the first stages of development and how the embryonic axis is formed and what influence this has on the future development of the anteroposterior axis. Answering these questions is the main theme of our continuing research.

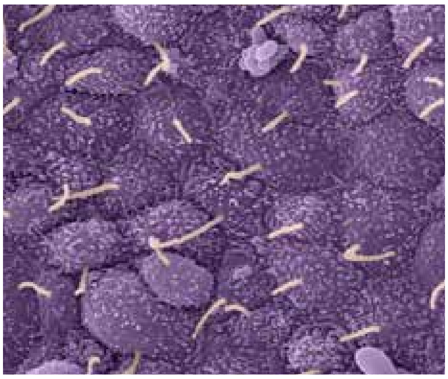


Cell contours in a mouse blastocyst (phalloidin staining, red), and NANOG protein expression (green). At this point cell specification can already be seen.

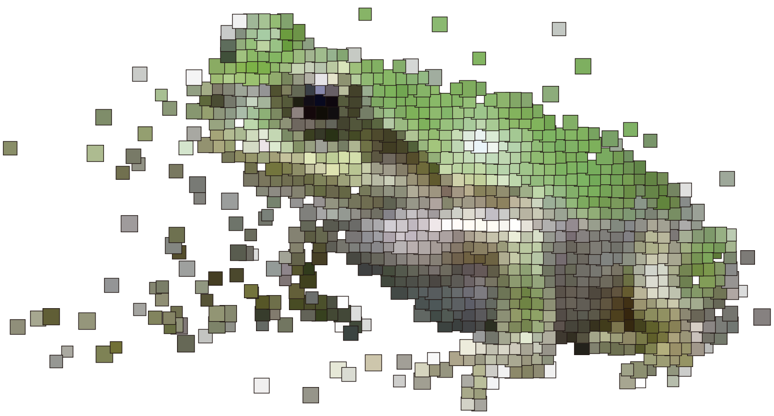
How the right and the left sides of the body are determined

Laboratory for Spatiotemporal Regulations (Associate Professor Shigenori Nonaka)

The heart is on the left-hand side and the liver and the gall bladder are on the right-hand side of the body. Why is this so? Why doesn't the body have a mirrored or a symmetrical plan? We are studying the mechanisms behind the body's left-right asymmetry. Experiments using mouse embryos have achieved interesting results. In the course of body formation from a fertilized egg, tiny hairs of approximately one two hundredth of a millimeter in length grow on a specific area of the body surface. The movements of these hairs rotate the surrounding fluid, causing a flow from the right to the left-hand side of the body. When the flow is artificially reversed, there arises an embryo with a mirrored body plan. We are now studying what this flow actually does.



Hairs on the body surface which determines the left-right asymmetry (colored in yellow).



The mechanisms of the formation and function of the brain

The brain and the nervous system act as the control tower of an animal, enabling functions such as the regulation of its internal environment, control of feeding behaviors, sensation of its external environment, memory and learning, and behaviors for escaping from enemies and communicating with friends. It is indispensable to investigate the formation and the function of the brain in order to elucidate the living mechanisms of animals.

How the brain is formed and how it works

Division of Molecular Neurobiology (Professor Masaharu Noda)

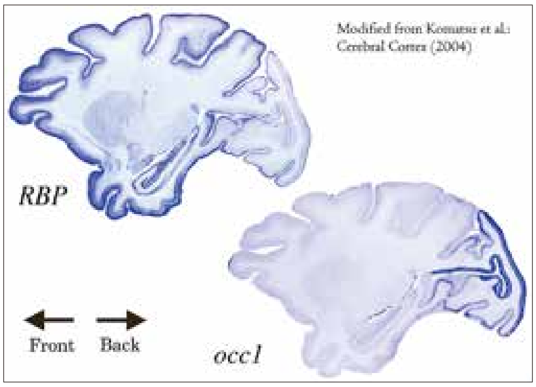
The brain receives various types of information about the external world through sensory organs such as the eyes and ears and directs an appropriate response through the processing and recognition of that information. The brain is also continuously monitoring internal conditions such as blood pressure and blood sugar levels, thereby controlling feeding and excretion behaviors. These brain functions are possible only through the correct functioning of the neural circuits formed during the embryonic development process. We are studying the mechanism that controls formation of the visual system as an example of how the brain is formed, and the mechanisms that control the homeostasis of the body fluid as well as the regulation mechanism of emotion and memory as examples of how the brain works.

Dehydration of the body causes a rise in the sodium ion concentration of the body fluid. The animal becomes thirsty and drinks water, avoiding salt water. We have clarified the sodium-level sensing mechanisms in the brain that control such drinking behaviors.

Learning brain, evolving brain

Division of Brain Biology (Professor Tetsuo Yamamori)

There remain various mysteries within our brain. What is happening in the brain when we become skilled in a new sport or when we learn something new? How similar and how different are the brains of various animals, such as monkeys and mice? In order to answer these questions, we focused on the gene and are studying how individual cells building the brain are combined and how they work using the methods of molecular biology and histology. "To visualize the brain and to analyze its function using the gene" is what we are attempting to do, and we expect to glimpse new aspects of the brain and its functions that have heretofore eluded scientists.

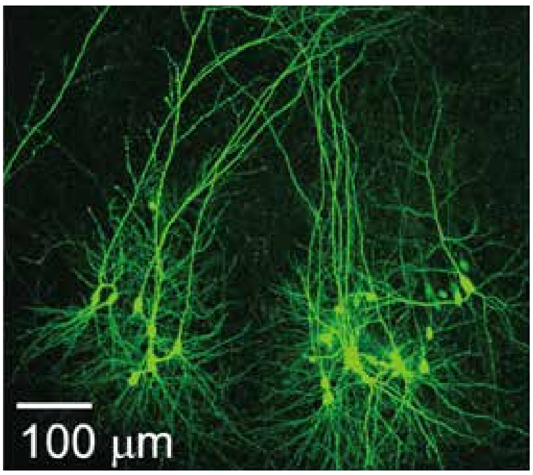


The genes each expressed in the association area (left) and the visual cortex (right) of the monkey brain.

Neuronal mechanisms of information processing

Division of Brain circuits (Professor Masanori Matsuzaki)

Animals are surrounded by various environmental changes. To adapt to these changes, animals have to recognize them, make decisions about what to do about them, and execute the appropriate action. These functions are processed in brains that consist of a tremendous number of neurons that contact each other via synapses. How are the external world and action commands represented in the cortical circuits of the brain? How are past experience and knowledge stored in the many synapses in the brain? The goal of our research is to answer such questions at the levels of single neurons and single synapses. At present, we are studying neuronal mechanisms underlying motor control and motor learning by using modern techniques such as two-photon imaging, optogenetics, chemical biology, molecular biology, and electrophysiology.



Two-photon image of hippocampal neurons

The way animals see

Laboratory of Neurophysiology (Associate Professor Eiji Watanabe)

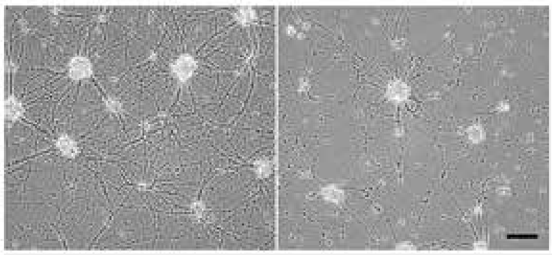
What does it actually mean to “see” things? Our brains take in light signals from the outside world, and then they use algorithms unique to the brain to process that data and produce the phenomenon known as “seeing”. This visual information processing is carried out by the countless neurons of our brains, but the whole story of how this mechanism works is so complicated that as of yet it is still not clearly understood. In order to better understand the processes by which animals see, our laboratory is focusing our research on the visual systems of individual animals. Using the techniques of psychophysics to quantitatively analyze the behavior of both animals and people we hope to elucidate the visual processing algorithms that lay at the root of an animal’s ability to see. We believe that through this research we will be able to understand a new aspect of what it means to “see”.

Left: The eye of a medaka; one of the model animals used to study the development of visual systems.
Right: The flash-lag effect; moving animals perceive stationary objects as slightly ahead of their actual position.

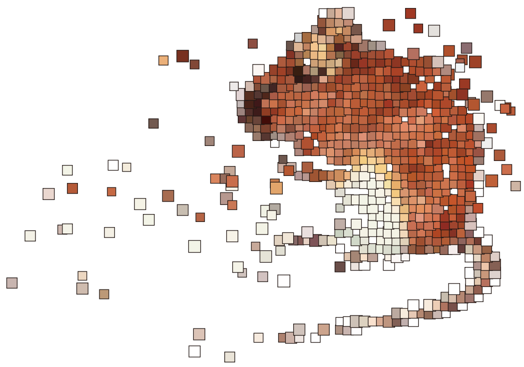
The local gene-expression system of neurons

Laboratory of Neuronal Cell Biology (Associate Professor Nobuyuki Shiina)

Gene expression, the process by which information from DNA is converted into mRNA and used in the synthesis of a functional gene product such as a protein, is the foundation of all life. Within neurons there is one essential aspect of the gene expression system that takes place in a decentralized manner. Neurons consist of the soma which contains a nucleus and the neurites that stretch out from it. In addition to the centralized gene expression system of the soma there also exists a decentralized gene expression system that provides local protein synthesis from mRNA in neurites at just the right time and place. It is believed that this system controls the location at which neurites will connect to each other, thereby forming neural networks. Our laboratory is researching the types of mRNA and the mechanisms of this local protein synthesis in order to better understand its relation to the formation of neural networks, memory, learning, and behavior.



Cultured mouse neurons; neurites can be seen connecting to each other and forming neural networks (Left). The right hand image shows diminished neural network formation after suppression of a protein important to local protein synthesis (RNG105). Bar = 100μm.



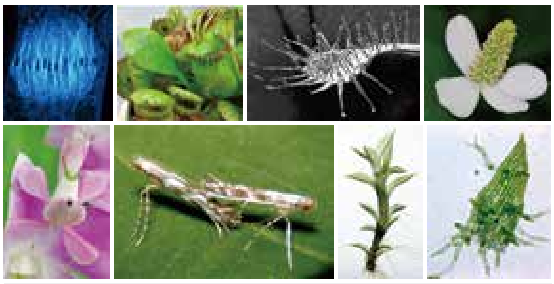
The evolution of living organisms

Organisms always evolve. Evolution can not be interrupted, and it results in the emergence of flowers and fish of various shapes and colors, mosses with an unremarkable appearance, human beings, and countless other kinds of organisms. Why, how and when do organisms evolve? We study the mechanisms of evolution with the hope of discovering clues to our own past and future.

Evolution of complex traits

Division of Evolutionary Biology (Professor Mitsuyasu Hasebe)

The theory of natural selection and the neutral theory of molecular evolution are powerful concepts in evolutionary biology. However, even with such theories, there still remain unexplained phenomena, one of which is the evolution of complexity. It is difficult to explain the mechanisms needed to evolve complex adaptive traits, which comprise many components and become adaptive only when all components are gathered together. However, based on evolutionary theory, each component should evolve one by one according to the accumulation of mutations. Understanding the evolution of complex adaptive traits will be advanced by analyzing the genes regulating such traits. We aim to get insights on new and general evolutionary theory through studies on intracellular complex structure formation via microtubules, pray-capture leaves, and digestive enzymes of carnivorous plants, pseudanthium of Houttynia cordata, host race change of moths, mimicry of flowering mantis, and stem cell formation with advanced techniques in molecular biology, cell biology, developmental biology, and genome biology.



Microtubules in a cell (upper left), Carnivorous plants Cephalotus follicularis (upper middle left) and Drosera spatulata (upper middle right), pseudanthium of Houttynia cordata (upper right), mimicry of flowering mantis (lower left), Acrocercops transecta for a study of host race change (lower middle left), the moss Physcomitrella patens (lower middle right) and its dissected leaf with reprogrammed stem cells from differentiated leaf cells (lower right).

Symbiosis of microbes and plants

Division of Symbiotic Systems (Professor Masayoshi Kawaguchi)

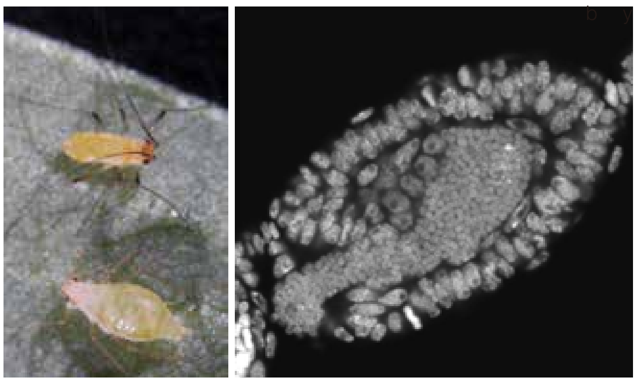
The symbiotic relationship between plants and mycorrhizal fungi came about concurrently with the evolution of terrestrial plants, and now mycorrhizal symbiosis is present in over 80% of plant species. This symbiotic relationship allows both organisms to enhance growth and proliferation due to the mutual exchange of photosynthetic products and inorganic nutrients, such as water and phosphate from the soil. The mycorrhizal fungi are allowed to stretch fungal hyphae into the roots of its host plant and form symbiotic structures known as arbuscules inside the root cells. It is thought that these arbuscules are the compartment where the symbiotic exchange of nutrients takes place. We are trying to elucidate the molecular mechanisms of plant-microbe symbiosis and symbiotic organ development.

Root of the legume *Lotus japonicus* with the mycorrhizal fungi stained green.

Symbiosis Genomics

Functional Genomics Facility (Specially appointed Associate Professor Shuji Shigenobu)

Symbiosis has contributed to the ecological and evolutionary success of many taxa provisioning novel traits, thereby facilitating exploitation of otherwise inaccessible niches. We are studying the symbiosis of the pea aphid with the bacterial symbiont *Buchnera* to understand the network of biological interactions at the molecular and genetic level. To this end, we take advantage of state-of-the-art genomics such as next-generation sequencing technologies.



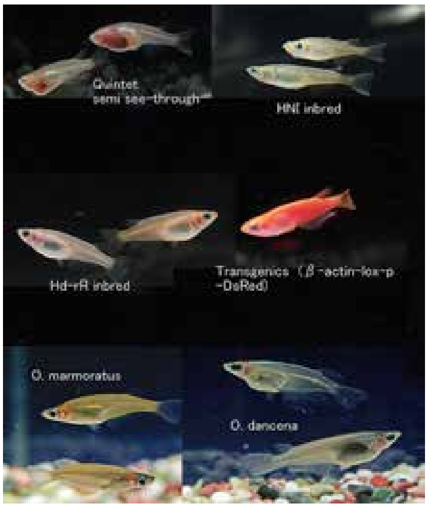
Aphids harbor bacterial symbionts called *Buchnera*. Aphid/*Buchnera* association is obligate and mutualistic with neither partner being able to reproduce in the absence of the other. (Left) Pea aphids. (Right) *Buchnera* cells vertically transmitting into a developing aphid egg.

The evolution of living organisms

Medaka Biology and Bioresources

Laboratory of Bioresources (Associate Professor Kiyoshi Naruse)

Medaka was first developed as a model organism in Japan, and many strains possessing various traits have been developed. In addition over 20 closely related species are distributed throughout South East Asia. In our laboratory we use these bioresources to understand a wide range of biological phenomena, from development to evolution, such as the genetic variety that gives rise to morphological differences of the individual, the molecular mechanisms involved in germ cell migration, and the evolution of sex chromosomes in closely related species. In addition, as the core institution of the Medaka BioResource Project, our laboratory oversees the collection and maintenance of many medaka strains and genome resources, and supplies them extensively to researchers at home and abroad.



Various medaka strains supplied by our laboratory

Mechanisms creating the diversity of the shape of butterfly wings

Laboratory of Morphodiversity (Associate Professor Ryuji Kodama)

The myriad of patterns and shapes that make up the wings of butterflies and moths are unique to each species. The wings just after puparization, however, have a smooth outline common to most species. A contour line appears with the shape of the adult wing just after this stage and the deaths of cells outside of this line bring about the shape of the adult wings. A similar kind of "programmed cell death" is also seen in the process of finger formation in human embryos. We are studying the mechanisms that determine the position and the shape of the contour line as an example of the mechanisms which enable the diversity seen in butterflies.

A cross section of the pupal wing. The round shaped part on the left is where the cell deaths are occurring.

The diversity of microbes explored using the genome

Laboratory of Genome Informatics (Assistant Professor Ikuo Uchiyama)

Thanks to the genomes of various living organisms being decoded, scientists have been able to better understand the evolutional processes of different species by comparing these decoded genomes. Genome analysis is meanwhile disclosing the true diversity of microbes, which exist in near limitless numbers in every part of the earth, including in our bodies and our surroundings. Our laboratory is using informatics to develop a method to systematically compare the vast amount of diversified genome information of microbial genomes and explore the diversity of the genome and the motive force which brought about this diversity.

A chart showing the result of an extensive analysis of how corresponding genes are included in the genome of various microbial species.

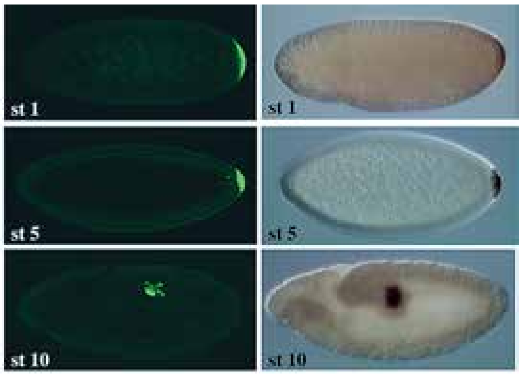
The Inheritance of life and genes – the mechanisms of sex differentiation

Living organisms inherit life from one generation to the next by passing on genetic information. The formation of two sexes, male and female, and thus the formation of the sperm and the egg, is indispensable to this process. We are studying the mechanisms determining sex, the mechanisms producing sperms and eggs, and the environmental factors capable of disturbing such mechanisms.

A mechanism for selecting reproductive cells

Division of Developmental Genetics (Professor Satoru Kobayashi)

Reproductive cells provide one of the essential abilities of a living organism: the ability to give rise to the next generation of life. In the process of embryonic development, the fertilized egg continually divides and many cells appear. A tiny number of them are selected as reproductive cells, while the rest of the cells become somatic cells, forming the body. Using fruit flies (*Drosophila*), we are studying the mechanisms responsible for selecting these important reproductive cells. We have clarified that a gene called nanos and mitochondria are both important in this process.

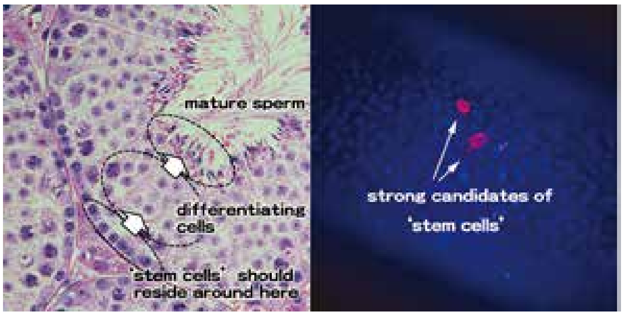


Fly eggs. Cells colored green (left figures) and brown (right figures) later become reproductive cells.

The secret to the continuous production of sperm

Division of Germ Cell Biology (Professor Shosei Yoshida)

The testes of mammals continually produce sperm over years or many tens of years. This continuous sperm production is essential for the reliable preservation of a species' offspring yet is carried out by a very small number of "spermatogenic stem cells". These are the fundamental cells which both create sperm cells (differentiation) and preserve themselves (self-renewal). Within the testicles of mice, cells that create sperm are orderly packed together (Left Image), but the location, disposition, and behavior of stem cells is not well understood. Our laboratory's research is concerned with finding and clarifying the nature of spermatogenic stem cells (Right Image).

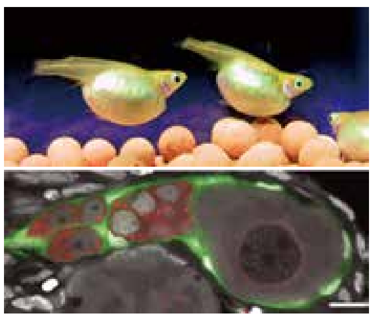


Left: Cross section of a mouse testicle. A large number of well ordered cells create sperm.
Right: The tiny populations of red dyed cells are thought to be stem cells within the large number of testicular cells (nuclei stained in blue).

Understanding the principles of sex differentiation and plasticity

Laboratory of Molecular Genetics for Reproduction (Associate Professor Minoru Tanaka)

There are many types of sex determination and differentiation systems. Some organisms' sex is determined by sex chromosomes, some change in the middle of their life. Regardless of this variety, the final and common destination of sexual development is to accomplish formation of the ovaries and testes, producing the eggs and sperm necessary for reproduction. We found that the presence of germ cells is critical for feminization, independent of sex chromosomes in medaka. In other words, in the absence of germ cells, the gonads are masculinized even if the medaka does not have the Y chromosome. We are analyzing the cellular mechanisms of sex differentiation and sexual plasticity using medaka as a model organism and by visualizing specific gene products and cells. During these analyses we have demonstrated, for the first time in vertebrates, the presence of germline stem cells present in ovaries. Our recent analysis shows that regulation of the stem cells is critically involved in proper sex differentiation.



(Upper) A medaka showing sex transformation, hotei. Though the fish is genetically male (XY), ovaries fill the expanded body. (Lower) Stem cells' presence demonstrated in the ovary (red areas to the left) and the cells surrounding them germ (green). White areas are cell nuclei. Egg is being formed from left to right.

"Protecting life science research from natural disasters"

Interuniversity Bio-Backup Project

The Interuniversity Bio-Backup Project for Basic Biology, (IBBP) is a system that backs up biological and genetic resources in order to realize life sciences research resilient to natural disasters in Japan. The project is administered by the National Institutes for Basic Biology in collaboration with 7 National Universities (Hokkaido University, Tohoku University, University of Tokyo, Nagoya University, Kyoto University, Osaka University, and Kyushu University).

Liquid nitrogen tanks of IBBP's genetic resources cryogenic storage system.

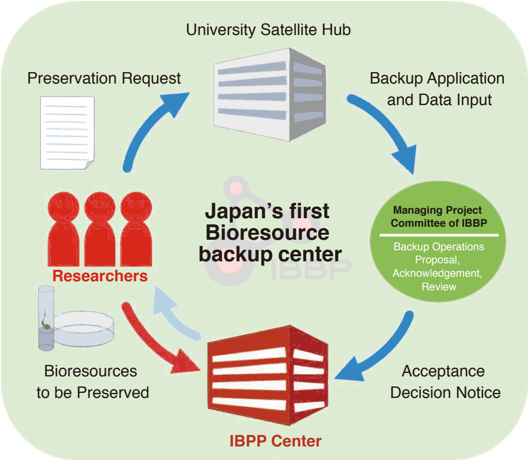
IBBP Center

The IBBP Center was established as the project's core facility at NIBB. Inside buildings capable of withstanding even very large scale quakes are 10 cryopreservation tanks (8 vapor-phase, 2 liquid-phase), 5 deep freezers, as well as automated maintenance systems, security systems, and emergency backup power generators. The IBBP Center works together with the university satellite offices in each region (Hokkaido University, Tohoku University, University of Tokyo, Nagoya University, Kyoto University, Osaka University, Kyushu University), and takes charge of requested backup and storage of biological resources that have been established by individual researchers. In the event of a disaster or accident leading to the loss of a researcher's bioresources, preserved samples will be promptly supplied back to the researcher so they can quickly resume their work.

As a result of the Great East Japan Earthquake that occurred on March 11, 2011, genetic resources of many universities in the Tohoku region and beyond were damaged or lost. As well as direct equipment damage caused by the earthquake valuable biological resources produced by research activities taking many years, that were currently being used in experiments, such as mutant and transgenic organisms, were lost due to long term power failures, and as a result, many researchers were forced to suspend or change the direction of their research programs.

Biological and genetic resources are essential not only in life sciences research, but in a variety of scientific fields. Loss of biological genetic resources by unforeseen circumstances is a clear possibility, and as such it is essential for development of stable life science research in Japan that measures are taken to prevent such loss.

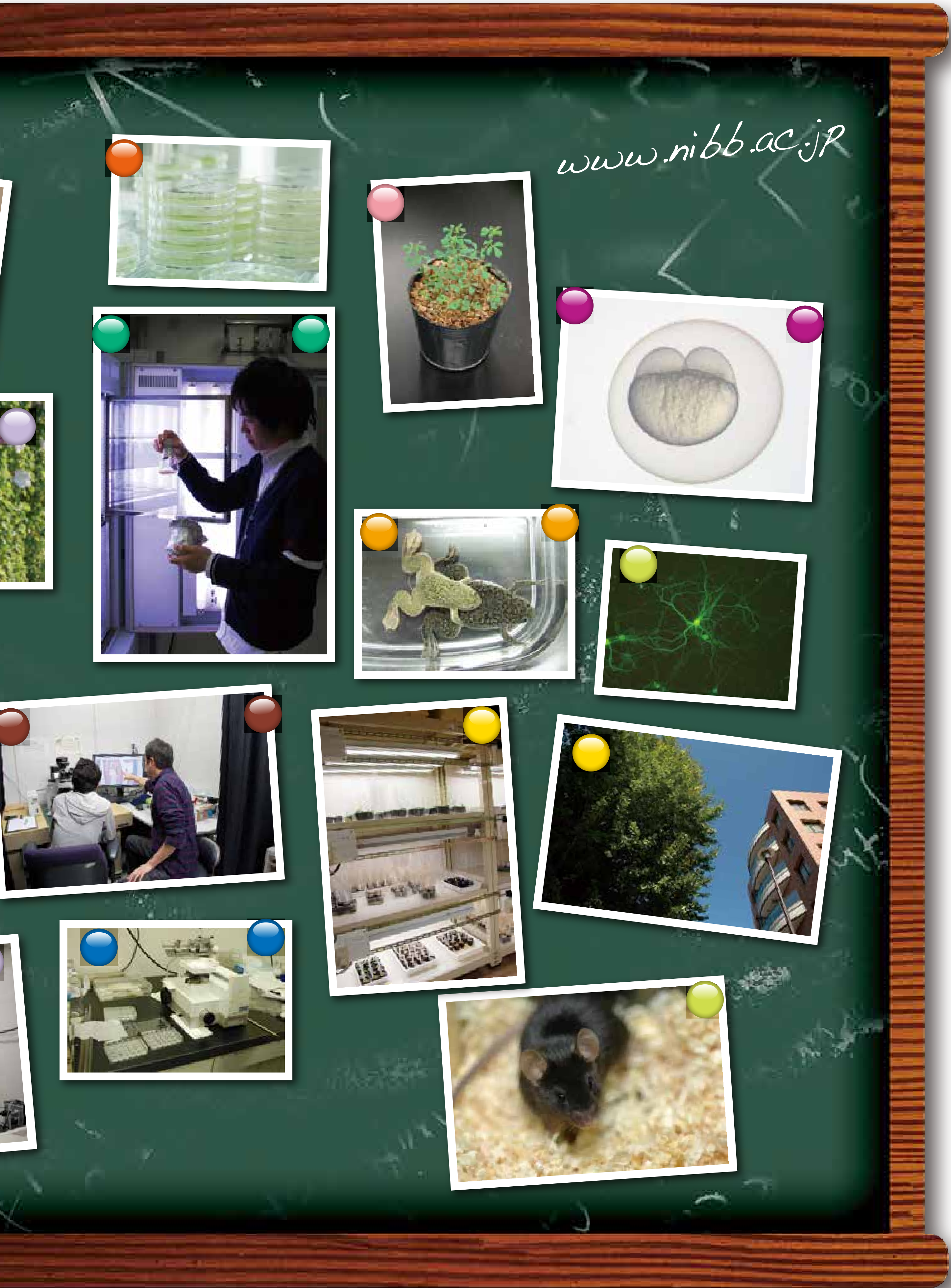
In light of these circumstances, the Interuniversity Bio-Backup Project began activities in 2012.



Paths of backed up biological and genetic resources

In addition the project aims to conduct joint research for development of new storage technology, and to establish new long-term storage methods for various biological resources.

National Institute for Basic Biology


www.nibb.ac.jp

Research support facilities

To efficiently conduct research activities, NIBB has its own facilities and shares research facilities with the National Institute for Physiological Sciences and the Institute for Molecular Science in Okazaki. There are facilities for the controlled cultivation, growth, and breeding of living samples for experiments and research activities, mid/large scale equipment for measurement and data analysis, radioisotope (RI) facilities and advanced analysis systems.

NIBB Core Research Facilities

The NIBB Core Research Facilities were launched in 2010 to support basic biology research in NIBB. They consist of three facilities that are developing and providing state-of-the-art technologies to understand biological functions through functional genomics, bioimaging and bioinformatics. The NIBB Core Research Facilities also act as an intellectual hub to promote collaborations among the researchers of NIBB and other academic institutions.

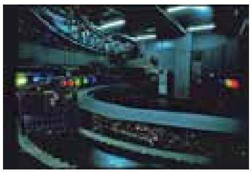
Functional Genomics Facility

The Functional Genomics Facility maintains a wide array of NIBB's core research equipment, from standard machinery like ultracentrifuges to cutting edge tools such as next generation DNA sequencers, which amount to 60 different kinds of instruments. The facility is dedicated to fostering collaborations with researchers both of NIBB and other academic institutions worldwide by providing these tools as well as expertise. Our current focus is supporting functional genomics works that utilize mass spectrometers and DNA sequencers. We also act as a bridge between experimental biology and bioinformatics.

Equipment maintained by the Functional Genomics Facility

Spectrography and Bioimaging Facility

The Spectrography and Bioimaging Facility assists both collaborative and core research by managing and maintaining research tools that use "Light". The facility also provides technical support through management of technical staff assisting in the advancement of collaborative and core research projects, as well as academic support to researchers. Among its tools are confocal microscopes and the Okazaki Large Spectrograph. The Okazaki Large Spectrograph is the world's largest wide spectrum exposure mechanism, capable of producing a range of wavelengths from 250nm (ultraviolet) to 1,000nm (infrared) along its 10 meter focal curve; allowing exposure to strong monochromatic light. The facility's microscopes, which are cutting edge devices such as confocal and two-photon excitation microscopes, are used by both internal and external researchers as vital equipment for core and collaborative research projects.



The Large Spectrograph

IR-LEGO

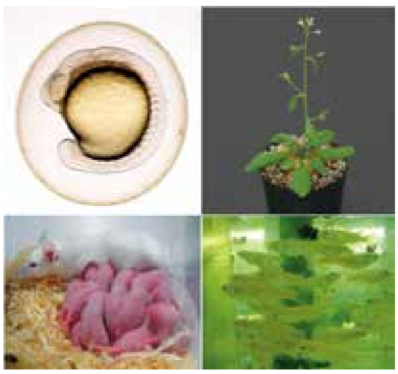
Data Integration and Analysis Facility

The Data Integration and Analysis Facility supports research activities using high-speed large- capacity computers. By building gene and protein sequence databases, it supports research mainly in terms of sequence analysis, expression data analysis, and imaging analysis. It has also developed analysis programs and programs for database publication via the Web to distribute the results of gene analysis for model organisms worldwide. In addition to computer-based analysis, the Data Integration and Analysis Facility supports NIBB's information-sharing infrastructure, the maintenance of an ultra high-speed network system, computer/network-related consultation, and introduction of new services.

NIBB Biological Information Analysis System

NIBB BioResource Center

To understand the mechanisms of living organisms, studies focusing on each gene in the design of life (genome) are required. The use of model animals and plants, such as mice, Medaka (*Oryzias latipes*), zebrafish, Arabidopsis, *Lotus japonicus*, and *Physcomitrella patens*, makes it possible to produce genetically controlled organisms with markers placed by genetic and cell engineering technology. Such marking allows detailed studies of genes and cell functions. The model organisms mature in a short period of time; therefore, changes in cells, organs, and individuals can be totally and efficiently observed. The NIBB BioResource Center has equipment, facilities, and staff to maintain such organisms safely, efficiently, and appropriately.



Model organisms used in biological research

Center for Radioisotope Facilities

Biological studies for the analysis of genetic functions and protein characteristics often require locating substances in living organisms. The Center for Radioisotope Facilities use radiation emitting materials, or radioisotopes, to investigate the behavior and location of genetic materials. The Center strictly controls the use of its radioisotopes to ensure safe handling.

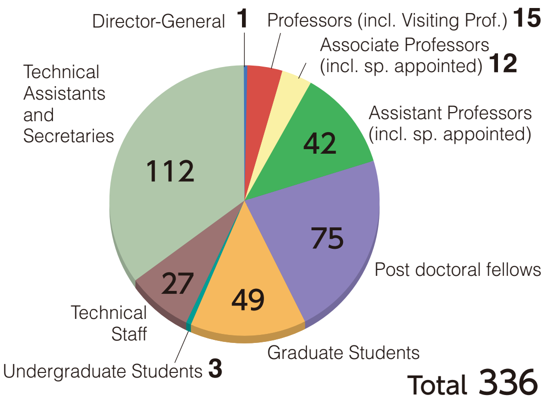
Radioisotope experiment

Outline of NIBB

Location of NIBB

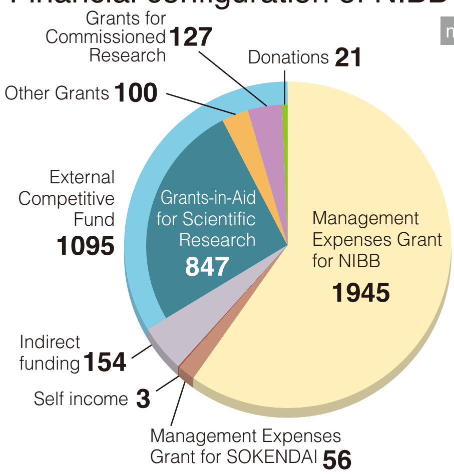
Laboratories of NIBB are located both in Myodaiji and Yamate areas.

Members of NIBB (As of 1st Feb. 2014)



Financial configuration of NIBB (Apr. 2012 - Mar. 2013)

numbers are in million yen



NIBB acquires numerous competitive funds in an effort made by individual researchers, including Grants-in-Aid for Scientific Research and Grants for Commissioned Research, in addition to national subsidies (Management Expenses Grants and Expenses Grants for SOKENDAI).

Open house and public relations

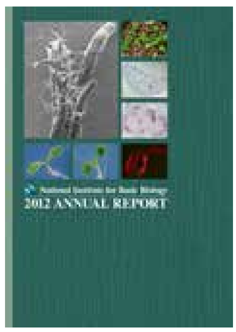
NIBB Open house

Each year, one of the three Institutes in Okazaki opens to the public in the fall. They welcome the public with a variety of events, such as introductions of research contents, exhibitions of research materials and equipment, lectures, etc. NIBB will hold its next open house in 2016.

Annual Report

The Annual Report introduces all the research being done at NIBB. The report is available to download from our homepage at:

http://www.nibb.ac.jp/en/pressroom/publication.html



Access

From Tokyo

Take the Tokaido Shinkansen and get off at Toyohashi, change to the Meitetsu Line and get off at Higashi Okazaki Station (approximately 20 minutes from Toyohashi).

From Osaka

Take the Tokaido Shinkansen and get off at Nagoya, change to the Meitetsu Line and get off at Higashi Okazaki Station (approximately 30 minutes from Nagoya).

From Central Japan International Airport

Get on the Meitetsu bus bound for JR Okazaki Station and get off at Higashi Okazaki Station (approximately one hour from the airport). Alternatively, take the Meitetsu Line for Nagoya and change at Jingu-mae Station to a Toyohashi-bound train and get off at Higashi Okazaki Station (approximately 70 minutes from the airport).

From Higashi Okazaki Station to Each Area

Turn left (south) at the ticket barrier and exit the station.
The Institute is a 7-minute walk up the hill (Myodaiji-area) or 20-minute walk (Yamate-area).

By car

Take the Tomei Expressway to the Okazaki Exit.
(approximately 10 minutes from the Exit).

大学共同利用機関法人
自然科学研究機構
基礎生物学研究所

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Issued in 2014
Edited by the Office of Public Relations, NIBB