Graduate School of Life and Environmental Sciences
Master’s and Doctoral Programs in Biological Sciences
Our research focus is basically in two areas, namely functional analysis of mouse genomes, and epigenetic dynamics during early embryogenesis and germline development. During early mammalian development, a cell lineage maintains its developmental pluripotency. Pluripotent cells in this lineage undergo large-scale changes in epigenetic status by a process called “genomic reprogramming.” This process is involved in phenomena such as X-chromosome inactivation or reactivation and genomic imprinting. Extensive genomic reprogramming also occurs during germ cell development.

To study these complex processes we use various approaches, including genetics, epigenomics, transgenic technology, and bioimaging. The knowledge obtained from these studies can be used to define vital transition points in this lineage and contribute to our understanding of the genes and factors that play important roles in these processes.

Select Publications
My research aim is to apply the strategy used by newts to regenerate their body parts to medical treatments that will save the lives of people who have suffered traumatic injury. I am currently trying to uncover the cellular and molecular mechanisms of newt body-part regeneration, which has been a biological mystery for more than two centuries. I intend to compare these mechanisms with those of mammalian wound healing and tissue repair, as well as with the pathogenic or oncogenic processes that occur after traumatic injury.

Among vertebrates, the newt is the master of regeneration. No other animal can match its ability to regenerate body parts such as the limbs, the tail and spinal cord, parts of the eye (such as the retina and the lens), and the brain, heart, and jaw. This regeneration is mediated by dedifferentiation or transdifferentiation of somatic cells at the site of injury.

Our current focus is on the retina, lens, and limbs. Recently, we established a highly efficient transgenic system using the newt Cynops pyrrhogaster. This is an undoubted breakthrough in our research field and will accelerate the accumulation of knowledge on regeneration of the newt’s body parts (Nature Protocols 6, 600-608, 2011).

Select Publications

In our body, proteins are in a dynamic state; the speeds of protein synthesis and degradation are tightly regulated. Protein degradation is individually regulated by the ubiquitin–proteasome system, which plays critical roles in many biological systems such as embryogenesis, the immune system, and memory.

The major goal of our laboratory is to gain an understanding of

1. the components and regulation of intracellular protein degradation at a molecular level
2. the physiological roles of selective protein degradation in our bodies.

The ubiquitin system
Ubiquitin is a small protein that acts as a degradation signal. Ubiquitin attaches to its substrate by a cascade reaction catalyzed by enzymes, namely E1, E2s and E3s.
(Keywords: Cullin, NEDD8, signalosome)

Proteasome activators
Proteasome is a barrel-shaped multisubunit protease complex that captures and degrades ubiquitinated proteins. The activity of the proteasome is regulated by multiple proteasome activators.
(Keywords: Ecm29, proteasome, PA28, PA200)

My lab is focusing on

1. the regulation and role of Cullin-RING ubiquitin ligase complexes in protein degradation.
2. the role of proteasome activators in protein degradation, by using multiple knockout mice.

Select Publications

The protists are a diverse group of eukaryotic and mostly microbial organisms. Some of them are parasites that have strictly reduced biosynthetic and energy metabolism, because they can acquire most metabolites from their hosts. Still, they have a number of metabolic pathways, which are likely to be essential to maintaining their lives. The purpose of my study is to understand the fundamental metabolic pathways required for life by analysing the strictly reduced metabolism in these protists.

I am especially interested in the metabolic function of the mitosome, an organelle of mitochondrial origin. Whereas mitochondria produce ATP via the TCA cycle and oxidative phosphorylation pathways, the mitosome does not generate ATP and lacks these metabolic enzymes. The only metabolic function that has been found in the mitosomes of *Entamoeba histolytica*, an anaerobic protozoan parasite infecting humans and causing amoebiasis, is sulfate activation. However, we predict that mitosomes possess additional functions, because they contain a number of proteins with unknown functions. Revealing these functions will enable us to understand not only the specificity of the metabolism of *Entamoeba*, but also the evolutionary history of mitochondria in the domain Eukarya.
The Kingdom Fungi is one of the most important on Earth. At present there are 100,000 known species, but the total number is estimated to be over 5 million. Our Laboratory of Mycology is situated in the Japan Alps in the Sugadaira Highland, at an elevation of about 1300 m. It has 30 ha of well-preserved natural fields, including grasslands and Pinus–Quercus forests. The lab has been managed by the late Emer. Prof. H. Indoh (1908–2003), the late Emer. Prof. K. Tubaki (1924–2005), and Emer. Prof. S Tokumasu (1945–).

The Kingdom Fungi is regarded a sister group of the Kingdom Animalia in the supergroup Opisthokonta. But how did fungi originate and diversify? In our laboratory, we are studying the natural history (taxonomy, phylogeny, and ecology) of a wide range of fungal taxa, by using living natural materials, with the aid of molecular biological approaches. Our focus is 1) the biodiversity of the Chytridiomycota and basal lineages of fungi, in order to elucidate the origin of fungi; 2) the biodiversity of the Zygomycota, to examine the interactions between fungi and other organisms; 3) the biodiversity and life histories (teleomorph—anamorph connections) of the Ascomycota and Basidiomycota.

Select Publications

My group is interested in elucidating the neuronal mechanisms of brain development and plasticity, using the fruit fly (*Drosophila melanogaster*) as a model organism. We are particularly interested in analyzing the brain networks involved in higher brain functions such as memory and cognition. Past studies have disclosed unexpected similarities in the genetic programs of brain development in flies and vertebrates. We have demonstrated that the *Drosophila Pax6* genes eyeless and twin-of-eyeless play major roles in the development of mushroom bodies, which are centers for higher brain functions such as memory in the fly brain. In light of these commonalities, we are also studying the molecular and genetic bases of human cognitive disorders such as bipolar disorder and schizophrenia by using the genetic tools available in this fascinating model system.

**Confocal image of the *Drosophila* brain**
Green: olfactory projection neurons labeled with GH146-GAL4.
Red: Homothorax protein expression.
Blue: Neuropiles stained with anti-NC82.

### Select Publications

The environments of the ocean are now rapidly changing as a result of processes associated with human activity. Such processes include eutrophication, increasing water temperatures, increasing CO₂ concentrations, and decreasing pH. These changes are most likely affecting the composition of biota. Structural changes in oceanic ecosystems will be followed by alterations in biogeochemical cycles, including the rate of fixation of CO₂ by photosynthesis, the isolation of abyssal carbon, and the long-term fixation of carbon through the production of refractory dissolved organic matter.

To elucidate the relationships between marine biota and ocean and global environments, we are studying oceanic biological activity in relation to the biogeochemical cycles of bioelements such as carbon, nitrogen, and phosphorus.

The distribution of phytoplankton pigments in the ocean is substantially affected by latitude, because vertical mixing in the cold water regions supplies nutrients to the surface layers. The increase in surface water temperature caused by global warming may cause declines in nutrient supply, phytoplankton biomass, and carbon fixation.

Select Publications


The central focus of our research is to gain insight into the origin and early evolution of eukaryotes. This is currently the most important open problem in evolutionary biology. We are using molecular and cellular biological methods, including comparative ‘omics’ analyses and molecular phylogeny, to approach the evolutionarily interesting issues presented by diverse eukaryotic microorganisms.

One of the goals of our research is to reconstruct a reliable eukaryotic tree. We are continuing to perform phylogenomic analyses using high-performance computing to elucidate the early phase of eukaryotic evolution. By using a refined tree of the organisms of interest, we compare genomic, transcriptomic, and proteomic data so as to trace the evolutionary history of the divergence of cellular functions and molecular mechanisms. Our recent focus is elucidation of the reductive evolution of mitochondria in a diverse anaerobic organismal group, the Fornicata, all of which contain no typical mitochondria but have mitochrondion-related, reduced organelles.

**Giardia intestinalis** is a flagellated organism belonging to a diverse anaerobic group, the Fornicata. It is a mammalian parasite that colonizes and reproduces in the small intestine, causing giardiasis. Tiny double membrane–bound organelles called mitosomes are present in the cell; these are considered to be reduced mitochondria.

(Photo by N. Yubuki)

**Select Publications**

Akira Hirao

Molecular Ecology of Plants

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The study of micro-evolutionary processes in wild plants, underlying the variety of morphological, reproductive and genetic traits associated with diversification, provides the conceptual basis for my research.

I mainly focus on plants inhabiting alpine environments that provide a steep environmental gradient and a large variety of habitat types on small spatial scales. Alpine ecosystems are ideal fields for examining the effect of environmental factors on micro-evolutionary processes in plants. Research approaches involve field surveys and genetic analysis. My past research includes landscape effects on fitness, population genetic structure, and ecotype differentiation in alpine plants. More recently, I have also focused on microbial organisms inhabiting floral nectar, which have potential consequences for interactions among a complex assemblage of plants, pollinators, and microbes.

Mountain landscapes are ideal for examining micro-evolutionary processes in organisms. They provide steep ecological gradients (e.g. altitude, precipitation or snowmelt timing) and a large diversity of different habitats (e.g. fellfield, snowbed or rocks).

Publications
Dynein-family molecular motor proteins hydrolyze ATP and move unidirectionally along microtubules. Although high-resolution crystal structures of their motor domains have been reported, it is still not clear how they change their structures to produce movement. By using cryo-electron microscopy we have analyzed the structures of axonemal dynein molecules complexed to microtubules in different nucleotide states and proposed a model explaining the mechanism of their motility.

Our next goal is to observe the high-resolution structures of dynein molecules during movement, and we are now developing the dynein-microtubule complex cross-linked by DNA origami structures. We are especially interested in how the direction of movement of these proteins is determined and how the two or three motor domains of a dynein molecule are coordinated.

**Select Publications**


We are seeking to improve process-based understanding of carbon dynamics in terrestrial ecosystems by investigating carbon fluxes and pools. By demonstrating such parameters and their relationships with various environmental factors, we will be able not only to estimate carbon sink capacity with high accuracy, but also to demonstrate the features of individual ecosystems. Current projects include

- Responses of alpine grassland carbon dynamics to recent environmental changes
- Relationship between biodiversity and ecosystem functioning in a highly diverse Tibetan grassland ecosystem
- Island ecosystem restoration focused on decomposition processes after the 2000 eruption on Miyake Island, Japan
- Reevaluation of the carbon sink capacity of old-growth forest ecosystems.

Select publications

Animal behavior results fundamentally from the coordinated activity of neural circuits. Our laboratory is studying the relationships among neurons, neural circuits, and behavior in ascidian larvae. These larvae have a very simple central nervous system (CNS) consisting of only about 100 neurons. Despite its simplicity, the CNS of ascidian larvae shares several properties with those of vertebrates. The small number of neurons in these larvae enables us to describe neural circuits at the single-cell level. Our ability to manipulate the activity of individual neurons makes it possible to elucidate how neural circuits function. We are using a combination of optogenetics, in vivo Ca²⁺ imaging, proteomics, and behavioral genetics in the ascidian *Ciona intestinalis* to gain an understanding of the operating principles of the neural circuits underlying animal behavior.

Cilia are microtubule-based organelles that extend from basal bodies and form on the apical surfaces of cells. We are also studying the developmental role and physiological functions of the cilia present in the nervous system of ascidian larvae.

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**Select Publications**


Our research goal is to explore the biological significance of sperm and eukaryotic cilia and flagella by using several marine organisms, including tunicates, sea urchins, sea snails, comb jellies, spiny lobsters, and flounder. The main projects in my lab are as follows:

**Biology of sperm:** Molecular characterization of sperm flagella; molecular mechanism and regulation of flagellar motility; sperm activation and chemotaxis by egg-derived substances; the ubiquitin–proteasome system in sperm function; genomics and proteomics analyses of testis-expressed genes and proteins; molecular mechanisms of spermatogenesis; the structure and function of gastropod parasperm; and the molecular diversity of sperm protein.

**Biology of cilia and flagella:** Structure and function of axonemal dyneins; regulation of flagellar motility by protein kinases and protein phosphatases; molecular architecture of the axoneme; cDNA and proteomics analysis of axonemal proteins; in vitro assembly of the axoneme; functions of cilia and flagella in development of the CNS and the immune system; phylogenetic analysis of ciliary and flagellar proteins; and evolution and diversity of cilia and flagella.

**Select Publications**


**Cilia and flagella**

Left eight panels show sperm from various animals. Right top: comb plate from a comb jelly, as viewed under an electron microscope. Right bottom: scanning electron microscopic and immunofluorescence images of stained parasperm from a sea snail.
Ken-ichiro Ishida

Plant Taxonomy and Phylogeny

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The research interest of my lab is to elucidate the diversity and evolution of photosynthetic protists (algae) and their non-photosynthetic relatives. The following three major subjects are the current focus of my research:

1. **Cellular evolution in endosymbiotic acquisition of plastids:** Plastids originated through primary endosymbiosis and were transferred to the other eukaryotic lineages through several secondary endosymbioses. We are interested in how photosynthetic endosymbionts were integrated as organelles into host cells. This mystery is being uncovered by various approaches, including genomics, cell biology, electron microscopy, and molecular phylogenetics.

2. **Taxonomy and phylogeny of protists:** We are looking for new protist species—especially ones that can be used to connect the missing links in the tree of life. We are collecting protists from the natural environment, establishing clonal cultures if possible, observing them under light and electron microscopes, and performing molecular phylogenetic analyses. We’re the Protist Hunters!

3. **Search for useful protists for biofuel production:** We are also studying how to look for oil-producing algae and protists in natural environments and how to establish cultures of high-performance strains.

Establishment of the Chlorarachniophytes, a photosynthetic protist group with green secondary plastids. A cercozoan protist engulfed a green alga and kept it as a plastid. The plastids of the Chlorarachniophytes still have a vestigial nucleus (nucleomorph) from the endosymbiotic green alga.

**Select Publications**


Mitochondria are dynamic organelles which fuse and divide continuously, and they have evolved with eukaryotic cells, developing a symbiotic relationship and complementing each other. Understanding "normal" and "abnormal" mitochondrial functions is very important to uncover the mechanisms of human diseases.

We are studying the impact of mitochondrial DNA (mtDNA) mutations on cellular or tissue functions using in vitro and in vivo models.

Publications

Takeshi Izawa

Laboratory of Plant Genomics
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Major Research Themes Centered on Furthering our Understanding of Rice as a Crop
1. Statistical modeling of the field transcriptome of rice in fluctuating natural environments
2. Molecular genetics of the control of flowering-time in rice, a model short-day plant.
3. Domestication processes in rice
4. Genome-wide evolution of conserved amino acid motifs in plants.

Select Publications
Original papers
I’m interested in how animal diversity has evolved during the long history of the Earth. Extant animal groups, classified into about 40 phyla, emerged prior to the Cambrian period, roughly 6-5 million years ago. Deuterostomia composed of three phyla – Chordata, Hemichordata and Echinodermata – also emerged around this era. To trace the detailed history of Deuterostome evolution, I have tackled a series of genome-decoding projects of animals standing at key positions in Deuterostome phylogeny. Ascidians, Lancelets, and Acorn-worms are typical examples of such model organisms for understanding Deuterostomia evolution. These genome projects demonstrated the genomic arrangement of each species and encouraged us to reconstruct the chromosomes of the common ancestor of these animals.

In future research, I would like to understand the interaction between environmental change on the Earth and genomic alteration of life. To address this, I am now planning to develop computational tools and a database that illuminate correlations between environmental changes and divergence of organisms.

Three animals which I have studied: left to right, Acorn-worm (*Ptychodera flava*), Lancelet (*Branchiostoma floridae*) and Ascidian (*Ciona intestinalis*).

**Publications**

Akira Kikuchi
Stress Physiology in Higher Plants

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Stress tolerance in higher plants is an interesting phenomenon. Plants are immobile and must evolve defense systems that are uniquely suited to their ambient environmental stresses. Several genes associated with these defense systems have been identified. Our aim here is to generate genetic lines conferring abiotic stress tolerance and to verify their performance. We are also studying the impacts of transgenic plants on biological diversity so as to establish an environmental biosafety risk-assessment system for transgenic plants. In addition, we are trying to elucidate the mechanisms of abiotic stress tolerance in higher plants by using GM (genetically modified) techniques, and we are studying the induction of somatic embryogenesis by abiotic stress. In this way, while elucidating the mechanism of abiotic stress in higher plants, we are also working on the development of abiotic stress–tolerant GM plants that can be used for crop production.

Somatic embryogenesis induced in carrots by abiotic stress
In carrots, somatic embryo production can be induced from apical tip segments by application and removal of stress treatment. The somatic cells are converted to embryogenic cells by the stress treatment. After removal of the stress, the embryogenic cell begins to develop into a somatic embryo.

Select Publications
Masatomo Kobayashi

Plant Physiology and Genetics

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The RIKEN BRC Experimental Plant Division promotes bioresource projects on Arabidopsis, plant-cultured cells, and plant DNA materials. Development and use of novel technologies are important in the promotion of such projects. In our Division we are currently studying the following issues:

2. Development and use of crop genetic resources by applying technologies and information derived from Arabidopsis research.
3. Development of resources and technologies for use with *Brachypodium distachyon*, a new experimental model for monocot plants.

*Arabidopsis thaliana* is an experimental plant that is used in more than 6000 laboratories worldwide. RIKEN BRC preserves more than 600,000 plant materials, including Arabidopsis mutants and full-length cDNA clones produced in Japan.

Select Publications

Germ cells are specialized cells that can transmit genetic materials from one generation to the next through sexual reproduction. All other cells of the body are somatic cells. This separation of germ and somatic cells is one of the oldest problems in developmental biology. In many animal groups, a specialized portion of egg cytoplasm, or germ plasm, is inherited by the cell lineage which gives rise to germ cells. This cell lineage is called germline. The germline progenitors eventually migrate into the gonads, where they differentiate as germline stem cells (GSC) to form eggs and sperm when the organisms are physically matured. Our laboratory aims to find the molecular mechanisms regulating germline segregation, germline sex determination, and GSC niche function in Drosophila.

Publications
Organisms in nature exist not in isolation, but in association with other organisms of different species. One-on-one interactions among species rarely occur in natural communities; instead, the organization of such communities is characterized by complex interactions. Therefore, the understanding of complex sets of species interactions is an important focus of today’s ecological studies.

There are six categories of species interaction: competition, predation, herbivory, parasitism, disease, and mutualism. To date, these interactions have been treated separately, although unified interactions need to be understood to elucidate community-organizing mechanisms. We are trying to elucidate such community-organizing mechanisms by using an interaction-web approach that integrates all aspects of species interaction.

Select Publications
We study the mechanisms of organ development using model organisms, such as African frogs (*Xenopus laevis*) and mice. Several stem cells, such as embryonic stem cells (ES cells), induced pluripotent stem cells (iPS cells), and mesenchymal stem cells (MSC) are promising cell sources for regenerative medicine due to their multiple differentiation abilities. We also investigate the mechanisms of the differentiation of stem cells into various functional cells.

Our goal is to develop methodologies for precise control of the differentiation of stem cells using the knowledge of developmental biology and novel technologies including cDNA libraries and chemical libraries. Especially, we focus on the establishment of reliable methods for the regeneration of important tissues, such as cardiac muscle, lung, and stomach.

Publications

*: equally contributed
We are interested in the fusion of archaeal and bacterial genomes, which is thought to have produced the origin of early eukaryotes. Phylogenetic studies give some information on which archaeon and bacterium were involved in the combination. The archaeon is thought to have been Crenarchaeae, but ambiguities remain about the bacterium. In order to construct an experimental system that enables the genome fusion, we isolated *Thermosipho globiformans*, as a model microorganism for the bacterial counterpart of the fusion, by deploying an in-situ cultivation device of original construction at a hydrothermal vent. We have shown that *T. globiformans* transforms to spheroids, which enlarge from 2 μm to more than 10 μm in diameter, and produces toga-less progeny in the periplasm. The toga-less nature is consistent with the known high susceptibility of Thermotogales to lateral gene transfer, and the progeny production represents a model for the generation of endoplasmic reticulum membrane from nuclear membrane.

Other topics from our laboratory include (1) the isolation of *Thermococcus* species that perform cell fusion, which is possible only with a nucleic acid-staining dye, (2) development of an anaerobic thermophile observation chamber (ATOC) for high-temperature microscopy, which enables live observation of the growth of anaerobic thermophiles, (3) syntrophy between *T. globiformans* and *Methanocaldococcus jannaschii*, which produces methane and is involved in the production of oil components from algae, and (4) effects of hematite (α-Fe₂O₃) on the cocultivation of syntrophic partners in the presence of elemental sulfur, which interferes with the syntrophy.

Select Publications
Hidekazu Kuwayama

Molecular Mechanisms and Dynamics of Biological Self-organization
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[English page is under construction]

Self-reproduction or Self-organization is a characteristic which is observed in all biological organisms. In my lab, we research self-organization using a cellular slime mold, *Dictyostelium discoideum*, as a model system, and a combination of experimental and theoretical methods. My aim is to clarify the molecular system that regulates cell orientation and to simulate its dynamics.

*Dictyostelium discoideum* is a solitary amoeboïd microorganism. It grows as a single cell, but under starvation it initiates chemotaxis towards cAMP, which is secreted by neighboring cells, and constructs a multicellular organism. This feature is simple but very useful for investigating how cells construct multi-cellular organisms. At present, we are focusing on the biological soliton phenomenon which was first discovered in my lab, as well as chemotaxis which involves questions on how cells recognize their environment. We are also interested in disease-causing genes related to biological self-organization. The techniques you learn in my lab are molecular biology, cell biology, developmental biology, genome biology and system biology.

Selected Publications

Ryuichiro Machida

Hexapod Comparative Embryology and Phylogeny

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Our team has been reconstructing the phylogeny and groundplan of the Hexapoda (Insecta s. lat.) by using a comparative embryology approach. So far we have tackled about 20 hexapod orders. Our present focus is on two subjects. The first is the early splitting of hexapods; the figure summarizes our recent advances. The other is the reconstruction of the phylogeny and groundplan of the Polyneoptera, which are composed of 11 orders; the Polyneoptera are difficult to reconstruct in terms of not only the interrelationships between each order but also their groundplan. So far we have studied the following aspects of nine polyneopteran orders: 1) the sister-group relationship between the Grylloblattodea and Mantophasmatodea; 2) the phylogenetic assemblage of the Phasmatodea, Embioptera, and Zoraptera; 3) the inter-group phylogeny of the Dictyoptera, formulated as “Mantodea + [Blaberoida + (Blattoidea + Isoptera)]”; and 4) the affiliation of the Dermaptera with the Polyneoptera.

A large international project has started with the aim of establishing a robust phylogeny of hexapods based on the results of expressed sequence tag analyses. This 1KITE (1000-species Insect Transcriptome Evolution) project has brought together internationally recognized experts in molecular biology, morphology, embryology, and bioinformatics from 19 global institutes of eight countries. The 1KITE project is coordinated through eight core institutes; our laboratory is the only core institute in Japan.

Comparative embryological synthesis of the early splitting of the Hexapoda. The Entognatha, which were previously well supported, are discounted, and the Diplura, which were previously regarded as being an entognathan constituent, are affiliated with the Ectognatha.

Select Publications
Stem cells and regeneration are currently hot research subjects in the life sciences and provide many possibilities for future treatments for major diseases, including organ damage and degenerative conditions. We are studying the mechanisms regulating stem cell maintenance, proliferation, and differentiation. Our experimental system uses the germline stem cells in *Drosophila* oogenesis. We also use neuronal stem cells in the regenerating newt retina and undifferentiated germline cells in developing newt gonads. Our approaches involve genetic, immunological, and molecular biological techniques.

Keywords on our research are “cell differentiation”, “regeneration”, “*Drosophila*”, “newt”, “germ cell”, and “stem cell”.

Steps in developmental potency (left), and a model mechanism of stem cell maintenance (right).

**Select Publications**
Kenji Miura

Plant Molecular Biology

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(1) Elucidation of molecular mechanisms for cold signaling and tolerance (Figure)
ICE is a transcription factor to control cold-regulated genes and cold tolerance. However, how ICE1 is regulated and cold sensor(s) have not been elucidated. To elucidate molecular mechanism, we isolated several interacting proteins of ICE1, including MYC transcription factors, kinases, and calcium-binding proteins. Characterization of these proteins for cold signaling and how these proteins regulate ICE1 are studied.

Cold stress should be perceived by cold sensor (unidentified). Then, ICE1-interacting kinase may activate ICE1 by phosphorylation. Other ICE1-interacting proteins, MYC transcription factors, act like a competitors of ICE1. These molecular factors control expression of cold-regulated genes and cold tolerance. Precise molecular mechanisms for cold signaling and identification of cold sensor(s) are to be studied.

(2) Production of allergens from plant tissues (collaboration with medical doctors)
As a definitive therapy of pollen allergy, sublingual desensitization therapy attracts attention. However, under the present circumstances, an extraordinary labor is required for extraction of allergen to use for this purpose. The aim of this study is production of allergen and extraction of large quantities by using other plants.

Publications
My lab is working on two projects: 1) the cellular and molecular mechanisms of sexual dimorphism of gametes in isogamous, anisogamous, and oogamous green algae; and 2) sexual reproduction in green algae, mosses, ferns, and gymnosperms. Marine green algae belonging to the Ulvophyceae, as well as the unicellular green alga *Chlamydomonas* and land plant sperm, are used mainly as our experimental systems.

**Sexual dimorphism of green algal gametes**

We have been focusing on asymmetric placement of the mating structure (cell-fusion apparatus) in gametes as a feature of sexual dimorphism in green algae. The gamete of green algae belonging to the Chlorophyta has two flagella elongated from the cell apex and a mating structure that is a specialized plasma membrane near the flagellar apparatus. The spatial position of the mating structure differs between the sexes. In the male gamete, the mating structure is located on the opposite side to the eyespot (E), whereas it is located on the same side as the eyespot in the female gamete. As a result of this difference, the two eyespots align on the same side of the planozygote after fertilization. Our lab is trying to elucidate the cellular and molecular mechanisms of mating structure development and placement in green algal gametes. We also aim to elucidate the mechanisms of gamete-type differentiation according to mating-type locus by using *Chlamydomonas* and ulvophycean green algae.

**Select Publications**

Apicomplexan parasites, including *Toxoplasma gondii* and malarial parasites, have an organelle called the apicoplast, which is a kind of plastid and developed from a secondary symbiont of the ancestor of red algae. Apicomplexan parasites have lost their photosynthetic activity because they gained a new, parasitic ability during evolution. However, they still possess the apicoplast, which is essential for their survival. The biology of *T. gondii* and malarial parasites is therefore similar in some ways to that of plant systems because they still have a plant inside the cell. We are investigating the plant-like nature of apicomplexan parasites as a target for the development of anti-parasitic drugs. We are also focusing on the parasitic ability that replaced their photosynthetic ability, and studying how they highjack host functions for their survival.

**Select Publications**

Mitochondrial genome (mtDNA) mutations and the resultant mitochondrial respiratory abnormalities are associated with a wide variety of disorders, such as mitochondrial diseases, neurodegenerative diseases, diabetes, and cancer, as well as aging. By using model cells and mice carrying mutant mtDNAs, we are studying the pathophysiological mechanisms of mtDNA-based disorders; our goal is to develop effective treatment strategies for these conditions.

Select Publications
Until recently, gene expression was thought to be controlled mainly at the level of transcription initiation by repressor or activator proteins. It has now been revealed that other mechanisms can regulate gene expression and involve RNAs that might act as antisense RNAs, sequestering molecules, or thermosensors. Bacterial pathogens sense their environments, and in response, virulence genes are induced or repressed through spatial and temporal regulation. These pathogens are also subjected to stress conditions, which require appropriate responses. Recent research has revealed that RNAs are key regulators in pathogens. Small RNAs regulate the translation or stability of mRNAs that encode virulence proteins, namely proteins that are triggered by environmental cues and stresses. In most cases, these small RNAs act directly on target RNAs by an antisense mechanism.

**Select Publications**


Hiroaki Nakano

Metazoan and Deuterostome Evolution

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We are studying the development of less studied, non-model animal groups, currently focusing on Placozoa, *Xenoturbella*, and sea lilies. Despite their phylogenetic importance, development of these groups are largely unknown, with that of placozoans still remaining a mystery. By revealing their developmental patterns, we aim to gain new information on the evolution of metazoans and deuterostomes.

Placozoa is an amoebae-like marine flat animal about 1mm in diameter, lacking tissues or organs, and even neurons or muscle cells. *Xenoturbella* is a marine animal about 1 cm long lacking typical bilaterian traits, belonging to a new phylum within the deuterostomes. Sea lilies are regarded as the most basal living echinoderm, and we have uncovered its development in 2003 for the first time since it was discovered in 1864.

Placozoa (left) possesses one of the simplest body plans within the metazoans. The simple body plan may represent the ancestral state of metazoans.

*Xenoturbella* (right) lacks an anus, gonads, coelomic cavities, and brain. In 2013, we made the first report of its development, 135 years after it was first discovered.

Selected Publications

Kentaro Nakano

Molecular Dynamics and Cellular Function of the Cytoskeleton

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My goal is to understand the molecular mechanisms regulating cell behavior, including cell division, cell morphogenesis, and intracellular transport, from the perspective of the cytoskeleton. These processes are fundamental to life. In my lab, unicellular organisms are used as a model to this purpose. We are using a combination of several methodologies, including genetics, cell biology and biochemical approaches, to achieve our aims.

Publications
My research is concerned with the molecular mechanisms of signal transduction and its modulation in sensory receptor cells. The techniques we use include electrophysiology (e.g. patch-clamp recording or current recording using a suction pipette), computer simulation, immunocytochemistry, and cell imaging.

We are currently working on olfactory transduction, taste transduction, and phototransduction, as follows: 1) Olfactory transduction: We use olfactory receptor neurons (ORNs) isolated from the newt to study the molecular mechanisms of the inhibitory responses induced by odorants and the physiological significance of these phenomena. We record and analyze the membrane currents activated by various odorants. We are also studying the amino acid responses of ORNs. 2) Taste transduction: We use taste receptors isolated from the frog and mouse to study the signal transduction mechanism and its modulation of taste receptor cells to determine differences in taste perception among animal species. 3) Phototransduction: We use photoreceptors from knock-in mice to study the mechanisms underlying the differences in sensitivity and kinetics between rods and cones.
Temporal coordination of cell proliferation and differentiation is essential for correct morphogenesis in multi-cellular organisms. Although a large number of studies have identified the genes that play important regulatory roles in spatial pattern formation, much less is known about the temporal patterning of development. My laboratory aims to elucidate the molecular mechanisms of developmental timing. We have taken molecular genetics approaches using mainly the fruit fly *Drosophila melanogaster* and the nematode *Caenorhabditis elegans*. Currently we are especially interested in the pathways of biosynthesis of steroid hormones (ecdysteroids and dafachronic acids) for the control of molting, metamorphosis, diapause, the circadian clock, and longevity. We are also studying the juvenile-to-adult switch regulated by evolutionarily conserved microRNAs, transcription factors, and epigenetic regulators.

Select Publications
Our major research interests include unique virulence mechanisms and metabolism of protozoa, particularly the enteric anaerobic parasite *Entamoeba histolytica*. We mainly focus on vesicular trafficking, phagocytosis, autophagy, proteases, amino acid metabolisms, drug development, and organellogenesis. Our research approaches are very robust, and include biochemistry, cell biology, live imaging, multi-omics including metabolomics, and reverse genetics. We always have several foreign students and guest researchers. We welcome you to our laboratory, full of international atmosphere. Our official language is English.

This electron micrograph has captured a moment of phagocytosis of human erythrocytes (red blood cells) by *Entamoeba*. Phagocytosis requires dynamic cytoskeletal rearrangement, membrane trafficking, protein transport, and energy production.

**Select Publications**

To answer numerous questions about cell motility, we have chosen the protozoan *Tetrahymena* as a biological tool. The *Tetrahymena* cell is surrounded by hundreds of cilia, and their beating produces the force that enables the organism to swim in water.

(1) Molecular Mechanism of Cytokinesis

Cytokinesis is the final event of the cell division cycle and results in partition of a mother cell into two daughter cells. *Tetrahymena* actin forms a contractile ring across the presumptive plane of division to contract the mother cell. Before the formation of the contractile ring, p85 and calmodulin localize on the presumptive division plane. We hypothesize that calmodulin and p85 play a role in the initiation of contractile ring formation and that actin and myosin play a role in contraction of the actin ring.

(2) Roles of Actin and Myosin in *Tetrahymena*

Actin and myosin play crucial roles in cell motility that include contractile ring contraction, transport of organelles, and cytoplasmic flow. Because *Tetrahymena* cell is unicellular, we expect that many actins and myosins play a role in maintaining cell functionality. To investigate this hypothesis, we have so far newly isolated 13 candidate *Tetrahymena* myosins and also several actin genes, including novel actin-related genes.

(3) Effects of Black Tea High-molecular-weight Polyphenol on Cellular Metabolism

We have found that black tea high-molecular-weight polyphenol increases mitochondrial membrane potential and swimming velocity in *Tetrahymena* and mouse sperm. These results suggest that this polyphenol increases ATP synthesis by activating cell metabolic pathways such as oxidative phosphorylation, and then increases swimming velocity.

Select Publications

Kazunori Oami

Behavioral Physiology and Electrophysiology

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We are interested in how simple organisms sense the external stimuli and how movements of such simple animals are regulated. We are using electrophysiological and behavioral approaches to explore these mechanisms. Our current projects include chemosensory transduction mechanisms in the protozoan *Paramecium*, the mechanisms regulating behavioral responses in *Paramecium*, and the mechanisms regulating motility in the tentacle of the dinoflagellate *Noctiluca*.

**Select publications**

Kazuharu Ohashi

Floral Adaptation to Pollinator Behavior

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I maintain diverse research interests, with the common theme of plant–animal interactions. My current interest is to understand how plants have evolved their traits to maximize reproductive success, as mediated through interactions with animal pollinators. According to the questions to be addressed, I adopt various approaches in my research: field observations or experiments, mathematical models, computer simulations, and laboratory experiments with bumble bees, which are among the major pollinators in temperate regions.

Some pollinators, such as bees and hummingbirds, learn to visit particular plants in repeatable sequences while collecting nectar or pollen from flowers. My recent studies have focused on the ontogeny and economics of this "traplining" behavior, as well as its possible consequences for floral evolution. I have found that the responses of pollinators to floral traits change significantly as they gain experience, and that this change this could have enhanced the evolution of complex combinations of floral traits. Currently I have been looking closely at floral color change as an evolutionary outcome of such dynamic interactions between plants and learning pollinators.

Select Publications
Our body fights against pathogens by using its immune system, which is a vast, systemic network of specialized cells and diversified molecules. Antibodies play a pivotal role in the immune system by discriminating and attacking infectious “non-self” agents. B-lymphocytes produce antibodies by regulating the rearrangement of antibody genes and maintaining the antigen specificities of antibody molecules. After an infection, subpopulations of antigen-specific B-lymphocytes achieve longevity to form immunological memory, which is reactivated upon infectious challenge a second time with the same pathogen.

My research interests include 1) the molecular mechanisms of antibody repertoire formation by pre-B-cell receptors in the early stages of B-lymphocyte differentiation; 2) the search for immunological niches that sustain memory B cells; 3) new in silico methods for optimizing the antigen-recognition sites of antibody molecules; and 4) establishment of monoclonal antibodies recognizing the universal epitopes of viruses.

Select Publications
Michiyuki Ono

Plant Physiology, Biotechnology, and Gene Literacy Education

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Research in Our Lab

We are probing the universal mechanisms of photoperiodic regulation of flowering. We are using *Pharbitis nil* (*Ipomoea nil*; morning glory), an obligate short-day plant, as well as *Arabidopsis thaliana*, a long-day plant. We have cloned and studied several genes for components of the circadian clock, photoreceptors, floral regulators, and florigen precursors.

As part of our developmental research on GM (genetically modified) plants, we are developing new methods for modifying the shapes and colors of flowers. In collaboration with medical doctors, we have also just started to study the production of edible vaccines by using transgenic crops.

We are investigating ways to deepen secondary students’ “gene literacy” through hands-on laboratory activities. For the general public, we are running activities such as a Science Cafe and Science and Art demonstrations to promote science communication and help scientists to present their work to the public.

Select Publications


Left: Seedlings of *Pharbitis nil* (morning glory) are very sensitive to short-day induction of flowering. Therefore, this species has long been used as a model for studies of photoperiodic induction of flowering. *Pharbitis nil* has been chosen as a model in the National BioResource Project (NBRP, http://www.nbrp.jp).

Right: A genetically modified flower in *P. nil*: the sympetalous (joined petals) corolla has been disrupted to form a choripetalous (separate petals) corolla.
In our lab, two major projects are progressing. One is the study on the development of embryos, asexual reproduction, and life history of marine animals, for example, acorn worms, flat worms, and colonial ascidians. There are many marine animals without names, and their manners of sexual and asexual reproduction are not known at all as well as their life histories.

The other one is on the function called “transplantation immunity” to distinguish allogeneic tissues or organs from autologous ones and to reject allogeneic ones. This function is a big obstacle to the treatment of organ transplants. Then, why do we have that function? Is there anything wrong if a person is a chimera by accepting allogeneic organ? In order to answer those questions, we are studying by using marine colonial animals (ascidians, bryozoans, and sponges) showing the allogeneic recognition similar to the transplantation immunity under natural environment.

Publications
We have developed a new bioassay system to find and evaluate natural bioactive compounds (e.g. phytochemicals, plant extracts, fermented foods, and animal tissues) that influence health and aging; this novel bioassay system uses nematodes to characterize the bioactivity of natural substances. Because of its biological characteristics (easy culture, short lifespan, and availability of mutants), the nematode is a suitable and well-characterized model for investigating the physiology and mechanisms of human aging and disease. We are using this animal to screen for biomaterials with potential benefits for human health.

To promote health (prevention and amelioration of lifestyle-related diseases) and youth (anti-aging and vitality), we are searching for natural bioactive compounds. We are scientifically evaluating the bioactivity of these substances and developing novel bioactive materials. We are also conducting applied studies to develop functional foods, functional feeds, cosmetics, and medicines.

Phytochemicals such as catechin from tea, resveratrol from red grapes, and hydroxytyrosol from olives are famous bioactive compounds that can act against aging and help protect against lifestyle-related diseases. We are using these materials in functional foods, cosmetics, medicines, and other materials to promote health and slow aging.

Select Publications
Vertebrate species derive most of ambient information through photoreceptors, where light is absorbed and signaled to the nervous system. Visual perception initiates with the absorption of light by rod and cone photoreceptors in the retina, which mediate dim light vision and bright light vision, respectively. In addition to this classical vision, light reception by inner retinal neurons or extraocular photoreceptors is thought to be of great importance to animal behaviors such as circadian phase shift and magnetoreception. The aim of our research is to elucidate underlying mechanism of the photoperceptions by which absorbed photons are converted into an electrical response and signaled to the brain. To achieve this goal, we mainly use electrophysiological technique, a powerful tool to characterize molecular mechanism in neurons, in combination with genetically manipulated animals.

**Selected publications**

Our group is studying the mechanisms of development of the ascidian *Ciona intestinalis*. This ascidian is an excellent model, because 1) its genome sequence has been determined; 2) it has quick embryogenesis (~18 h from fertilization to the swimming larval stage); 3) it has a simple body plan, with about 2600 cells making up the body in the tadpole stage; 4) its basic body plan is shared with the vertebrates; and 5) technologies for studying its genetic functions have been established; they include transposon-mediated germline transformation and mutagenesis.

In particular, we are focusing on 1) mutagenesis of *Ciona intestinalis* with transposons to uncover novel gene functions; 2) the molecular and cellular mechanisms of metamorphosis; 3) formation and differentiation of the nervous system; 4) maternal gene functions and egg formation; and 5) the evolution of chordates in terms of genetic function.

**Select Publications**


Yukie Sato

Behavioral Ecology

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The general aim of my research is to reveal the mechanisms of ecological diversification at the level of species and populations, as well as speciation mechanisms. Furthermore, I deal with behavioral variations in different individuals of the same population. In particular, I focus on social behavior and mating behavior in spider mites. Spider mites are small arthropod herbivores less than 1 mm in length. They are good model organisms because they complete their development (egg to adult) in a short period (ca. 5 - 20 days under optimal conditions) and they can be mass-reared in small spaces. These advantages allow investigation of the following projects:

- Kin selection and kin competition
- Geographic variation in lethal male-male combat
- Reproductive isolation among populations showing different male-male aggression
- Evolution of alternative male mating tactics
- Reproductive interference between invasive and native spider mites
- Evolution of social behavior in spider mites

Females of two congeneric spider mites (Tetranychus evansi -left, T. urticae -right), one endemic to Europe and the other invasive, at least partly due to reproductive interference.
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Publications

Kyoichi Sawamura

Mechanisms of Speciation in *Drosophila*

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Do you know what an interspecific hybrid is? Mules from mares and donkeys, leopons from lionesses and leopards… Interspecific hybrids are rare in nature; most of them are sterile and therefore cannot produce descendants. If these hybrids were not rare, then biological species would become fused and lost from the world. In other words, species exist because of reproductive isolation: the origin of new species is completed by acquiring reproductive isolation between populations. Therefore, speciation is a major driving force of evolution. The purpose of our research is to elucidate the genetic mechanisms of speciation.

Our model organism is *Drosophila*. Genomic sequencing has been completed in 12 *Drosophila* species. The biodiversity of this genus is spectacular: 3950 extant species (and 12 fossil species) have been described in the Drosophilidae. Furthermore, *Drosophila* has many crossable sibling species pairs and can be used to provide useful experimental systems for investigating the genetic mechanisms of speciation.

A cross between *Drosophila melanogaster* and *Drosophila simulans* produces unisexual sterile hybrids. We have elucidated the genetic bases of postmating isolation by analyzing mutations that rescue the hybrids from lethality or sterility. The genes isolated so far are *Lethal hybrid rescue*, *Hybrid male rescue*, *zygotic hybrid rescue*, *Nucleoporin 96*, *Nucleoporin 160*, and *JYalpha*.

**Select Publications**

Eukaryotic cilia and flagella are projections on eukaryotic cells. The microtubule-based structure in cilia and flagella is called an axoneme and is composed of molecular motor dynein and several regulatory proteins. The structures of the axonemes have been highly conserved through evolution and play important roles in sperm motility, embryonic locomotion, current generation in epidermal tissues such as the oviduct and trachea, and cell signal reception.

We are using the embryos or sperm of marine invertebrates such as tunicates, sea urchins, fishes and snails to study the regulatory mechanism of ciliary and flagellar movement. Research topics are signaling pathway in sperm motility activation and sperm chemotaxis toward egg-derived substances, and regulation of flagellar and ciliary waveforms. To analyze motility and waveforms in cilia and flagella we are using a high-speed camera, a stroboscopic lighting system, auto-tracking software, and a Ca$^{2+}$-imaging system.

**Publications**

Photosynthetic organisms have played important role in the change in global environment such as decreasing atmospheric CO₂ and increasing O₂ concentrations. Such changes induced the evolutionary change in photosynthetic mechanisms. Especially marine photosynthetic organisms have played key roles in global environmental change during 3 billion years. Using microalgae we study on unique mechanisms that photosynthetic organisms have developed to adapt such change in environment. We especially study on the CO₂ concentrating mechanism (CCM) and unique metabolisms that function for the efficient utilization of CO₂ in microalgae. The coccolithophores in Haptophytes are unique marine phytoplanktons that produce both organic and inorganic products by photosynthesis and intracellular calcification, respectively. The keywords in our laboratory are “The Mechanisms of Carbon Fixation and Metabolisms in Coccolithophores” and “How to Use Coccolithophore’s Potential for the Renovation of Global Environment and Algal Biofuel Production as Renewable Energy Source”.

The coccolithophores were one of important sources of petroleum in Arabian countries and lime stones in Dover, UK. The organisms have a great potential for sequestrating carbon by fixing atmospheric CO₂ and transporting its products to oceanic sediment even at present. Especially, the cosmopolitan coccolithophore Emiliania huxleyi produces a huge bloom and plays a key role for the control of global environment and climate. One of our themes is: “How to use the potential of coccolithophores for reducing atmospheric CO₂, sequestrating carbon and producing oils”.

Publications
Confocal image of mitochondria in kidney from mtGFP-Tg mice. Mitochondria were visualized by using green fluorescent protein. Nuclei are counterstained with DAPI (blue).

Hiroshi Shitara

Molecular Genetics of Mitochondrial DNA in Mammals

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Mitochondria play important roles in cell functions such as ATP production and apoptosis. Mammalian mitochondria contain multiple copies of approximately 16-kbp double-stranded DNA with a closed circular conformation. Two genetic characteristics that are major specific phenomena observed during the inheritance of mitochondrial DNA (mtDNA) are maternal inheritance and rapid segregation. We have been investigating the mode of mtDNA transmission in a mouse model.

Our particular focus is the genetic machinery of rapid segregation. Usually, 1000 to 10,000 copies of mtDNA molecules exist in a single somatic cell, and the mutation rate of mtDNA is higher than that of nuclear DNA. Thus, mtDNA is thought to show heteroplasmcy: in other words, more than one type of mtDNA exists in a cell. However, rapid shifts in mtDNA variants between generations have been observed in several species, and mtDNA homoplasmcy is maintained in most individuals. Our group previously proposed models for the mitochondrial bottleneck effect, which is a concept for the genetic machinery of rapid segregation. We are currently investigating mtDNA and mitochondrial segregation by using transgenic mouse strains.

Select Publications
Living organisms recognize changes in their environmental conditions and regulate their gene expression to acclimate to such changes. However, the molecular mechanisms of signal perception by cellular sensors are not yet well characterized. We developed a way to construct chimeric sensors, which contain a signal-recognition domain from an unknown uncharacterized sensory kinase and a kinase domain from the well-studied phosphate-deficient sensor, SphS, from the cyanobacterium Synechocystis sp. PCC 6803. This system is a powerful tool for studying the functions of sensory kinases and the molecular mechanisms of signal perception, as well as for developing artificial switches to regulate gene expression in systems biology.

Construction of a chimeric sensory kinase in Synechocystis. A phosphate sensor, SphS, regulates expression of the phoA gene encoding alkaline phosphatase (AP). The chimeric sensory kinase containing the signal-recognition domain of an uncharacterized kinase and the kinase domain of SphS regulate the expression of the phoA gene under the conditions perceived by the uncharacterized sensory kinase.

Select Publications
Regeneration and Adaptive Evolution of Wild Plants with Environmental Variation

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My goal is the integration of population ecology and population genetics to elucidate (1) the effects of natural selection due to ecological factors on genes and allele dynamics; and (2) the ecological and population consequences of genetic change. One of our recent targets has been wild Arabidopsis, which is ecologically diverse and genetically tractable. Arabidopsis kamchatica ssp. kamchatica and ssp. kawasakiana are allopolyploids originating independently from the same parental species (see Figure below). Although these allopolyploids inherited identical genome components, they show surprising differences in their ecology. Subspecies kamchatica is a perennial herb with a remarkably wide altitudinal distribution—from 30 to 3000 m—even at a single latitude, whereas ssp. kawasakiana is an annual herb limited to low altitudes. We performed a natural demography census, laboratory and field common-garden experiments, and genome-wide microarray and next-generation sequencing. We found that 1) natural selection and population maintenance mechanisms change with altitude; 2) many traits related to life history, defense, and stress tolerance are genetically distinguished with altitude; 3) populations have evolutionarily adapted to their own altitudes; and 4) there is strong diversifying selection of the genes for trichomes and photoreceptors, and the allele frequencies of these genes change with altitude.

Select Publications
Yukihiko Toquenaga

Population Biology
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I am an associate professor in the Doctoral Program in Biological Sciences at the University of Tsukuba, where I teach ecology, theoretical biology, biometry, and computer programming. I specialize in population biology using a wide range of materials, including natural communities of egrets and herons in the eastern region of the Kanto Plain; laboratory populations of bean weevils collected from all over the world; natural populations of bumble bees in urban and rural regions, and the \textit{in silico} digital bugs that occupy gigabytes on the hard disks attached to my computers. I am using these materials to question, in an evolutionary sense, why some organisms live in groups but others tend to live solitarily. My speciation philosophy was converted to Wrightian from Fisherian when I studied evolution and ecology under Prof. Michael Wade in 1995–1996. I believe that Wright’s shifting balance scheme is realistic. I’m often described as a theoretician, but I consider myself primarily to be an ecological field worker. Somehow I have become good at capturing wild egrets and herons by hand!

The photographs (clockwise from the top left panel) show a larva of \textit{Callosobruchus maculatus}, a notorious bean-weevil pest of legume seeds, constructing a rough wall inside a bean when it happened to break into the cavity of another larva. The larva has used feces and a secreted substance to form the wall. The \textit{C. maculatus} larvae are of the scramble type, so multiple adults can emerge from a bean, but if the wall structure is artificially removed the larva will fight with the other larva in the cavity and one or both of them will die as a result. The rough wall acts as a kind of language that prevents fights between inherently quarrelsome larvae.

Select Publications

Neuron–Glia Network Mediated by Protein Degradation

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Protein degradation regulated by ubiquitin proteasome and autophagy systems in the central nervous system is critically important to the cellular basis of neuronal networks. Perturbation of this cascade causes various disorders, such as neuronal degeneration and mental retardation. The major goal of our project is to understand the mechanisms that underlie the modification of synaptic connections and neuronal inflammation regulated by both neurons and glial cells. We are focusing on how impairment of protein degradation leads to synaptic dysfunction and inflammation in the brain. We are also interested in developing new tools to screen for small compounds and proteins associated with neuronal disorders caused by aberrant protein degradation.

Select Publications
Eukaryotic cells perform a variety of motile activities, many of which are dependent on actin filaments. However, it is not well understood how actin filaments simultaneously perform different functions within a cell. We propose that actin binding proteins (ABPs) and mechanical strain induce cooperative conformational changes of actin filaments, and the resultant structural polymorphism is correlated with the functional diversity of actin filaments. To test this, we are performing a series of biochemical and biophysical experiments, taking advantage of our unique system to express recombinant actin.

Publications
Our interest is in the evolutionary processes of various animal body plans. We are especially interested in the following issues.

1) Establishment and evolution of the chordate body plan. Chordates acquired several novel characters such as notochord, dorsal central nervous system, vertebrae, and pharyngeal arches. We explore how these novel organs evolved by comparing developmental genetics in amphioxus and lampreys.

2) Evolution of echinoderm larval morphology. Echinoderms show two types of larvae, pluteus and auricularia. We asked how these discrete larval morphologies evolved by comparing developmental genetics in sea urchins and starfish.

3) Evolution of bivalve shell plate in bivalve mollusks. Bivalve mollusks acquired bilaterally separated shell plates, and this unique morphology is visible as early as the gastrula stage, showing that the separated shell plates are established by modifying their early embryogenesis.

4) Establishment of the unique body plan of caprellids. The unique body plan of the caprellids was established from a gammarid-like body plan through the loss of some thoracic limbs and abdominal segments. We are seeking the genetic modification response for this loss. We are interested in this phenomenon because some caprellid species re-acquired the limbs.

Expression of pax3/7 and soxE, whose homologues are involved in the differentiation of the dorsal neural tube in vertebrates, mark dorsal part of the acorn worm nerve cord, showing that acorn worms possess similar DV patterning mechanism in their nerve cord. (Miyamoto and Wada, Nature Comm. (2013).

Publications


Organisms interact with other organisms and with their ambient environments. Because these processes are components of ecosystems, we need to understand not only biological activities but also environmental factors if we are to understand ecosystem mechanisms.

Although humans receive various ecological services from marine ecosystems, the mechanisms by which this occurs are less well understood than in terrestrial ecosystems. We are trying to figure out the dynamics and flows of organic matter derived from marine organisms (e.g., macroalgae, phytoplankton, and bacteria) by using field investigations and chemical analyses. Recently, we have been focusing on 1) the fate of macroalgal organic matter; 2) ocean acidification and its effect on marine organisms; and 3) biotic and abiotic formation of marine snow particles.

Selected Publications
Kazuo Watanabe

Plant Genetic Diversity, Environmental Biosafety, and Bioethics

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The research interests at the University of Tsukuba are
1) Molecular genetic and cytogenetic studies aimed at the conservation and genetic diversity of underutilized species, with an emphasis on crop species in developing countries
2) Production of transgenic plants and environmental biosafety assessment of transgenic plants, with an emphasis on biological and genetic diversity.
3) Sustainable enhancement of the germplasm of genetic resources by using biotechnology applications, with an emphasis on polyploid species and polyploidy genetics.
4) Multidisciplinary studies as part of biodiplomacy associated with United Nations agendas in various international forums. Such studies include sharing of access to, and the benefits from, genetic resources, biosafety, and bioethics, with an emphasis on legal, socioeconomic, and developmental issues.

Select Publications
Mamoru Watanabe

Conservation Ecology

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For my doctoral research, I studied swallowtail butterfly life history strategies in relation to host-plant dynamics under secondary succession. I now have a strong interest in the behavioral ecology of the Lepidoptera and Odonata. My current research is on the sperm competition, reproductive strategies, and life-history strategies of butterflies and dragonflies; I have been a student of butterflies for more than 30 years.

In addition to the study of life-history strategies, my work is motivated by the desire to provide scientific recommendations for conservation of an endangered damselfly. Throughout 10 years of the mitigation project, the extinction risk for the damselfly has now reduced. Papers and a leaflet on the project are available.

In 1998, a tiny habitat of the brackish water damselfly, Mortonagrion hirosei, was discovered in Ise, in Mie Prefecture, Japan. It was a dense reed community in brackish water in an area reclaimed after the construction of a sewage plant. To preserve the local population of the damselfly, we started a mitigation project. We quantified the insect's population parameters, life history, and behavior and the salinity tolerance of its larvae. We also measured the abiotic environment. A technique for evaluating habitat availability was developed. Now, the population has increased in both the original and an established habitat, and the mitigation project has proved successful.

Select Publications
Carefully considered public communication of science and related issues is vital for a healthy relationship between science and the society that both depends on and supports it. It is becoming increasingly apparent that this communication is multifaceted, highly complex, and must be better understood to face the challenges of our progressively science-reliant society.

I have broad academic interests in the areas of public perceptions of science and scientists; the portrayal of science in news and the media; risk perception; and the use of visual media to communicate science concepts and issues in informal education settings.

I develop and conduct undergraduate and postgraduate courses in communication skills and introductory science communication. These courses are designed to equip students to effectively communicate their future research. In a previous life I trained in marine biology and environmental chemistry, and worked on projects searching for potential new drugs from marine invertebrates.
The primary research goal of our lab is to understand the molecular mechanisms of embryonic axis specification and formation in the sea urchin. It has been suggested that this embryo has two independent, maternally specified axes, primary (anterior–posterior) and secondary (dorsal–ventral). My previous work [3] showed that specification of these two axes is linked by a single transcription factor, FoxQ2, during early embryogenesis. The linking pathway involves a double repression mechanism in which Wnt/ß-catenin signaling, which is essential for primary axis specification, represses FoxQ2, which represses both the nodal expression required for secondary axis specification, and BMP2/4, a factor downstream of Nodal. My goal is to try to understand how FoxQ2 is related to, or interacts with, those signaling pathways like the Wnt/ß-catenin, Nodal, and BMP2/4, which are responsible for axis specification and formation.

Another research goal is to understand the molecular mechanisms of neurogenesis, including the specification and patterning of the neurogenic ectoderm that develops at the anterior end of the sea urchin embryo.

Blocking Wnt/ß-catenin signaling produces permanent blastulae with an expanded anterior neurogenic ectoderm. Left: Serotonin (green) and synaptotagmin (magenta) in a normal embryo. Right: The number of serotonergic neurons is increased in the Wnt/ß-catenin–blocked embryo.

Select Publications