2017 Survey on Promoting Development in Okinawa:
Practical survey on forming an innovation ecosystem in Okinawa

Research Activity Report at OIST

March 2018

Japan Economic Research Institute Inc.

Introduction

The Okinawa Development and Promotion Bureau of the Cabinet Office analyzes and evaluates prospective efforts towards the formation of domestic and international innovation ecosystems, which has served as an impetus for activities in Okinawa along with the utilizing of exchanges of opinions with various players involved in ecosystem formation in the prefecture. Such activities include a survey project conducted with an aim to prepare basic materials essential for potential ecosystem formation in Okinawa.

In implementing the survey project mentioned above, it was necessary to fully examine the research activities of the Okinawa Institute of Science and Technology Graduate University (OIST), which is expected to play a key role in the formation of ecosystems in Okinawa. In preparation of realizing this purpose, it was important for each player to firmly grasp the research activities and other advancements made at OIST before exchanging opinions; thus, it was deemed necessary to produce and utilize materials that could present OIST's research activities in a straightforward manner.

This booklet is the result of the endeavor mentioned above and has been arranged for the use of existing and potential players as reference when exchanging opinions on ecosystem activity.

The preparation of this material was carried out by Japan Economic Research Institute Inc. and was commissioned by the Okinawa Development and Promotion Bureau of the Cabinet Office. In addition, a portion of the document preparation for this booklet was entrusted by Japan Economic Research Institute Inc. to Institute for Future Engineering.

To finish, We would like to thank everyone at the Technology Development and Innovation Center who gave us their full cooperation in preparing this material.

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Okinawa Institute of Science and Technology (OIST)

The OIST Graduate University shall conduct internationally outstanding education and research in science and technology, and thus contribute to the sustainable development of Okinawa, and promote and sustain the advancement of science and technology in Japan and throughout the world.

Central Concept

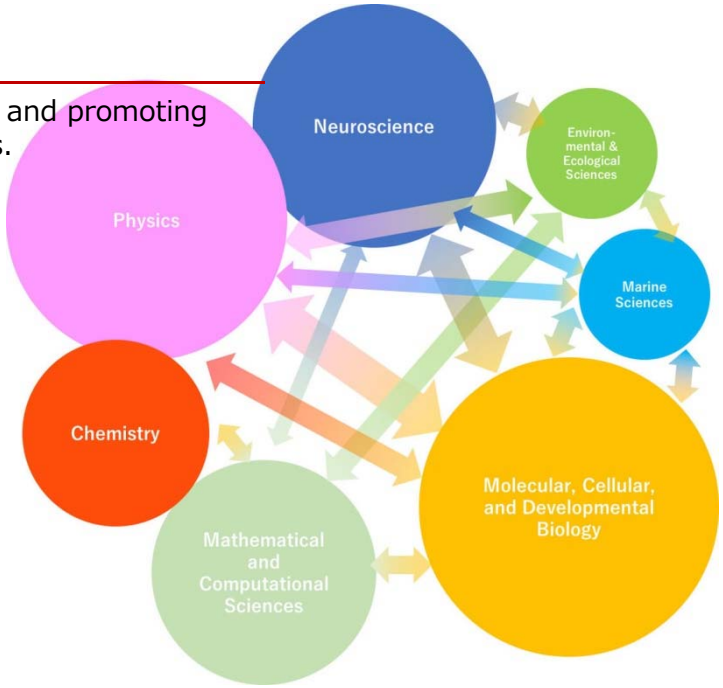
- **Best in the World** : Recruit the best students in the world to work in an environment that encourages creativity, uniqueness, and diversity.
- **Flexible :** Encourage innovation, creativity, and adaptability; accommodate new initiatives; ensure a thoroughly interdisciplinary academic environment; and treat every student as a unique individual.
- **International** : Recruit over half of the faculty and student body from outside of Japan and use English as the official language.
- **Global Networking** : Host, attend, and participate in international meetings, conferences, workshops, and other events to enhance the university's visibility and increase research and education opportunities.
- **Collaboration with Industry** : Create an environment where research outcomes are developed and applied by industry for the benefit of society, the sustained development of Okinawa, and the competitiveness of Japan.

Campus（Onna-son, Kunigami-gun Okinawa, Japan ）

Research Fields

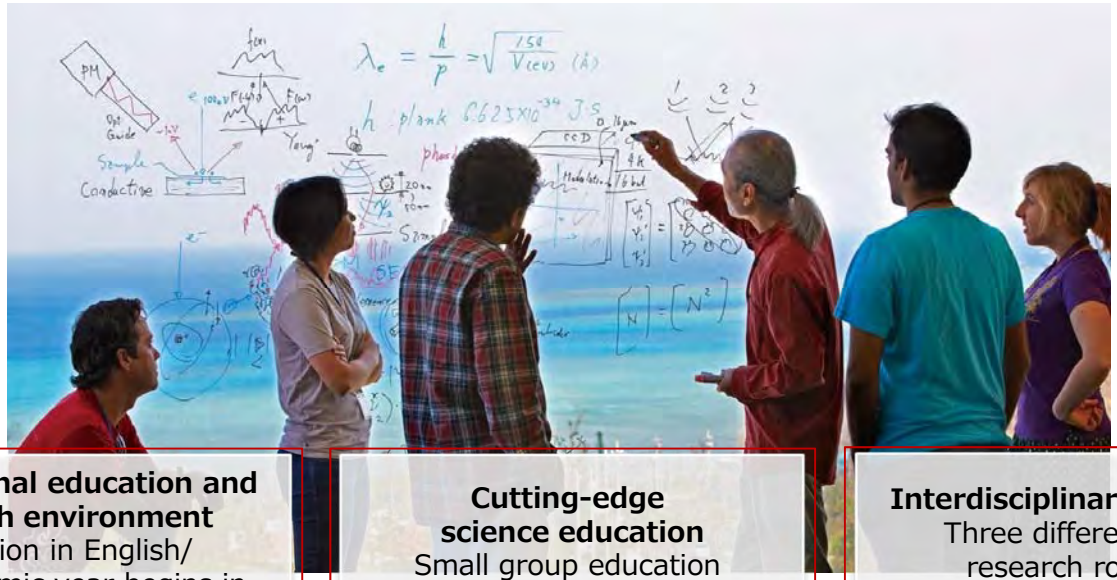
Seven fields are integrated into one graduate school, and promoting interdisciplinary research beyond the field boundaries.
Currently, 59 research units are active.
(As of August 2017)

- Physics
- Chemistry
- Neuroscience
- Marine Science
- Environmental and Ecological Sciences
- Mathematical and Computational Sciences
- Molecular, Cellular, and Developmental Biology



Education

OIST offers the innovative doctoral course program for five years.



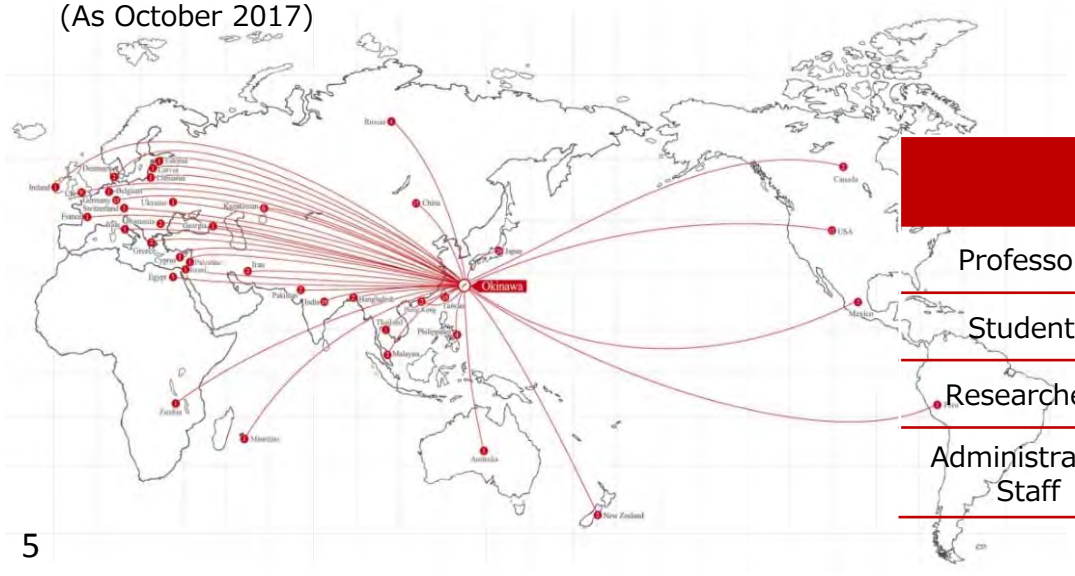
International education and research environment
Education in English/
The Academic year begins in September

Cutting-edge science education
Small group education by world-class faculty

Interdisciplinary education
Three different fields research rotations

Students and Staff Members

1,028 students and staff members have gathered from more than 50 countries.
(As October 2017)



	Japanese	Non-Japanese
Professors	22	39
Students	28	129
Researchers	154	232
Administrative Staff	360	64

The Technology Development and Innovation Center fosters innovation ecosystem in Okinawa to create new businesses and industries based on R&D.

Organization

Technology Development Innovation Center is working as a one-stop shop office relating to industry-academia collaboration and technology transfer activities in OIST, to develop the inventions born from the laboratories into innovation that brings social and economic benefits.

- **Technology Licensing Section** builds a strong intellectual property portfolio of licensable technologies from discoveries made by OIST researchers and markets these technologies to established companies for commercialization.
- **Business Development Section** works closely with OIST researchers and companies to enable innovative research partnerships and negotiates sponsored and collaborative contracts with industry.
- **R&D Cluster Programs Section** supports developmental research projects that move discoveries made in OIST laboratories towards commercialization. The Section also promotes the development of Okinawa as regional center of R&D with OIST as a core component.

Series of support

Technology Development Innovation Center offers a series of support related to intellectual property and commercialization of research results.

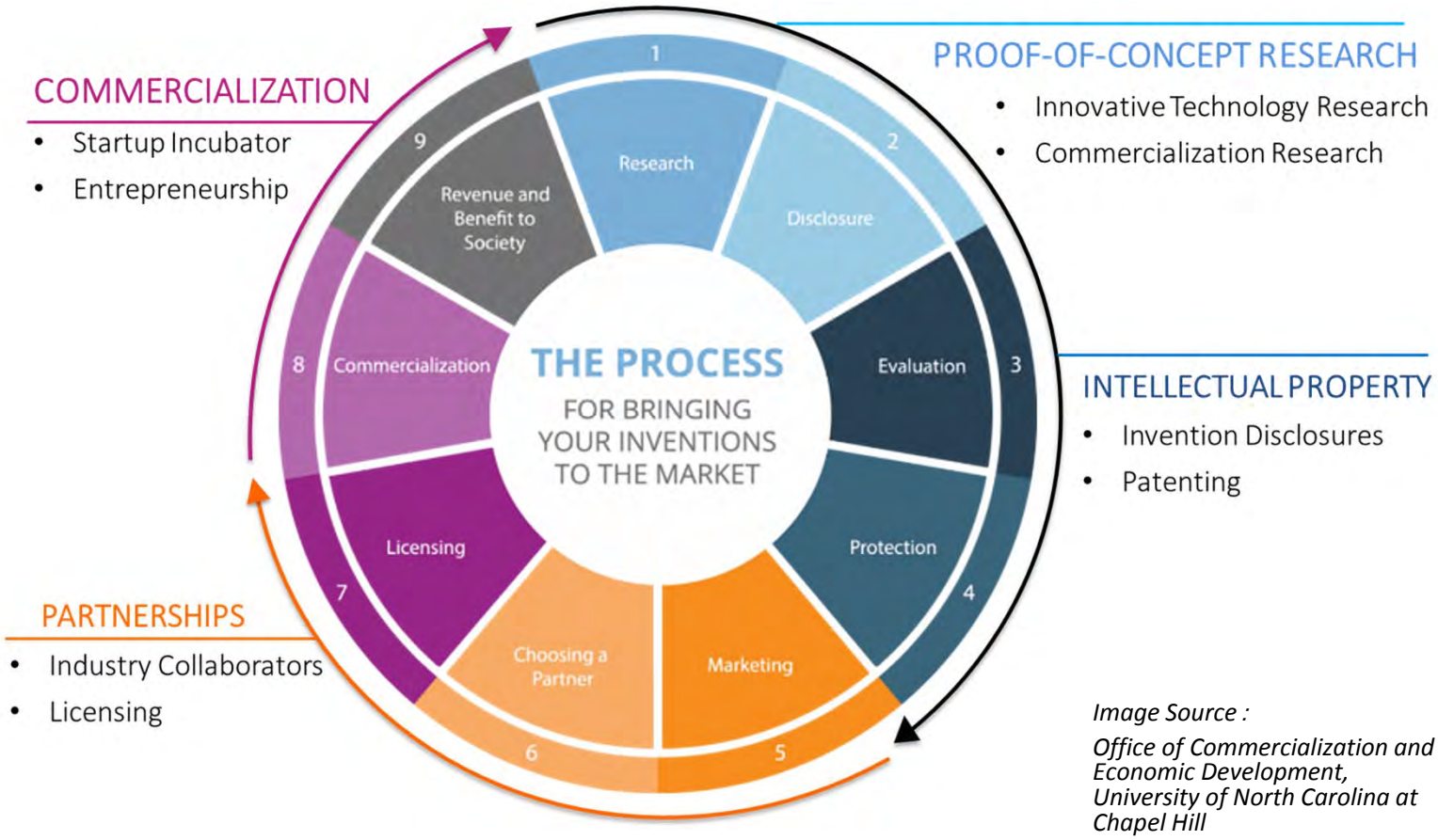
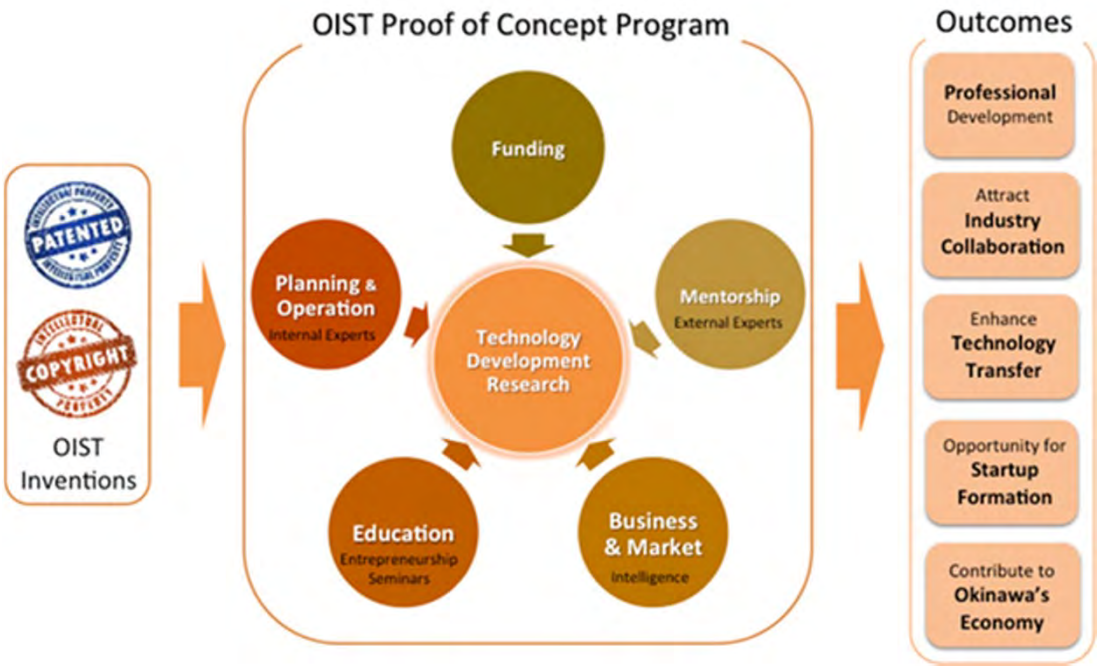


Image Source :
Office of Commercialization and Economic Development, University of North Carolina at Chapel Hill

Proof Of Concept Program

The OIST Proof of Concept (POC) Program is an internal, competitive funding program that is designed to help bridge the technical and funding gap between lab discoveries and commercialization, thereby enhancing the impact of OIST research on society.



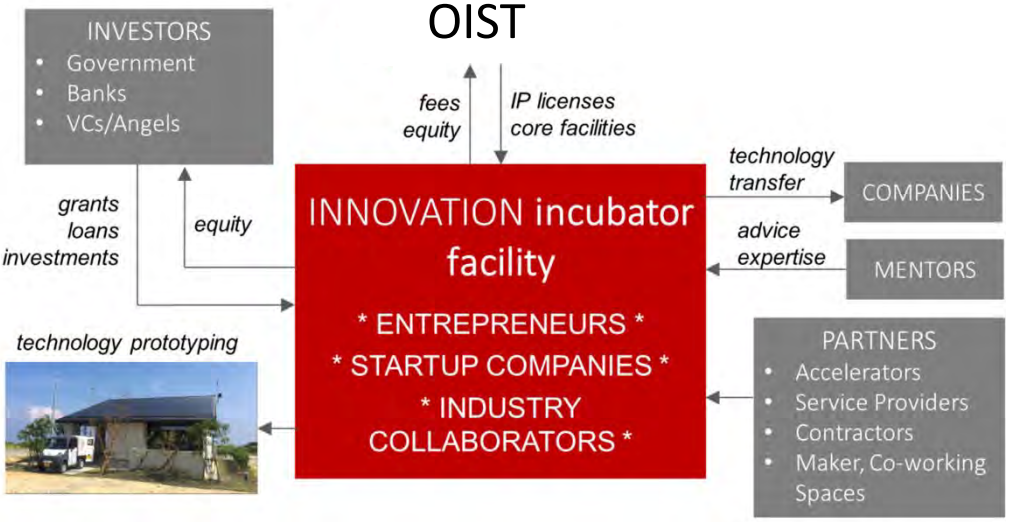
Creating Ventures from OIST

OIST is also promoting the creation of high growth venture businesses in Okinawa, and holds seminars and workshops aimed at building networks and promoting entrepreneurial activities. In addition, it is also directly supporting promising projects derived from OIST's research.

Okinawa Protein Tomography Ltd. (Okinawa PT), which provides a molecular-structure-analysis service, was born as the first startup from OIST in 2014.
Now, preparation is advancing towards the second venture establishment from OIST based on the waste water treatment technology using a microbial fuel cell.

The future efforts towards the innovation ecosystem creation in OIST

OIST is planning to set up an incubator facility that will serve as a base for entrepreneurs and start-up companies.
In addition to providing laboratories and offices, the incubator facility brings OIST's excellent research results and other innovative ideas to commercialization by intangible support such as finance and legal aspects is prepared to be offered.



Research

Luminescent Molecules that Inhibit Cancer Metastasis (Ru-complex)

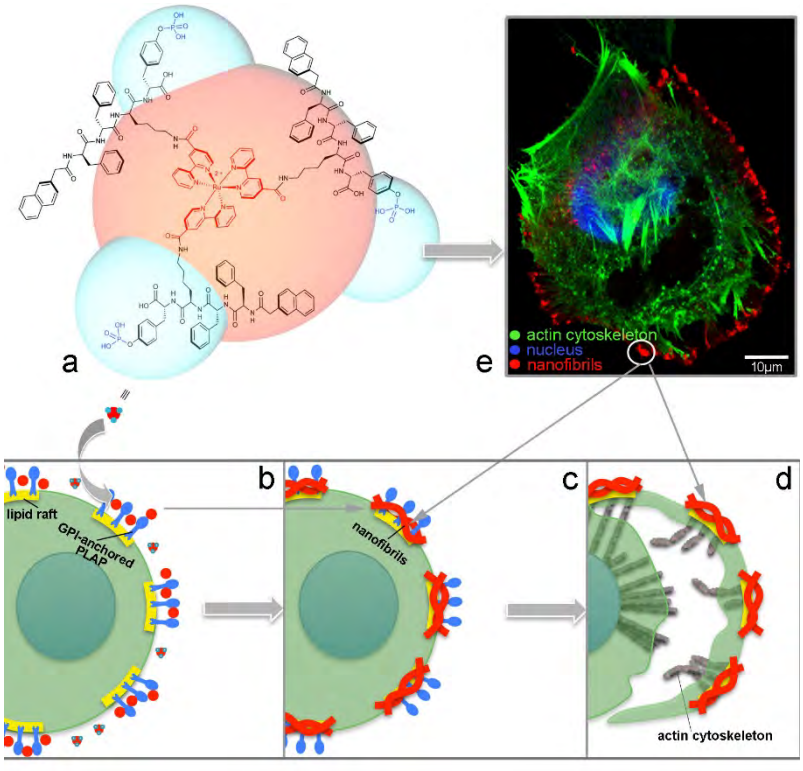
Expectations for the new therapy development that prevents cancer metastasis

Research background

Cancer metastasis, that is another tumor formation by cancer cell migration from the original site to a distant site, is a major health threat. In order to inhibit the cancer cell migration (locomotive movement of a cancer cell), scientists have tried to approach the problem of cancer migration by targeting molecules that are specifically or highly expressed in cancer cells, but finding an appropriate target has proved challenging.

Research

For cell morphogenesis and cell migration, a cytoskeleton, that is a complex network of interlinking filaments inside the cell, is necessary. The cytoskeleton is combined with the lipid raft on the cell surface. The research team in OIST succeeded in producing the luminescent molecule (Ru-complex) which inhibits cell migration by interacting with this lipid raft. The luminescent molecules are selectively combined with the enzyme “glycosyl phosphatidylinositol anchor placentas alkaline phosphatase (GPI-anchored PLAP)“ highly expressed on lipid rafts of cervical cancer cells and they self-assemble into nano-scale fibers (nanofibers). Lipid rafts are further tied off by formation of nanofibers on lipid rafts. Consequently, the associated cytoskeleton components get tied up, pinning the cancer cell on the substrate and preventing it from moving at that site. In response, the cancer cell tries to migrate away from the immobilized site and expands the cytoskeleton, but the mechanical force by the cytoskeleton ultimately ruptures the cell. It is also possible to target different types of cancer cells by modifying the structure of the luminescent molecule. A new window can be opened in cancer therapy if it works on real tumors in animals. (Published in "Chem" magazine of Cell Press)



Luminescent molecules that inhibit cell migration:
a) A luminescent molecule is combined of three peptide molecules which attach the phosphate group (light blue) centering on the Ru- complex (red). b) The luminescent molecules react with PLAP on lipid rafts of cancer cells to lose phosphate groups, c) self-assemble to form nanofibers and fix the cells at the periphery of the cancer cells. d) Cancer cells rupture and die as a result of excessive expansion of the cytoskeleton to escape. e) Visualization of cell rupture by immunostaining of cervical cancer cells.

Keywords

Polymer chemistry, Soft matter, Tumor biology, Molecular biology, Cell biology

Applications/Future development

- Operative verification of the luminescent molecule by animal experiment
- Development of luminescent molecules targeting different types of cancer cells

Opportunity for joint research and technology transfer

- Contract research companies in biopharmaceutical R&D : provide luminescent molecules.

Introduction of the research unit

Bioinspired Soft Matter Unit

Unit leader : Ye Zhang Assistant Professor

Nature designs materials as hierarchical architectures with complex composite structures spanning the nano to near-macro length scales to create unique combinations of properties that are often difficult to achieve with synthetic materials. The task of the Bioinspired Soft Matter Unit is to understand such amazing mechanisms and develop new man-made materials to mimic the structure, properties or performance of natural materials or living matter.

<Related research theme>

Development of the photosensitizer for more effective photodynamic therapy

In the photodynamic therapy used for the treatment of a brain tumor, when a drug called a photosensitizer is injected into the bloodstream and then the drug-filled cell is exposed to light, the photosensitizer in the drug will emit active oxygen and it will annihilate a cell. Photodynamic therapy is a precise targeted therapy that acts locally on the area containing cancer cells and does not damage normal surrounding cells. On the other hand, for further improvement of photodynamic therapy, research of the more effective photosensitizer is continued. In Bioinspired Soft Matter Unit, hypothesis on a new way of constructing a photosensitizer by adding the natural amino acid taurine into the Ru-complex's chemical makeup. After observing the effects of this new photosensitizer on cancer cells, it was found that the taurine-modified Ru-complexes were able to enter cells effectively while maintaining the conventional function, and that a large amount of active oxygen was generated when exposed to light. Furthermore, it became clear that the new substance developed this time is effective especially for brain tumors among cancer cells. (Published in "Chemical communications" published by the Royal Institute of Chemistry)

Research unit website : https://groups.oist.jp/bsmu

Targeted Drug Delivery System

Development of the drug delivery system opening new therapies

Research background

Currently, drugs are administered in a systemic way and tissues or organs that do not need the drug receive it, leading to unwanted side effects. Recent advances in nanotechnology and biology are opening up the possibilities in targeted drug delivery system (DDS), where drugs or compounds can act specifically on target tissues or pathogens, and it is expected to be put to practical use at an early stage.

Research

In Parkinson's disease, a neurodegenerating disease, impairment appears in a motion of the body with shortage of neurotransmitter dopamine. In OIST, the research team discovered a new method to repetitively release dopamine freely using a laser, through interdisciplinary study beyond the field of neurobiology and physics.

As for the method, at first, dopamine is confined in a lipid or fat capsule called liposome tethered to a gold nanoparticle. When the capsule is irradiated with femtosecond laser, the energy of laser is absorbed by the gold nanoparticles and then transferred to the liposome, the capsule is opened and the inner dopamine is released.

The length of time and therefore amount of dopamine released can be precisely controlled by the intensity and length of time the laser is on. Moreover, since liposome is not destroyed by laser, the release of dopamine contained within the liposome can be repeated and controlled.

From now on, the actual proof using living body tissues or animal organisms progresses, and if patterns that dopamine is secreted in a normal brain can be copied and reproduced, great progress will be brought to the treatment of Parkinson's disease. The technology of releasing a wide variety of drugs, compounds and naturally derived compounds to the necessary places in the required amount and timing as desired expands new possibilities to the medical field, not limited to Parkinson's disease. (Published in the electronic journal "Scientific Reports")

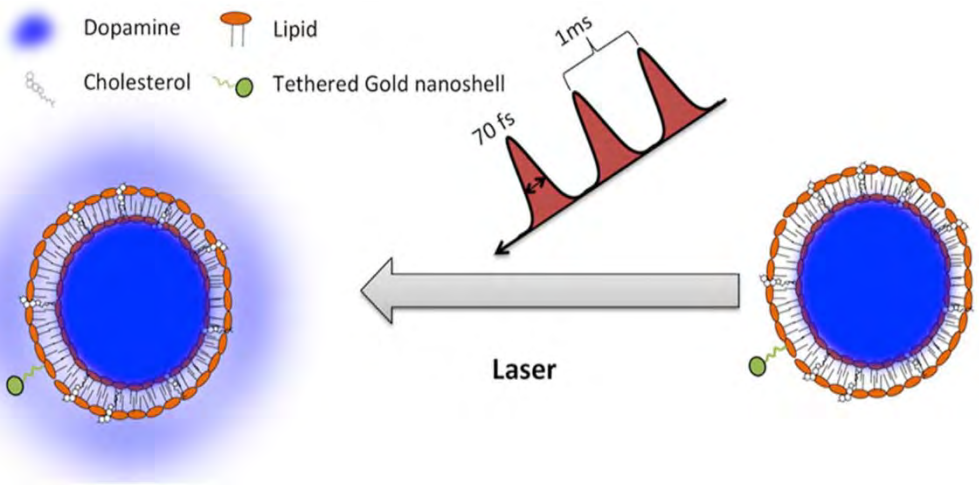


Diagram of liposome encapsulating dopamine that is tethered to a gold nanoparticle. The liposome is then activated with the laser, which releases the dopamine. Diagram courtesy *Scientific Reports*

Keywords

Neuron・Synapse・Neural circuit, Neurodegenerative disease, Femtosecond laser, Drug delivery system

Applications/Future development

- Verification of the effectiveness of laser-activated liposomes in living tissues and animals.
- Identification of the DDS targets in other diseases.

Opportunity for joint research and technology transfer

- Currently accepting contacts from companies interested in joint research and licensing of this technology

Patent protection
PCT/JP2014/083496「METHOD FOR CONTROLLED RELEASE WITH FEMTOSECOND LASER PULSES」（US : 15/103,423 EU : 14870369.7）

Introduction of the research unit

Neurobiology Research Unit

Unit leader : Jeff Wickens Professor/Dean of Graduate School

The goal of the Neurobiology Research Unit is to understand neural mechanisms of learning in the brain. The Unit studies physical changes that take place in synapses due to learning experiences, and how these changes depend on dopamine, a chemical that plays a key role in motivation. This research has the forward goal of developing better treatments for disorders such as Parkinson's disease and attention-deficit hyperactivity disorder.

Research unit website : https://groups.oist.jp/nru

Femtosecond Spectroscopy Unit

Unit leader : Keshav Dani Assistant Professor

Using intense, ultrafast laser pulses, the Femtosecond Spectroscopy Unit explores the optical properties of matter. Its members study graphene and other two-dimensional materials for their potential in transparent, flexible electronics; research semiconductors for photocatalytic and solar energy applications; and investigate applications of ultrafast laser pulses to biology and medicine.

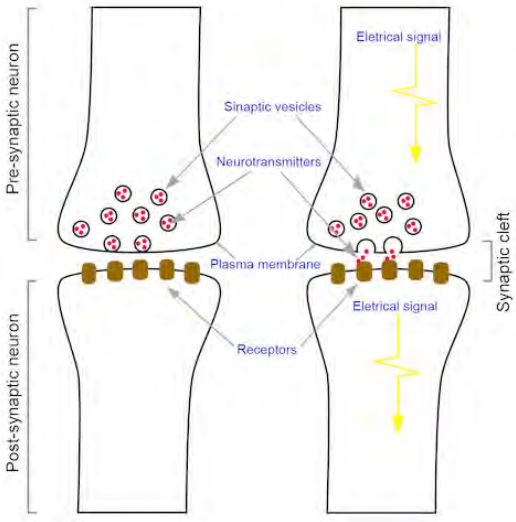
Research unit website : https://groups.oist.jp/fsu

Media Supplement for Giant Synapse Culture

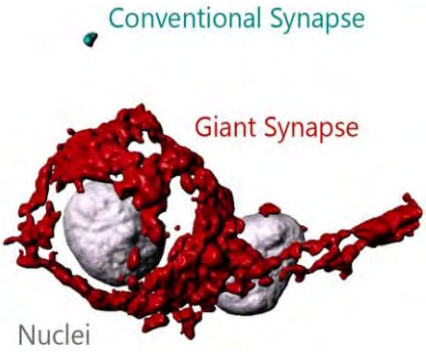
Technology for giant synapse culture may pave the way for progress in synaptic research

Research background

Transmission of information between neurons is carried out via synapses, the point of contact between two neurons. Recent research suggests that synaptic malfunction occurs in the early stages of neurodegenerative diseases, such as Alzheimer's disease and Parkinson's disease, requiring scientists to elucidate the synaptic mechanism which may subsequently lead to the development of remedies for treating such diseases. In their inherent state, synapses are far too small, leaving it difficult for scientists to observe its internal dynamics, even with the assistance of powerful microscopes. Brain stem sections of mice can provide researchers with big synapses called calyx of Held, which are serviceable for scientific analysis, though such brain stem sections are perishable and can only be used for experiments of up to 24 hours. In addition, the neuron cell density of such sections is high, a restriction that renders it nearly impossible for scientists to isolate a single synapse for experimentation.



When an electrical signal arrives at a terminal of one neuron, chemical messengers called neurotransmitters contained within synaptic vesicles are released in the synaptic cleft. The released neurotransmitters bind to receptors on the cell membrane of the next neuron(post-synaptic neuron), which in turn trigger an electrical signal that is transmitted along the next neuron.

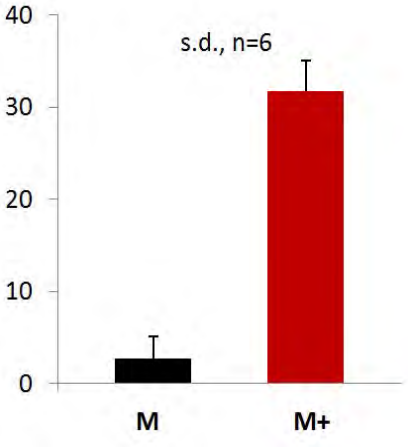


3D reconstruction of different types of synapses.

Research

Following the discovery of some specific factors vital to promoting the formation of giant synapses, a type of media supplement was successfully developed to cultivate large synapses with morphologically and physiologically similar properties to those of calyx of Held. The cultured synapse has a volume ratio 2000 times the size of a normal synapse, making it possible for scientists to conduct studies using high-resolution imaging as well as oversee long-term experiments of up to about 30 days which allow them to manipulate and record the effects of gene expression in neurons. What's more, drug screening through in-vitro testing can be efficiently managed. These potential undertakings provide new possibilities for specific research which aims to elucidate the function of synapses. With the technology to cultivate giant synapses, mechanisms of synaptic malfunction can be investigated and the development of new therapeutic agents for some neurological diseases can be expected to accelerate.

(Published in "Journal of Neuroscience")



Assessment of synaptogenic effect of standard culture medium without (M) and with (M+) the medium supplement of this technology. Vertical scale is number of giant synapses per 35 mm dish.

Keywords

Neuron･Synapse･Neural circuit, Neural information processing, Neurodegenerative disease, Electrophysiological screening

Applications/Future development

- Construction of a synapse model for identifying neural signaling pathways
- Identification of novel neural drug targets for neurological conditions, including Alzheimer's and Parkinson's diseases

Opportunity for joint research and technology transfer

- Reagent manufactures (cell culture technology) : create in vivo-like environment on a plate to culture giant synapses, including those from the central nervous system, the auditory and visual system, and the neuromuscular junction.
- Contract research companies in biopharmaceutical R&D : provide accessible synapses in-vitro for the development of new treatments for neurological diseases including Parkinson's, Alzheimer's, and ADHD diseases

Patent protection

PCT/JP2012/002129 "Neuronal culture medium and method for producing in vivo-like and enhanced synaptogenesis neuron model" (JP : Patent 2014-547209 US : 14/388,340 EP : 12872506.6)

Introduction of the research unit

Cellular and Molecular Synaptic Function Unit

Unit leader : Tomoyuki Takahashi Distinguished Professor (Fellow)

The Cellular and Molecular Synaptic Function Unit strives to understand the mechanisms that regulate neurotransmitter release at synapses by studying the calyx of Held, a synapse large enough to enable simultaneous measurements od presynaptic and postsynaptic electrical signals. Insights into synaptic transmission should lead to a better understanding of neuronal communication.

<Related research unit>

Elucidation of the mechanism for synaptic vesicle transportation within the presynaptic terminal

Impairment in the release of neurotransmitters is known to cause certain neurological diseases. Neurotransmitters carried within synaptic vesicles may fail to reach their intended targets along the passage. By tracking the trajectory of vesicle movement using giant synapses, scientists have noted that the movement of a vesicle within the presynaptic terminal is not randomized by simple diffusion as thought before, but rather active towards its intended target and has been found to have mobility in its movement. Further comparison experiments with smaller synapses have revealed that the movement of vesicles varies with size and type of synapses as well as with the molecules that form the vesicles. (Published in "eLife")

Elucidation of the mechanism responsible for the onset of Parkinson's disease

Research has found that excessive expression of the protein "alpha-synuclein" in neurons is associated with the development of Parkinson's disease, a neurodegenerative disease. Experiments using giant synapses have revealed a mechanism which results in toxicity due to excessive expression of alpha synuclein, causing impairment of the sustained maintenance of neurotransmission. (Published in the online version of "The Journal of Neuroscience" published by the North American Neuroscience Society)

Research unit website : https://groups.oist.jp/cmsfu

Mechanism of Differentiation of Rogue Th17 Cells Causing Autoimmune Disease

Discovery of new molecular mechanisms leading to the development of breakthrough therapies for autoimmune diseases

Research background

The self-defense mechanism to protect the body from invasion of pathogens such as bacteria and viruses is called “immunity”. When the immune system stops functioning normally, its biogenic substances and cells will be recognized as "foreign bodies" and will be attacked, and the symptoms of autoimmune diseases, such as rheumatoid arthritis, ulcerative colitis and multiple sclerosis, will appear. These diseases are increasing especially in advanced countries, and it is supposed that there are 700,000-800,000 patients of rheumatoid arthritis also in Japan. Many autoimmune diseases are designated intractable diseases selected by Japanese government, and development of the therapeutic methods have been an important issue.

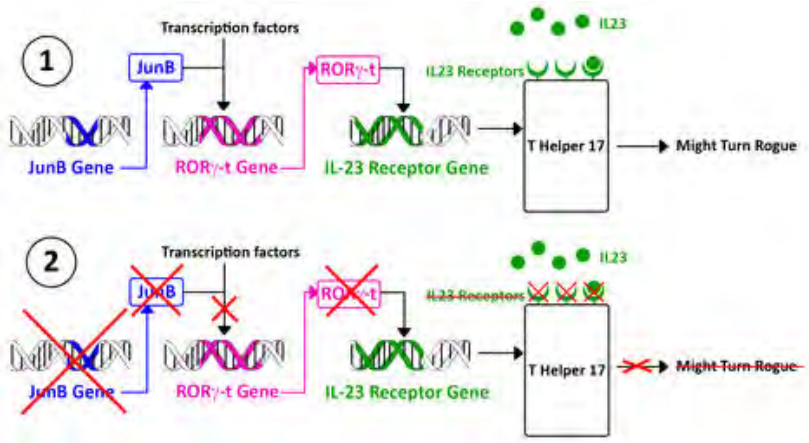
Until now, it is already clear that “Th17 cell” a type of T Helper cell (lymphocyte) which is an immune cell, is closely involved in the onset of autoimmune diseases. However, there are healthy and rogue ones in Th17 cells, and Th17 cells help maintain the normal function of the intestine, while they differentiate into rogue and have a very high ability to induce inflammation. Therefore, the therapy development for the autoimmune disease targeting only Th17 rogue cells, rather than healthy Th17 cells, is underway around the world.

Research

The differentiation to Th17 cells from T Helper 17 cells (naive T cells) produced in the thymus is induced by two or more cytokines (TGF-beta, IL-23, etc.). In particular, it is known that IL-23 is involved in the differentiation of naive T cells to rogue Th17 cells and induces autoimmune diseases by differentiating healthy Th17 cells into rogue cells. However, it was not clear what kind of molecular mechanism promotes the differentiation of rogue Th17 cells by IL-23.

In OIST, 283 transcription factor proteins expressed in Th17 cells was investigated, and it was shown clearly that the transcription factor "JunB" is necessary for differentiation inducing of rogue Th17 cells by IL-23. On the other hand, in mice experiments, it was also found that JunB is not required for differentiation of healthy Th17 cells.

This suggests that JunB may be a therapeutic target for new autoimmune diseases with minimal side effects that aim only at toxic Th17 cells and do not affect healthy Th17 cells. Regarding autoimmune diseases, the current central therapy is to suppress the whole immune system, but with this therapy there is a problem of reducing the ability of the patient's body to fight the disease. This research result will bring a new way to the present situation. (Published in a English science journal "Nature Communications")



1) The normal process in which JunB can activate the Interleukin 23 (IL23) receptor gene to make the T Helper 17 cell sensitive to Interleukin 23. This potentially lead to the T Helper 17 cell to turn toxic. 2) Knocking down JunB prevents the production of Interleukin-23 receptors, and the T-Helper 17 cell cannot turn rogue any longer, but is still able to fight infections.

Applications/Future development

- Elucidation of the transcription control mechanism by JunB in Th17 cell
- Elucidation of JunB's involvement with diverse functions of Th17 cells

Opportunity for joint research and technology transfer

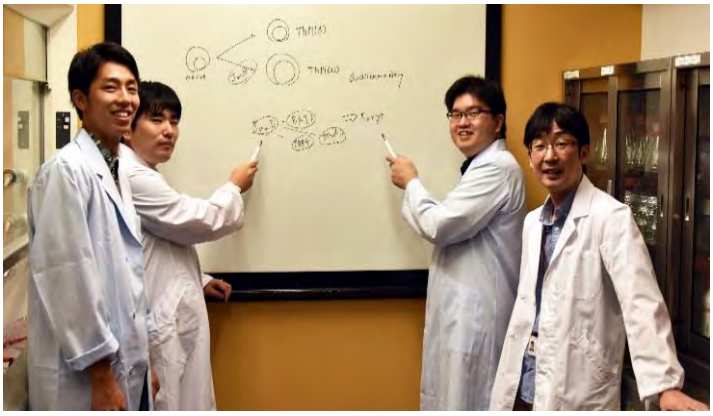
- Joint research with pharmaceutical companies: identify the drugs that control the activity of JunB

Introduction of the research unit

Immune Signal Unit

Unit leader : Hiroki Ishikawa Assistant Professor

All animals and plants have an innate, or non-specific, immune system to fight infection and disease. Unlike innate immune system remember pathogens they have encountered. The immune Signal Unit studies how cells in the adaptive immune system and form memories of pathogens, with the aim to design more and better vaccines.



<Related research theme>

Elucidation of molecular mechanism of innate immune system

All animals and plants have some form of non-specific innate immune system, that is an organism's first and immediate weapon against infection or disease. This system is considered evolutionarily older than the adaptive immune system, a more specialized defense that researchers believe evolved in the first jawed vertebrates over 450 million years ago. The innate system always responds to pathogens first and this subsequently activates the adaptive system. Only working as a pair can they defend the body successfully.

"STING (stimulator of interferon genes)" is an important gene that controls the response of immune cells, and in knockout mice lacking STING, the entire innate immune system cannot defend the mice themselves against these pathogens, leaving them lethally susceptible to even the weakest infections.

Research unit website : https://groups.oist.jp/isu

Mechanism of Post-transcriptional Regulation of Fat-burning Gene (Ucp1)

Elucidation of a fat-burning promotion mechanism by latest gene research

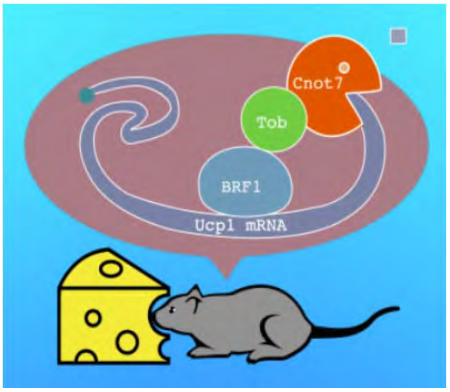
Research background

Obesity is a risk factor for lifestyle-related diseases such as diabetes, hypertension, heart disease, cancer, and has become a global problem. However, no safe and effective medical treatment is available so far, and countermeasures are limited to individual efforts such as healthy lifestyle, exercise and dietary restrictions.

Up to 100 kinds of genes related to body shape or metabolism have been identified so far, and uncoupling protein 1 (UCP 1) is synthesized by one such gene. UCP 1 has the function of generating heat from stored fat as a raw material in mitochondria of brown fat cells. It is already known that UCP1 decreases with obesity, its decrease causes less heat generation that proceeds fat accumulation, and obesity progresses further. However, the detailed mechanism at the genetic level of the increase and decrease of UCP1 was not known.

Research

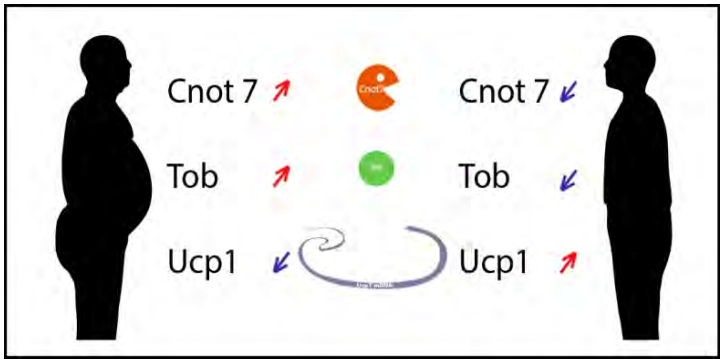
Since the genetic information of DNA is copied to a messenger RNA (mRNA) (transcription) and protein is synthesized (translation) based on mRNA information, mRNA is an important substance which controls the gene expression amount. In OIST, the experiments using mouse fat tissues revealed that the proteins called Cnot7 and Tob bind to Ucp1 mRNA and degrade it, then expression of Ucp1 gene is suppressed, and fat burning is inhibited as a result.



Decomposition of Ucp1 mRNA by Cnot7 and Tob :
The degradation of UCP1 mRNA in fat cells is mediated by Cnot7 and Tob.

While the expression amount of genes synthesizing Cnot7 and Tob increases in fat tissues of obese mice, the expression amount of Ucp1 gene in fat tissues of mice deficient of these genes increases remarkably, and even when eating the same amount of high calorie diet compared with normal mice, obesity tended to be less likely to occur.

If identification of compounds that inhibit the function of Cnot7 and Tob and suppress Ucp1 mRNA degradation proceed, it may lead to discovery of anti-obesity drugs. Moreover, it can be expected to be applied to livestock industry etc. by promoting Ucp1 mRNA degradation and increasing the weight of livestock. (Posted on Cell Press's open access electronic journal "Cell Report")



The mechanism of obesity at the gene level:

Obesity correlates with the increase of Cnot7 and Tob, which reduce Ucp1. This suggests that lean individuals have less Tob, Cnot7, and higher concentrations of Ucp1.

Keywords

DNA, mRNA degradation, Gene, Obesity, Deadenylase enzyme

Applications/Future development

- Identification of the compound promoting fat burning

Opportunity for joint research and technology transfer

- Contract research companies in biopharmaceutical R&D : required material transference agreement (MTA) on candidate inhibitory compounds
- Pharmaceutical company: conduct joint development of anti-obesity drugs

Introduction of the research unit

Cell Signal Unit

Unit leader : Tadashi Yamamoto Professor

Using a mouse model, the Cell Signal Unit explores the cause of various diseases that include cancer, neuronal disorders, immunological diseases, and diabetes/obesity at the molecular level. Practically, the Unit studies biochemical reactions that cells use to respond to environmental cues with special emphasis on mechanisms by which unneeded RNA copies are destroyed to silence gene expression.

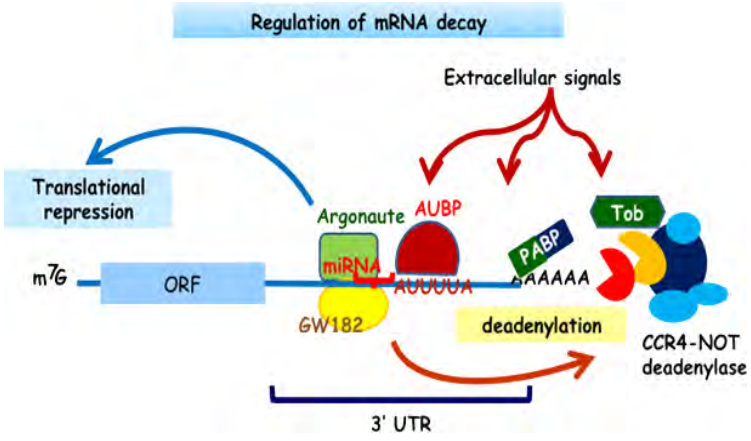
<Related research theme>

Revealing the physiological role of CCR4-NOT complex

The CCR4-NOT complex composed of at least 11 subunits including Cnot7 plays an important role in deadenylation (mRNA degradation) of mRNA as a transcriptional regulatory factor. By creating and analyzing knockout mice lacking the genes of each subunit of the CCR4 - NOT complex, it has been elucidated that the CCR4 - NOT complex is involved in a wide range of biological phenomena such as energy metabolism and spermatogenesis.

Elucidation of the molecule mechanism of programmed cell death

Planned suicide of cells is called "programmed cell death (PCD)", which is an important mechanism in maintaining organismal development and tissue homeostasis, such as eliminating old cells that are incapable of maintenance or dividing, or potentially harmful cells. On the other hand, neurodegeneration results from too many cells being culled by PCD and leads to incurable diseases such as Huntington's, Alzheimer's, and Parkinson's. It became clear that deficiency of Cnot3 which is a subunit of a CCR4-NOT complex leads to necroptosis, which is a kind of PCD, and some human inflammatory diseases such as rheumatoid arthritis and psoriasis have been shown to be due to dysregulation of the CCR4-NOT complex.



Research unit website : https://groups.oist.jp/csu

Technology to Make and Analyze Ribozyme Mutants

Development of a new method in ribozyme research

Research background

DNA base information is copied to RNA, protein is synthesized based on the information of the RNA, and the protein catalyzes various chemical reactions in vivo as an enzyme. In the early 1980s, an RNA enzyme (ribozyme) acting as a catalyst was discovered, and it was revealed that RNA is involved in both genetic information and biochemical reactions. Later, it has been known that ribozymes exist in various organisms including vertebrates, but many of their roles and functions have been still unclear.

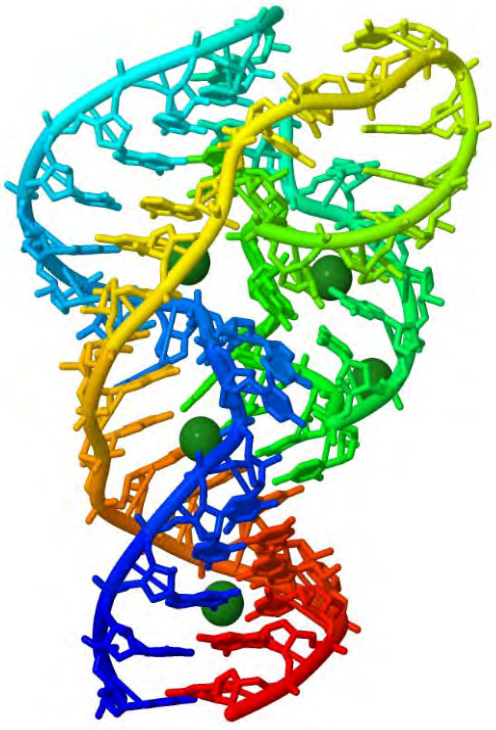
When studying the structure and properties of ribozymes, researchers usually make a mutant in which a specific base of a ribozyme is replaced with another base, and examine the change in functional aspects, etc., by the mutation. A 'single' mutant is a ribozyme that differs in only one base from the original ribozyme, and a 'double' mutant differs in two bases from the original ribozyme. For example, even for the small ribozyme made of 48 bases, there are 10,296 single and double mutants in total, and the conventional techniques allow only to make about several tens of variants at most in one experiment. Therefor, researchers must select arbitrary parts of the ribozyme as mutation targets, thus potentially overlooking other parts of the ribozyme that may be important for its function.

Research

In OIST, using a high-performance DNA sequence analyzer, researchers made mutants for specific ribozymes comprehensively, and developed a new method of verifying those mechanisms. By using this new method, all single base and double base mutants in "twister type ribozyme" found in rice genome were made and their catalytic activities were measured, whereby the base important for the activity of the ribozyme has been identified.

Moreover, since a significant fraction of the mutants retained detectable ribozyme activity, the ribozyme is highly robust against mutations.

Deeper understanding of ribozymes could allow the technical development to control gene expression in living cells and viruses applying the knowledge, and in the future it is expected to lead to progress in gene therapy and regenerative medicine. (Published in Angewandte Chemie magazine)



3D structure of the "twister ribozyme"

Applications/Future development

- Control of the gene expression by a ribozyme
- Application to gene therapy or regenerative medicine

Opportunity for joint research and technology transfer

- Currently accepting contacts from companies interested in joint research and licensing of this technology

Introduction of the research unit

Nucleic Acid Chemistry and Engineering Unit

Unit leader : Yohei Yokobayashi Associate Professor

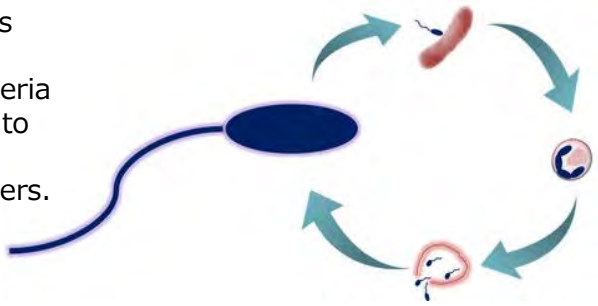
Nucleic acids DNA and RNA are fundamental building blocks of life. These biomolecules display remarkable chemical functions such as information storage, catalysis, and molecular recognition. The Nucleic Acid Chemistry and Engineering Unit's goal is to harness the versatile chemistry of nucleic acids to design and engineer functional nucleic acids (DNA, RNA, and their synthetic analogs) that operate in test tubes, devices, and living cells.

<Related research theme>

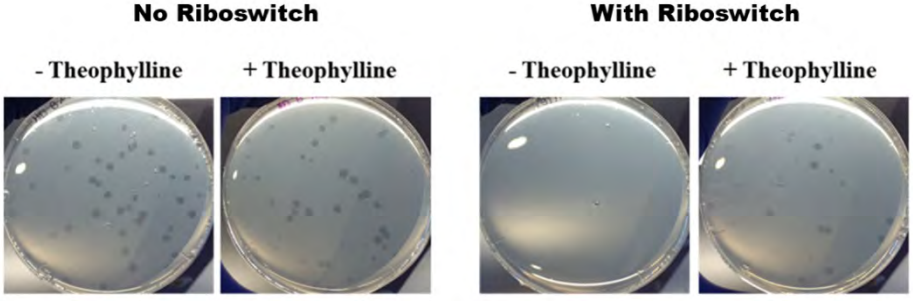
Research of predatory bacteria towards development of new antibiotics

While bacterial resistance to antibiotics increases and it becomes difficult to treat infectious diseases such as tuberculosis and gonorrhea etc., attentions have gathered for the predatory bacteria called "living antibiotics". Bdellovibrio bacteriovorus is harmless to humans yet lethal to its prey "Gram-negative bacteria" which includes baddies such as E. coli, Salmonella, Legionella, and others. Currently researchers are developing genetic manipulation techniques to control the timing and extent of predation of Budellovibrio bacteriovorus.

(Published in ACS Synthetic Biology issued by American Chemical Society)



Bacterial predation by *B. bacteriovorus*



Petri dishes containing *B. bacteriovorus* and its prey *E. coli*.

Research unit website : https://groups.oist.jp/naceu

Resistant-Starch Okinawan Rice

Resistant-starch Okinawan rice aiming at prevention of lifestyle-related diseases

Research background

In recent years in Okinawa Prefecture, the obesity rate for both men and women, lifestyle-related disease prevention of the prefecture's population is recognized as and urgent issue. Although carbohydrates such as rice are decomposed into glucose in the process of digestion and used as a major energy source, excessive glucose causes lifestyle-related diseases such as obesity and diabetes.

The rice strain rich in starch which is hardly degraded to glucose is called a resistant-starch rice, and "Amiromochi" was developed at Kyushu University about 30 years ago as such. Amiromochi has a harder texture and inferior taste compared to conventional rice, and the yield when cultivating in Okinawa is reduced to about half compared with Honshu due to the influence of climate and others.

Grain of rice

Research

In the OIST prefecture-commissioned project “Nutraceutical Okinawan Rice Development to Prevent and Improve Lifestyle-related Diseases" (a sectoral outstanding performance award (in R&D and new technology sector) of The Food Action Nippon Award 2015) , researchers bred Amiromochi with a local variety “Yugafumochi" suitable for the climate of Okinawa, and developed a new resistant-starch rice variety that can obtain high yields even in subtropical climates. Due to efficient selection by molecular analysis and genome analysis using the next-generation genome sequencer and shortening of the vegetation period by an artificial climate chamber, field experiments are also initiated in less than three years from the start of the project.

The field test site of the new strain of resistant-starch rice:
The field test started in 2015.

Furthermore, in collaboration with the University of the Ryukyus School of Medicine, Osaka Prefecture University, Ishikawa Prefectural University etc., benefit assessment of the new rice strain is underway. Suppression of increase in blood glucose level, decrease in cholesterol level and decrease in lipid accumulation in the liver were verified in the experimental evaluation using mice, and clinical trials in humans are also conducted jointly with the University of the Ryukyus Hospital.

The new strain of resistant-starch rice can be applied to various foods, and the development of processed food products using rice flour has also started. While lifestyle-related diseases like type 2 diabetes have become life-threatening issues not only in Okinawa Prefecture but around the world, the resistant-starch rice has become a highly desirable disease prevention tool that can be applied to a weight loss method without dietary restriction.

Applications/Future development

- Market creation of the resistant-starch rice by health food development and others using the resistant-starch rice.

Opportunity for joint research and technology

- Food processing companies: develop processed food products using the resistant-starch rice.
- Medical related companies: conduct clinical trials for the prevention of lifestyle-related diseases such as diabetes.

Patent information
Varieties registration application pending

Introduction of the research unit

Plant Epigenetics Unit

Unit Leader : Hidetoshi Saze Assistant Professor

Genes dictate many aspects of how living things look and act, but genes are also controlled. Epigenetics, is the study of mechanisms that determine whether a gene is active or not, and thus whether it has any effect on an organism. The Plant Epigenetics Unit studies epigenetic regulation in Arabidopsis and rice. It is also improving traits of rice crops by applying genomic information obtained by high-throughput sequencing technology.

<Related research theme>

Elucidation of the mechanism for suppressing the influence of transposable elements

Approximately 98% of the human genome is made of “junk DNA” which does not have genetic information, and much of junk DNA originates from a gene group called transposable elements or “jumping genes”. The transposable elements jump around and insert themselves randomly in other parts of the genome, and these insertions are often deleterious because they could alter gene expression in a way that induces genetic disease. While defense mechanisms are known to stop other molecules from binding to the intruded transposable elements and stop the transcription of a different sequence into mRNA, it is newly found that transcription of normal mRNA progresses by joining the protein named IBM 2 to the transposable elements in the experiments using Arabidopsis. (Published in "Nature Communications")

Research unit website : https://groups.oist.jp/peu

Biomolecule Patterning Technology in Microfluidic Devices

Big hope for disease diagnostic applications brought by nanoscale new technology

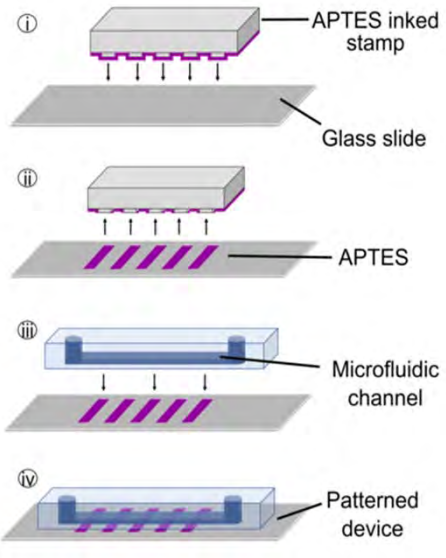
Research background

The specific substances which increase or decrease in vivo by being affected with disease are called biomarkers, and used as indicators of the status of disease and degree of cure. Disease diagnostic device kits which can measure the concentration of disease biomarkers within a patient's biological sample simply, fast and in low cost are required in clinical sites, and the kits with built-in microfluidic devices have been in use in recent years. When body fluids, such as blood and urine, are put into the diagnostic device, a biomarker in the body fluid is captured by a bio-receptor (protein) which is placed in advance on the sensor surface of the device, and the concentration of the biomarker can be calculated from the fluorescence intensity by adding a fluorescent dye that binds to the captured biomarker.

Although bio-receptor molecules can be transcribed and placed on the substrate surface of the device by microcontact printing (μCP) technology, when applying this technology to the nanoscale for DNA molecules and the like, deformation of the stamp shape and damage of the bio receptor occur and affect the diagnostic result.

Research

In OIST, researchers have developed a micro/nano printing technology as a new procedure to create a pattern of a bio-receptor in a microfluidic device. As a procedure, first, a water-soluble ink (APTES: silicon and oxygen compound) that captures the bio-receptor is transferred to the substrate, and then the bio-receptor is chemically linked to the pattern of APTES molecules formed. By using this technique, it is possible to avoid problems such as reduction in the activity of bio-receptor molecules in nanoscale patterning, and to produce a high-resolution bioassay (bioassay) system with long shelf-life at high speed and at low cost. In addition, one stamp allows to produce a substrate on which different types of bio-receptor molecules are arranged and this feature is expected to contribute to diagnosing complex diseases such as cancer that relies on tests by many biomarkers at the same time. (Published in "Analyst" issued by the Royal Institute of Chemistry)



A micro/nano printing technology:
(i) Applying the APTES solution to the stamp surface, (ii) pressing the stamp surface to transfer the APTES molecules onto the glass substrate, (iii) combining the microfluidic structure with the patterned glass surface, (iv) attaching bioreceptors to the pattern of the APTES molecules in each flow path, and then a sensor element such as a test kit is completed.

Keywords

Bioassay, Surface patterning, Microcontact printer, Nanocontact printer

Applications/Future development

- Nanoscale DNA assays, protein assays
- Development of a microfluidic integrated device by combined with a business-use microcontact printer etc.
- Low volume applications
- Establishment of point-of-care diagnostic method

Opportunity for joint research and technology transfer

- Licensing to diagnostic medical equipment makers etc.

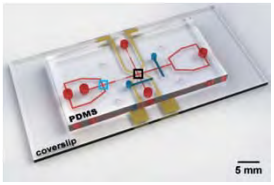
Patent protection
PCT/JP2017/003621「MICRO- AND NANOCONTACT PRINTING WITH AMINOSILANES: PATTERNING SURFACES OF MICROFLUIDIC DEVICES FOR MULTI- PLEXED BIOASSAYS」 (US : provisional 62/290,067)

Introduction of the research unit

Micro/Bio/Nanofluidics Unit

Unit leader : Amy Shen Professor

The Micro/Bio/Nanofluidics Unit focusses on using complex fluids and complex flows to create objects with morphology and structure tailored precisely for applications in biotechnology, nanotechnology, and energy. The unit employs lab-on-a-chip platforms with analytical capacity to study the physics of flow, the transport of mass, momentum, and energy, and reactive processes at nano- and micron length scales. Novel device designs have the potential to significantly enhance understanding of single-cell behavior, development biology, and neuroscience. These strategies can be used to address challenges in drug screening and the development of bio- and chemical-sensors for disease, security, and environmental monitoring.



Microfluidic device : performing mixed separation and the chemical reaction of various solutions in the flow path.

<Related research theme>

Revealing polymeric fluids behavior at the microscopic scale

Researchers do not yet fully understand how micro fluids – particularly complex ones of biological origins - behave at micro scales in microchannels. Although the time (relaxation time) for the polymer in a dilute solution to return to its original shape after it being deformed by the flow is an important physical quantity characterizing the molecular motion of the polymer in the solution, current techniques for the relaxation time measurement of the small amount and the dilute solution were insufficient for it. By designing and developing a new microfluidic device, it became possible to measure the relaxation time of such a solution and characterize the dilute polymeric fluids. (Published in "Journal of Rheology" published by the American Physical Society)

Research unit website : https://groups.oist.jp/mbnu

Okinawa Marine Science Center

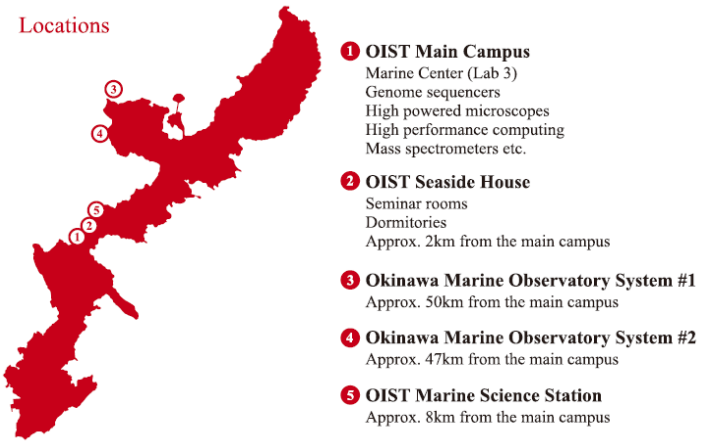
Revealing the effects of the ocean currents on marine organisms which live in hydrothermal vents and coral reefs around Okinawa

Research background

The Okinawa Marine Science Center (OMSC) is a Research Confederation hosted by OIST. It is comprised of members (OMSC members) consisting of researchers and students who come from universities and research institutions in Okinawa. OMSC members will benefit from having access to the outstanding array of research facilities and equipment available at OIST.

Goal of OMSC

In Okinawa there are unique marine environments such as coral reefs, deep-sea hydrothermal vents, the Black Current (Kuroshio), and mangroves. The goal of OMSC is to establish a Center of Excellence in Marine Science by taking advantage of the world-class research resources (facility, equipment and human resources) at OIST.



OIST Marine Science Station (Marine station)

The onshore marine facility at Seragaki Port, located near Onna-son campus of OIST, will accommodate researchers who need to collect marine species locally and to maintain them alive for prolonged periods. This facility will serve both OIST and non-OIST scientists, enabling controlled experiments on coral responses to changing physical, biological and chemical conditions.

Okinawa Marine Observatory System

To enable real-time and continuous monitoring of Okinawan coral reef ecosystems, two cable-type ocean-observing systems have been installed. Physical, biological, and chemical variables are monitored and underwater cameras designed for plankton monitoring have been installed to capture temporal variations. Water samples are collected several times every month and stored in order to determine the accuracy of underwater sensors and process samples in the laboratory. Collaborators are permitted to bring their own sensors and OIST will connect them and carry out maintenance. Data storage is available, thereby allowing OIST to be an excellent testing site for ocean observing instruments.

Research

1) Investigation on the effects of global warming and ocean acidification to coral reefs ecosystems
2) Exploring the origin of life on Earth by studying deep-sea creatures living in hydrothermal vents

Current projects

Development of a deep-sea observation system enabling continuous real-time monitoring of coral reefs near Okinawa

Investigation of the hydrothermal vent areas using the research vessels of private companies and other research institutions

Kevwords
Real-time marine environment forecasting system, Okinawa coral reef,
Population variation of marine ecosystem

Applications/Future development

- Design of highly effective plans for protecting native species living around the hydrothermal vents at seabed-resource development (deep-sea drilling work that retrieves metals from the ocean floor).
- Greater efforts to protect the ecosystem from the impact of seabed-resource development with offshore drilling

Opportunity for joint research and technology transfer

- Domestic and foreign researchers can participate in OMSC as a technology core of marine research.
- Professional advice and collaborative research on the investigation of Okinawa's unique marine environment is available.

Introduction of the research unit

Marine Biophysics Unit

Unit leader : Satoshi Mitarai Assistant professor

In the Marine Biophysics Unit, researchers are investigating the effects of the ocean currents on marine organisms which live in hydrothermal vents and coral reefs around Okinawa. Using a drift buoy, population genetics, computer modeling, a wave power driven remote control probe, and a physical ocean observation method, this unit is mapping the Kuroshio Current, tracking the distribution of larvae of deep-sea creatures, searching for starfish sources that damage corals, and monitoring the occurrence of plankton.

<Related research theme>

Quantification of larva dispersal of deep-sea organisms living in hydrothermal vent areas

Deep below the ocean's surface, there are hydrothermal vent fields, or submarine hot springs that can reach temperatures of up to 400 °C. There are inhabitants specific to hydrothermal venting zones such as Gandalfus yunohana and Rimicaris kairei. They survive using various chemical substances emitted from the hydrothermal vents. Recently, OIST researchers and collaborators have computed the dispersal of larvae from these hydrothermal vent ecosystems to understand and safeguard the animals found there. (The results are reported in the Academy Bulletin of the United States (PNAS))

Research unit website : https://groups.oist.jp/mbu

Decoding Whole Genome of Okinawa Mozuku

Aimed at mozuku seaweed cultivation and its industrial use

Research background

99% or more of domestically cultivated mozuku is produced in Okinawa Prefecture and the 90% or more of it is Okinawa mozuku. In Okinawa, mass-farming of mozuku was successfully achieved and has become one of their most important aquatic products. In 2006, the production volume of Okinawa mozuku was about 20,000 tons annually, and the market size based on the shipping price reached about 5 billion yen. However, in 2010 the production volume fell below 10,000 tons, after that it has been changing while fluctuating between 10,000 tons and 20,000 tons. It is supposed that the main cause of the fluctuation is due to the effects of weather such as insufficient sunshine in winter. It is an urgent task to stabilize the production of Okinawa mozuku.

Moreover, brown algae including Okinawa mozuku constitute a seaweed bed which is a living place for marine creatures, and it is the most important element of the coastal ecosystem. Getting to know more about brown alga containing mozuku leads also to protecting the diversity of the creatures living in seaweed beds.

Mozuku farmed in the sea (Izena island)

Okinawa mozuku with vinegar

Research

OIST, the Okinawa Prefectural Fisheries and Ocean Technology Center (Itoman-shi, Okinawa) and other institutions succeeded for the first time in decoding the whole genome (all genetic information) of Okinawawa mozuku, which is actively cultivated in Okinawa.

A genome, in which all genetic information is packed, is indispensable for understanding the living thing. However, genomic information on algae including brown algae such as Okinawa mozuku is only slightly decoded. Therefore, as a first step, the research team worked on the genomic analysis of Okinawa mozuku, which revealed that the genome of Okinawa mozuku is smaller than that of other brown algae and has fewer genes. In addition, the research team has revealed that a part of the genes considered to be involved in the synthesis of polysaccharide "fucoidan", which is contained much in the unique slime of brown algae and is also reported for health functionality, is fused to the genes of Okinawa mozuku.

The biggest challenge at Okinawa's mozuku farming sites is to stabilize production, and the instability in production is thought to be mostly caused by environmental factors. In the Okinawa Prefectural Fisheries and Ocean Technology Center which is a joint research partner of this research, from this point forward, researchers are planning to work on hybrid technology of mozuku and develop varieties that can cope with various environments. All the genomic information on mozuku decoded this time is expected to be effective and helpful to objectively judge the hybrid strains.

Keywords

Okinawan mozuku, Genome decoding, Bioinformatics, Brown algae, Fucoidan

Applications/Future development

- Hybrid technology development of mozuku
- Cultivation technology development for mozuku seaweeds
- Development and improvement of new varieties by selection of strains containing many functional ingredients such as "fucoidan"
- Elucidation of the evolution process of whole brown algae

Opportunity for joint research and technology transfer

- Using genome information, it is expected to improve added value to mozuku seaweeds and in order to achieve this, joint research with private companies will be required.
- As mentioned above, researchers are planning to develop varieties for stable mozuku production and expect a transfer of this technology in the future.

Introduction of the research unit

Marine Genomics Unit

Unit leader : Noriyuki Sato Professor

Exploring the genomes of marine organisms will help in clarifying their large-scale evolutional strategy and relationships among organisms in ecosystems. The Marine Genomics Unit has a technology to search large genomes at high speed and became the first laboratory in the world to decode gene sequences of coral, zooxanthellae, and molluscs. Moreover, in this unit, the research team has discovered evidence that there exists a common ancestor connecting humans and starfish.

<Related research theme>

Finding the Dicyemida's proper position on the animal phylogenetic tree

By utilizing the next generation type sequencer, the researchers revealed that Dicyemida is a member of the spiral animal group (spiral cleavage animal) and was born from their common ancestor, and also that it is the closest relation to Orthonectida which is another marine parasite phylum within the Spiralia clade. (This paper is published in Zoological Letters)

Genome sequencing of crown-of-thorns starfish (Acanthaster planci)

In collaboration with Australian researchers, using crown-of-thorns starfish collected at two places, Okinawa and the Great Barrier Reef, Australia, the genome of crown-of-thorns starfish which is a predator of corals was sequenced, and the candidate proteins that seem to be used by crown-of-thorns starfish for communication specific to species were successfully identified. (The results of this research are published in the science magazine "Nature" in the UK)

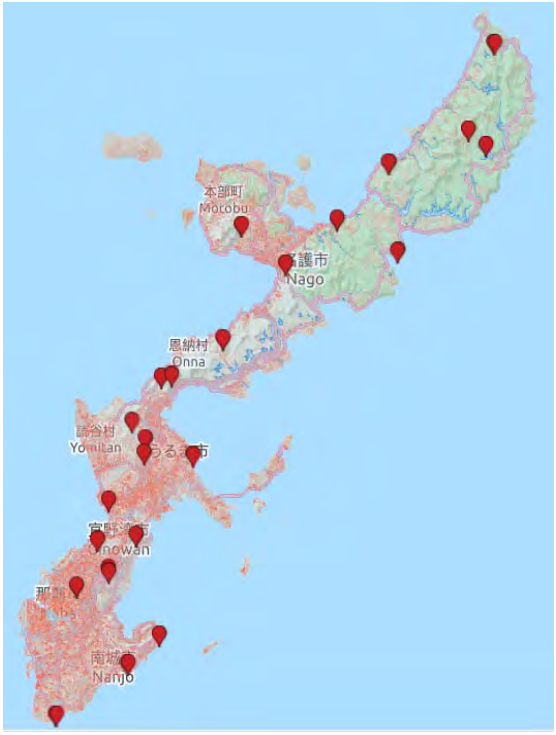
Research unit website : https://groups.oist.jp/mgu

OKinawa Environmental Observation Network/OKEON

Monitoring the environmental changes of Okinawa and revealing their impact

Research background

It is a globally important issue to monitor the environmental changes such as climate change, the devastation of habitats of animals and plants, intrusion and spread of invasive species, and then to understand the impact on the future. OIST has established the OKinawa Environmental Observation Network (OKEON), and is working on building the Okinawa terrestrial environmental monitoring system and a collaborative user network involving researchers at OIST, collaborators of various institutions, museums and high schools across Okinawa, and the local governments etc., under "OKEON Churaumi Project".



Locations for investigation:
24 monitoring sites covering the north to the south of the main island collect arthropods, record weather data, and monitor the distributional and appearance of mammals and birds throughout the year.

Research

In OKEON Churaumi Project, in order to understand how natural and anthropogenic factors affect the present and future of the natural environment of Okinawa, at the monitoring sites and other research sites spanned across the main island of Okinawa, the project members are conducting research utilizing the latest technology such as a gene analysis system, geographic information system, and database system that integrates and shares this information.

- **Arthropod Sampling** : Three flying insect traps (SLAM traps) are installed at 24 monitoring sites throughout the island and collected all year round. The current natural environment and its changes are analyzed and tracked using insects by studying insect faunas, their seasonal changes and annual changes at each investigated site.
- **Acoustic Monitoring** : By recording sound in the environment, the seasonal changes of the spread and activity of given species such as birds are found.
- **Ecological Genomics** : A new high-throughput technology is under development to analyze the genes of large numbers of samples collected. By using this, the biodiversity of Okinawa can be deeply analyzed to the gene level.
- **Camera Trapping** : Camera traps record the spread and activity of mammals and other animals. They provide the basic data for understanding the impact of the invasive species on the natural environment in central and south.
- **Physical Parameters** : Wind speed in a plot, wind direction, rainfall, air temperature, humidity, soil temperature, soil moisture, solar insolation, etc. are recorded all year round. The weather change in a plot is recorded thereby more precisely, and used for investigation of the seasonal change of a biological activity, etc.
- **GIS** : The current situation of land use and vegetation inside the main island of Okinawa are assesed. Furthermore, by tracking the transition from the past to the present, the temporal change of the terrestrial environment is clearly shown. It also helps predict environmental changes by simulation using this data.

Keywords

Environment monitoring, Gene analysis, GIS, Weather observation

Applications/Future development

Planning and launching of various projects using OKEON are advancing, and monitoring of fire ants has started as the second project, under the cooperation of Okinawa Prefecture and Incorporated Foundation Okinawa Environmental Science Center.

Opportunity for joint research and technology transfer

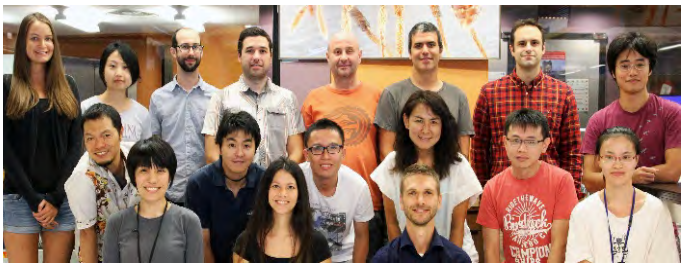
OKEON will contribute to the realization of a next-generation environmental symbiotic society through cooperation in a wide range from research to natural environment education with local universities, high schools, museums, and governments etc.

Introduction of the research unit

Biodiversity and Biocomplexity Unit

Unit leader : Evan Economo Assistant Professor

The Biodiversity and Biocomplexity Unit explores how ecological and evolutionary processes generate and sustain biodiversity. The unit integrates theoretical, field, and lab approaches to investigate how species evolve, move around, and adapt to their environments. Projects focus on the dynamics of ant communities in the Pacific islands, global diversity patterns of all ants, and macroevolution of the “hyperdiverse” ant genus *Pheidole*.



Research unit website : https://groups.oist.jp/bbu

Ecology and Evolution Unit

Unit leader : Alexander Mikheyev Associate Professor

Evolution is the unifying principle of life sciences. Recent technological advances have revolutionized the way it is studied, providing new insights into historical questions. The Ecology and Evolution Unit utilizes cutting-edge technology to address a wide range of research questions. The Unit’s investigations have included coevolution of mutualists, landscape genetics of adaptation by herbivores to host plants, genomic changes in little fire ant castes that influence invasiveness, coevolution of leaf-cutting ants and their cultivated fungi, and proteomics of pit viper venoms. Future projects will employ massive sequencing of environmental samples and museum collections to link major themes in ecology and evolution.

Research unit website : https://groups.oist.jp/evolution

Microbial Fuel Cell

Water treatment technology to mitigate wastewater treatment problems in the world

Research background

Wastewater left over from production activities brings a big environmental impact on the ecosystem. Local Okinawa industries such as awamori production and livestock industry including hog raising and poultry farming, discharge a large quantity of organic wastewater. The running and maintenance cost of wastewater facilities for the wastewater treatment is not inexpensive at all, and has become an issue pressing on management for companies and business owners.

Research

At OIST, researchers created a device called "microbial fuel cell" that cleans wastewater containing environmental pollutants while also generating electricity in the process. Special microbes are contained in the equipment, and when wastewater passes through the inside of the equipment, they break down the organic matter in the wastewater. Furthermore, electricity is generated by passing electrons generated at breaking down of organic matter to the electrode. This device is very promising as a practical technology because it produces more energy than it consumes, it costs less and maintenance is easy.

In 2016, it was adopted by a program for new industry creation started–up from universities (START) grant from the Japan Science and Technology Agency (JST), and now at the awamori brewery in Okinawa Prefecture, researchers are working on increasing the wastewater treatment capacity and improving the efficiency of using energy generated from microorganisms. Moreover, the combination of the microbes in equipment was changed and the microbial fuel cell which can operate stably for a long-term against various kinds of wastewater was successfully developed. Pilot studies are proceeding at both domestic and overseas sites, such as hog farms, a whiskey distillery in Scotland, and a winery in California, USA, in addition to the awamori brewery.

This technology can generate sustainable energy while treating wastewater and also is inexpensive and easy to handle. Therefore, it is effective not only in the industrial world but also in cleaning water for drinking in developing countries, and it is expected to contribute to water resource improvement around the world.

MFCs in the OIST Biological Systems Unit lab containing treated and untreated wastewater from the Okinawa Prefectural Livestock and Grassland Research Center.

The OIST Biological Systems Unit has placed MFCs at an Awamori distillery in Okinawa.

Keywords

Microbial fuel cell, Sustainable energy, Bioelectrochemical system

Applications/Future development

- Increasing the wastewater treatment capacity and improving the utilization efficiency of energy generated from microbes
- Identifying microbes for applying to different kinds of wastewater
- Developing a new technology to recover and remove substances such as nitrogen and phosphorus produced in the breakdown process of microbes

Opportunity for joint research and technology transfer

- Currently accepting contacts from companies interested in joint research and licensing of this technology

Patent protection
US : provisional 62/464,736

Introduction of the research unit

Biological Systems Unit

Unit leader : Igor Goryanin Adjunct Professor

The Biological Systems Unit is working on devices in which microorganisms break down waste, releasing energy in the process. Key Okinawa industries such as awamori distilleries, pig and chicken farms, sugar manufactures, and municipal wastewater treatment facilities stand to benefit economically and environmentally from this approach.

<Related research theme>

Wastewater cleaning in hog farms

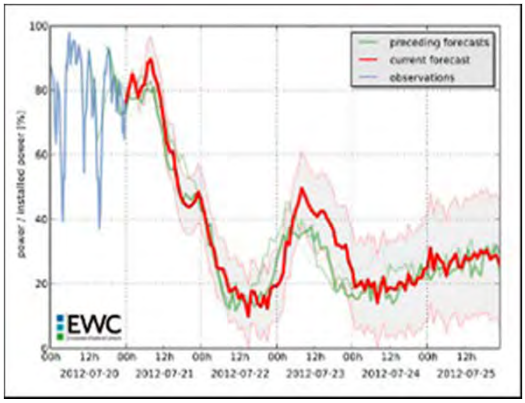
From the agricultural and livestock industry such as hog farming, a large amount of sewage containing organic substances, odor-causing substances and others is discharged. Usual methods of treating and recycling such wastewater include aeration, utilizing it as fertilizer, and in abroad, confining it to specialized ponds and wetlands to undergo natural cleansing processes. In areas with many hog farms like Okinawa, wastewater treatment and recycling are major issues, and OIST researchers are working on wastewater cleaning by microbial fuel cells. (Posted on "Scientifica")

Research unit website : https://groups.oist.jp/bsu

Improving Output Power Prediction in Renewable Energy Use

Contribution to prevention of income loss and of power transmission grid instability caused by power generation fluctuation

Research background



Predictive model currently created by EWC (European Weather Consult)
Predicted renewable energy data and actual power production data are shown. The blue line shows the actual power generation value, the red line shows the expected value for 5 days, the green line shows the predicted value before that, the portion indicated by the shadow represents the confidence interval of the expected value for 5 days. As the time series progresses, the confidence interval of the prediction becomes larger and the reliability falls.

The amount of energy generated by renewables fluctuates depending on the natural variability of resources at any given time. Unlike thermal power generation and nuclear power generation, production volume of renewable energy cannot be controlled. Moreover, since there is no electric storage device in the power grid, the produced energy must be consumed immediately, otherwise a possible risk of collapsing the grid may occur. Particularly on windy days, power surges have been known to overwhelm the electrical grid, causing power outages.

For this reason, when utilizing renewable energy, operators (power producers etc.) of power generation facilities predict fluctuations in power generation during a planned period using a forecast model in order to properly control the operation of facilities and to protect the power grid from power generation instability.

However, since the accuracy of forecasting based on these models is limited, inappropriate driving control and oversupply are incurred, resulting in transmission system instability due to excess or deficiency of electric power.

Moreover, these forecast models are not only used by operators for mitigating the power generation fluctuation and efficient facility operation but also used for trader's decision making in a power transaction markets.

Research

The new forecast model developed by the assistant professor Mahesh Bandi of OIST enables quantification of time series of forecast error from the actual power generation amount when using renewable energy, and by correcting and improving this forecast model, it can lead to prevention of revenue loss caused by power generation fluctuations and to prevent power transmission system instability. Advantages of the forecast model are that 1) forecast error can be analyzed by utilizing minimum data (power generation amount forecast in time series and actual power generation amount) and 2) data sample period can be set freely.

Keywords
Renewable energy, Wind power generation, Marine power generation, Solar power generation, Forecasting, Operation control, Penalty, Energy market, Spot energy market, System stabilization of electricity grid

Applications/Future development

- Construction of an accurate prediction model for generated electric energy by various types of renewable energy through utilization of renewable energy observation data (big data)
- Contribution to an evaluation method of business feasibility for renewable energy related businesses

Opportunity for joint research and technology transfer

- Currently accepting contacts from companies etc. interested in licensing of this technology
- Results of proof of concept by real environment data for feasibility verification are available.

Patent protection
PCT/JP2016/000950 System and method for determining prediction error for variations in renewable energy（Japan : 2017-542194）

Introduction of the research unit

Collective Interactions Unit

Unit leader : Mahesh Bandi Assistant Professor

The Collective Interactions Unit is an experimental group with broad interest in soft matter physics, applied mathematics, dynamics, and their application to biological problems. The unit researchers are working on research in the general field on macroscopic, nonrelativistic substances and their interactions. Currently I am interested in research topics on interfacial hydrodynamic, powdery solids, and biological mechanisms of the human foot.

<Related research theme>

Research on spectrum of wind power fluctuation

While governments try to phase out coal-fired energy that can be stably supplied over the coming decades, having a stable supply of renewable energy becomes increasingly important issue. In order to mitigate and manage fluctuations in renewable energy supplies, we need to understand the causes of fluctuations in energy supplies and the nature of fluctuations in energy production. (A single-author paper explaining the statistical characteristics of wind fluctuation is published in Physical Review Letters)

Research unit Website : https://groups.oist.jp/ciu

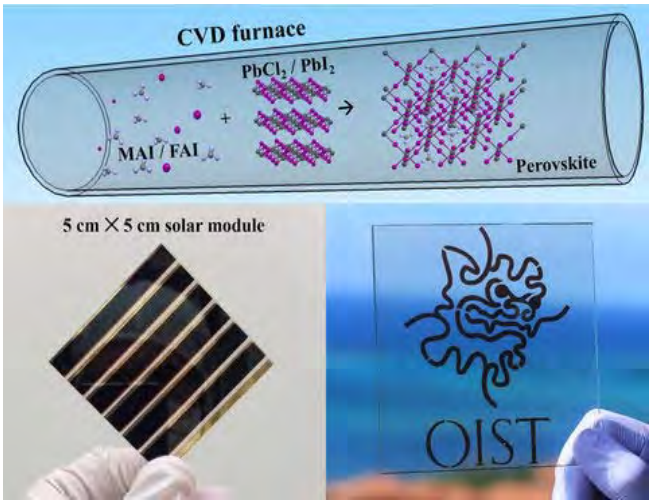
Research and Development of Low Cost High Efficiency Organic Solar Cells

Aiming for practical mass production of perovskite films by chemical vapor deposition

Research background

Perovskite solar cells are one promising candidate for next generation solar cells. Although perovskite solar cells are still at the stage of R & D, the conversion efficiency has reached to a level equivalent to mainstream silicon solar cells and the production is made possible with a coating process in a normal temperature and normal pressure environment, without a high temperature and vacuum process. Therefor, perovskite solar cells have an advantage that manufacturing cost can be drastically reduced. On the other hand, there were problems that stability being low, degradation being fast, and the cell module size being difficult to be increased.

In Energy Materials and Surface Sciences Unit led by Associate Professor Yabing Qi, the research team has developed solar cells using halogenation perovskite films. This technology improves the conversion efficiency compared to conventional solar cells and contributes to stabilization and upsizing.



Top photo depicts how perovskite films are made using the chemical vapor deposition (CVD) technique. Bottom left shows a perovskite solar module produced using the CVD technique. Bottom right displays the OIST logo made from perovskite using the same technique.

Research

The research unit discovered that the use of a methylamine solution during post-annealing of organo-metal halide perovskite MAPbI3 led to a decrease in problems associated with grain boundaries. Grain boundaries appear as gaps between crystalline domains and can lead to charge recombination. This is a common occurrence in perovskite films and can reduce their efficiency. The above post-annealing process to fuse crystal grain boundaries reduced charge recombination and showed an outstanding conversion efficiency of 18.4%. Furthermore, the perovskite films treated in this way exhibited exceptional stability and reproducibility, proving useful for industrial production of solar cells.

While perovskite films can be made with relative ease on a small scale in laboratories, they can be difficult to replicate on the large scale needed for mass production. The research unit used chemical vapor deposition, a cost-effective process commonly used in industry, to create large solar cells and modules of FAPbI3 perovskites. The solar cells and modules commonly used in the industry are significantly larger, e.g., 12cm^2, than those commonly studied in academia, typically <0.3cm^2. Furthermore, these solar modules show enhanced thermal stability and maintain relatively high efficiencies. Many perovskite solar cells lose efficiency drastically as they are scaled up, and this feature is noteworthy. This research has contributed greatly to practical application of perovskite solar cells. (The paper is published in Journal of Materials Chemistry A magazine)

Keywords

Perovskite, Organic solar cell, Chemical vapor deposition

Applications/Future development

The unit has published research results on the discovery of some special products of perovskites decomposition, and is working on the problem of lifetime in addition to increasing the efficiency and size of perovskite solar cells. Further research in this field aims at bringing the dream of utilizing cost-effective renewable energy resources into reality.

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Opportunity for joint research and technology transfer

- The unit has numerous patented technologies for perovskite solar cell production and evaluation including their peripheral technologies.
- Licensing to solar-cell makers is available.

Patent Protection

PCT/JP2015/005541 Doping operation Hole transport layer for perovskite based devices（Japan : 2017-523004), PCT/JP2015/004078 Perovskite film based on low pressure chemical vapor deposition and method of manufacture (Japan 2017-509804）, PCT/JP2015/003450 System and method for manufacturing perovskite film based on multi-source deposition (Japan : 2017-505580）, PCT/JP2015/002041 System and method for manufacturing perovskite film for solar cell applications（Japan : 2016-565516）

Introduction of the research unit

Energy Materials and Surface Sciences Unit

Unit leader : Yabing Qi Assistant professor

Energy Materials and Surface Sciences Unit is developing cost effective and large area photovoltaic films (organic thin film solar cells) made from an organic material (plastics). Such an organic thin film solar cell is lightweight and flexible. In addition, it can be produced by roll-to-roll method like newsprint, and will be a solar cell to cover windows, walls, and many other surfaces.

The EMSS Unit uses state-of-the-art advanced material characterization instruments and a clean-room device fabrication facility to investigate the properties of various individual materials consisting the solar cell and the interactions at their surfaces/interfaces between materials. Based on the research results, the unit is working on improving the solar cell performance by optimizing materials selection and device structures.

<Related research theme>

- Research on performance improvement of perovskite solar cells
- Development of perovskite-based LED lights

Research unit website : https://groups.oist.jp/emssu

Off-grid Electricity Distribution System

Stable and efficient electric supply from renewable energy

Research background

The operation of a generation/distribution system of energy with high versatility called Open Energy System (OES) is seen as the future vision of renewable energy. Unlike intensive types of power generation/distribution by large-sized electric power plants, the OES enables power generation of power generation/distribution by small-sized business proprietors, such as detached houses, local communities, and towns and villages, using renewable energy sources, such as wind power and sunlight. By making generation/distribution of energy local, the OES is expected to boost a stable supply of renewable energy and help developed nations breakaway from dependence of fossil fuels.

Moreover, highly humid areas where air conditioners are a necessity, such as in monsoon climates, has spread throughout the Asian region, and with rapid population growth, it is expected that CO2 emissions will continue to rise from this point forward. Also in Japan, although the energy consumption in the industry sector has reduced about twenty percent over the past 30 years, the energy consumption in the residential sector has doubled. So, in countries where future growth is expected, long-term countermeasures for energy consumption in the residential sector is considered to be much more necessary.

DC-power-transmission network system installed at the teacher lodgings of OIST

OIST sustainable living experiment building

Research

In the OIST open energy system, solar panels attached to the roofs of a total of 19 residences generate electricity, and an energy server is placed at each house.
In order to exchange information directly among servers, the houses interchange electric power mutually, and electric power is automatically distributed according to users' demand. Surplus power is stored in a lithium ion battery (Phospho-olivines Lithium Ion battery) using the olivine type iron phosphate developed by Sony, and can be used for days with few amounts of solar radiation. And an administrator can supervise the amount of generation and consumption of electricity in real time, and can grasp the situation of the distributed electric power supply. At the teacher lodgings at OIST, the off-grid system there has supplied a stable source of electrical power without breaking off since December 2014.

OIST is promoting “Sustainable Living Project" with Misawa Homes as joint research using a sustainable living experiment building and equipment. Also in areas of Asia, Africa and the Middle East where infrastructures, such as electric and electrical equipment and water are not in place, electric power (7 kW at maximum) from the solar battery generated by 88 solar panels installed on the roof of the experiment building, purposely offers energy for a comfortable living environment. The electric power generated by the two sets (1 kW each) of wind power generators installed on the outside of the experiment building, charge electricity with direct current (DC) and with a DC supply system, the house demonstrates it can power and make use of DC air-conditioners and DC consumer electronics.

Keywords

Renewable energy, Open energy system, Sustainable living

Applications/Future development

In the area of Asia Africa and the Middle East where infrastructures, such as electricity and water, are not yet in place, the “Sustainable Living Project" aims at offering a comfortable living environment. The project aims at introducing the structure utilizing renewable energy to the utmost as well as Open Energy Systems carried out at OIST to the community of island areas and developing countries.

Opportunity for joint research and technology transfer

At the present time, the “Sustainable Living Project“ is carrying out joint research with Misawa Home Institute of Research and Development Co. Ltd. and Pues Corporation, and OIST and Sony Computer Science Laboratories, Inc. (Sony CSL) jointly designed the DC-power-transmission network system installed at the faculty lodgings of OIST. In the future, we will develop OIST as a major institution of sustainable research and build R & D clusters in this research field, aim to expand international cooperation with universities, research institutions, and companies, and establish start-up companies.

Introduction of the research unit

Integrated Open Systems Unit

Unit leader : Hiroaki Kitano Professor (Adjunct)

Globally health care and sustainability are particularly important problems in our present-day setting. These are highly integrated open systems such as living organisms and social systems such as energy and transportation systems. The Integrated Open System Unit aims to understand the fundamental principles of these open complex systems and to apply the knowledge to the real world. From now, we will deploy our activities internationally through Garuda Alliance and Sustainable Living.

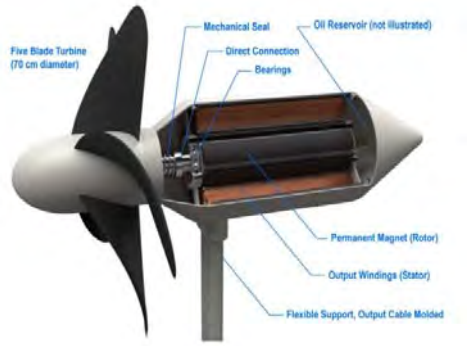
<Related research theme>

- Open energy system
- Micro grid system using exchangeable cells for electric vehicles
- Sustainable life in highly humid areas

Research unit website : https://groups.oist.jp/obu

Development of Wave Power Generator

Sustainable future with cheap and clean energy



The blades of this five-blade turbine rotate on their axis when influenced by ocean waves. The axis is attached to a permanent magnet electric generator, which is the part of the turbine that transforms the ocean wave energy into usable electricity. The ceramic mechanical seal protects the electrical components inside of the body from any saltwater leakage.

Research background

Energy use of fossil fuel pushed the industrial revolution and contributed to subsequent technological development. However, its reserves are limited and efforts to shift to a low-carbon society is an urgent task. The day when energy resources, such as oil and coal, hit the bottom is coming soon.

Solar power and wind power generation can be said to be the flagship of the energy revolution, but as the world's energy consumption continues to increase, it is impossible to cover all the necessary power with these two energy sources.

One effective energy sources that can be a solution to this is the wave power, which is the power of a wave as it strikes the coast.

The inline small wave power generators generate electricity by utilizing a flow of a eddy generated from crumbling waves. (Imaged figure)

Research

In the Wave Energy Converter (WEC= Wave Power Generator) project started in 2013, we install power generator turbines in locations where the waves occur near the coastline, such as wave-breaking blocks and coral reefs. In these places the generator turbines are exposed to ideal waves, not only producing clean and renewable energy, but also it can help to protect the coast from erosion. The power generating turbine itself is designed to bear not only the force of an intense wave but extreme weather like a typhoon. The blades are designed to rotate carefully at the calculated speed and to allow creatures to escape even if caught between the blades.

Now, Professor Shintake and the researchers of a research team complete the first phase of the project, and for the first commercial experiment, we are preparing to install a turbine with a diameter of 0.35 m equipped with blades of half the size of the actual size blades. In this project, we will install two wave power generators and turn on LEDs as an actual proof experiment.

Keywords

Renewable energy, Ocean energy, Wave energy, Wave power generation

Applications/Future development

30% of the coastline of Japan mainland is covered with tetrapod and wave barrier, and if these are replaced with special wave blocks and wave barriers, it is possible to protect the coast and to generate about 10 GW (equivalent to ten nuclear power plants) of clean and renewable energy at the same time by using only 1% of the mainland coastline.

Opportunity for joint research and technology transfer

- Under inquiry reception from the companies interested in the joint research and licensing of this technology

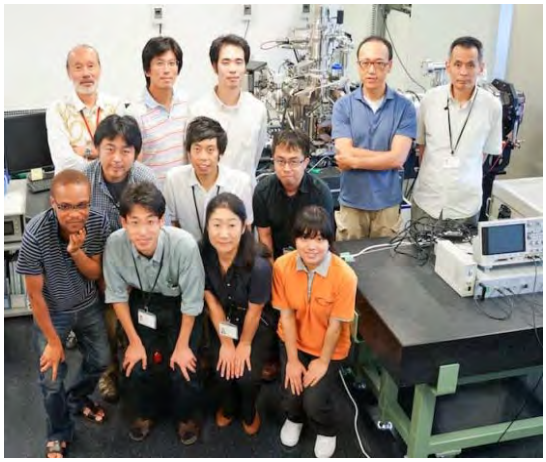
Patent information
PCT/JP2015/003576 "Wave energy transducer" (Japan: 2017-501431)

Introduction of the research unit

Quantum Wave Microscopy Unit

Unit leader : Tsumoru Shintake Professor

A low energy electronic microscope which the quantum wave optical microscopy unit newly assembled can create DNA and the clear hologram of a virus not using a lens.
The time-consuming crystallographic method becomes unnecessary by using this new technology, and we expect to obtain a one-molecule picture with sub nanometer resolution. In the renewable energy power generation project which has a big different aspect, we are studying the electricity conversion of marine energy by taking advantage of the geographical conditions of Okinawa.



<Related research theme>

1. Development of an atomic resolution microscope technology for biological research
  1-1. Development of an atomic resolution microscope of new principle using electron coherent scattering and digital holography
  1-2. Technology development of new electron beam crystal structure analysis by forming nanocrystals of membrane protein by FIB and analyzing using low energy electron diffraction
  1-3. Technological development of X-ray microscope based on a completely new principle
2. Technology Development to generate power using wave force
3. Life activity observation by laser interferometer

Research unit website : https://groups.oist.jp/qwmu

New Contactless Magnetic Couplings for Applications in Microfluidics, Renewable Energy, and Nautical Propulsion

New possibilities of contactless magnetic gear

Research background

In conventional mechanical gears, gears and gears directly mesh to transmit power. Therefore, there are drawbacks such as vibration, noise, generation of dust due to abrasion of gears, and maintenance such as lubricating oil periodically and replacing gears is necessary.

Research

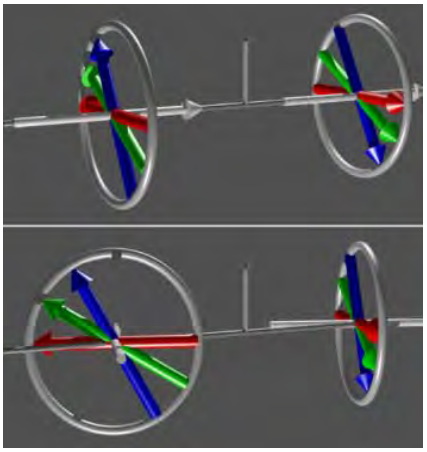
By using a powerful permanent magnet made of an alloy of iron, boron, and neodymium, a contactless magnetic gear is constructed to solve the drawbacks of the conventional contact type gear.

Moreover, it makes it possible to establish freely the angle of gradient of an input axis and an output shaft (left figure B). Depending on arrangement of two magnets, the third magnet is added to a specific location, and it becomes possible to maintain a smooth connection (right figure).

Possibilities of the smooth magnetic coupling which can produce uniform operation are great, and the applications to nano technology, micro fluidics, robot engineering, etc. are anticipated.

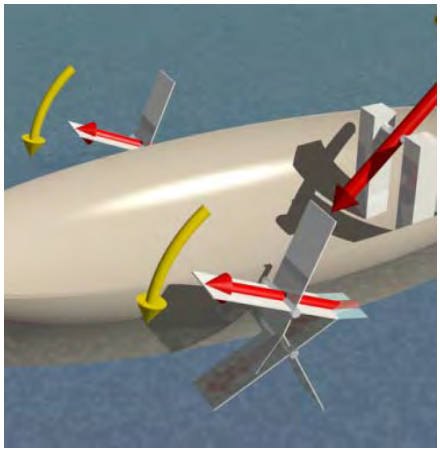
A

B



A) Classical configuration where the two rotating magnets (shown in rotation in red, green and blue arrows) share the same rotation axis (gray arrows). A similar setup is used in modern milk whisk and food mixers, as well as magnetic stirrers in chemistry labs.

B) One configuration studied in this research with the rotating magnets having their rotation axes (gray arrows) perpendicular to each other.



Illustrative example of a paddle boat using three interacting rotating magnets (red arrows) as a drive. Two magnets are connected to the paddles and one to the driver. If the driver magnet is rotated, the paddles move accordingly (yellow arrows).

Applications/Future development

- Application to nano technology, micro fluidics, robot engineering, etc.
- Theory verification by the actual proof experiment using a trial product.

Opportunity for joint research and technology transfer

・ Under inquiry reception from companies interested in the joint research and license of this technology

Patent information
US : 15/846,565

Introduction of the research unit

Mathematics, Mechanics, and Materials unit

Unit leader : Eliot Fried Professor

Soft matter is a relatively new field of research that has been rapidly progressing with substances composed of multiple atoms and molecules as research targets.

Generally soft matter is a substructure belonging to the micro-mesoscopic region, and as the name implies, it refers to substances that are easily deformable. In Mathematics, Mechanics, and Materials unit, statistical mechanics, the continuum mechanics , differential geometry, asymptotic analysis, a bifurcation theory, large-scale computing science processing, etc. unifying all methods, we research them broadly from the foundation to application. Now, we are researching disc-shaped high-density lipoprotein, perforated lipid duplex film, bacterial suspension which is an agent with self propulsive force, three phase boundary line dynamics under the evaporation / condensation state of the droplets on a surface.

<Related research theme>

Expansion of application field of soft matter

The "soft matter" of the field of surface tension, Kirchhoff Plateau's problem, the stability of soft material, flow patterns, etc.

Research unit website : https://groups.oist.jp/mmmu

Smart Gas Sensing Platform for Mobile Devices

Production method of uniform iron nanocubes

Research background

Scientists have tried to understand nanoparticles for many years. Production of nanocubes has especially attracted attention because of applicability for biosensors and gas sensors.

Nanoparticles can be made by physical or chemical methods, but the advantage of the physical method is that there is no contamination by the organic substances normally found in chemical methods. However, with the physical method, there was a problem that it was difficult to produce a required amount of uniformly sized nanocubes.

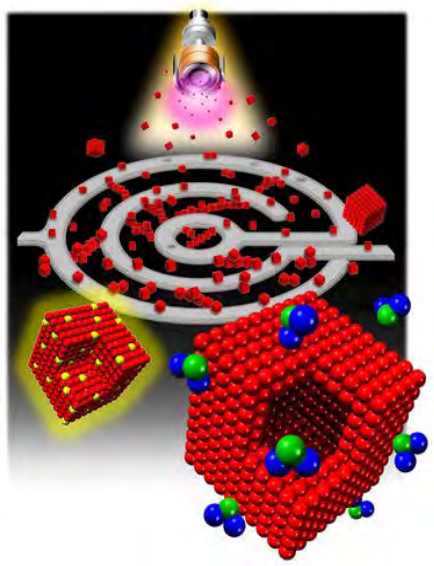
The Smart Gas Sensing Platform (SGSP) monitors gases such as carbon monoxide (CO), oxygen (O_2), ammonia, fluorine, nitrogen oxides, etc. in consumer and industrial applications, and has a wireless function which enables seamless connection with smartphones and tablets. If uniform iron nanocubes can be produced, electronic devices as SGSP of nitrogen dioxide can be manufactured.

Research

In order to make it possible to manufacture electronic devices for SGSP aiming at miniaturization of gas detection devices, OIST researchers and colleagues have proposed a method of producing unique iron nanocubes using magnetron-sputtering inert-gas condensation method. With the process, argon gas is heated first and is plasma ionized next.

And since the target material is iron, a magnet is appropriately installed behind an iron target. This manipulates the shape of plasma and determines that argon ions surely irradiate the target (target of sputtering). As a result, iron atoms are sputtered out from the target (sputtering occurs), and argon atoms and iron atoms collide with each other to form nanoparticles. It makes it possible to carry out precise operation of the plasma and to produce uniform iron nanocubes by controlling the magnetic field.

Uniformity is an important point to apply for sensors. In the production stages of nanocubes, the method of controlling the size, shape, and quantity is indispensable. And it became possible to produce the uniform iron nanocubes applicable to mass production by the above-mentioned physical process, and SGSP for nitrogen dioxide became possible.



This schematic depicts the production of iron nanocubes using magnetron-sputtering inert-gas condensation and the use of these cubes in NO_2 sensors.

Keywords

Nano sensor, Gas sensor, Nano particle, Nano cube

Applications/Future development

The applications to mining, medical facilities, industrial processes and management, architectural skills and amenity, home NOX detection, etc. are possible.

Opportunity for joint research and technology transfer

- Gas sensor makers, joint research, and licensing agreements are possible.

Patent information
PCT/JP2017/024566 "Very high sensitivity nitrogen dioxide gas sensor based on an iron nano cube"

Introduction of the research unit

Nanoparticles by Design unit

Unit leader : Mukhles Ibrahim Sowwan Associate professor

An aggregate of nanometer sizes formed by aggregation of tens to millions of atoms is called nanocluster / nanoparticle. In nano metric size, physical and chemical properties can be operated by controlling the chemical composition and grain size of material. The applications to catalytic reaction, nano electron devices, and medical-engineering technology are anticipated, and especially the nano cluster of metal is attracting interest. At this research unit, we create the nanocluster / nanoparticles which consists of one or two kinds of metal, and the nano cluster / nano particles of core shell structure with various grain sizes using the vapor growth of the magnetron sputtering method, we research those structural characteristics, magnetism, the electronic state, the chemical property, and the applied technology.

<Related research theme>

Expansion of the applicable field of nano cluster
Applicable fields are expanded to super high power silicon cells, Lycurgus cup, CO nano sensor, nanowire, etc.

Research unit website : https://groups.oist.jp/ndu

Efficient Goal Estimation for Intelligent Systems

Development of an autonomously adjustable reinforcement learning algorithm

Research background

Machine learning to create performers of various tasks based on data has been put to practical use in the field of image recognition and speech recognition, and it is the center of current AI technology. Among them, reinforcement learning has been attracting attention due to various success stories recently, which makes it possible to acquire action selection strategies adapted to the environment through trial and error based on the remuneration for behavior.

The Human brain is choosing essential things from various information, using the past learning for solving new problems, or changing actions suitable for a specific situation, and more reliable and safer action at any time, and it has realized practical learning.

For example, the person can instantaneously identify the person and obstruction that should be watched even in a crowded place according to the direction to which he wants to go, and can avoid a collision.

In addition, it is common that a person who can play Shogi to some extent progresses to play chess early, and it is possible to switch depending on the situation whether you point it as determined or think deeply during Shogi 's game.

However, conventional reinforcement learning has the problem that a designer needs to designate beforehand the information which should be observed or it is necessary to redo learning for every problem, and its application in real life is restricted.

The product image of this joint research

Research

OIST and Fujitsu Laboratories has focused on such a brain learning method, adopting the mechanism based on the latest brain science findings, and makes it possible for AI to adjust autonomously in the situation which conventional manual reinforcement learning could not adjust. We will start joint research to develop more applicable reinforcement learning algorithms that can be adjusted in a timely manner.

Specifically, we mainly developed new technologies in the following three areas that are more demanding among the issues for practical application.

1. Technology of extracting information suitable for reinforcement learning automatically out of mass data which changes dynamically
2. Transition learning technology of putting past experiences to action selection policy of the other problems
3. Cooperation and parallel reinforcement learning technology which chooses the best action among two or more policies according to the conditions

The research team of professor Kenji Doya of OIST was responsible for making a mathematical model of the nerve calculating mechanism from a viewpoint of brain science, and reflecting it to the reinforcement learning algorithm. Fujitsu Laboratories participated in making its algorithm from a viewpoint of optimization and control engineering, and developed simultaneously the programming method which utilizes calculation resources best.

Keywords
Objective function, Assumption aim, Intelligence system, Robot engineering, Robotic control, Reverse reinforcement learning

Applications/Future development

OIST and Fujitsu Laboratories will work on the issue of adapting to a large amount of input information, flexible correspondence for environmental change, and conservative correspondence, etc. in order to learn multiple strategies in parallel and make use of it for action selection.

In addition, based on the results of collaborative research, we will develop an AI solution that enables computers to acquire environmentally adapted measures more efficiently in real-world applications such as ICT system management, energy management, etc. without manual setting and adjustment.

Opportunity for joint research and technology transfer

・ Licensing to energy management system-related companies

Patent information
PCT/JP2017/004463 "DIRECT INVERSE REINFORCEMENT LEARNING WITH DENSITY RATIO ESTIMATION" (U.S.: 15/425,924)
Japan: 2016-066470-"control equipment of hybrid car both systems and hybrid car both systems, and control method of hybrid car both systems", 2016-066572-"working vehicle"

Introduction of the research unit

Neural computation unit

Unit leader : Kenji Doya Professor

Neural computing unit aims to understand the biological basis of the human mind by fusion of top-down theoretical models and bottom-up biological experiments.

<Related research theme>

Mathematical modeling and proof experiment of brain and environment

This research aims at understanding the biological base of the human mind by fusion of top-down theoretical models and bottom-up biology experiments. The molecule and gene relevant to various mental disorder, such as schizophrenia and depression, are clarified by progress of molecular biology in recent years. However, many of these mental disorders are caused as a result of complicated interaction with the environment of molecules or genes.

In order to understand such interaction, mathematical modeling including dynamics of brain and environment, computer simulations and robot experiments are indispensable.

So, We work on three major subjects:
1. development of a novel computational framework for system identification of biological networks;
2. neurobiological experiments to study the dynamic functions of neuromodulators in regulating adaptive behaviors;
3. robotic experiments to explore adaptive mechanisms necessary for survival and reproduction in dynamic environments.

By combining theoretical, biological, and engineering approaches, the research shall produce novel software tools for dynamic modeling, highly adaptive robots with emotion-like regulatory functions, and new approaches to therapy and prevention of psychiatric disorders.

Research unit website : https://groups.oist.jp/ncu

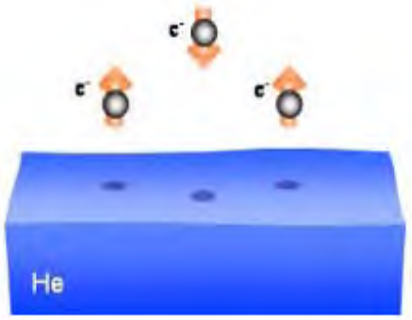
New Quantum System towards Quantum Computing

Creation of the same quantum bit using a liquid helium system

Research background

The future vision of the quantum computer has become a topic among many companies, governmental organizations as well as specialists.

Instead of calculating and saving data within a transistor or a memory in the form of the conventional binary bit "1" and "0", in the world of a quantum computer, it calculates in infinite combination also including the state of taking 1 and 0 simultaneously (superimposition), using systems, such as atoms, ions, or electrons, as a "quantum bit". Since the defect and impurity in material affect the function of each quantum bit at random, one of the problems in research of the quantum computer using a solid is that it is very difficult to make the same quantum bit consistently.



On liquid helium electrons move freely and are easy to control.

Research

In the quantum dynamics unit of OIST, an extremely small device was created utilizing the property of the electron which floats on the liquid helium surface, and it discovered the electron on liquid helium becomes a new candidate for the realization of quantum computer, and increased the possibility of the early realization of quantum computer.

It is because the system of liquid helium is pure, and has no defects and makes the production of identical quantum bit possible theoretically, makes electron movement possible, which might be said to be almost impossible by using the other systems.

In order to utilize the electron on the liquid helium surface for quantum computing, it is necessary to isolate each electron on the helium surface and to control quantum degrees of freedom such as electron movement and spin.

Moreover, as an electron needs to be moved to somewhere else, it becomes important to understand the physics of the interaction between an electron and the helium surface.

The electron on liquid helium can form a two-dimensional (2D) crystal, and it was discovered before this that a peculiar phenomenon occurred by the interaction between electron and surface wave, when this crystal moved along the helium surface.

However, the researchers of OIST searched for how these phenomena were influenced with the size of an electronic crystal for the first time in the world, and they created the device with a very small channel with which the electron trap was incorporated in order to isolate the only one two-dimensional electronic crystal which consists of a comparatively small number of electron.

By applying alternating voltage to one of the electrodes of this device, the electronic crystal is moved on the liquid helium surface.

Since the movement of this electron induces electric current to another electrode by the mirror image effect, it is detectable by measuring that electric current using a commercial current amplifier and lock in detector.

Keywords

Quantum computing, Quantum bit, Quantum dynamics, Quantum information processing

Applications/Future development

- Realization of a clean and integratable system using the existing mobile quantum bit
- Quantum computer

Opportunity for joint research and technology transfer

- Under inquiry reception from companies interested in the joint research and license of this technology

Introduction of the research unit

Quantum dynamics unit

Unit leader : Denis Konstantinov Associate professor

When particles, such as electrons, are trapped in a narrow area, the property as wave motion becomes remarkable.

In order to understand this behavior, quantum-mechanical explanation is needed.

Unlike the classical mechanics objects which move along a clear orbit, such particles are explained by probability density and the uncertainty principle.
In quantum dynamics, movement of the particles which cannot fully be explained according to classical mechanics and electromagnetism is explored.
In this unit, we research the complicated multi-particle systems, the foundations of the many interesting quantum phenomena.

By explaining logically the phenomena confirmed by experiments, we aim at applications from various fields, such as realization of quantum information processing.

The super-conductive magnet used for the quantum experiment

<Related research theme>

Research of the very-low-temperature complicated quantum system which is greatly separated from an equilibrium state using Magneto-optical transport and spin resonance.
The development for very-low-temperature atomic gas, solid state nano structures, nano optical devices, next-generation nano devices

Research unit website : https://groups.oist.jp/qdu

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