RIST TUS

Research Institute for Science & Technology

Tokyo University of Science

2013

RIST creates new directions in science which are achievable "only in TUS".

Building a better future with Science

RIST TUS
Research Institute for Science & Technology

Bio and Pharmacy

- Center for Technologies against Cancer
- Center for Physical Pharmaceutics
- Research Center for RNA Science
- Center for Environmental Health Science for the Next Generation
- Research Center for Chirality
- Translational Research Division
- Division of Pharmaco-creation Frontier
- Division of Bio-organometallics
- Glycotechnology Project
- Organ Regeneration Research Project

Information and Societal

- Center for Fire Science and Technology
- Division of Next Generation Data Mining Technology
- Mountain Atmosphere Research Division
- Division of Intelligent System Engineering
- Division of Integrated Science of Oshamambe town
- Division of Advanced Communication Researches

Structural Materials

- International Research Division of Interfacial Thermo-fluid Dynamics

Fundamentals

- IR FEL Research Center
- Leading-Edge Holography Technologies Research and Development Center
- Quantum Bio-Informatics Research Division
- Imaging Frontier Research Division

Functional Materials

- Research Center for Green and Safety Sciences
- Photocatalysis International Research Center
- Advanced Device Laboratories
- Photovoltaic Science and Technology Research Division
- Division of Ecosystem Research
- Division of Nanocarbon Research
- Division of Thermoelectrics for Waste Heat Recovery
- Division of Colloid and Interface Science
- Division of Synergetic Supramolecular Coordination Systems in Multiphase
- Na-ion Batteries Project

A message from the Director General

The Research Institute for Science and Technology (RIST) was established in November 2005 to coordinate collaborative research activities in the whole university. It consists of Research Centers, Research Divisions, Social Relation Liaison Projects, Technical Division and Center for National Joint Usage / Joint Research.

Centers, Divisions and Liaison Projects are limited-term research groups on specific scientific targets with members selected throughout whole university, and sometimes even from outside. The Centers are funded jointly by Ministry of Education and the university, while Divisions are financially supported solely by the university and expected to be cores of new Centers. Social Relation Liaison Projects are collaborative activities based on agreement between the university and industries. Technical Division houses experimental equipment open to university members. Research Center for Fire Safety Science is one of the nationally selected organizations for joint usage/joint research open to outside university and is now extending its activities internationally, especially in Asia.

All the members of RIST, which have different organization structure, explore their activities for their own but at the same time collaborations between members are strongly encouraged to open new horizon in science and technology. To substantiate this, they are grouped into 5 categories, Functional Materials (FM), Structural Materials(SM), Bio and Pharmacy (BP), Information and Societal (IS), and Fundamentals (F). RIST as a whole has an annual meeting, RIST-Forum, while groups in each category have meetings frequently.

I hope and believe that new directions in science which are achievable “only in TUS” will be created based on the very unique research organization, RIST.

Director General, Research Institute for Science and Technology
Dr. Hidetoshi Fukuyama

Tokyo University of Science

Only in TUS

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Tokyo University of Science 2013

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Information and Societal

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Technical Division

Center for National Joint Usage/Joint Research

Focus

Rist Organization Chart

Functional Materials | Established: April 2013

Photocatalysis International Research Center

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Director President, Tokyo University of Science

Akira Fujishima

Research Content

To deepen the photocatalysis technology for the construction of practically usable photocatalysis systems.

Objectives

To advance the photocatalysis to the next-stage by integrating technology with self-cleaning, artificial photosynthesis and environmental cleanup.

Future Development Goals

To establish top-level center for photocatalysis, as well as to transmit remarkable achievement towards the world in order to expand the field of photocatalysis.

The field of photocatalysis can be traced back more than 80 years to early observations of the chalking of TiO2-based paints and to studies of the darkening of metal oxides in contact with organic compounds in sunlight. During the past 20 years, it has become an extremely well researched field due to practical interest in air and water remediation, self-cleaning surfaces, and self-sterilizing surfaces. During the same period, there has also been a strong effort to use photocatalysis for light-assisted production of hydrogen.

The fundamental aspects of photocatalysis on the most studied photocatalyst, TiO_2, are still being actively researched and have recently become quite well understood. The mechanisms by which certain types of organic compounds are decomposed completely to carbon dioxide and water, for example, have been delineated. However, certain aspects such as the photo-induced wetting phenomenon, remain controversial, with some groups maintaining that the effect is a simple one in which organic contaminants are decomposed, while other groups maintain that there are additional effects in which the intrinsic surface properties are modified by light. During the past several years, powerful tools such as surface spectroscopic techniques and scanning probe techniques performed on single crystals in ultrahigh vacuum, and ultrafast pulsed laser spectroscopic techniques have been brought to bear on these problems, and new insights have become possible. Quantum chemical calculations have also provided new insights. New materials have recently been developed based on TiO_2, and the sensitivity to visible light has improved.

In the Photocatalysis International Research Center, we will develop fundamental and applied research of the photocatalysis. The center provides support for interdisciplinary photocatalytic materials research and education of the highest quality by collaboration with industry, academia, and the government under one roof while addressing fundamental problems in science and engineering that are important to green innovation.

Research on the Energy Photocatalysis

Utilization and conversion of solar energy to fuels and electric energy are an urgent issue in the world. It is indispensable to construct clean energy systems in order to solve the issues.

Hydrogen will play an important role in the system because it is an ultimate clean energy. It can be used for a fuel cell. Moreover, hydrogen is used in chemical industries. Hydrogen has to be produced from water using natural energies such as sunlight if one thinks energy and environmental issues. Therefore, achievement of solar hydrogen production from water has been urged. Photocatalytic water splitting is an attractive reaction and will contribute to an ultimate green sustainable chemistry and solving energy and environmental issues resulting in bringing an energy revolution. We are working on the development of new photocatalyst materials for solar water splitting and CO_2 fixation based on the original strategy for the design of photocatalyst materials. Moreover, science to understand photocatalytic processes is studied.

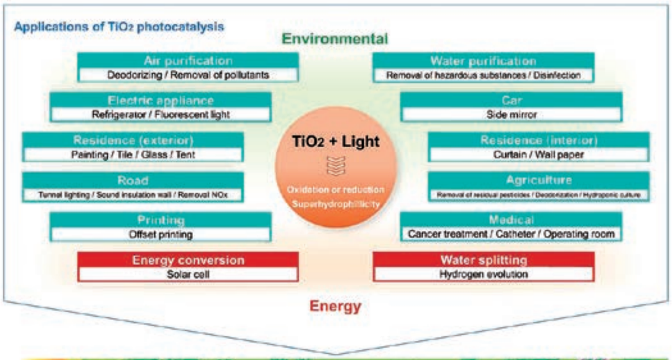
Research on the Environmental Photocatalysis

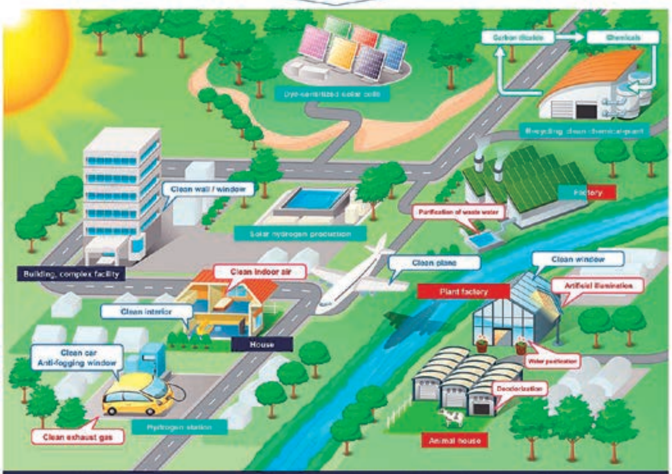
As the single most important effect of TiO_2 photocatalysis, its bactericidal activity has been studied in various microorganisms, as well as in fungi. In addition, the mechanism of this antimicrobial photocatalysis has been revealed as the loss of cell membrane integrity caused by electrons/holes or by reactive oxygen species. While photocatalysis for air-purification has been scientifically studied for more than two decades, and the bactericidal activity of TiO_2 photocatalysts is thus well known, in-depth studies of selective applications of TiO_2 photocatalysts are still required. Therefore, we are mainly engaged in research in the following themes for development of novel photocatalytic air-purification units.

○Developing test methods for tracing quantitative decrease of airborne bacteria in the fields based on the JIS and ISO standard test methods for antibacterial performance.

○Fabrication of prototype air-purification unit using a novel photocatalytic filter, titanium-mesh sheet modified with TiO_2.

○Evaluation of antibacterial performance of prototype air-purification unit together with other tests for decomposition of gaseous pollutants.





Vision of future community based on photocatalysis

We push forward with our work, as plants grow toward the light.

Akira Fujishima

Innovation of science and technology for solving energy and environmental issues in a global scale and a life style is urged. Photocatalysis has been paid attention for that science and technology. Researchers with high potentials in TUS work together on the important topics through collaboration in this center. We push forward with our work for the sustainable future.

Functional Materials　　Established: April 2010

Research Center for Green and Safety Sciences

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Director　Professor, Department of Applied Chemistry, Faculty of Science Division I

Izumi Nakai

Research Content

We will develop advanced safety materials and analytical methods in the fields of "battery", "light", "food and health".

Objectives

Development of advanced materials friendly to human being and that of analytical techniques for supporting safety.

Future Development Goals

To create a society where people can enjoy happy life by utilizing advanced science and technology.

Modern society is now in the high technology community. The materials are produced in cost oriented and citizens have been forced to risk purchasing them without trust in their safety. For example, lithium batteries are developed in favor of performance and price, which may cause the fire accident. It is not rare to see plastic containing toxic cadmium, imported processed foods with high amounts of food additives and deceptive labeling of their production origin. In addition, our citizens are still poorly being explained in general understanding against scientific products with lack of scientific evidence such as the “minus ions”. Almost every year, we meets infectious diseases caused by widespread virus. We don't know the danger of genetically modified foods. Therefore, as a comprehensive research base to solve these problems, which contemporary society is facing ,"Green and Safety Research Center(GS-Lab)" was established in the Tokyo University of Science, accredited by the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Members (Table 1) of the Research Center for Green and Safety Sciences belong to one of the three themed research groups shown in Fig. 1. The cutting-edge researchers of our university are taken in major issues in terms of safety and technology, join in three forums (Fig. 2), i.e., the battery forum, the light forum and the food and health forum. Each forum is focusing on developing people-friendly advanced materials and promoting the development of analytical techniques, which supports peoples' peace of mind as the primary purpose. At the same time, we will reveal the usefulness and risks inherent in advanced materials and properly convey their principles and problems to the public. The educational activities based on social infrastructure are aimed to support the creation of intellectual community based on science and technology.

Each member of the three forums is participating in promoted research based on their specialty and interest. For example, the food and health forum is working on developing analytical technique for trace elements and isotope ratio in order to elucidate the provenance of foods. The members are also interested in developing a method for removing toxic heavy metals from the environments, and in developing safe and secure friendly cosmetics. The battery forum is focusing on development of safe, resource constraints and low environmental impact energies, such as lithium ion secondary batteries, fuel cells, and solar cell materials. The light forum is focusing on developing nitride semiconductor based red LED and others new friendly alternative light source consists of the three primary color LED bulbs which can contribute less energy and reduce CO_2 emissions. In addition, developments of new photo catalysts and utilization of solar energy technology are being studied for the safe and secure.

Finally, as the first mission of the university is human resources development, the feature of this project is innovatively to develop the consideration in appropriate material safety and security and to show our students and general teenager students in a meaningful way, rather than the performance oriented of materials science research mind. This center aims to give proper information and knowledge of science and technology for ordinary citizens and to eliminate the public's fear of a miss understanding such as in genetically modified foods and the food forgery. We will try to explain the meaning and importance of our targeted science and technology to human beings including from junior high school students to senior citizens. This approach will meet the opinion offered by our government in last spring that scientists must explain the importance and meaning of his scientific activity to general public using plain words, i.e. promotion of scientific conversation between scientists and general public.

Izumi Nakai

The purpose of our research in this center is not for the pursuit of profit and efficiency but for the happiness of our human beings.

We will develop advanced materials and energy technology, which are friendly to human beings as well as friendly to environment. We will also develop analytical techniques for safety life. This center will promote citizen-focused research appropriate to university. And we will actively communicate with citizens as interpreters of science and technology and help their communication with science & technology.

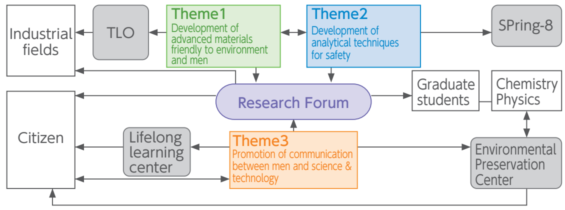
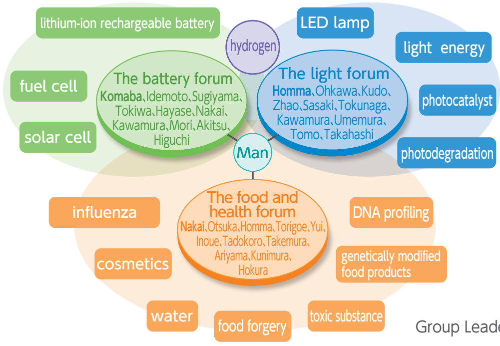


Fig. 1　Collaboration among thematic research groups and related organizations



Group Leader: boldface

Fig. 2 Members of the forums and targets of their researches

Table 1　Research forum and research topic of each member of the forum

The food and health forum	
◆◎ Izumi Nakai	Provenance analysis of foods and forensic analysis of material evidence based on the trace element signature
Makoto Tadokoro	Research on water molecular clusters H-bonded at the bio-molecular surface and exploitation of gas-storaged molecular crystal based on huge water cluster
Hidetaka Torigoe	Development of novel methods to trap heavy metal ions and to analyze DNA base sequences for human health
Hidenori Otsuka	Physiologically active biomaterials and their application to life science
Masayuki Inoue	Development of human- and nature-friendly teaching materials for chemical education
Masaharu Takemura	Study on Life Science Communication for the Food & Health
Hiroharu Yui	Physiologically active biomaterials and their application to life science
Kaoru Ariyama	Development of methods for determining the geographical origin of food and establishment of its certification system
Shinsuke Kunimura	Fundamental study on development of analytical method for trace elements in foods using X-ray fluorescence spectrometry with a low power X-ray tube
Akiko Hokura	Study on accumulation mechanism of heavy metal in plants by utilizing synchrotron radiation X-ray analysis
The battery forum	
◎ Shinichi Komaba	Eco-friendly Materials for Electrochemical Energy Devices
Yasushi Idemoto	Search of guiding principle for safety and development of electrode material for Li ion battery
Shunsuke Mori	An assessment of the contribution of technology developments on environmental, food and energy security issues
Masanori Hayase	Development of a Miniature Fuel Cell for Hydrogen Eco-energy System
Kazuyasu Tokiwa	Development of new electrode materials for Li-ion battery using high-pressure technique
Mutsumi Sugiyama	Fabrication of next-generation solar cells using safety materials
Takashiro Akitsu	Preparation and measurement of hybrid metal compounds for battery
Tohru Higuchi	Development of new material for solid state oxide fuel cell in intermediate temperature region
The light forum	
◎ Yoshikazu Homma	Safety evaluation and functionalization of carbon nanotubes
Akihiko Kudo	Clean production of hydrogen using photocatalysts for safety of human being
Yasufumi Kawamura	Energy & Environment Learning for citizenship
Kazuhiro Ohkawa	Development of optoelectronic materials consist of safety elements
Xinwei Zhao	Green and safety of semiconductor photocatalysts
Eiji Tokunaga	Photogeneration of clean energy from photosynthetic organisms and its measurement
Takeo Sasaki	Development of Photopolymers Safely Convertible to Component Monomers by Light Irradiation
Kazuo Umemura	Safety evaluation of nanomaterials by single cell analysis
Tatsuya Tomo	Creation of safety energy by new chlorophyll
Hiroshi Takahashi	Safety and development of the fluorescence imaging technology

◆ Center Director　◎ Group Leader

Open campus :SEM observation for visitors.

Symbol of the center: lotus flower from Byodo-in temple.

Functional Materials | Established: April 2009

Advanced Device Laboratories

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Director Professor, Department of Applied Physics,
Faculty of Science Division I

Kazuhiro Ohkawa

Research Content

Research of devices that contribute to energy saving, green energy, and energy recycling.

Objectives

Our first objective is to consider global warming from the angle of energy and to contribute to society through the development of devices that can help conserve energy, make energy generation greener, and recycle energy. We also aim to promote scientific and technological progress in the field of materials and devices while furthering the development of our students as human resources.

Future Development Goals

A high level of technological power has been achieved by allying with the research laboratories. With the ultimate goal of returning to society the benefits of achievements in science and technology, we have begun team research in such fields as electronic devices and solar cells.

What Universities Can Do to Make Life More Bountiful

The "environment" and "ecology" have become challenges common to the entire human race. In the world of technology as well, green energy and the saving of energy have become important research themes, along with the development of the necessary materials, components, and devices. At the Tokyo University of Science, we began conducting energy and materials research on such themes as the environment and energy conservation early on, and from a number of approaches. As the saying goes, "technological innovation begins with the discovery of new materials and devices," and in more than a few cases, research on devices has had an impact sufficient to revolutionize the technological scene in a number of different domains. It therefore goes without saying that this field of research has an extremely vital role to play.

The Advanced Device Laboratories (ADL) is an organization that functions as a base for collaboration among allied researchers around the axis of research on devices. While conducting basic research, it serves to reinforce such activities as joint research with industry, commissioned research, and technological guidance, and engages in advanced device research activities. Even on research themes that were previously difficult for a single research institute to solve alone, it is possible to exhibit a high degree of technological strength when organic bonds form among research labs for the sharing of equipment, etc., and in many cases, this leads to fruitful research and new developments. When alliances between universities and industries are added, the speed at which problems are solved can be expected to accelerate.

By thus achieving the development of new devices, we would like to contribute to the movement in science and technology to give back to society. We also want to engage in the kinds of effective collaboration both within the university and with industry that can play a role in solving energy problems. Through these kinds of research activities, we aim to educate students who can carry our world into the future.

Joining with Industry to Create the Advanced Devices of the 21st Century

– An Example of a University-Industry Alliance –

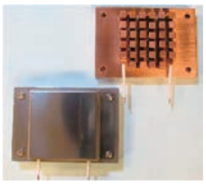
Among the thermoelectric conversion elements that have been researched and readied for practical use thus far, those including organic substances are the mainstream. If they are to be widely used in the future, it is important that the environmental load be low for the raw materials, the component materials of the elements, the intermediate products, and the final products themselves. It is also important that elements converting exhaust heat to electrical energy be composed of semiconductor materials that do not harm living organisms and also represent a low environmental burden.

The thermoelectric conversion material that derives electricity from high-temperature exhaust heat must be useable in a severe environment where the temperature ranges as high as 500℃; moreover, the devices must be made from material that takes account of the environmental load. Of the materials used in the past, a lead-tellurium (Pb-Te) system would be adequate for practical use of an exhaust heat power generating device, but if it were discarded carelessly, it could become a source of pollution, so it is important to use a substance, such as Mg_2Si, that has a low environmental burden.

Kazuhiro Ohkawa

New devices should not only provide new functions that make our lives richer; they must also, of course, be safe for humans and environmentally friendly. What can universities do in this regard through their ties with the greater community? To search for answers to this question, we are striving to develop into a research division that can play a role in making Japan a world leader in green energy technologies, while lending an ear to the voices of industry.

Development of the Mg_2Si raw material through joint research has been completed, and we are now in the process of producing an engineering sample of the "Mg_2Si exhaust heat power generating element."



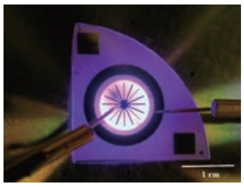
(Photo: The system whereby the module used for performance testing of the Mg_2Si exhaust heat power generating element generates electricity can be viewed at http://www.tus-iidalab.net/Info/Movie-Thermoelectric.html (The related data can be viewed with the prior consent of joint research partners).)

Beyond Devices, Device Evolution Through Integration – Introduction of ADL Research Technology –

At the Advanced Device Laboratories (ADL), we would like to work together with industry to achieve new energy sources, green energy, and energy savings through research and development of state-of-the-art devices so as to tackle environmental problems, such as global warming, that require solution on a global scale. Drawing upon the special characteristics of this research domain, which has attracted particularly high degrees of interest from many other fields, we aim to be an organization that can contribute to human society by promoting various kinds of joint research and creating novel enterprises.

Energy-Saving Devices	● High-efficiency LEDs and lasers ● Smart, energy-saving, next-generation electronic devices

- RGB optical devices using nitride semiconductors – Efficient energy saving
- UV to IR LEDs using oxide semiconductors with rare earth additives
- Development of next-generation high-speed, high-frequency devices
- Ferroelectric polarization control devices
- Transparent transistors



(Photo: Blue LED)

Clean Energy Devices	● Hydrogen production system ● Fuel cells

- High-efficiency hydrogen production system using nitride optical catalyst
- Development of solid electrolytes for fuel cells

(Photo: Nitride optical catalyst)

Energy Recycling Devices	● Thin-film solar cells ● Thermoelectric conversion elements

- CIGS and Sns thin-film solar cells – For the post-silicon age
- Development of thermoelectric elements for solar power generation – Using semiconductors with a low environmental burden to protect people and the earth

(Photo: Solar cell materials)

Functional Materials | Established: April 2010

Photovoltaic Science and Technology Research Division

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Director Professor, Department of Industrial Chemistry, Faculty of Engineering Division I

Hironori Arakawa

Research Content

Research and development of economical, high-performance, next-generation photovoltaic cells and new, efficient photovoltaic power-generation systems.

Objectives

Activating research and development of technologies for the utilization of solar energy, focusing on photovoltaic power generation, thus contributing to solving the issue of global warming, and knowledge sharing at the national and international level.

Future Development Goals

Carrying out collaborative research with active interaction between researchers from different specialized fields and developing new photovoltaic cells and energy processes.

Background and reasons for establishing the department

The most pressing important issue in the 21st century is global warming, and to resolve this problem, a considerable shift from fossil fuels to renewable energy sources, centering on solar energy, is required. Photovoltaic power generation is a highly promising technology, and the number of photovoltaic cells produced in recent years has increased dramatically. Moreover, the development of economical and high-performance photovoltaic cells is crucial not only for industries but also for universities and public research institutes.

With this background, this research department was established at the Tokyo University of Science in April 2010. This department aims to accelerate research on photovoltaic power generation, share its accomplishments at home and abroad, and contribute to solving the issue of global warming.

Constituent members of the department

This department currently includes 13 members, whose names and academic details are listed in Table 1. The specialized fields of the various members are chemistry, electronics, physics, materials, and systems, in six faculties, five departments, and two external organization. Collaborative research activities by each of these members, who are specialized in different areas of science, are of paramount importance for the development of photovoltaic power-generation technologies. We also welcome the participation of people who are interested in research related to photovoltaic power generation.

Research fields of members

Various types of photovoltaic cells such as Si semiconductor series (single-crystal, multicrystal, thin-film, amorphous), compound semiconductor (CdTe, CIGS, GaAs, InP, etc.), organic photovoltaics (dye-sensitized, organic thin-film), and oxide photovoltaic cells are becoming commonplace or are the subjects of active research or development. The specialized research fields of the members of this department are shown in Table 2. The department has one group that researches photovoltaic cell devices and another that researches photovoltaic power-generation systems that make effective use of the photovoltaic cells. The photovoltaic cell group aims to carry out superior research on photovoltaic cells and solar-thermal cells, including studies on nanocrystal Si, copper indium gallium selenide (CIGS), SnS, dye-sensitization, organic thin-film, and magnesium silicide (Mg2Si) thermal cells. The group for photovoltaic power-generation systems aims to carry out original research and development, focusing on three-dimensional photovoltaic power-generation modules, one of the future photovoltaic power-generation systems, the application of photovoltaic cells to space systems, and the development of systems with high reliability and long lifetime.

Aiming at collaborative and unique research.

In addition to the research content described above, we also aim to pursue unique research within this department. The collaborative research plan is shown in Figure 1. This collaborative research is the original research on photovoltaic power generation pursued by the Tokyo University of Science, and it is different from that carried out by other research institutes.

Hironori Arakawa

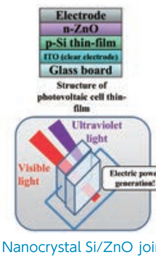
This research department is focused on research into photovoltaic cells and systems in which these cells are used. While many local and foreign research institutes and centers are carrying out extensive research on solar-electric power generation, we, although on a small scale, aim to function as a unique, specialized research department.

Table 1. Research content for the photovoltaic power-generation research department

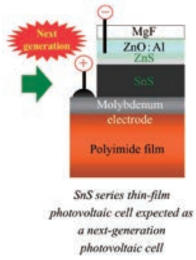
Organization of photovoltaic power generation research development				
Affiliation of key role	Job title	Name	Academic degree	Main research field
(Chief of department) Faculty of Engineering Division I Industrial chemistry department	Professor	Hironori Arakawa	Doctor of Engineering	Solar energy conversion technology / Catalytic chemistry
Faculty of Engineering Division II Electrical engineering department	Professor	Toshiaki Yachi	Doctor of Engineering	Energy conversion engineering / photovoltaic power-generation system
Faculty of Science Division II Physics deapartment	Professor	Zhao Xinwei	Doctor of Engineering	Semiconductor nanomaterial engineering / thin-film photovoltaic cell
Faculty of Industrial Science and Technology, Materials science and technology department	Professor	Tsutomu Iida	Doctor (engineering)	Heat-electricity converting electric power generation,Environmental load semiconductor material engineering
Research Institute of Science and Technology	Professor	Tokio Nakada	Doctor of Engineering	Semiconductor material engineering / thin- film photovoltaic cell, CIGS solar cell
Tokyo University of Science, Suwa, Faculty of System Engineering Electronic system engineering department	professor	Yoichi Hirata	Doctor (engineering)	Energy conversion engineering / photovoltaic power-generation system
Tokyo University of Science, Suwa, Faculty of System Engineering Electronic system engineering department	Associate professor	Yasuyuki Watanabe	Doctor (engineering)	Organic Photovoltaics (DSC, OPV) , Inorganic Photovoltaics
Faculty of Science and Technology Electrical engineering department	Lecturer	Mutsumi Sugiyama	Doctor (engineering)	Semiconductor material engineering / thin- film photovoltaic cell
Faculty of Engineering Division I Industrial chemistry department	Assistant Professor	Hironobu Ozawa	Doctor (science)	Organic Photovoltaics (DSC), Organometallic chemistry
Research Institute of Science and Technology	Assistant Professor	Taizo Kobayashi	Doctor (engineering)	Semiconductor material engineering / thin- film photovoltaic cell, CIGS solar cell
Research Institute of Science and Technology	Assistant Professor	Zacharie Jehl Li Kao	PhD	Semiconductor material engineering / thin- film photovoltaic cell, CIGS solar cell
AIST, RCPVT	Visiting Professor	Yuji Yoshida	Doctor (engineering)	Organic Photovoltaics
Meteorological Research Institute	Visiting Professor	Takahisa Kobayashi	Doctor of Science	Weather research for Photovoltaics

Table 2. Research fields of members

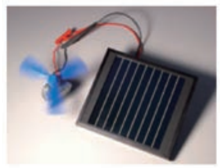
Photovoltaic cell device	ZHAO Xinwei	Nanocrystal-Si photovoltaic cell, nanocrystal Si/ZnO joint
	Tsutomu Iida	Magnesium silicide (Mg_2Si) solar thermal power system
	Tokio Nakada	CIGS photovoltaic cell
	Mutsumi Sugiyama	CIGS•SnS photovoltaic cell
	Taizo Kobayashi	CIGS photovoltaic cell
	Zacharie Jehl Li Kao	CIGS photovoltaic cell
	Hironori Arakawa	Dye-sensitization photovoltaic cell, Solar hydrogen
	Hironobu Ozawa	Dye-sensitization photovoltaic cell
	Yasuyuki Watanabe	Organic thin-film photovoltaic cell
	Yuji Yoshida	Organic thin-film photovoltaic cell
Photovoltaic power generation	Toshiaki Yachi	3D photovoltaic power-generation module
	Yoichi Hirata	High reliability and long-term stability of system
	Takashisa Kobayashi	Influence of weather condition on photovoltaics



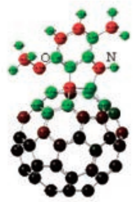
Nanocrystal Si/ZnO joint



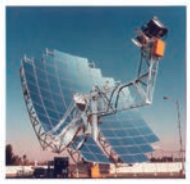
CIGS and SnS photovoltaic cell



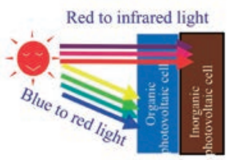
High-performance dye-sensitization photovoltaic cell



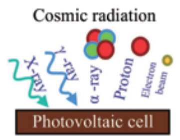
Modified fullerene for organic thin-film photovoltaic cell



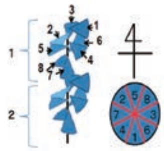
Solar thermal power generation



Organic / inorganic compound photovoltaic cell



Space-use photovoltaic cell



High-efficiency photovoltaic power-generation system

Figure1 Research content for the photovoltaic power-generation research department

Functional Materials | Established: April 2010

Division of Ecosystem Research

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Director Professor, Department of Pure and Applied Chemistry, Faculty of Science & Tchnology

Yasushi Idemoto

Research Content

We take the initiative in promoting and developing an ecosystem that has low environmental impact.

Objectives

On the basis of the Japanese concept of mottainai (which roughly translates as what a waste), we propose new ways to decrease environmental load with dual focus on "energy saving and resource saving (no consumption)" and "regeneration and recycling (no disposal)."

Future Development Goals

We propose an innovative technology because the effective use of energy and the development of alternative materials would be important for the future.

Ecosystem research is vital because it arises from social demand and academic concern. Energy development is important, but carbon dioxide emission must be reduced by the efficient generation and consumption of energy, for the benefit of the next generation.

We are engaged in constructing an ecosystem that aids energy saving and has low environmental impact, on the basis of the "mottainai concept." This concept is now known worldwide, and it is based on energy saving and resource saving (no consumption) and regeneration and recycling (no disposal). Members are grouped according to their primary focus, and each group concentrates on a particular aspect and conducts applied research.

The groups are divided into three subgroups according to the research and development theme: Material Development (Synthesis), Device Development (Application), and Evaluation and Systems. Each subgroup conducts pioneering research by using a multilateral approach instead of a traditional approach. We also develop new technologies by promoting collaboration among groups that share the same methodology. Innovation is achieved by the promotion of close collaboration among research groups that share the same objective and subgroups that share the same methodology vertically and horizontally. In addition, a review group consisting of group leaders, subgroup leaders, and an adviser promotes continuous collaboration and carries out regular cross-evaluation. We synergize our research activities by incorporating advice from experts in other fields and external agencies and by introducing new methodologies. The outcome is new materials and systems that have a relatively low environmental impact.

The research division is divided into two groups, and the members of each group focus on specialized fields (Fig. 1).

(1)Energy Saving and Resource Saving group (Gunji, Arimitsu, Yuasa, Itagaki, Shono, N.Sakai, Matsumoto, Idemoto, Mori, Tanaka, Tsukada, Kondo, Aikawa, Shitanda, Ikeda, Kitamura, and Ishida)
This group focuses on the development and practical application of alternative energy, alternative resources, and energy-saving materials and systems that use new functional materials (fuel cells and systems using light energy).

(2)Regeneration and Recycling group (H.Sakai, Fujimoto, Idemoto, Nojima, Sasaki, Takeda, Dowaki, Nagata, K.Sakai, Yamaguchi, Kitamura, Ishida, and Takenaka,)
This group focuses on regeneration and recycling, and in particular, new methods for utilizing surplus energy.
Figures 2 and 3 summarize the projects and collaboration of the groups.

The projects and collaboration are described below.

Development of fuel cell device using alternative electrode catalyst made of platinum:

The Device Development subgroup of the Energy Saving and Resource Saving group is planning to evaluate fuel cell devices by using the fixed electrolyte film developed by the Material Development group and the electrochemical system that will be developed by the Evaluation and System subgroup.

Development of small generating device using piezoelectric MEMS:

The Device Development subgroup of the Regeneration and Recycling group is carrying out evaluation studies using the high-performance nonleaded piezoelectric materials developed by the Material Development subgroup and the new depth direction analysis method based on the focused ion beam; details of this method will be discussed by the Evaluation and System subgroup.

Development of light-driven device:

The Device Development subgroup of the Regeneration and Recycling group is synthesizing a probe molecule using the alternative reduction catalyst developed by the Material Development subgroup.

The research conducted by this research division is centered on the effective use of energy. We propose innovative methods for technological development, with emphasis on the development of alternative materials.

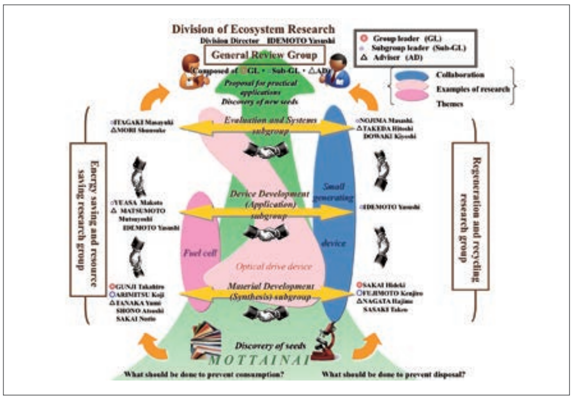

Fig. 1 Organization of Ecosystem Division

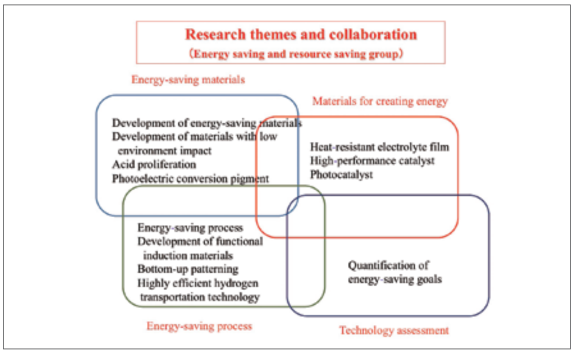

Fig. 2 Summary of Energy Saving and Resource Saving Group

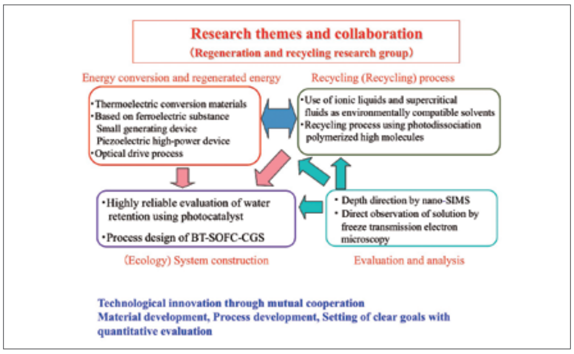

Fig. 3 Summary of Regeneration and Recycling Research Group

Yasushi Idemoto

This division was established in April 2010, and it is staffed with researchers in chemistry, physics, electronics, architecture, and management. We are addressing issues related to the development, application, and evaluation of materials. We aim to meet social demands holistically by carrying out interdisciplinary research beyond the borders of traditional academic fields. The new ecosystem axis is the main focus of our activities.

Functional Materials | Established: October 2012

Division of Nanocarbon Research

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Director Professor, Department of Physics, Faculty of Science Division I

Yoshikazu Homma

Research Content
Research and development on carbon nanotubes and graphene.

Objectives
To investigate novel properties relating to carbon nanotubes and graphene, and to develop material sciences utilizing the nanospace of nanotubes and the interaction between nanotubes and biomolecules.

Future Development Goals
To promote advanced researches on nanocarbons based on tight and highly active collaborations of division members.

Carbon nanotubes and graphene are low dimensional materials (with linear and flat shapes, respectively) composed of networks of 6-members rings (honeycomb structure). Owing to strong covalent bonds of carbon atoms, they have excellent mechanical strength and chemical stability enough to sustain the monolayered structure in a free space. Furthermore, they exhibit properties peculiar to the geometrical configuration and low dimensionality, which cannot be expected for three-dimensional crystals. As you can see from the fact that the Nobel Prize in Physics 2010 relates to graphene, nanocarbons such as carbon nanotubes and graphene are extensively studied in basic science. In the future, nanocarbons are expected to play a main role in an industrial revolution as iron and silicon did in the Industrial Revolution and the information technology revolution, respectively.

The Division of Nanocarbon Research covers topics of nanocarbons from fundamental to applied researches by collaboration of experts in theoretical and experimental condensed matter physics, electrical engineering, thermal engineering, and biophysics. We expect synergy effects by enhancing mutual discussion and exchange of ideas in the division.

Research topics

Material Sciences in Nanospace

○We use an individual single-walled carbon nanotube as a well-defined nanospace, and study the interactions between nanotubes and molecules such as water and alcohol by optical spectroscopy, electron microscopy and molecular dynamics simulations. Thereby, we elucidate the structure and phase of the molecules in the nanospace. We also study the interaction between nanotubes and polymers, aiming at application of polymer-nanotube composites.

○We regard systems composed of nanotubes with adsobates or defects as extended composites, and study the basic properties by first-principles electronic state calculations and model calculations.

Nanotube-Biomolecule Interaction

○We study structural properties of composites composed of nanotubes and biomolecules (DNA, protein). Specifically, we fabricate biodevices with nanotubes functionalized by DNA, and examine whether the structural properties of the biomolecules are retained, and whether the molecular recognition function is retained.

○We theoretically investigate the host-guest interactions of the nanotube/ biomolecule composites, and clarify the effect on the properties of the composites.

Growth Control of Nanocarbons

○We develop techniques for precise structural control of nanocarbons based on the various nanotube synthesis techniques such as vertically-aligned growth on silicon and silica substrates and horizontally-aligned growth on quartz substarte.

○We study novel synthesis methods of nanocarbons utilizing arc discharge by changing the discharge ambience, electrode materials, etc. We also study novel methods for graphene synthesis.

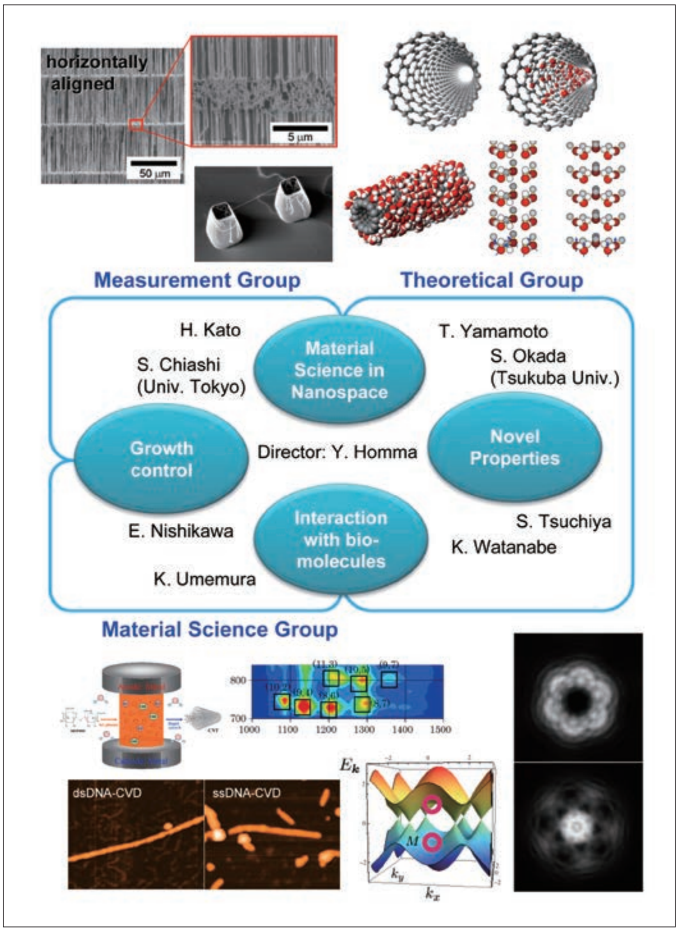
Theoretical Study on Novel Properties

○We perform first principles or semi-empirical simulations in order to clarify the responses of electrons or atoms in nanocarbons to laser or high electric field. We are aiming at theoretical descriptions of experimentally observed phenomena such as field electron emission, laser induced electron emission, laser stimulated coherent phonon generation/plasma oscillation excitation, etc.

○We analyze the electric transport in nanocarbons by using simulation techniques in order to understand the interactions between nanotube/graphene and high speed electrons.

○We theoretically study the super conductivity of nanotube and graphene, and predict the basic properties.

○We analyze the electronic structure of nanotube composites in their ground states, and also the phenomena relating to their excited states.



Yoshikazu Homma

Nanocarbon is an active research field with increasing publications. Our research division is unique in that advanced researchers of nanocarbons are getting together and perform researches with wide scopes. In particular, tight collaborations between theorists and experimentalists are our strength. We are aiming at creating a new field based on our researches.

Functional Materials | Established: April 2013

Division of Therrmoelectrics for Waste Heat Recovery

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Director Professor, Department of Materials Science and Technology, Faculty of Industrial Science & Technology

Keishi Nishio

Research Content

R&D on waste heat recovery systems using solid-state thermoelectric energy conversion technique.

Objectives

To research and develop materials and power generation systems which is used for the waste heat recovery for the automotive and industrial application fields.

Future Development Goals

To research and develop appropriate thermoelectric materials and thermoelectric power generation systems which is installed to the automotive exhaust line and the industrial furnaces, in order to obtain fuel-efficient system.

The earth's environment will undergo great changes within our own lifetime if we keep consuming fossil energy on such a massive scale as we are doing now. The earth's environment could drastically change in our children's era due to global warming. "What about the generation of atomic power?" We worry that we are dumping atomic waste caused by our wastefulness on to our children or our grandchildren, or even that we are passing the problem on to their descendents some thousands of years in the future. Although an individual person possesses only limited power, we feel that the time has arrived when we must start moving towards a "sustainable society for the future."

Human beings are really just creatures who are supported by the ecological food chain, although we supposedly possess higher intelligence compared with the other creatures that inhabit the earth. Thus, we must start to think more seriously about the global environment….

Improvements in energy and environmental problems cannot progress at a sufficiently high pace to make a difference sometime today or tomorrow. Therefore, proactive studies that look ahead for some tens of years are necessary. From a material's standpoint, not only steps to ensure future resources, but also studies of materials that could maximize energy conversion efficiency are required. From the view point of environmental conservation, studies of materials that represent a low environmental burden are needed. There is now a trend towards the prohibition of some poisonous materials that were previously permitted to be used in small amounts, irrespective of how desirable their performance is.

In this Division, we have been developing materials for energy conversion to tackle the global warming that is being caused by the mass consumption of fossil fuels. In particular, considerable weight is currently being placed on the study of materials for power generation from waste heat. Using these materials, heat energy, which is the final phase of energy consumption, can be recycled into electrical energy. Concurrently, we have also been pursuing environmentally friendly semiconductor energy conversion materials, while studying environmentally "low-load" production processes. Environmental semiconductors are semiconductor materials that are abundant on the earth and which comprise of materials that are friendly to living creatures and to the environment.

The main advantage of thermoelectric conversion as compared to thermodynamic conversion results from the absence of any moving parts. Being entirely static, the device is vibrationless and is not affected by wear. In the context of increasing energy prices and climate change, thermo-electric conversion is of the highest interest for producing electric power from waste heat. It has also attractive applications for low and near ambient temperature refrigeration.

Especially, the automotive industry is anxious for the installation of thermoelectric generators (TEG) because of the strict fuel consumption regulation in EU. As is shown in the figure, almost all current models could not pass the regulation at 2020, except for some hybrid system or next generation of diesel engines. Since ~70 % of initial gasoline is emitted as waste heat when we drive, if some percentages of discarded heat can be reused, then fuel consumption is improved. An on-board TEG system is one possible technique to conserve fuels and supply electricity. In our research division, we are currently working corresponding research issues listed below to proceed appropriate thermoelectric materials and TEG adopted for the automotive application and the industrial furnaces.

Keishi Nishio

In this Division, we have been developing thermoelectric materials and systems for energy conversion to tackle the global warming that is being caused by the mass consumption of fossil fuels. Using our state-of-the-art thermoelectric technology, heat energy, which is the final phase of energy consumption, can be recycled into electrical energy. Concurrently, we have also been pursuing environmentally friendly semiconductor energy conversion materials, while studying environmentally "low-load" production processes.

Thermoelectric material development and fabrication

Synthesis of powders and bulk materials using methods of

- High energy ball milling (synthesis/mechanical alloy/doping)
- Combined process of vibration ball milling and spark plasma sintering (synthesis & doping)
- All molten synthesis (synthesis & doping)
- Manufacture-oriented all molten synthesis
- Mechanochemical and self-flux synthesis

Fabrication of nano-structures with enhanced functionality as post process of the materials developed with fabrication methods of

- High energy ball milling (nanostructurization)
- Melt spin synthesis (nanostructurization)
- Direct nanostructure-formation during spark plasma sintering process

Powder compaction and sintering for thermoelectric chip fabrication

- Standard Material Consolidation (thermoelectric chip fabrication)
- Spark plasma sintering (thermoelectric chip fabrication)
- Plasma activated sintering (thermoelectric chip fabrication)

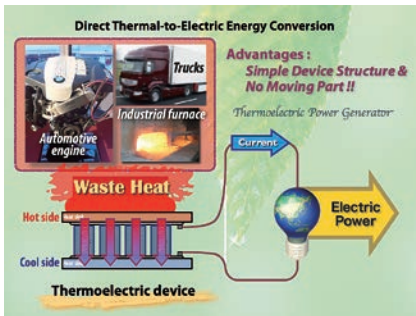
Application and development of advanced characterization and measurement methods for thermoelectrics

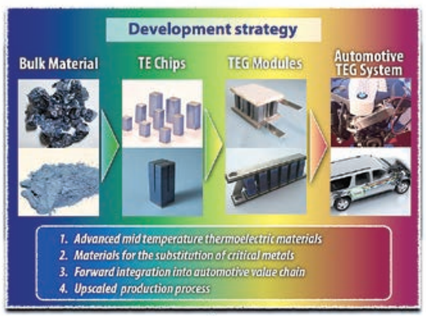
- Physical properties of thermoelectrics
- Structure of thermoelectrics from meso- to atomic scale
- Combined approach of XRD, SEM and TEM
- Chemistry and structure at the nanoscale by advanced electron microscopy
- Electronic band structural analysis using synchrotron based techniques
- In-situ analyses for durability enhancement

Computational thermoelectric material and power generation module structure design

Modeling and rational design of thermoelectric material.

- Identifying fundamental properties, including temperature dependence of thermoelectric power, and optimal uses of the material classes delivered by the first principles calculations using the all electron FLAPW/LDA (Code:ABCAP)
- Designing the optimal nanostructures from lattice thermal conductivity perspective using the mulitscale phonon transport calculations based on first principles.
- Finite elemental





Functional Materials | Established: April 2013

Division of Colloid and Interface Science

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Director Professor, Department of Industrial Chemistry, Faculty of Engineering Division I

Takeshi Kawai

Research Content

General research on surfaces and interfaces.

Objectives

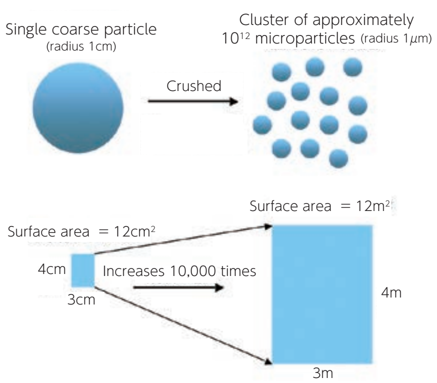
To play a leading role in colloid and interface science both in Japan and internationally.

Future Development Goals

We afford a deep understanding of surface phenomena from fundamental aspects and the practical aspects by the assist of exchanges of information and closer collaboration between interdisciplinary researches. In particular, we give intensively attentions to "static and dynamic surface behaviors" and "dimension of target-objects".

All physical objects have surfaces. A boundary surface (interface) also exists between two mutually contiguous objects. Interface science is a discipline that researches surfaces and interfaces.

Let us take, for example, a coarse spherical particle with a radius of 1cm. By crushing this particle, we can create a cluster of microparticles with a radius of 1μm. Since the total volume of the entire cluster of microparticles is the same as that of the coarse particle (4.2cm^3), it is easy to calculate that we can create 10^{12} microparticles in this way (see the diagram below). The surface area of the coarse particle, however, is 12cm^2 or 3cm by 4cm, about the same size as the palm of your hand. But when the coarse particle is crushed, the total surface area increases 10,000 times to 12m^2 or 3m by 4m. In other words, the cluster of microparticles has an unbelievably large surface area. With such a large total surface area, the properties and behavior of the cluster of microparticles (colloid particles and nanoparticles) are determined by the properties of their surface area.



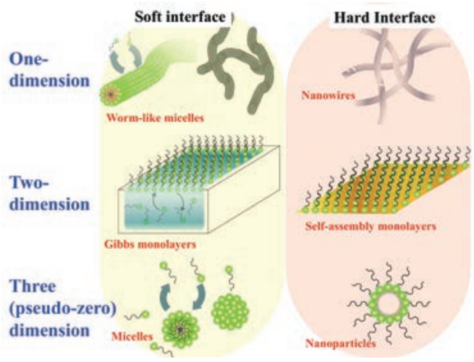
Interface science has a broad range of application, and is related to a variety of fields including surface active agents (surfactants), microparticle (colloid particle and nanoparticle) dispersed systems, microcapsules, gel, solid surfaces, powders, bio-interfaces and environmental colloids.

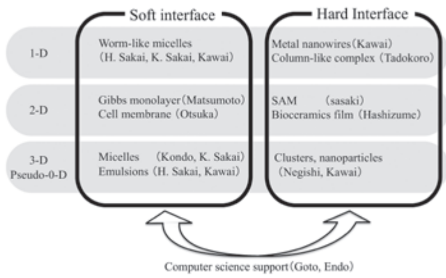
The Division of Colloid and Interface Science was established in January 1981. The first Director, Professor Kenjiro Meguro (Department of Applied Chemistry, Faculty of Science) was succeeded by Professor Tamotsu Kondo (Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences), Professor Minoru Ueno (Department of Applied Chemistry, Faculty of Science), Professor Kijiro Konno (Department of Industrial Chemistry, Faculty of Engineering), Hiroyuki Ohshima (Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences), and Professor Takeshi Kawai (Department of Industrial Chemistry, Faculty of Engineering) leading up to the present incumbent. The members come from all faculties of TUS, and have played a leading role in interface and colloid science both in Japan and internationally.

The Division of Colloid and Interface Science had been shifted to the Center for Colloid and Interface Science during 2008〜2013, because a project application was accepted as the MEXT Program for the Development of Strategic Research Bases. The project theme was "Creation and Application of Nano/Biointerface Technologies," and the research unit consisted of 5 groups: biointerfaces, biomaterials, nanomaterials, nanospace, and interface theory/analysis. In this project, we approached the interface as the locus of temporospatial expression of function, and our goal was to create temporospatially controllable nano/biointerface technologies.

Now, we restarted the division of colloid and interface science with new members from April 2013. The main research project is the deeper understanding of dynamic surface phenomena of "soft interface" and "hard interface". Here, "soft interface" is referred to a dynamic ineteface where molecules and atoms are continually going in and out thorugh the interface, whereas "hard interface" means a static interface where no exhange of molecules and atoms take place at the interface. The representative materials of the former are spherical and worm-like micelles, emulsions, vesicles and Gibbes monolayers, while the latter are metal nanoparticles and nanowires, nanoporous materilas made of organic complexes, self-assembled monolayers on solid substrates. "Soft interface" and "hard interface" can also be called "dynamic interface" and "static interface", respectively, and the both interfaces are classified into three basic groups according to dimesions, namely, zero and three dimesion, one dimension and two dimension. We aggressively pursue the fully understanding of the fundamental phenonema and the fuctions at the both interfaces, and hope to achieve the development of novel functional materials.

In this project, we are going to investigate intensively the role of water molecules present at interfaces such as solid-liquid, liquid-gas and solid-gas interfaces. It is general known that water molecules at interfaces play a crucial role in performances of various functional materials including biomaterials, however, the detailed functions and structure of water, and interactions beween substrate molecules and water remain unsolved.





Takeshi Kawai

Every objects have surfaces, and there are interfaces between objects. Surface science is a science which studies surface phenomena emerged from restricted spaces at interfaces or boundaries, and covers a wide interdisciplinary research fields. Further, surface science has an interest side and some surface science researches pursuit conceptual understanding of the phenomena, although it is one of materials science. We sincerely hope that outcomes of our project will contribute to the progress of many other fields.

Functional Materials | Established: April 2013

Division of Synergetic Supramolecular Coordination Systems in Multiphase

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Director Professor, Department of Chemistry, Faculty of Science Division I

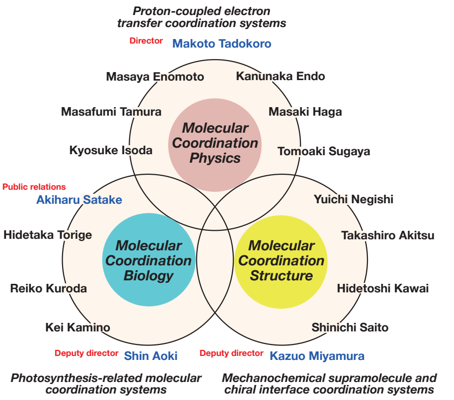
Makoto Tadokoro

Research Content
Performing structural, physical, and functional evaluation of organic, inorganic, and biological complex molecular systems.

Objectives
The Division of Synergetic Supramolecular Coordination Systems in Multiphase joins together synthesized complex molecules (organic-inorganic complex molecular devices) to create complex functionality that would be difficult for a single molecule to attain, and aims to produce novel synergistic effects.

Future Development Goals
A scientific field is needed that attempts to control molecular arrangement and proactively utilizes intermolecular interactions. In particular, possible future advancements include biological functions, proton-coupled electron transfer systems, and mechanical-photochemical energy conversion that are governed by intermolecular interactions.

Research Aims
Researchers who target molecules such as inorganic-organic complex molecules perform molecular design to study the synthesis of target molecules with new functionality. For example, useful new molecular systems that do not exist in nature are being constructed one after another, such as artificial proteins, molecular machines, molecular superconductors, multiferroic molecular crystals, photomolecular catalysts, Grätzel solar cells, and organic thin film field effect transistors. Furthermore, in addition to the rapid pace at which functional molecules are being developed by these ideas, a trend has recently appeared toward the development of "molecular coordination systems," which join together different functionalized molecules. Synergistic complex supramolecular systems that join together these different functionalized molecules are characterized not only by the combination of their existing functions, but also by the appearance of synergistic effects. At the Division of Synergetic Supramolecular Coordination Systems in Multiphase, several molecules synthesized by different members of the group are mutually interacted to create complex functionality that is difficult to obtain from a single molecule, in an attempt to produce novel synergistic effects. When building this kind of molecular system, although virtually all of the molecules can be synthesized at the current scientific level, controlling the arrangement of these molecules in order to harness their intermolecular interactions has become an extremely important problem. Accordingly, this research attempts to bring together various strategies for controlling crystal structure, surface organization, molecular arrangement, and molecular structure.



For example, the ultimate ensemble that uses synergistic complex systems with these kinds of functionalized molecules is a photosynthesis system. In such a system, the individual molecules on a thin film including many biological molecules appear to function together in an overall uniform interaction (Figure 1), allowing photosynthesis to convert 70% of solar energy into chemical energy, stored in the form of high-energy molecules such as ATP and NADPH. In this kind of complex system, molecules that have several roles interact on the thin film to create the target functionality.

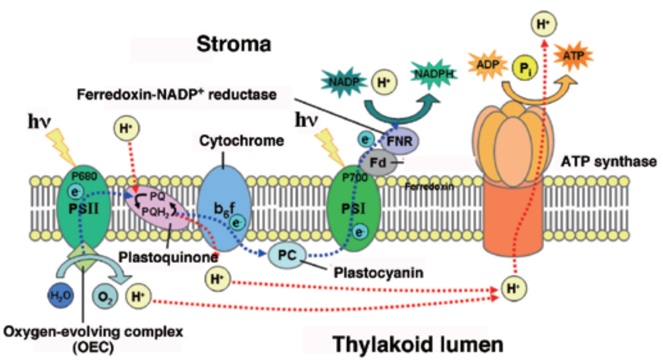


Fig. 1 Biological photosynthesis system (by Wikipedia)

Makoto Tadokoro
Almost all researchers who work on molecular coordination systems focus on molecules. Although molecular design and molecular synthesis have become possible following previous scientific advances, challenges still exist in making these molecules self-organizing and harnessing the intermolecular interactions between them. Biological molecules represent the only known "complete molecular devices" to achieve this feat, and we plan to continue with our research on mimicking the intermolecular interactions of these molecules.

Three supramolecular coordination themes
In our research division, the first goal is to develop the individual functionalized molecules. The next goal is mutually to interact different molecules in supramolecular and crystallographic assemblies to develop molecular systems with novel functionality to produce synergistic effects (even under a scanning tunneling microscope). Our research is therefore divided into the following three themes, the aim of which is to mutually construct molecules and induce intermolecular interactions using systems that are controlled in an advanced way.

1. Molecular coordination physics: This theme focuses on solid-state physical properties such as optics, magnetism, and conductivity. The synthesis in this research theme focuses on controlling the electron system by giving degrees of freedom to the molecules and ions. We are striving to build molecular coordination systems with a proton-coupled electron transfer in particular.
2. Molecular coordination structure: This theme conducts research into interlocking compounds that act as mechano-chemical supramolecules, metallic clusters that have limited to novel structures and numbers, and the chirality of interface structures and crystals. We create molecular machines that exhibit supramolecular motion and chirality that controls on the interfaces and in the crystals, metal cluster catalysts that exhibit physical properties for controlling structures and numbers.
3. Molecular coordination biology: This theme involves molecular design based on biological energy conversion such as photosynthesis. We aim for energy conversion, such as from light energy to chemical energy or chemical energy to mechanical energy, through the use of molecular complexes based on biological mimic systems such as porphyrin complexes, electron transfer complexes, and luminescent complexes.

Establishment of the Division of Synergetic Supramolecular Coordination Systems in Multiphase
Over the last several years, many academic staff members specializing in coordination chemistry have been employed at the Tokyo University of Science, particularly in the Faculty of Science. For this reason, the " Supramolecular Coordination Chemistry Research Group in Tokyo University of Science " was established in 2010 with the aim of bringing together capabilities (molecular design, molecular synthesis, and molecular analysis) from the various schools within the Tokyo University of Science (January 18, 2011). In other words, an attempt was begun to create a place for academic exchange and cooperative research between academic staff and students who belong to the physically separated Kagurazaka area and Noda campuses. The aim was to hold discussions and conduct research in a carefree and innovative way in order to make a major contribution to this field and to have a large impact both domestically and internationally. Research group members applied for funding for our research activities through a 2011 "Grant-in-Aid for Collaborative Research" awarded by the dean for "Chemistry Related To Photosynthesis Using Metal Complexes and Supramolecules." The funds were used to purchase a fluorescence lifetime spectrometer, which is currently being utilized in collaborative research between our members. Our second conference on funding for our collaborative research was held on July 9, 2010, at Building 14 of the Faculty of Pharmaceutical Sciences. After the keynote lecture titled "Chemistry related to photosynthesis using metal complexes and supramolecules," by Professor Akiharu Satake of the Faculty of Science at our university a presentation session was held by the research group members. For our third conference on November 18, 2011, the symposium "Interface Science and Coordination Chemistry—An Approach to Biological-Related Functions" was held. The conference had such main features as a chairman, presentations, and a statement of purpose. Furthermore, on August 23, 2012, the researchers seeking approval to establish the new division gathered and held a Preparatory Meeting on Establishing the Division of Synergetic Supramolecular Coordination Systems in Multiphase.

Functional Materials　Established: April 2012

Na-ion Batteries Project

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Director　Professor, Department of Applied Chemistry, Faculty of Science Division I

Shinichi Komaba

Research Content

Research on the development of high performance battery materials for Na-ion batteries

Objectives

Our project aims to develop Na-ion batteries to realize the sustainable energy development in the future.

Future Development Goals

Our goals are to find new high performance electrode materials and to study the detailed reaction mechanisms for the further development.

Message

The demand for new batteries beyond Li-ion batteries is now rapidly growing. Our project was founded in collaboration with a company to realize the development of high-energy and safe Na-ion batteries. The development of Na-ion batteries is expected to create sustainable society with the renewable energy resources in the future.

Introduction

To achieve green and sustainable energy development, it is now clear that the substitution of alternative energy sources for fossil fuels must be considered. This realization resulted in the introduction of electric vehicles, which are equipped with large-scale lithium batteries as power sources, to the automotive market. Furthermore, lithium batteries have potential applications for energy storage within electrical grid systems to effectively use electricity from power plants, solar cells and wind turbines. The demand for large-scale rechargeable lithium batteries is rapidly growing. To achieve sustainable energy development, we must reconsider the feasibility of lithium, which is certainly the essential element in lithium batteries. Lithium is widely distributed in the Earth's crust, but is not regarded as an abundant element as shown in Fig. 1. Although nickel, cobalt, and copper are also important elements for the high energy lithium batteries, these elements are also known as less abundant elements, similar to lithium. These facts inevitably restrict the development of large scale lithium batteries. In contrast, sodium resources are unlimited everywhere, and sodium is the second-lightest and smallest alkali metal next to lithium. Rechargeable Na batteries consisting of two different sodium-insertion materials without metallic sodium are a promising candidate for such large-scale applications. In this project, our goals are to realize the Na-ion battery as high-energy, cost-effective, and safe batteries, especially for large-scale energy storage systems.

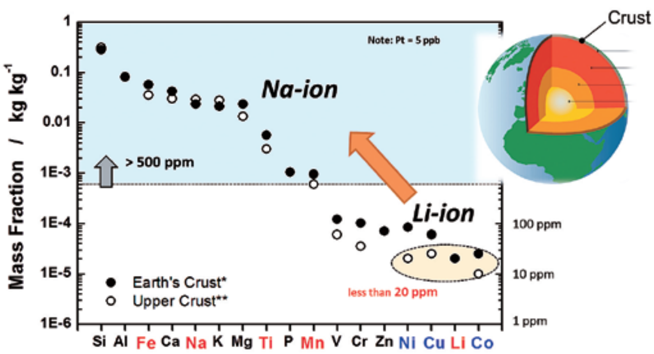

Fig. 1　Elemental Abundance in Earth's Crust

*CRC Practical Handbook of Physical Properties of Rocks and Minerals, CRC Press, Boca Raton, FL, (1989).
**S.R. Taylor, S.M. McLennan, The continental crust: its composition and evolution, Blackwell Sci. Publ., Oxford, 330 pp. (1985).

Na-ion batteries

Li-ion batteries are well known as rechargeable batteries for portable electronic devices. Na-ion batteries essentially consist of the same technology with Li-ion batteries, except charge carriers. Na ions are utilized instead of Li ions. A schematic illustration of Na-ion batteries is shown in Fig. 2. Na-ion batteries mainly consist of two sodium insertion materials, positive and negative electrodes, with electrolyte solution. On charge process, Na ions move from the positive to negative electrode through electrolyte solution with simultaneous movement of electrons through an external circuit. A discharge process proceeds in the opposite direction. Na ions and electrons come back to the positive electrode. The other battery materials, such as conductive agents, polymer binders, and suitable electrolyte additives are also necessary to achieve stable cycling as the rechargeable batteries. There are several difficulties in the development of Na-ion batteries with good performance similar to Li-ion batteries because the suitable chemistry for Li- and Na-ion batteries is often different each other. Therefore, the extensive research efforts to develop new positive and negative electrode materials, binders, electrolytes, and additives are all necessary to realize high performance Na-ion batteries.

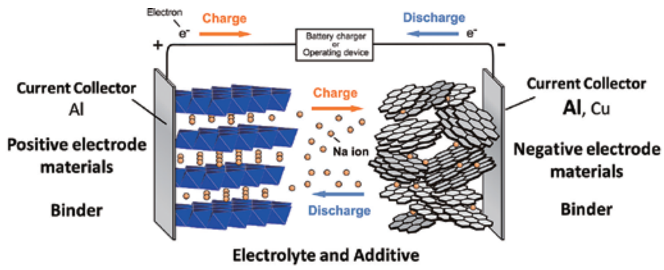

Fig. 2　Schematic illustration of Na-ion batteries

Planning of research activities

In our research project, a series of battery materials is developed toward Na-ion batteries as high-energy, cost-effective, and safe battery systems. Specifically, positive electrode materials are required to be high capacity, high voltage, and safe. In contrast, non-graphitic carbons as negative electrode materials are found to deliver the high capacity in Na cells. The further optimization and control of structures of the non-graphitic carbons are necessary as negative electrodes for Na-ion batteries. Furthermore, binders, electrolytes, and additives play the important role in bringing out the potential of these electrode materials developed in our project. These research efforts would realize the development of Na-ion batteries designed for large-scale applications in the future.

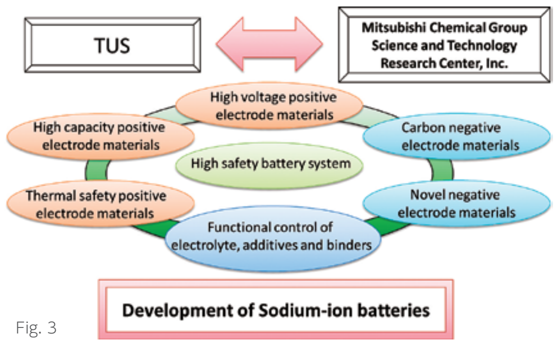

Fig. 3

Structural Materials Established: April 2012

International Research Division of Interfacial Thermo-Fluid Dynamics

i2plus@rs.tus.ac.jp

Director Associate Professor, Department of Mechanical Engineering, Faculty of Science & Technology

Ichiro Ueno

Research Content

Non-linear thermo-fluid dynamics in the vicinity of three-phase boundary line and its application.

Objectives

We, international and interactive research group, focus on heat/mass transfer phenomena in micro- and nanometer scale to realize high-efficient devices through making full use of interfacial thermo-fluid dynamics.

Future Development Goals

Final goal of our research project is to realize technologies for low consumption of energies and low contamination of environments. Through the research activities, we also focus on educational contributions by embodying international environments for students as well as researchers.

This research division (nicknamed as 'I^2plus') was established in the Research Institution for Science and Technology (RIST), Tokyo University of Science, in April 2012. This division consists of young researchers from Europe, the United States, and this university, Tokyo University of Science. We set our final goal as to develop high efficient, low consumption of energies and low contamination of environments as 'earth-friendly' devices of heat/mass transfer in micro- and nanometer scale. Typical examples of technologies for applications are techniques of gas/liquid/solid manipulating under low energy input; fluid handling and/or heat transfer with high heat flux in a very small area for fuel-cell or electric vehicles, controlling ultra-fine chemical reaction with a very tiny amount of test fluids for environmental controls, and so on. Such technologies are indispensably required not only for our society after the severe disaster and accident in 2011, but also for fatal issues of global energy problems due to the explosive development of the quality of life in the third world. It is one of the prominent features of this research division that we vigorously promote research and education in collaboration with researchers of the world.

Research

Our final goal is to establish a mesoscopic dynamics of the fluid in the vicinity of the solid-liquid-gas three-phase boundary line (contact line) and to apply it to engineering technologies. In this dynamics, we have to solve the problems in multiscale and multiphase systems; we treat the prime factors such as energy states near the interface due to the chemical and physical barriers, and microscopic movement, deformation and diffusion near the contact line, and their interactions. Target issues in this research division are phenomena emerged near the boundaries of two phases (solid-liquid, liquid-gas, and gas-solid), and phenomena emerged near the three-phase boundaries (Fig. 1); typical examples for former phenomena are such as condensation, generation and collapse of gas/vapor bubbles, and adsorption, and those for latter are such as wetting and dewetting. We especially focus on following topics;

(A) measurement and control of thermal-flow field near the micro- and nanometer-scale movable and deformable interface,

(B) elucidation of thermal-flow field and its near-wall structure in micro- and nanometer-scale channel, and,

(C) elucidation and control of mass transport near the micro- and nanometer-scale movable and deformable interface.

Education

In parallel with the research activities, several workshops (I^2plus Workshop) and seminars (I^2plus Seminar) open to the public will be held in a fiscal year. In the I^2plus Workshop, students and faculty members make active discussion through presentations of latest results. In order to accelerate 'cross-cultural' interaction, students are actively encouraged to join the poster sessions. In the I^2plus Seminar, we will invite researchers from all over the world to have fruitful discussion and inspirations. We have invited speakers from Lunds Universitet (Sweden), Technische Universität Wien (Austria), University of Florida (the United States), Univ. Paris-Sud XI (France) and others. In JFY2013, we host i^2plus 1st International Symposium on Interfacial Thermo-Fluid Dynamics at Noda-Campus, Tokyo University of Science on 4th April (Fig. 2). We had fruitful discussion and exchanged ideas with speakers/participants from France, Israel, Sweden, the United States and others as well as the students at Tokyo University of Science.

We also make strong efforts to realize exchange of students between foreign universities in order to provide international environments for researches and daily lives for young students as well as faculty members. In the JFY2012, two master-course students in Dept. Mechanical Engineering, Fac. Science & Technology at TUS stayed to join collaborative research at Dept. Chemical Engineering at University of Florida, and a Ph.D. candidate from that department stay at Dept. Mechanical Engineering, Fac. Science & Technology at TUS. Another master-course student in Dept. Mechanical Engineering, Fac. Science & Technology at TUS stayed at the Microgravity Research Center in Université Libre de Bruxelles (Belgium) and a faculty member stayed at Université Lille 1 (France) to prepare the program of the exchange students and faculties for collaborative researches. In the JFY2013, a master-course student will stay at Université Lille 1 to carry out a series of experiments for the collaboration among Technion (Israel), Univ. Lille 1 and TUS.

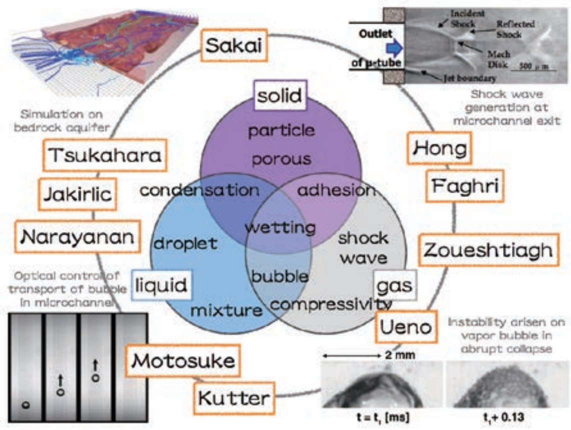

Fig. 1 Prime factors of phenomena within a phase or between/among phases.

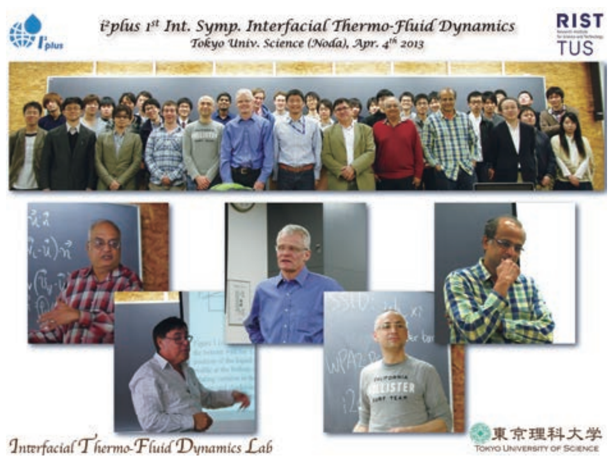

Fig. 2 Snapshots at i^2plus 1st International Symposium on Thermo-Fluid Dynamics (Noda Campus, Tokyo University of Science, 4th April, 2013).

Ichiro Ueno

A group of young researchers from various fields of mechanical, electrical and electronics, chemical, and material engineering started this research division in April 2012. Our goal is to make contributions to scientific and technological issues in order to realize 'earth-friendly' technologies through the international activities on research and education.

Bio and Pharmacy   Established: April 2009

Center for Technologies against Cancer

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Director Professor, Research Institute for Biological Sciences (RIBS)

Ryo Abe

Research Content

Research on the safety technology to protect human life and property from fires, and research on the fire science to support it.

Objectives

To promote the development of fire science and fire safety engineering, as well as the training of young researchers and specialist professionals.

Future Development Goals

To establish an education and research center at the highest level of the world, to meet various social demands concerning fire safety, and to make a contribution to society.

History of Center's Establishment

The "Tokyo University of Science Researcher's Network" emerged from discussion among a group of several faculties and graduate-level research courses who were working toward applying for global COE program 5 years ago. It was launched as a venue for exchange occurring through research efforts that bring faculty members together in a multidisciplinary manner. The members of this network strive for an understanding of fields of research that are different from their own, not only to broaden the scope of their own research, but also to excavate and create integrated research domains as well as totally new domains. With this core group of members we have called out to other researchers who are investigating research related to cancer, and our alliance with the National Cancer Center Hospital East since 2007 has provided the basis for holding the Integrated Cancer Research Center Working Group. Since 2009 we have been presenting a lecture series entitled "Answers to Questions You Are Too Embarrassed to Ask about Cancer," which pairs a medical specialist with one of our faculty members to target any of our students and teaching/administrative staff. We plan to offer these lectures 6 times a year. The 3 lectures that have already been held were attended by over 130 of students, faculty members, and administrative staff members in each time.

Based on these history and our achievements thus far, we applied for the fiscal 2009 MEXT Support Program for the Creation of Strategic Research Bases at Private Universities with the goal of producing more concrete results through substantive joint research. Our application was accepted, leading to the real start of practical research activities on the part of the Center for Technologies against Cancer.

The Significance of This Research Center's Establishment

At the leading edge of medical treatment, the nonmedical science and technology (i.e. Science, engineering, pharmaceutical science, and life science), which heretofore played only a peripheral role, will hold the key to innovative new fields of medicine. As a comprehensive university in the field of science and engineering, the Tokyo University of Science has been the one of myriad advancements in a great diversity of specialized fields. At this base, researchers active in not only the fields of medical science, molecular biology, and pharmaceutical science, but also mathematics, information science, applied biological science, industrial chemistry, mechanical engineering, material engineering, and bioengineering are working on projects by networks of researchers from a diverse mix of fields under the banner of "Creation of advanced science and technologies for cancer treatment."

Another special characteristic of this base is its powerful alliance with the National Cancer Center Hospital East, one of Japan's finest medical institutions specializing in cancer, and its location very close to the hospital (only 3 km away). The Research Center for Innovative Oncology that belongs to the National Cancer Center's Hospital East is an ideal base for collaboration toward the development of the kind of basic science and technology for cancer treatment that we aim for, because it is developing sophisticated diagnostic imaging techniques with which to pursue surgical, internal, and radiotherapy methods.

As seeds for the future growth of industry in Japan, there is tremendous significance to the development of medical treatment technologies such as therapeutic drugs, diagnostic equipment, and medical devices based on innovative science and technology created in Japan through an alliance between "cancer treatment" and fields that focus on "making things."

Ryo Abe

This Center established based on collaboration with researchers in the community of Tokyo University of Science that was expanded in the process of applying for global COE program for past few years. Through the activities of this Center, we would like to further expand our network of researchers in different fields and help to improve the research environment for young researchers as well, by trying a variety of new approaches, such as openly soliciting new research themes from within the university community.

Research Groups, Team Composition, and Projects

Visualization/Recognition Alliance Group

Aims to create visualization and recognition technology making possible the early detection of cancer development and metastasis through development imaging data analysis systems. The production of hybrid probes combining SPECT/CT probes with NIR excitation fluorescence-emitting luminescent nanoparticles containing rare earth doped ceramic nano-particles, as well as using mouse SPECT/CT images is one of major research themes.

Drug Discovery/DDS Science Alliance Group

● Biodevice Team

Engage in the selective collection of cancer cells, the development of silicon devices for cellular alignment that can be applied to drug sensitivity tests, and the search for novel surfactants needed in the preparation of nanomaterials (nanobubbles).

● Drug Discovery Team

Our projects include the development of anti-cancer agents and methods for cancer cell analysis, based on synthetic organic chemistry, coordination chemistry, supramolecular chemistry, photochemistry, and computer chemistry.

Mathematical Information Science Alliance Group

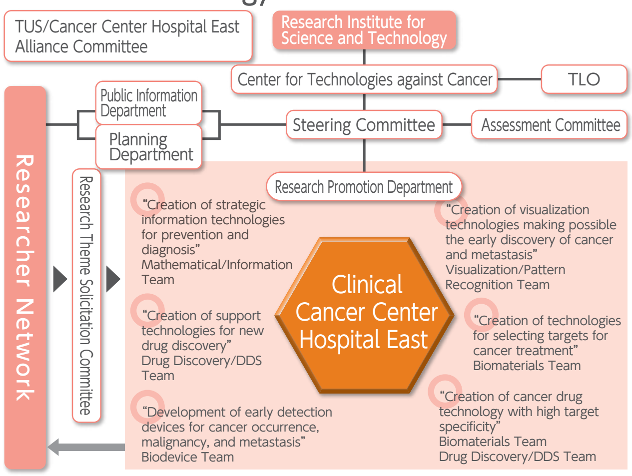
● Mathematical/Information Analysis Team

Assess prognosis and therapeutic effect based on clinical data, and create computer models to predict changes over time for diagnosing recurrences.

● Biomaterials Team

Produce antibodies that recognize HLA-tumor rejection antigen peptide complexes and use them in the development of diagnosis and treatment methods for cancer.

Base for the Creation of Basic Science and Technology for Cancer Treatment



Center for Technologies against Cancer
Tokyo University of Science

Bio and Pharmacy　　Established: April 2010

Center for Physical Pharmaceutics

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Director　Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences

Kimiko Makino

Research Content

R&D on drug delivery systems.

Objectives

With a view to promoting commercially viable DDS, our aim is to learn the structure of human body and to deliver medicine to the target organ when the medicine is needed.

Future Development Goals

To research and develop more efficient drug delivery systems with lower side effects of drugs.

Nanomedicine

Nanomedicine is medical treatment at the "nano" scale of about 100 nm or less. From 1980's, progress in developing nanosized hybrid therapeutics and drug delivery system has been remarkable and products have been approved for clinical use. Most are anticancer therapies, polymer-coated liposomes (Doxil®/Caelyx®), antibodies (Herceptin®, Avastin™), a nanoparticle containing paclitaxel (Abraxane™). The concepts of antibody-conjugates, liposomes, nanoparticles, polymer micelles stem from the 1970s. Liposomes are biocompatible drug carriers, but easily release drugs quickly or do not release drugs and sometimes captured by the reticuloendothelial system (RES), even when the liposome surfaces are coated by hydrophilic polymer layers. Particles with the diameters larger than 200 nm are easily recognized by RES and digested by macrophages after intravenously administered. To escape from the recognition by RES, many studies have been reported. For this purpose, synthetic biocompatible polymers have been developed.

Preclinical and clinical evidence of this formulation (Doxil®/Caelyx®), Fig. 1, has demonstrated that the nanoparticle, especially pegylated liposome, delivery system leads to greater localization of doxorubicin to tumor site and consequent improved efficacy, as well as, reduced toxicity. For vascularized tumors, the selective accumulation and retention of liposomes is a result of the combination of 'leaky' tumor neovasculature and malfunctioning lymphatics, integrated in enhanced permeability and retention (EPR) effect, as shown in Fig. 2.

Nanosized particles have high surface-to-volume ratio, could be especially dangerous, although they are less effectively taken up by macrophages and can reach brain passing through blood brain barrier (BBB). Any toxicity of nanoparticles depends on the route and frequency of administration, and polymer used to prepare the particles.

Pulmonary drug delivery system

The lung (adjectival form: pulmonary) is the essential respiration organ, and two lungs are located in the chest on either side of the heart. Their principal function is exchange of oxygen and carbon dioxide, transporting oxygen from the atmosphere into bloodstream and releasing carbon dioxide from the bloodstream to atmosphere, by the passage of air through the mouth to the alveoli. The air progresses through the mouth or nose, it travels through the oropharynx, nasopharynx, the larynx, the trachea, the primary bronchiole, the secondary bronchiole, the terminal bronchiole, the respiratory bronchiole, and finally reaches the alveolar duct where the gas exchange of CO_2 and O_2 takes place. Recently, there have been many attempts to improve systemic delivery of peptide and protein drugs by routs of administration other than injection. The drug delivery in these studies have included nasal, rectal, buccal, and respiratory rout of administration. Because of the unique physiological characteristics, lung is an attractive port of entry to the systemic circulation for the administration of drugs. That is, the alveoli present a large surface area for adsorption of about 100 m^2, a very thin diffusion path separates the airspace form the blood stream, i.e., the alveolar epithelium, the vascular endothelium and their respective basal membranes are less than 0.5 μm thick. Also, the high blood flow of about 5 ℓ / min of the pulmonary circulation rapidly distributes molecules throughout the body without first-pass hepatic metabolism, and the metabolic activity locally in the lungs is relatively low. Together with the success of design of new inhalers, pulmonary delivery of small drugs and proteins has reached clinical trials of drugs such as insulin, calcitonin, interferon, and hormone.

The environment in the lungs is very moist, and the humidity in the respiratory tract is almost 100 %. To reach alveolar through the respiratory tract, the medicine should have the proper size and density, shown as an aerodynamic diameter. As shown in Fig, 3, the particles with the aerodynamic diameters between 2 and 5 μm can efficiently reach alveoli. The particles smaller than 1 μm are easily inhaled by respiration but exhausted from lungs without deposition in alveoli, like tabacco smoke. The aerodynamic diameter of the particle, d_{aer}, is defined as equation (1) which is simply derived from Stokes' equation,

$$d_{ae} = d_p \sqrt{\frac{\rho_p}{\rho_0}} \qquad (1)$$

where d_p is the diameter of the particle which is usually measured using laser diffraction, ρ_p the density of the particle, ρ_0 the density of water at the same temperature.

As mentioned before, the environment in the lungs is very moist, which makes it hospital for bacteria and it causes infectious diseases in the lungs. For the treatment of these infectious diseases, direct delivery of antimicrobe agents to the lungs through respiratory tract has been considered to be effective. This is included in local injection of medicine to the lungs. Also, this concept has been applied to the treatment of lung carcinoma.

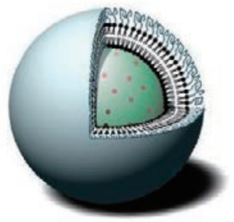


Fig. 1 Pegylated liposomal doxorubicin

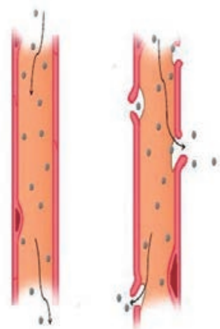


Fig. 2
Pegylated liposomal doxorubicin in normal (left) and tumor vessels.

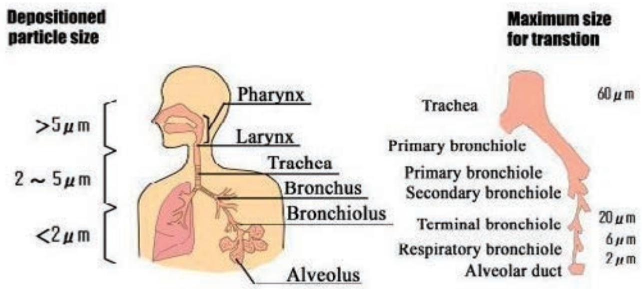
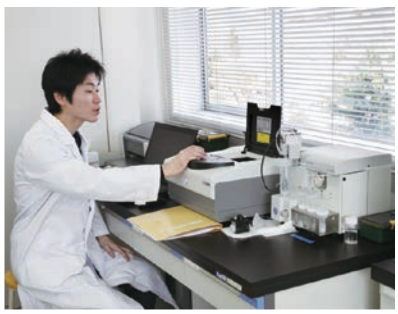


Fig. 3 Deposittioned particle size in respiratory tract.



Kimiko Makino

DDS is an indispensable means of making drugs work more efficiently. In this center, we develop biocompatible and biodegradable particles with nano- or micro-size to deliver bioactive materials to the target organs, such as skin, brain, lungs. For this purpose, new drug molecules and polymers are also developed. Intelligent tablets including oral disintegration system will be developed.

Bio and Pharmacy | Established: April 2010

Research Center for RNA Science

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Director Professor, Department of Biological Science & Technology, Faculty of Industrial Science & Technology

Hiroaki Shimada

Research Content

We conduct a comprehensive analysis of functional RNAs and study the mechanism for the control of life processes.

Objectives

We comprehensively analyze the mechanism for the control of life processes, by focusing on RNA. In addition, we carry out a multilateral analysis of life phenomena from new points of view in order to establish an interdisciplinary research base beyond the borders of the traditional academic framework.

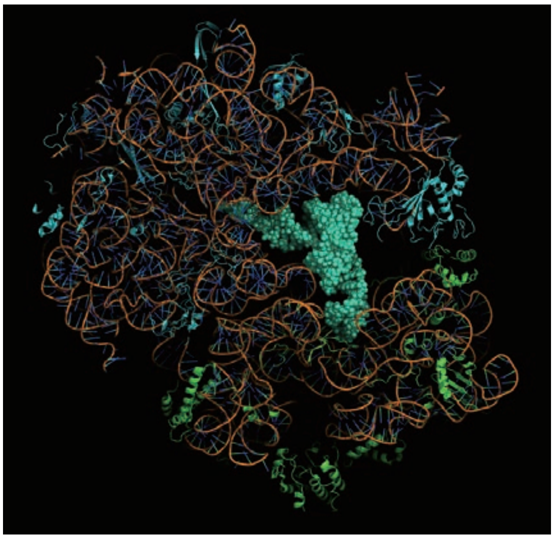
Future Development Goals

We clarify the unknown functions of functional RNAs and develop a new technology for drug development and biomass productivity improvement on the basis of the knowledge obtained.

Background to the establishment

After the completion of the genome project, it has become clear that higher organisms have complex function-control systems that cannot be understood from genome information alone. These systems control gene information at the transcriptional and translation levels. They also include genome-modified epigenetic function control and control after translation. It has become clear that functional RNAs matter in various scenes. This indicates that RNAs play an important role in maintaining life phenomena. In addition, research on the functional molecules responsible for intercellular interaction is important because this interaction clearly plays a vital role in regulating life processes.

Our research center is implementing a five-year project on the comprehensive analysis of control mechanisms, with specific focus on RNA from FY2010, funded by Ministry of Education, Culture, Sports, Science and Technology. We plan to carry out multilateral analysis of life phenomena from new points of view, without following the conventional research framework. We thus wish to create an interdisciplinary research base beyond the borders of the traditional academic framework.



tRNA combined with a ribosome, where proteosynthesis occurs. The blue object in the center is the tRNA. A large subunit exists above the ribosome, and a small subunit exists below the ribosome.

Research activities

There are various kinds of RNAs, including one that extracts and carries genome information and another that combines with a protein and a DNA molecule and thus exerts a physiological effect. It is known that many noncoding RNAs exist in a cell and play an important role in life activities, but their functions have not yet been clarified in detail. Our main research activities include a comprehensive analysis of the functions of RNA related to various life phenomena, such as epigenetic control of a gene, function control at the translation level, and intercellular and intermolecular interactions. Because RNA is important for the study of life evolution, we can explore the essentials of life by studying the role of RNA in the control of life phenomena.

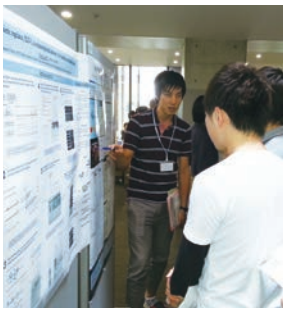
Research system

This research center conducts research on the following five aspects of RNA science and carries out multilateral verification of life phenomena in which functional RNAs play a central role.

Research Center for RNA Science

(Comprehensive analysis of the control mechanisms of life, focusing on RNA)

1. Research on the structure and gain-of-function of RNA.
2. Analysis of the functions of vivo RNA in plants.
3. Analysis of RNA functions related to signal transmission between cells and between tissues.
4. Analysis of epigenetic gene function control through an RNA intermediary.
5. Research on the structure and functions of functional RNAs.



"Invitation to RNA World," public symposium held by the Research Center for RNA Science

Hiroaki Shimada

Research Center for RNA Science covers a research area beyond the border of the traditional academic fields, which will construct a new framework focusing on the RNA Science. Researchers in fields of the life science, chemistry, and physics participate in this center to collaborate for establishment of a sustainable future society.

Bio and Pharmacy | Established: April 2011

Center for Environmental Health Science for the Next Generation

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Director Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences

Ken Takeda

Research Content
We perform research on next-generation health and science, in particular cutting-edge research related to the identification and prevention of disease.

Objectives
The Center is investigating environmental factors such as airborne nanoparticles that might affect the metabolism or function of the brain, lungs, liver, or kidneys of the next generation, and we are working toward developing a strategic research foundation for creating a society in which the next generation of children can lead healthy lives.

Future Development Goals
We will prevent disease in the next generation of children that might be caused by environmental nanoparticles as a primary or background factor. We hope to preserve an environment that guarantees the healthy growth and development of the next generation.

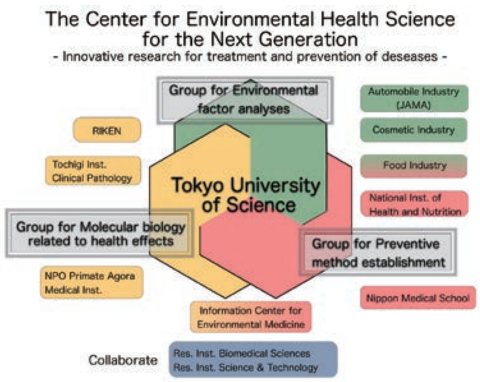
The Center started as a five-year project after having been selected as a 2011 recipient of the Private University Strategic Research Formation Assistance Grant from the Japanese Ministry of Education, Culture, Sports, Science and Technology.

Goals
Our goal at the Center is to form a strategic research foundation for building a society in which the next generation of children can lead healthy lives. To achieve this, we have gathered the combined wisdom of the Research Institute for Science and Technology, and will work in cooperation along with outside research institutes in order to realize an environment that guarantees the healthy growth and development of the next generation. We will also work toward a better understanding of the effects of exercise and nutrition on health, and promote methods of disease prevention and treatment.

Background of the Center
Recent years have brought about great changes in the social and lifestyle environments in which we live, in some cases leading to the emergence of new factors that affect human health. One particular problem both domestically and abroad is environmental factors that affect the growth and development of children.

In 2010, the Japanese Ministry of the environment began a 15-year study, the “Japan Eco & Child Study”, a nationwide epidemiological investigation related to child health and the environment. The goal of the study is to investigate the hypothesis that exposure to environmental factors from the fetal period through childhood might play a role in areas such as fertility and pregnancy, congenital abnormalities, psychoneurotic development, immunity and allergies, and the metabolic and endocrine systems.

The director of the Center and the colleague are already establishing the academic frontiers of the Private University Strategic Research Formation Assistance Grant from the Japanese Ministry of Education, Culture, Sports, Science and Technology through health sciences research related to nanoparticles. The Center has already used animal experiments to demonstrate the maternal-to-fetal transfer of nanoparticles and nanomaterials released into the environment, which are produced as the base materials for use in nanotechnology.



Ken Takeda

We hope that the activities of this Center contribute to the creation of an environment that allows the children of the future to live healthy lives.

In order to further reveal the health effects of nanoparticles and nanomaterials on the next generation and to better understand the effects of exercise and nutrition on the health and development of children, we established the Center for Environmental Health Science for the Next Generation by bringing together researchers from different fields from within the University, starting with the School of Pharmaceutical Science and other research departments. Research is also being performed in coordination with outstanding institutes and researchers from outside the University that have made advances in nanoparticle-related health sciences, for example with Prof. Masao Sugamata, director of the Tochigi Institute of Clinical Pathology.

Desired results of the Center's research
1)At present, there are almost no overseas research institutes that are focusing on the health effects of nanomaterials on the next generation. Nonetheless, we have already obtained promising results. We hope that the new team formed at the Center will lead the world in research related to environmental health science on the next generation.

2)We hope to identify environmental factors, pathologies, and molecular mechanisms related to allergic and autoimmune diseases which have become prevalent in children in recent years, and we hope to establish treatment methods for those diseases.

3)We hope to develop experimental primate model systems in order to identify how microparticles and various nanomaterials in exhaust fumes affect the next generation, and then to extrapolate data related to effects on human health and the establishment of treatment methods.

4)Various nanoparticles are unintentionally created and released into the environment during the course of daily life. We intend to focus in particular on the nanoparticles found in diesel exhaust and cigarette smoke, and to identify their health effects on the next generation. By analyzing the behavior and mechanisms of nanomaterials created from other microparticle sources, we hope to identify health effects on children and the next generation.

5)We will examine the effects of exercise and nutrition in order to help prevent next-generation health effects due to environmental factors. We also aim to find methods of disease prevention through the pharmaceutical management of diseases at the early stages of symptom development.

The significance of research at the Center
The goals set forth by this Center will not be attainable through traditional models of medical and environmental research. What is required is an academic union of the fundamental areas of nanomaterial health science (such as nanoscale physics, chemistry, analysis, toxicology, pathology, and molecular biology) with the new viewpoints of the next generation of health sciences (immunology, nutrition, kinesiology, pharmacology, and medicine). In doing so, we hope that the characteristic aspects of a technical university will lead to the establishment of new frontiers and the development of new integrated academic areas, as well as aid in the training of young researchers. We hope that the Center's research will help to create an environment where the children of the next generation can live healthy lives.

Bio and Pharmacy | Established: April 2012

Research Center for Chirality

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Director Professor, Division of Applied Chemistry, Faculty of Science Division I

Isamu Shiina

Research Content

Research on chirality at levels ranging from the molecular level to that of aggregates.

Objectives

The amino acids and other components of living organisms are chiral. Our objectives are to develop methods for the asymmetric synthesis of chiral compounds, to elucidate the origins of molecular chirality and to develop asymmetrical synthesis.

Future Development Goals

On the basis of the fruits of research carried out in the past by our individual members, we aim to further promote research in fields related to chirality, giving consideration to our members' other alliances.

Introduction

Research Center for Chirality was established in April of 2012.

An object is said to be chiral when it is non-superposable on its mirror image, as are the palms of your left and right hands. Biogenic compounds such as L-amino acids and D-sugars could be expected to have 2 possible enantiomers, each of which would differ in action from the other, but we know that in many cases, only one of these actually exists in nature.

This, then, presents one of the important challenges in research: developing methods of asymmetric synthesis that can be used to produce the other, missing enantiomer, which is desired for the properties it would offer. Elucidating the origins of chirality in biogenic compounds, together with the processes by which it is generated and amplified, is one of science's unsolved problems. And because chirality is observed not only at the molecular level, but also at the level of individual organisms (visceral situs, etc.), the elucidation of its origins at the molecular level becomes an important theme in terms of shedding light upon the genesis and differentiation of life. Recently, at our university, a great deal of interest has been focused upon molecular chemical research on such topics as how chirality is generated by chiral autocatalytic reactions and how asymmetrical organocatalysts are produced. Thus far, our university's efforts have steadily born fruit in the form of useful findings in such areas as remote asymmetric induction in diastereoselective and enantioselective asymmetric synthesis.

Objectives

Research Center for Chirality, organized around the concept of chirality, brings together researchers from our university who work in fields of chiral molecular chemistry. The goals of its projects are to elucidate the origins of chirality and the process of its amplification, to develop chiral complexes and asymmetrical catalytic reactions using asymmetrical organocatalysts, and to open up the field of the asymmetric synthesis of useful chiral compounds by diastereoselective and enantioselective reactions. In this way, we aim to produce results in the field of chiral science that will position us at the top global level in terms of the originality of our Research Center.

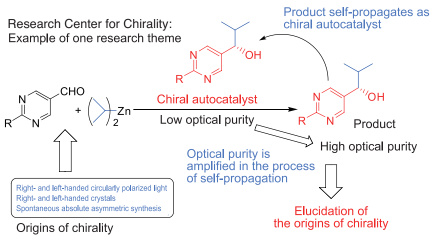
Characteristics

One of the characteristics of Research Center for Chirality is that the level of the research into chirality conducted by our constituent faculty members is high from a global standpoint in terms of both quality and quantity. Our research group bringing together researchers of chiral molecular chemistry has the distinction of being one of the few such units in the world. The elucidation of the origins of chirality has long been regarded as one of the unsolved mysteries of science. The utilization of chiral autocatalytic reactions can be expected to contribute much to the solution of this problem. Trail-blazing activities in asymmetric synthesis using asymmetrical organocatalysts and complex catalysts can also be expected to yield environment-friendly techniques that are applicable to asymmetric synthesis of pharmaceuticals and the like. Through these kinds of research, the center will contribute to the establishment of a deeper appreciation of the profundity of the natural world in relation to chirality, and our work is also significant in that it will provide new techniques for the asymmetric synthesis of chiral substances.

Research on chirality has attracted the attention of many researchers worldwide, and it is an area of intense competition, but our faculty's research on chirality is exceptionally original and ranks top-class globally in terms of both quality and quantity. Almost nowhere else in the world will you find a research center that brings together researchers from wide range of molecular chemistry to devote their main efforts to the study of chirality. This center has produced extremely advanced research results on the topic of chirality, and it is regarded with great expectations for its potential not only to provide valuable asymmetric synthesis methods for chiral substances, but also to provide clues to one of the great unsolved mysteries of science by shedding light upon the origins of the chirality of biogenic compounds.

Research Content

A: Elucidating the origins of chirality through chiral autocatalytic reactions: We endeavor to elucidate the origins of chirality by using chiral inorganic substances and dynamic chiral factors together with chiral autocatalytic reactions that improve enantiomeric excess, in order to obtain chiral compounds with high optical purity.



B: Asymmetric preparation of chiral compounds by kinetic resolution: development of asymmetric kinetic resolution for the preparation of chiral drugs.

C: Synthesis of chiral compounds: Development of manufacturing methods for chiral compounds by the following 2 approaches.

C-1: Development of asymmetrical reactions: These investigations of asymmetrical aldol and other reactions have as their aim the construction of chiral quaternary carbon centers, for which a good method of synthesis has not previously been available. We also are working on chiral transcription synthesis of spiro skeletons and one-pot synthesis of spirocyclic oxindoles. By applying chiral catalysts to chiral hetero Diels-Alder reactions and chiral epoxidation reactions, we also synthesize chiral building blocks. Finally, with an eye toward chiral sulfoxide compounds that can easily be synthesized as optically active starting materials, we are using 1,4-remote concurrent asymmetric induction to synthesize various useful chiral intermediates.

C-2: Development of chiral catalysts: Asymmetrical catalytic reactions that synthesize large quantities of chiral compounds from catalytic amounts of chiral initiators are one of the outstanding methods of synthesizing optically active substances. To this end, the development of superb catalysts is regarded as essential. Our center has developed transition metal catalysts possessing surface chirality or helical chirality, and we have applied these to polymer synthesis reactions (polymerization reactions) to control the main chains (primary structure) of the generated polymers and synthesize optically active polymers. Moreover, we are working on the design of amino acid-derived organic chiral catalysts and the development of practical asymmetric synthesis methods allowing for the synthesis of large quantities of substances. Lastly, we are conducting research on methods of synthesizing chiral compounds that do not use organic solvents, with the goal of discovering exceptional methods of asymmetric synthesis that are environmentally friendly.

Isamu Shiina

Living creatures including human-being act in the world of three dimensions. In the world of three dimensions, both structures expressed by the coordinates of [x, y, z] and [x, -y, z] are possible, *i. e.*, enantiomers. However, many biologically related compounds are composed with only one enantiomer. We will promote the research on (1) the origin of homochirality of biocompounds and (2) enantioselective synthesis of biologically active compounds.

Bio and Pharmacy | Established: April 2009

Translational Research Division

fukai@rs.noda.tus.ac.jp

Director
Professor, Department of Medicinal and Life Science, Faculty of Pharmaceutical Science
Fumio Fukai

Research Content

Development and clinical application of results obtained from basic research to the diagnosis, treatment, and prevention of diseases.

Objectives

With the final objective of enabling medical practice to benefit from the fruits of basic research:

1. Refine new drugs, new technologies, etc., developed by our university to the point where they can find clinical applications.
2. Contribute to individualized medical care by analyzing biological samples obtained from patients in medical care settings.

Future Development Goals

Joint research conducted by our division in collaboration with medical institutions is expected to bear fruit in the future; e.g., results of ongoing clinical trials on the theme of the natural compound sulforaphane's protective effect against large intestine carcinoma.

About Translational Research

Translational research (TR) is an area of activity concerned with reevaluating the clinical application potential of the basic scientific findings and technologies discovered by the research laboratory and refining them to the point where they can be used in clinical settings. In other words, it is a kind of research that bridges basic research with clinical practice. The slogan "From Bench To Bed Side!" is often used overseas to denote TR.

History of the TR Division's Establishment

Japanese researchers have produced some outstanding results in basic research, but the translational research that is needed to bring these research results to life in clinical settings has not gained sufficient ground. This is one of the major impediments to the development of new drugs in Japan. Superb basic research has been conducted at a number of the departments within our university, and we have amassed a large number of seeds that hold the potential to contribute to tomorrow's medicine, but because our university does not have either the own or the affiliated hospitals, we have few points of contact with medical institutions, which makes it difficult to share with clinical practitioners the results of our university's basic research.

Recently, a number of universities have embarked upon the preparation of research systems for the clinical application of their basic research results by establishing internal TR divisions centered on their departments of medicine. We, too, have set up a TR Division within the university as a liaison point for joint research with medical institutions. Forming alliances with medical institutions for the powerful promotion of translational research is indispensable to the effort to find clinical applications for our basic research.

Objectives of the TR Division

In the TR Division, our university's researchers join hands with departments of medicine and medical institutions to conduct translational research bridging basic and clinical research, with the objective of taking the seeds discovered, invented, and developed by our university and growing them to the point where clinical application becomes possible.

To this end, we are proceeding with research from the following 2 approaches:

(1) Allying with medical institutions to conduct the clinical tests necessary to find clinical applications for the new drugs, new technologies, etc., developed by our university's researchers.

(2) Analyzing the clinical specimens provided by medical institutions to contribute to individualized medical care by returning the results of analysis to the scene of medical treatment.

Members of the TR Division and Their Research Themes

As of this writing, in July 2013, the TR Division is composed of 16 in-house researchers (15 from the Faculty of Pharmaceutical Science, and 1 from the Faculty of Science) and 20 guest researchers from outside of the university community.

In-House Researchers (16)

Faculty of Science : Hidetaka Torigoe (Applied Chemistry); Faculty of Pharmaceutical Science: Junichiro Oka, Yukie Hamada (Neuro-Pharmacology), Masayo Komoda (Medical Safety Science), Takehisa Hanawa, Yayoi Kawano (Clinical design); Takashi Hirota, Atsusi Miyajima (Drug Metabolism); Kimiko Makino (Faculty of Pharmaceutical Science: Physical Pharmaceutics, DDS); Chikamasa Yamashita, Michiko Horiguchi (Physical Pharmaceutical); Kazunori Akimoto (Molecular Medical Sciences); Yoshikazu Higami, Yuka Sudo (Molecular Pathology), Fumio Fukai , Takuya Iyoda (Molecular Patho-Physiology).

Fumio Fukai

The TR Division is an organization established with the goal of clinical application of the results of our university's basic research, achieved through joint research with medical institutions in the local community. We invite the participation in our division of researchers who are interested in the clinical application of their research results.

Guest Researchers (20)

University of Tsukuba: Ichinosuke Hyodo and Hideo Suzuki (Gastroenterology), Akira Matsumura and Tetsuya Yamamoto (Neurosurgery), Yoshinori Harada (Critical path Research and Education Integrated Leading Center), Masayuki Noguchi (Diagnostic Pathology), Nobuhiro Ohkohchi (Surgery), Hitoshi Shimano (Endocrinology and Metabolism).

Tokyo Medical Univeristy: Yasushi Matsuzaki (Hepatology)

Tokyo Jikei Univeristy, School of Medicine: Toshifumi Ohkusa (Gastroenterology)

National Cancer Center Research Institute: Yasuhito Uezono (Cancer Patho-Physiology), Michihiro Muto (Cancer Prevention Basic Research)

Kagawa University: Takuya Matsunaga (Hematology)

Tokyo Metropolitan Institute of Gerontology: Kazuhiro Shigemoto (Geriatric Medicine)

Saga University: Hiroaki Kodama (Chemistry and Applied Chemistry)

Shonan Kamakura General Hospital: Satoshi Takeshita (Cardiology)

Juntendo University Hospital: Masahiko Tanabe (Breast Cancer)

Tomonaga Clinic Hospital: Osamu Tomonaga (Diabetes and Lifestyle Related Diseases)

Osaka University Hospital: Koji Yamamoto (Medical Center for Translational and Clinical Research)

National Institute of Infectious Diseases: Masayoshi Fukasawa (Virology)

Development and Clinical Application of Novel Drugs and Technologies

1. Clinical trials of functional foods for cancer chemoprevention (Fig. 1).
2. Improving the efficiency of boron-neutron capture therapy for brain tumors (Clinical Neurology and Neurosurgery Department of the Tsukuba University Hospital)
3. Development of anti-tumor drugs targeting tenascin-C.
4. Establishment of eradicable treatment method for leukemia with minimal residual disease (MDR) (Fig. 2).

Promotion of Individualized Medical Care

1. Influence of DNA methylation upon individual differences in pharmacokinetics and its prediction (Department of Gastrointestinal Internal Medicine, University of Tsukuba)
2. Development of diagnostic methods and treatment approaches for lifestyle-related disease, utilizing human biobanks (Department of Pathology, University of Tsukuba, others)

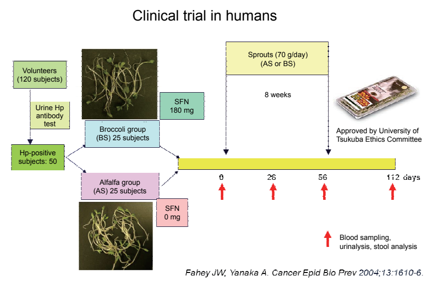


Fig.1: Clinical trial of sulforaphane's protective effect against gastric cancer

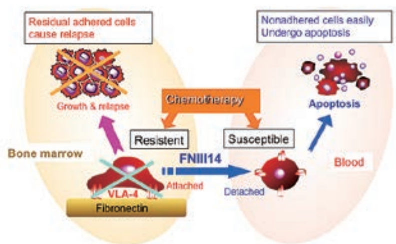


Fig.2: Eradication of minimum residual diseases of leukemia by combination therapy of anticancer drug with the antiadhesive peptide FNIII14.

Bio and Pharmacy | Established: October 2011

Division of Pharmaco-creation Frontier

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Director Professor, Department of Biochemistry, Faculty of Pharmaceutical Sciences

Sei-ichi Tanuma

Research Content

Establishment of a new drug-creation system based on *in silico* platforms.

Objectives

To research and develop a new drug-creation system combining the identification of crinical-target proteins by genomics/proteomics analyses and highly sophisticated structure-based *in silico* drug-design methodologies and methods, thereby making a contribution to the development of novel pharmaceuticals.

Future Development Goals

To develop a new discipline, theoretical drug-creation biochemistry , based on biological physicochemistry , which is one of the strengths in Tokyo University of Science.

Characters of the Division of Pharmaco-creation Frontier

The Division of Pharmaco-creation Frontier(PCF) was established in October 2011. Its predecessor was the Research Institute for Genome and Drug, where analyses of apoptosis regulatory mechanisms and development of *in silico* drug-design methodologies and methods were performed. For example, validation of drug-targeting proteins by new established assay methods using model mouse, preparation of monoclonal anti-bodies against transcriptional factors, and development of *in silico* drug-creation methodology targeting protein-protein introduction(COSMOS and BIOS methods).

While sharing the same basic perception of issues, the Division of PCF is characterized by its forcus on the generation of new drug lead compounds using our established *in silico* drug-creation platforms, and by development of practical drug-creation systems.

Organization of the Division of PCF

The Division of PCF currently consists of 15 experts in such diverse specializations as Molecular Biology Biochemistry, Cell Biology, Genetics, Molecular Oncology, Molecular Neurology, Drug-metabology, Genomic-pharacology Bioinformatics, Organic Chemistry, Pharmaco-kinetics, Enviromental-heath Science, Brain Science, Surgery, and so on. Collaborative relationships among these individuals are illustrated in Figure 1.

In-house Researchers(15)

Sei-ichi Tanuma, Toshiyuki Kaji, Jun-Ichiro Oka, Takashi Hirota, Yoshikazu Higami, Takeshi Wada, Fumiaki Uchiumi, Takumi Uchiro, Kazunori Akimoto, Ryoko Takasawa, Makoto Fujikawa(Faculty of Pharmaceutical Sciences),Fumio Sugawara , Sadakazu Furuichi, Sachihiro Matsunaga(Faculty of Science and Technology), Yasufumi Murakami, (Faculty of Industrial Science and Technology)

Guest Researchers(4)

Masanobu Uchiyama(University of Tokyo), Tamotu Takahashi((University of Hokkaido), Yasuhiro Matsumura(National Cancer Hospital), Kou Sei(Fukutan University Hospital)

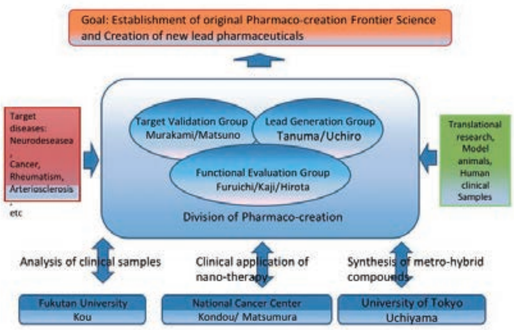


Figure 1. Organization of the Division of Pharmaco-creation Frontier

Research Contents of the Division of PCF

In the Division of PCF, our researchers join hands with in house 3 groups researchers and gust researchers to constrict theoretical drug-creation systems with the objective of generating the new lead compounds. Toward this end, we are proceeding with research from the following approaches.

(1)Target Validation Group

Identification and validation of novel drug-target proteins by *Drosophila* genetic assay system, Western-blotting screening using monoclonal anti-bodies, and microarray system.

(2)Lead Generation Group

Structure-based virtual screening and drug design targeting the proteins discovered by the target Validation Groups using COSMOS and BIOS methods for protein-protein interaction and protein-DNA/RNA interaction, respectively. Especially, new metalohybride compounds are designed and synthesized.

(3)Functional Evaluation Group

Small lead compounds generated by the Second Group are functionally evaluated by cell cultures and model animals(Figure 2). Also, pharmaco-kinetics of metalohybride compounds are analyzed in detail.

(4)Allying with Outside Institutes

Constructing the library of novel metarohybride compounds and analyzing the clinical specimens provided by medical institutes to contribute to identification of new drug target proteins.

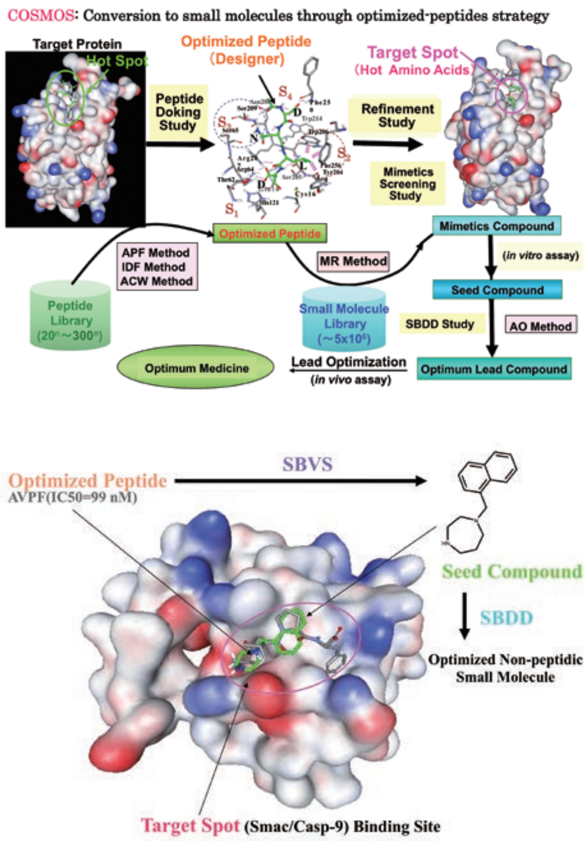


Figure 2. A Novel Methodology for *in silico* Drug Design, COSMOS

Sei-ichi Tanuma

Recently, there are many problems in pharma-companies such as decrease of new approved pharmaceuticals and less strategies for new drug discovery. To find a way out of the difficulties, researching and developing on novel drug-creation systems using *in silico* strategies are very important. We would like to contract a base for theoretical drug-creation, which is able to send it to the world. We invite the participation in our division of researchers who are interested in drug-creation approaches.

Bio and Pharmacy | Established: October 2012

Division of Bio-organometallics

bio-organometallics@rs.tus.ac.jp

Director Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences

Toshiyuki Kaji

Research Content

We perform reserch of Bio-organometallics, a new science field of bilogy using oraganic-inorganic hybrid molecules.

Objectives

To perform a joint research project by reserchers in the field of chemistry, molecular biology, physics, computational sciences, toxicology, and analytical science of oraganic-inorganic hybrid molecules.

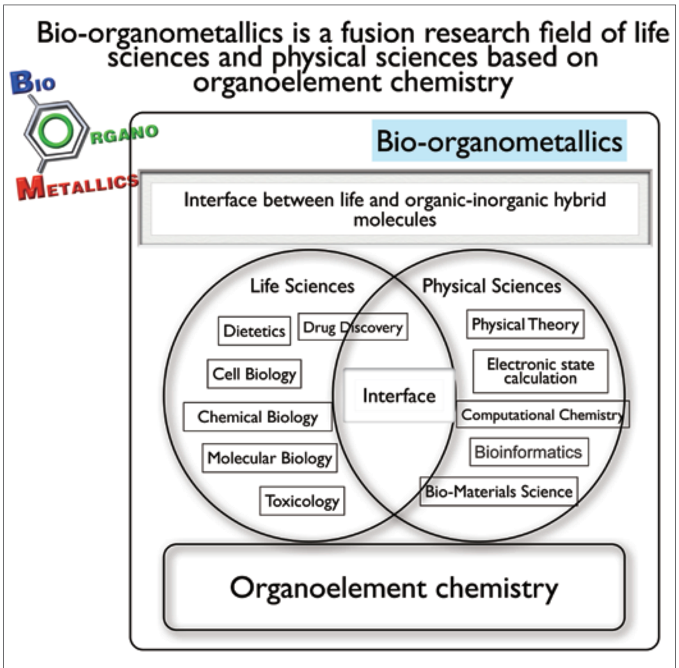
Future Development Goals

Based on the new concept of bio-organometallics, the researchers in various research fields perform a joint research and show the result unrealizable by the conventional sciences.

What is bio-organometallics?

Although chemical compounds are classified as organic compounds or inorganic compounds, organic-inorganic hybrid compounds (organometallic compounds and coordination compounds) have both characteristics. Since pioneering researchers, such as Grignard and Wittig, utilized the hybrid molecules in the field of synthetic chemistry, organic element chemistry is splendidly developed. However, in most cases, the usefulness of the hybrid molecules is still evaluated as synthetic reagents, and the contribution to life sciences is in a very insufficient situation.

This division really begins and develops bio-organometallics reseach. Bio-organometallics means biology of organic-inorganic hybrid molecules. Taking advantages of the outstanding characteristics of hybrid molecules, we perform studies to regulate biomolecules and biological systems, those to exhibit the specific biological activities of metals in the target molecules and tissues, and those on organic element chemistry and computational sciences of the hybrid molecules. In addition, these studies variously collaborated and will make a new field of life sciences and technology.



Toshiyuki Kaji

The division of bio-organometallics was founded in October, 2012. It is very significant for bio-organometallics research to obtain a research base in Tokyo University of Science. We will send the research results of bio-organometallics by making full use of organic-inorganic hybrid molecules prior to the world through joint researches among researchers of various research fields.

The strategy to use organic-inorganic hybrid molecules

The characteristics of the hybrid molecules from the viewpoint of life sciences are as follows: (1) The metal atm in the hybrid molecules can change the three-dimensional structure of the molecules. (2) The molecular structure can control the dynamic states in the living body and biological activities of the metal atom. (3) The metal atm in the hybrid molecules can change the electronic state of the molecules.

Taking advantages of these characteristics, we use the hybrid molecules as a tool to analyze biological systems, like a molecular probe of chemical biology, and as sead/lead compounds of drug design. Furthermore, we would like to utilize the hybrid molecules as a tool to analyze the interrelationship between the electronic state and biological activity of chemical compounds.

Organization of the division of bio-organometallics

In order to develop bio-organometallics research, researchers in the field of chemistry, molecular biology, physics, computational sciences, toxicology, and analytical science of oraganic-inorganic hybrid molecules are organized from the inside and outside of the university. These researchers not only perform their original bio-organometallics research in their field but also organically collaborate each other, utilizing the mutual research results.

In-house Reseachers

Toshiyuki Kaji (Faculty of Pharmaceutical Sciences), Noriaki Hamada (Faculty of Science and Technology), Satoru Miyazaki (Faculty of Pharmaceutical Sciences), Takumi Uchiro (Faculty of Pharmaceutical Sciences), Ryoko Takasawa (Faculty of Pharmaceutical Sciences), Akira Sano (Faculty of Pharmaceutical Sciences), Yo Shinoda (Faculty of Science and Technology)

Guest Researchers

Masanobu Uchiyama (University of Tokyo), Masahiko Satoh (Aichi Gakuin University), Chika Yamamoto (Toho University), Shuji Yasuike (Aichi Gakuin University), Yasuyuki Fujiwara (Aichi Gakuin University), Tomoki Kimura (Setsunan University), Hiroshi Naka (Nagoya University), Hitomi Fujishiro (Tokushima Bunri University)

Desired results of the Division's research

The division of bio-organometallics accumulates the research results that is difficult or impossible to obtain by traditional ways of thinking.

1. We establish the technology to synthesize organic-inorganic hybrid molecules that have a specific three-dimensional structure necessary for a specific biological activity and send metal ions to a target biomolecules, leading to a criation of new organic element chemistry which cultivates life science.
2. We search and find unique biological activities and toxicities of the hybrid molecules and discover the molecular targets. We also find out about new biological systems, new functional proteins and new sead/lead compounds of drug design. In addition, we establish the technology to analyze the hybrid molecules to support the biological experiments.
3. We establish the methodology to understand the mechanism of biological activities of organic-inorganic hybrid molecules from the three-dimensional structure and the electronic state of the molecules. Furthermore, we develop the methodology to the bridging technology that connects the hybrid molecules to life sciences.

We originate a new research current by developing the above research and show the infinite vitality of bio-organometallics prior to the world.

Bio and Pharmacy   Established: July 2007

Glycotechnology Project

tsujilab@rs.noda.tus.ac.jp

Director Professor, Research Institute for Science and Technology

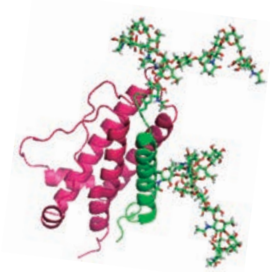
Takashi Tsuji

Research Content

We aim at creating the next generation of biopharmaceuticals through our glycotechnologies such as characterization of biological functions of glycan, application study of peptide glycosylation technology, and development of chemical synthesis method for the homogeneous glycoprotein pharmaceutical.

Objectives

Our goal is to connect the results obtained through research to technologies and new drug development to benefit society. We hope to jointly develop technologies that will lead to improved safety and cost reduction of bio-pharmaceuticals with private companies. Thus, we aim at research & development that meets society's needs.



Glycosylation is the most widespread post-translational modification found on glycoproteins and glycolipids. It has been well established that the glycans play essential roles in various biological processes, such as activation of immune system, tumor metastasis and virus/bacterial infection. Therefore some of physiologically active glycoproteins have developed to be biopharmaceuticals.

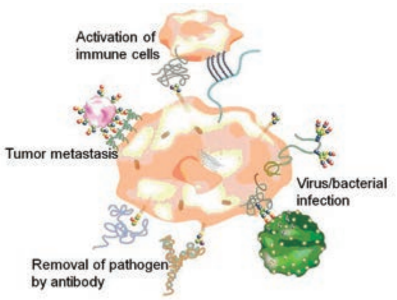


Fig.1 Various biological phenomena mediated by the glycans on cell surface.

We aim at creating the next generation of biopharmaceuticals through our glycotechnologies. Our collaborator, Prof. Yasuhiro Kajihara at Osaka University and his colleagues have succeeded in developing a long-awaited method for the large-scale preparation of intact human complex-type asparagine-linked glycans (complex *N*-glycans). They also developed an efficient chemical synthetic method or site-specific glycosylation of peptides using complex *N*-glycans and pioneered a way to the complete chemical synthesis of glycoproteins carrying one particular glycan structure. By using of those techniques, Glytech, Inc. has established a new advanced manufacturing technology for complex *N*-glycans and has been developing the chemical synthesis technologies for glycopeptides and glycoproteins.

Our goal is to connect the results obtained through research to technologies and new drug development to benefit society. We hope to jointly develop technologies that will lead to improved safety and cost reduction of bio-pharmaceuticals with private companies. Thus, we aim at research & development that meets society's needs.

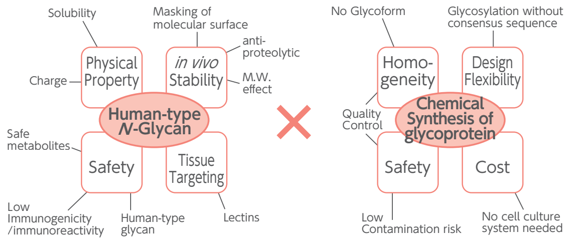


Fig.2 The aim of Glycotechnology. Combination of human-type N-glycan and chemical synthesis of glycoprotein enables to develop a chemical synthesis technology of bio-pharmaceuticals with improved activity and quality.

R&D Activities

1. Studies on the biological function and structure of glycan in physiologically active glycoprotein.

Glycans play key roles in protein folding, quality control in the endoplasmic reticulum (ER) and protein trafficking within cells. However, it remains unclear whether all positions of protein glycosylation are involved in glycan functions, or if specific positions have individual roles. We demonstrated the integral involvement of a specific *N*-glycan from amongst the three glycans present on inducible costimulator (ICOS), a T-cell costimulatory molecule, in proper protein folding and intracellular trafficking to the cell surface membrane. These studies will contribute to the current understanding of the roles of *N*-glycans in the functional regulation of glycoproteins.

2. Development of peptide glycosylation technology.

Bioactive peptides synthesized by endocrine organs function as hormones that regulate various physiological phenomena *in vivo* and hold some promise as therapeutic agents for the treatment of various diseases. However, most peptides are limited in terms of clinical application because of their short half-lives *in vivo*. To improve the stability of these molecules, we have developed a peptide glycosylation strategy using a chemo-enzymatically synthesized human complex-type glycan. We believe that our technology make a substantial contribution to the development of chemical modification methods for peptide therapeutics.

3. Biological analysis of chemically synthesized glycoprotein pharmaceutical using human complex-type glycan.

The glycan moieties in glycoprotein provide abundant structural diversity called "glycoform". The current production systems of biopharmaceuticals based on mammalian cell culture do not control glycosylation and thus produce a mixture of different glycoforms even if the medicine should be strictly regulated. Thus, the new manufacturing system should be needed for more homogeneous glycoprotein pharmaceutical with highly quality.

As a solution to the above problems, we have proposed a new chemical synthesis method for the homogeneous glycoprotein pharmaceutical. We demonstrated that a chemically synthesized erythropoietin analog and interferon-beta 1a which carry homogeneous human-type complex glycan have similar biological activity *in vitro* and/or *in vivo* as same as the cell-derived protein pharmaceutical. By the use of our technology, our collaborator, Glytech, has been developing a successor of interferon-beta and a new manufacturing system of a therapeutically effective protein.

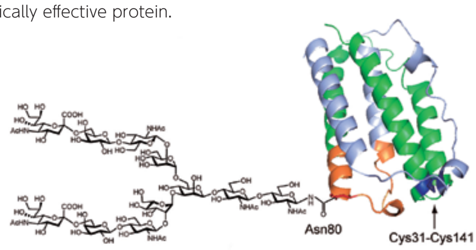


Fig.3 The structure of fully chemical synthesized interferon-beta 1a with human complex-type sialylglycan.

Bio and Pharmacy Established: January 2009

Organ Regeneration Research Project

tsujilab@rs.noda.tus.ac.jp

Director Professor, Research Institute for Science & Technology

Takashi Tsuji

Research Content

We conduct the basic research on regenerative medicine in and development of the technologies for the future organ replacement regenerative therapy.

Objectives

To create the technologies for the future organ replacement regenerative therapy, this project addresses researches on the three-dimensional cell processing to regenerate organ germ, organ design, the construction of vascular network and an organ culture.

Background of this project

Concepts in current regenerative therapy include stem cell transplantation and two-dimensional uniform cell sheet technologies, both of which have the potential to restore partially lost tissue or organ function. Organ replacement regenerative therapy is expected to provide novel therapeutic systems for donor organ transplantation, which is an approach to treating patients who experience organ dysfunction as the result of disease, injury or aging. To develop the technologies for the future organ replacement regenerative therapy, this project addresses researches on the three-dimensional cell processing to regenerate organ germ, organ design, the construction of vascular network and an organ culture. Although it has tried to manufacture three-dimensional artificial organs via cell aggregation, carrier and cells for more than 30 years, well-functioning organs have not been produced yet. Almost all organs, including ectodermal organs such as the hair follicle, tooth and salivary gland, develop from their organ germs by which is induced by epithelial and mesenchymal interactions during embryonic organogenesis. Therefore, we have developed the concept that organs can be regenerated from organ germs by reproducing the organogenesis process.

Research Activities

1. Development of three-dimensional cell manipulation to generate a bioengineered organ germn

In 2007, we have developed a three-dimensional cell manipulation method to reconstitute organ germ between epithelial and mesenchymal stem cells, designated as an organ germ method (Fig. 1, *Nature Methods*, 2007).

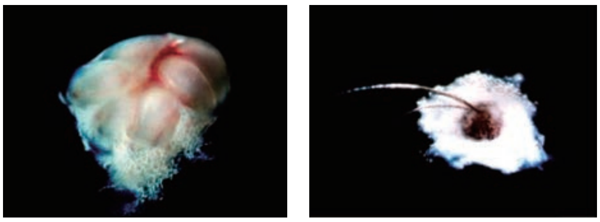


Fig1. Regenerated tooth(*left*) and regenerated hair(*right*)

2. Tooth regeneration

Our study provides a successful replacement of an entire and fully functioning organ in an adult body through the transplantation of bioengineered organ germ, reconstituted by the organ germ method (Fig. 2, Fig. 3, *PNAS*, 2009). The bioengineered tooth germ can successfully erupt and can achieve functional occlusion with an opposing tooth in an adult oral environment, indicating that bioengineered teeth have the potential to recover the masticatory performance of a normal, natural tooth.

Fig2. Oral photograph of a bioengineered tooth

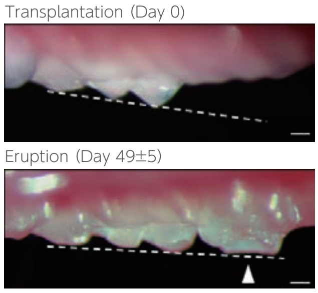


Fig.3 The bioengineered tooth during the processes of eruption

3. Hair regeneration

Recently, we demonstrate fully functional hair organ regeneration via the intracutaneous transplantation of a bioengineered hair follicle germ. The bioengineered hair follicle germ are reconstituted with adulthair follicle-derived epithelial and mesenchymal stem cells. The bioengineered follicles also show restored hair cycles and piloerection through proper connections with surrounding host tissues such as the epidermis, arrector pili muscle and nerve fibres (Fig. 4 and Fig. 5, *Nature Commun*. 2012). This study thus reveals the potential applications of adult tissue-derived follicular stem cells as a bioengineered organ replacement therapy.

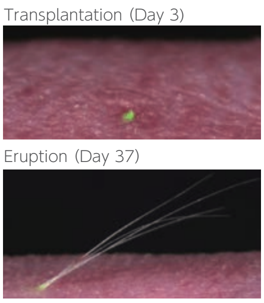


Fig.4 The bioengineered hair

Fig.5 Hair follicle regeneration on nude mice

4. Organ Culture

The development of a system to culture, maintain, and raise the organs ex vivo is required for the realization of organ regeneration. We address the development of the vascular network reconstruction technology and manufacturing medical equipment for long-term conservation of the donor organs *in vitro*. Further, we expect to develop the next generation basic technologies to create bioengineered donor organs.

Information and Societal Eatablished: April 2004

Center for Fire Science and Technology

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Director Professor, Department of Architecture, Faculty of Engineering Division II

Makoto Tsujimoto

Research ContentGoals

Research on the safety technology to protect human life and property from fires, and research on the fire science to support it.

Objectives

To promote the development of fire science and fire safety engineering, as well as the training of young researchers and specialist professionals.

Future Development Goals

To establish an education and research center at the highest level of the world, to meet various social demands concerning fire safety, and to make a contribution to society.

Fire science at TUS

In 1981, Tokyo University of Science established Department of Fire Science and Technology in its Institute for Science and Technology. The aim was to set up a research center that would promote research on the safety technology to protect human life and property from fires, and research on the fire science that supports the technology. This development was initially started by the inauguration of a course on Architectural Fire Safety Engineering when the Department of Architecture, TUS was founded some 40 years ago. In this way, TUS laid the foundations of research and education on fire science ahead of the times, when such developments were unknown in other universities. These foundations have yielded a strong track record of achievements since then, as amply illustrated in the fact that we have received two prestigious awards from the International Association for Fire Safety Science, the highest authority body of its kind in the world. The first of these was awarded for "Meritorious achievements in research contributing to the advancement of fire safety science", and the second was for "Meritorious achievements in education producing numerous researchers in fire science". In the past, Japan has suffered many fires in large buildings, which have claimed a large number of human lives. Members of the Department of Fire Science and Technology, TUS have been involved in appraising the majority of these serious building fires since 1968.

In recognition of this track record, the Department was included in the 21st Century COE Program of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in fiscal 2003, as a "Center of Advanced Fire Safety Science and Technology for Buildings". It is currently engaged in activities aimed at establishing itself as a research and education center on fire science and fire safety engineering at the world's highest level. Other aims are to promote the advancement of fire safety engineering and the training of young researchers and specialist professionals. We will continue our efforts in offering innovative education and research to protect human lives and properties from fires.

Following the 21st Century COE Program, which concluded in 2007, the Global COE Program 2008, which would conclude in 2012, further adopted the "Center for Education and Research on Advanced Fire Safety Science and Technology in East Asia". Now, the Center restarted as a five-year project after having been selected as a 2013 recipient of the Private University Strategic Research Formation Assistance Grant from the MEXT.

Fire Research and Test Laboratory

Taking the opportunity of being adopted as the 21st Century COE Program, this laboratory was built in March 2005. It is one of the largest and most functional laboratories in the world meant solely for fire science. Built at Noda campus, it has a building area of 1,500 m^2, and gross floor area of 1,900 m^2, and a height of 20 m (Photo 1). Members of the Center constructed a basic plan and did the designing utilizing their wealth of experiences, so that the laboratory would enable us to promote world-leading researches on fire sciences.

In March 2006, a large scale refractory furnace was added. Other large scale experimental facilities to be included in the laboratory are composite furnace, fire-resistance assessment machines for outer wall materials, and combustion performance testing facilities, which are needed internationally, to contribute to the advancement of innovative researches.

Purpose and importance

The Center for Fire Science and Technology was promoting formation of research and education center with the Global COE Program (Fig. 1). The 21st COE Program, "Center of Advanced Fire Safety Science and Technology for Buildings" produced two major outcomes, one is the development of "theory" pertaining to performance-based fire safety design, and the other is the development in "practice" through experimental research utilizing the full-scale experimental facilities. Upon these two pillars, the Center will further research and deepen our knowledge of how to control the potential fire risks (Fig. 2) that are increasing along with the emergence of new spatial configurations (high-rise or underground) and use of new materials (e.g. aluminum and plastics). These are inevitable changes brought about by modernization, industrialization and increased need of energy conservation. Specifically, in response to the drastic modernization in East Asia where appears to be utilizing new spatial configurations and materials, fire risk needs to be assessed in major cities, working together with researchers of each region, and utilizing research network and specific education system to be developed in order to establish effective measures for such risk. These activities will help society to control critical accidents from occurring in underground facilities or high-rise buildings.

Once a fire accident occurs, by applying theory and utilizing the full-scale test facilities a highly reproducible analysis can be made, and then effective and specific measures can be taken to prevent a recurrence of similar fire accidents. In addition, the professional abilities of fire protection engineers (who put the safety measures into practice based on research findings) could be better defined and better standardized via education provided to firefighters.

Graduate School of Global Fire Science and Technology

The Master's Course in Fire Science & Technology at the Tokyo University of Science's Graduate School of Global Fire Science & Technology was established in April 2010 is the first postgraduate fire science course in Asia, and is aimed at those employed in the area of fire science and safety (such as the construction, firefighting, and nonlife insurance industries) as well as students from Japan and overseas who want to become fire prevention technicians and fire officers.

The graduate school represents one aspect of the MEXTs Center of Excellence (COE) program, "Center for Education and Research on Advanced Fire Safety Science & Technology in East Asia", being promoted by the Center for Fire Science and Technology, and aims to establish Asia's first definitive fire science education facility. The school to familiarize students with basic theory in a practical setting uses the Fire Research Test Laboratory.

In addition to the Master's Course, students also have the opportunity to continue their studies, such as Doctoral Course in Fire Science & Technology established in April 2012.

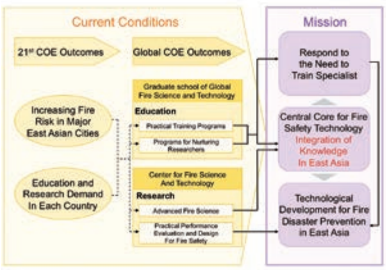

Photo 1
Fire Research and Test Laboratory

Fig. 1 Perspective of the Center for Fire Science and Technology

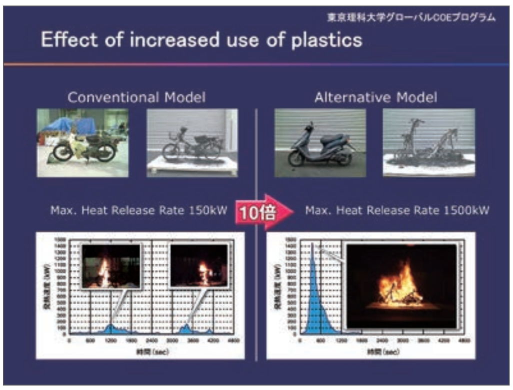

Fig. 2 Effect of increased use f plastics

Makoto Tsujimoto

Safety and security play pivotal roles in social development. TUS has, as a core of the fire safety engineering community both domestically and internationally, contributed to their advancement. In recent years, major cities in East Asia in particular have been undergoing marked development at a speed that no other Asian countries, including Japan, have ever experienced. We have a duty to mitigate this urgent situation sufficiently and, at the same time, to develop the innovative educational research system to prevent the occurrence of such fire accidents.

Information and Societal | Established: April 2011

Division of Next Generation Data Mining Technology

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Director Professor, Department of Industrial Administration, Faculty of Science & Technology

Hayato Ohwada

Research Content

Extraction of habitual patterns and knowledge from lifelog biometric databases.

Objectives

Creation of new, highly sophisticated methods of information processing by combining traditional statistical methods with AI-based inference engines to develop data mining tools capable of extracting habitual patterns and other knowledge from databases.

Future Development Goals

Attainment of the world's highest level of data mining tool performance as demonstrated through participation in competitive contests, and provision of new tools for supporting various scientific and technological development efforts.

The Division of Next Generation Data Mining Technology was established in April 2011. While new itself, its predecessor was the Research Institute for Science and Technology Knowledge Interface, established in 2005 (and formally concluded in March 2011). The institute to took a broad, multi-disciplinary approach to the development of techniques for the extraction of meaning from vast amounts of data; moreover, as announced at international conferences and presented in scientific journals, among the many accomplishments of the institute are the application of parallel inductive learning and inference engines to data mining systems, the development of multi-domain motif search tools for use in bioinformatics systems, and the use of rotational illusions in medical image analysis systems.

While sharing the same basic perception of the issues, the Division of Next Generation Data Mining Technology is characterized by its focus on the development of next-generation data mining technologies for medical/biometric applications and Web-based data. Toward this end, it contains within its organizational structure a multidisciplinary range of specialties centered on core proficiencies in artificial intelligence and statistics. Here, experts bring together their expertise to create new, highly sophisticated methods of information processing by combining traditional statistical methods with AI-based inference engines to develop data mining tools capable of extracting habitual patterns and knowledge from the web and from biometric lifelog databases. The division currently consists of 14 experts in such diverse specializations as knowledge engineering, cognitive science, statistical science, bioinformatics, system engineering, and even civil engineering. Collaborative relationships among these individuals are illustrated in Figure 1.

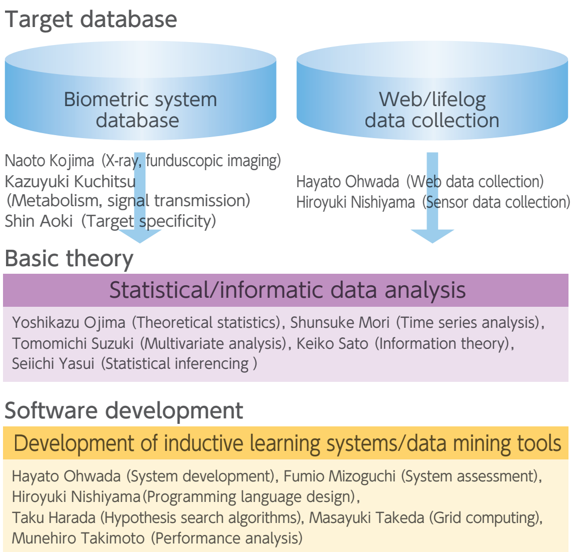

Fig.1 Collaboration among researchers within the Division of Next Generation Data Mining Technology.

Hayato Ohwada

We have brought together experts in various fields, including informatics, statistics, bioinformatics, and life sciences, as we strive to develop the world's most effective data mining tools and to broadly demonstrate their usefulness.

Although established only one year ago, the division is already advancing a number of interesting research projects, among them the so-called "Li-Phone (Life-log using Phone)". This project seeks to collect behavioral data for subsequent mining by tracking the usage of an individual's smartphone to create a lifelog—a continuously updated record of what a user does and when and where the user does it. GPS or another such function is used to track location; the smartphone itself, similarly, is used to monitor the person's calling history, Web browsing history, e-mail traffic, and so on.

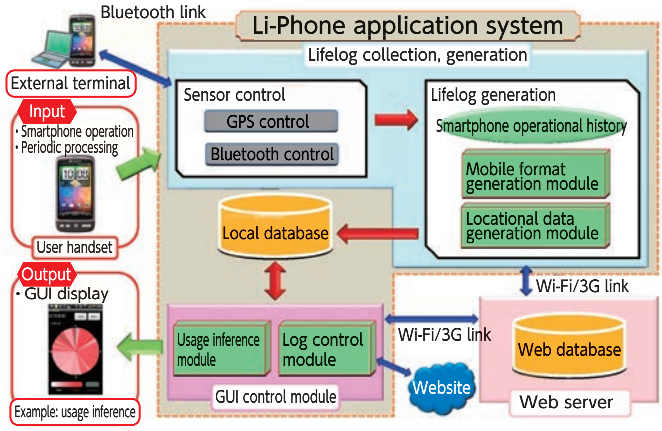

Fig.2 Li-Phone system configuration

Figure 2 shows the configuration of the Li-Phone system. This system utilizes the smartphone's GPS and communications capabilities to continuously maintain a real-time record of the user's position and calling history (ingoing and outgoing calls, Web browsing, etc.). We thus obtain an account of not only where the user was at a certain time, but also how that person was using his or her smartphone.

In our research, we utilized this system to track the smartphone behavior of 10 participants. An examination of the resulting lifelogs revealed that users tended to use their smartphones within certain timeslots and that those slots were relatively unhurried times of day for them. We also found that the patterns evident within the lifelogs could be used to predict the user's busy time periods on the following day. Figure 3 presents an example.

Fig.3 Prediction of user's status by day or date based on location and behavior histories (in this example, 09 February prediction for 10 February)

Information and Societal | Established: April 2011

Mountain Atmosphere Research Division

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Director
Associate Professor, Department of Physics, Faculty of Science Division I

Kazuhiko Miura

Research ContentGoals

Long range transport of atmospheric pollutants, aerosol-cloud interaction.

Objectives

To clarify the effect of aerosols on climate change, the MARD will activate the collaborated research and make the network of Japanese mountain atmosphere observatory.

Future Development Goals

This network of Japanese mountain atmosphere observatory will expand to the international one in future.

Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance on the climate system (IPCC2007). Aerosols affect the climate both directly (by scattering and absorbing radiation) and indirectly (by serving as nuclei for cloud formation). These effects remain the dominant uncertainty in radiative forcing (Fig.1).

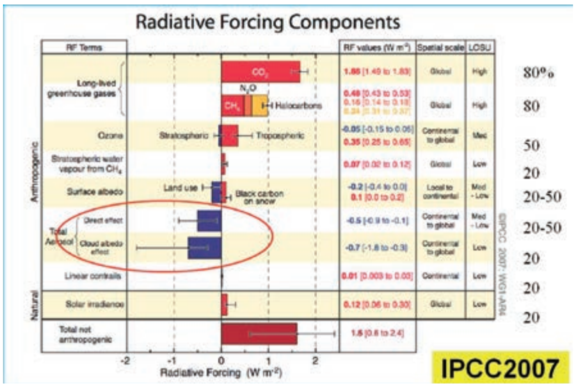

Fig. 1 Global average radiative forcing estimates and ranges in 2005 for anthropogenic CO_2 , CH_4, N_2O and other important agents and mechanisms (IPCC 2007).

Sulphur and organic species originated from ocean make new particles to increase the number of cloud condensation nuclei and change properties of cloud. However, in the planetary boundary layer (PBL), there are many sea-salt particles that provide surfaces for heterogeneous chemical reactions with sulphur or organic gases (Fig.2). There are a few papers of new particle production observed in the PBL under a high-pressure system. It suggests that particles are produced in the free atmosphere (FT).

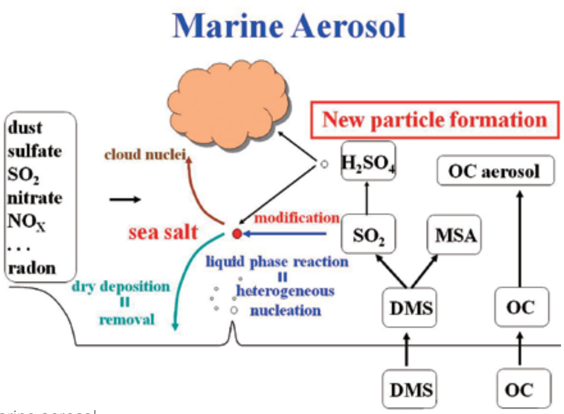

Fig.2 Marine aerosol.

Because of the altitude, mountain sites are well suited to studying aerosol-cloud interactions. We operate a network of mountain observation stations that studies processes of long range transport of atmospheric pollutants across East Asia and Japan, mixing between the PBL and the FT, new particle production and cloud formation. There are a few observatory of mountain site in the GAW (Global Atmosphere Watch) stations, WMO (world meteorological organization). Japanese mountains are important watching observatories, because they located in the east edge of the Eurasia.

Fig. 3 Japanese network of observatory on moutain sites

Our station on Mt. Fuji is particularly important, as Fuji is an isolated peak normally situated in the FT. The purpose of the MARD is not only activating the collaborated research of Mt. Fuji but also making the network of Japanese mountain atmosphere observatory, and in future, to expand it to the international one.

Fig.4 The observatory on Mt. Fuji.

Kazuhiko Miura

It can be said that the free troposphere is the background atmosphere where the influence of the man activity is a little. Mountains located in the free troposphere are likened to the observation towers of nature. We research on the background air pollution, the inetraction of aerosol and cloud and their effects on climate change.

Information and Societal | Established: April 2011

Division of Intelligent System Engineering

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Akira Hyogo

Research ContentGoals

R&D on human-like, human-friendly intelligent systems with autonomy for medical and space applications.

Objectives

To research and develop human-like, human-friendly intelligent systems with autonomy for medical and space applications by amalgamating different engineering technologies and sciences, thereby making a contribution to society and mankind.

Future Development Goals

To research and develop even more intelligent, more human-like, safer and more advanced intelligent systems with autonomy for medical and space applications.

Intelligent systems draw on a number of disciplines, including information engineering, image engineering, discrete mathematics, computer science, artificial intelligence, IT engineering, radio wave systems, medical bio-electronics, analog electronic circuits, integrated circuit engineering and semiconductor circuit engineering. Our task is to research and develop human-like intelligent systems with autonomy for medical and space applications.

Basic research on intelligent systems for medical applications

Here, we are mainly engaged in research in the following five areas.

○Bio-information sensing and healthcare

Research on sensing for bio-interfaces, and so on, and extracting various bio-information for healthcare.

○Radiowave communication systems for wearable IT devices

We are researching and developing PAN (Personal Area Network) wireless communication systems using UWB (Ultra Wideband) for wearable (body-attached) IT devices. We are also clarifying the electro-magnetic wave transmission properties of body surfaces and conducting R&D on UWB compatible antennas. Beyond these, we will produce various bio-information via networks using these systems for provision to healthcare.

○Energy supply systems for embedded systems and data transmission systems

Research on energy supply techniques for embedded systems e.g. embedded artificial hearts or capsule endoscopes and also data transmission systems and circuits.

○Cancer diagnosis and therapy using a microwave

○Wireless energy supply system for embedded systems and wearable IT devices

Research on space crafts with autonomy

Higher level intelligence and making to autonomy are requested from control systems of space crafts as the mission that they should accomplish variously becomes complex. Since there are strong requirements in weight and capacity in the equipment in the space unlike one on the earth, higher performance devices are strongly required for space crafts. Therefore, main purpose of this research is how to reduce the size and weight of the control computers and sensor systems in space crafts keeping their performance.

Research on downsizing of systems, and high-frequency and low power circuits

For medical and space applications of an intelligent system, downsizing and the low power consumption of the system are strongly required. And also the higher frequency operation is required of the circuits for high-volume data transmission and high-speed operation. Here, we are mainly engaged in research in the following three areas.

○Research on high-frequency analog circuits

In the intelligent systems of the future, it will be essential for systems to communicate and exchange vast amounts of information with each other. To this end, we are conducting R&D on GHz-band high-frequency front ends, including high-frequency circuits, low noise amplifiers and mixers for wireless LANs, and so on.

Akira Hyogo

This division reorganized in April 2011, and has been starting newly to aim at the medical and space applications. In this division, we will tackle research and development of human-like and human-friendly intelligent systems with autonomy for medical and space applications using a lot of valuable research results which are improved and united further more by our talented group of research personnel and excellent equipment.

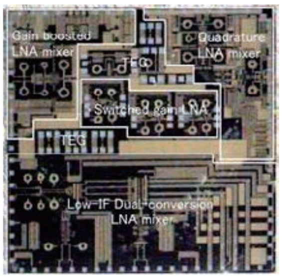
○Low-voltage, low-power circuits

As the scale of intelligent systems increases in future, so the range of applications is expected to broaden. Since battery operation and power-saving operation will be essential, we are also researching and developing circuits that operate at 1.5V or less.

○Integrated circuits

All the circuits necessary for the system are integrated for making of the system micro, and the techniques to achieve it with one integrated circuit researched.

By pursuing the research efforts outlined above, we will be able to construct systems with enhanced performance and turn all terminals into advanced information terminals. Moreover, by integrating all of these circuits, we will also be able to achieve ultra-compactness.



Research on communication method and network where an intelligent system is supported

Due to send and receive data efficiently, we are studying antennas, transmission lines, signal processing circuits and also communication protocols.

Research on energy systems where an intelligent system is supported

The focus is addressed to life and the energy system in the region, and the evaluation model of the decentralized energy system and the ideal way of a regional traffic system as Global warming measures are researched.

We think these techniques can adjust to the system from which energy-saving is demanded when medical applications such as the embedded devices are applied.

Research of software and theory to make hardware systems work more flexibly and autonomous

Due to make hardware of intelligent systems work more efficiently, the software, the programming language, and the information theory, and so on, are researched to support theoretically for the systems.

Information and Societal　Established: October 2011

Division of Integrated Science of Oshamambe town

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Director　Professor, Department of Biological Science and Technology, Faculty of Industrial Science & Technology

Yasuhiro Tomooka

Research Content

We study and support Oshamambe town, in collaboration with the citizens and local government.

Objectives

To support Oshamambe town by solving problems in scallop culture with biological and engineering technologies, and by participating in its socio-economic activities.

Future Development Goals

We have developed collaboration systems among researchers, managers of scollop fishery, leaders of the citizens and local government, and began to make progress toward to our goals.

Introduction

Twenty-five years have passed since Faculty of Industiarl Science and Technology was established. Freshmen of the Faculty live in the dormitory and study for one year in Oshamambe campus in Hokkaido, where they can enjoy the nature of the northern island and collaborate with the society of the small town in various activities. Their second year starts in Noda campus. More than 5,000 students have graduated from the Faculty and they have been highly evaluated in various Japanese business societies.

During the last 30 years, however, the population of the town has become half in number and gotten aged because of low rate of birth. This is a general phenomenon occurring in many local governments all over Japan. The citizens and local government of Oshamambe town have taken it seriously and have studied how to cope with the situation. It is critically important for freshmen in Oshamambe campus to live in the Town in good socio-economic condition. This Division has been established to collaborate with the citizens and local government and to find better future of the town. To achive the goal, the following personals participate in this project ; 1 from Faculty of Science Division 1, 3 from Faculty of Science and Technology, 13 from Faculty of Industrial Science and Technology of Tokyo University of Science, 1 from Kyoto University.

Subdivision: Biology and Fishery of Scallop

Group of Biology of Scallop

Hokkaido area gets more than 90% of catch and culture of scallop, and the main industry of Oshamambe town is scallop culture. The advanced technology in the culture has produced scallop with high quality and quantity, although the industry has biological and environmental difficulties to be solved.

In spite of advanced technology in culture of scallop, developmental biology of scallop has been poorly understood. In this group, we focus our efforts on mollecular analysis of reproduction and larval growth of scallop, especially growth of the adductor muscle. The basic biology of scallop will help to solve problems in culture.

Group of Technology of Scallop Fishery

Cadmium is acccumulated in the digestive gland of scallop and the gland is removed during meat-processing. Oshamambe town constructed a plant to extract cadmium and to re-use the glands as fertilizer. However, it was found that the plant did not function as designed. The cadmium-contamination is one of unsolved issues for scallop fishery communities in Northern Japan. This group collects information from these communities and commodates better extracting methods with them. This group also develops original methods to remove the metal by using protein-technology.

In the Funka Bay (Uchiura Bay) scallops are hung into sea water with rope downed from a raft. During culture periods, many animal like ascidians and seaweeds attach the culture equipments, inceaing the raft weight. The heavier raft causes extra-labor and extra-cost of fishermen. This group improves the raft system with better materials.

Group of Materials Science of Scallop Shell

As other shell fish fishery does, scallop fishery produces tons of shell. Shell of shell fish mainly contains calcium carbnate. Many methods have been already established to re-use shell, although many of them are expensive and not practical. This group physically and chemically analizes raw and treated shell materials and aims to find new methods to use scallop shell as functional materials.

Subdivision: Socio-economic Study of Oshamambe town

This subdivision socio-economically studies Oshamambe town and develops deep relationship between the campus and the town.

The population in the town was 11,164 in 1980 and it decreased to 6,429 in 2010. Among the population, the elderly (>65 years old) was about 10% in 1980, but it increased up to 30% in 2010, indicating that the population has been rapidly getting aged. The local government estimates population of 5,800 in 2020, although the number might be influenced by many factors such as administrative efforts. This subdivision considers the reasonable size of the town population and proposes to take a measure to maintain the population.

The freshmen living in the dormitory are also citizens of the town and their roles are getting more significant than ever as the town's population has been getting aged. For instance, they play significant roles in the town, by participating as volunteers in town's festivals, teaching kids science and having a music concert with groups of citizens. This subdivision develops further tight relationship between the campus and the town.

More than 5,000 freshmen have lived in Oshamambe town and graduated from the University since the Faculty was established. Most of them love the town and people, and some of them re-visit the town. The graduates are latent human source to support the town. They must be happy to be involved in re-building the town. In collaboration with alumni association of the University, this subdivision establishes an Oshamambe association united with internet among the graduates and ask their suggestion and collaboration.

Oshamambe town has its history, culture and tradition in addition to its own natural environment and historic relics. In collaboration with the local government and groups of citizens, this subdivision evaluates them as possible commercial sources for sightseeing.

Bird view of Oshamambe campus and Oshamambe town

Oshamambe campus and Oshamambe town and Uchiura Bay

Yasuhiro Tomooka

The Oshamambe campus has been supported by the Oshamambe society, and the small town in Hokkaido now has many socio-economical dificlties. This Division is going to study and support the society of the town, using our talented group of research personnel and excellent equipment, in collaboration with the citizen and local government.

Information and Societal Established: April 2012

Division of Advanced Communication Researches

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Director Professor, Department of Applied Electronics, Faculty of Industrial Science & Technology

Makoto Itami

Research Content

Research on next generation high-speed and highly-reliable short range communication technology.

Objectives

In the area of high-speed and highly-reliable short range communication that is the key to realize advanced ICT services, a feasible short range communication system is developed in cooperation of communication, network and device research areas.

Future Development Goals

In order to realize advanced communication systems, development of elemental technologies and practical systems is performed by cooperation of researchers on three groups.

Recently, advances of wireless communication technologies such as cellar phone, wireless LAN and so on are remarkable and the communication speed beyond 100Mbps can be made available under mobile communication environments. Moreover, the opportunities to use wireless communication in our daily lives are more and more increasing by the rapid diffusion of sophisticated mobile information terminals such as smart phones and tablets. As represented by the word of 'Ubiquitous', the wireless communication technologies hence will be more familiar and they will become more and more important.

In this research division, we target the short range communication technology for research. It is considered that the role of the short range communication technology becomes more and more important among the various communication technologies. For example, in the office environment, the demands for wireless-izing of information equipment, sensor network and so on are increasing and their seamless operation is highly expected. By the wireless office environment, the ICT infrastructure that realizes advanced and comfortable office environment is constructed. Toward the goal, it is necessary to develop a high-speed and highly-reliable short range communication technology. The short range communication technology is the key technology in the wide range of applications such as office, home, medical field, factory, ITS, logistics and so on, and its realization is more and more required in the near future.

In this research division, our primary research target is the short range communication technology. In the realization of a short range communication system, the system requirements that are different from the cases of long range and middle range communication systems such as cellar phone and wireless LAN must be considered and different approaches should be actively performed. Moreover, the short range communication closely depends on the application, the research and development that the total system is considered is necessary. In addition, the early realization of the system is also important in the area of wireless communication that the generation change is very quick. Hence, in this division, the experts of the network technology and the device technology in addition to the experts of the communication technology perform researches together to realize an advanced and feasible system. Cooperation of exports is necessary to realize the practical system. As shown in Fig. 1, this research division currently consists of three research groups: "Communication and Signal Processing Group", "Network Group" and "ICT Device Group". In each group, the elemental technologies are researched and developed. In addition, the total system is developed in cooperation with these three groups.

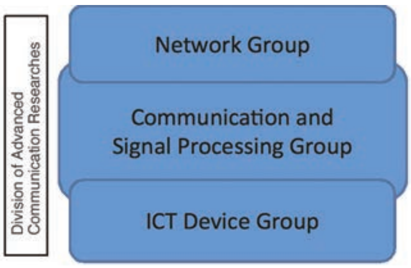

Fig. 1 Group Structure

Makoto Itami

The role of short range communication technology is more and more important to sophisticate ICT in the office, home, medical field, factory, ITS, logistics and so on. In order to realize short range communication systems, not only the advance of elemental technologies but also the integrated system development is required. In this research division, a feasible short range communication system is researched and developed in cooperation of communication, network and device research areas.

The research topic in each group is as indicated below.

1. Communication and Signal Processing Group

In the Communication and Signal Processing Group, researches on physical layer communication scheme and signal processing technology that are appropriate to short range communication. In short range communication, fast communication speed, simultaneous operation of large number of devices, guarantee of real time transmission, low power consumption and so on are required. In addition, the available frequency band is limited and development of the communication scheme that efficiently utilizes the limited frequency band is necessary. In this division, a high-speed and highly-reliable short range wireless communication scheme that utilizes the limited frequency band efficiently is researched and developed in cooperation with the experts in communication systems and signal processing. The use of basic communication schemes such as UWB(Ultra Wide Band) and OFDM(Orthogonal Frequency Division Multiplexing) are assumed and the technologies such as signal processing, coding, etc. to sophisticate them are researched. Moreover, it is assumed that the short range wireless communication is operated as the underlay of existing wireless communication systems or operated in the white spaces. Therefore, the communication scheme that can achieve optimal performance considering the interference against the other communication systems is researched. Exploiting newly available frequency bands is also a research topic in this group.

2. Network Group

In the Network Group, the network technology that connects the large numbers of short range wireless communication devices efficiently is researched. In the applications of short range wireless communication such as sensor network, RFID, etc., it is assumed that large number of devices are being operated simultaneously in a small area. Under such situation, construction of an efficient network is necessary in order to administrate these communication devices efficiently and optimize the frequency utilization in time and space. The Network Group develops the network technology that is appropriate to the short range communication in cooperation with the Communication and Signal Processing Group. In addition, the technology to use the network seamlessly in the various applications, the technology to optimize communication resources, cross layer optimization to achieve optimal frequency utilization and power consumption are researched.

3. ICT Device Group

In the ICT Device Group, the device technology that is required to realize a short range wireless communication system is researched. In the short range communication systems, it is assumed that large numbers of devices are used under mobile environments. Therefore, reduction of the device size and development of low power consumption device are important research topics in addition to development to high speed devices. In order to develop a practical device, the cooperation between the ICT Device Group and the Communication and Signal Processing Group mutually confirming the needs and seeds in device development is necessary. An optimal device development is performed in close cooperation with the Communication and Signal Processing Group.

As mentioned above, in this division, research and development of the next generation short range wireless communication technology are performed in cooperation of three research groups. In addition, the research that contribution to the Japanese and international standardization is taken into consideration is also expected.

Fundamentals | Established: April 1999

IR FEL Research Center

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Director Professor, Department of Chemistry, Faculty of Science Division I

Koichi Tsukiyama

Research Content

- Basic and applied research relating to photo science using mid infrared free electron laser
- Development of far infrared free electron laser

Objectives

Contribution to the basic and applied research in the various field of science and technology. The research fields contain chemical reaction dynamics, spectroscopy of molecules and clusters, diagnostics of surface, material processing, etc.

Future Development Goals

Development of a Laser Center involving infrared free electron laser, ultra short pulse laser, and frequency tunable dye laser, etc.

In April 1999, the IR FEL Research Center (FEL-TUS) was established at the TUS Noda Campus as a base for enhancement of IR FEL and development of new photo-science using IR FEL, a research project under Grant-in-Aid for Creative Scientific Research. While development research on the Free Electron Laser (FEL) itself is underway in a number of research institutions, FEL-TUS is one of the few facilities that prioritize research on the use of light by harnessing the characteristics of FEL as a mid-infrared light source.

Figs. 1 and 2 show a schematic outline of the FEL device and the structure of the undulator. An electron beam generated by a high-frequency electron gun has its energy spread regulated by an α-magnet, and is forced towards the linear accelerator. The electron beam, now accelerated to a maximum 40 MeV, passes through a deflecting magnet and is led towards an undulator. This is a radiation-producing device in which thin permanent magnetic plates (using SmCo for the poles) are aligned periodically in vertical bipolar alternation, generating a magnetic field that is modulated in the fashion of a sinusoidal wave. When accelerated electrons are passed through the undulator, the electrons oscillate and generate synchrotron radiation in the tangential direction. This synchrotron radiation is accumulated inside a pair of gold-coated concave mirrors (called optical resonators) set at both outer ends of the undulator, and is amplified by a strong reciprocal effect with the electron beam. FEL light is output through a 1mm-diameter pinhole in the upstream mirror. In this respect, FEL has no laser medium and its principle of oscillation differs essentially from the original laser (Light Amplification of Stimulated Emission of Radiation). The main body of the FEL is surrounded by a 2 m thick concrete wall to prevent neutrons and γ rays from leaking out. The FEL light emitted from the resonator is first converted to parallel rays, then propagated in free space mode in a vacuum to ensure that it is guided with its properties being retained inside the laboratory. Although small in scale, FEL-TUS is a facility that includes an accelerator. As such, the advice and guidance of experts are vital to its operation and management. In fiscal 2009, our Center was selected as an Accelerator Science Support Project of the High-Energy Accelerator Research Organization, and currently maintains a stable operational status under a system of full support.

A marked characteristic of FEL is that it involves no limit on oscillation wavelength due to absorption of the medium; in principle, oscillation is possible in any wavelength region. Of course, generating ultraviolet light with FEL requires an electron beam of correspondingly high energy, along with a commensurate increase in facility scale. FEL-TUS is designed specifically for the mid-infrared region (MIR). Its practical oscillation wavelength is 5~11 μm, which corresponds to the absorption frequencies for vibrational modes of molecules. Another major characteristic lies in the time structure of oscillation. The repetition frequency of FEL-TUS is 5 Hz, and pulses made every 200 ms are called macropulses. Each macropulse consists of a string of micropulses at 350 ps intervals (see Fig. 3). The peak power of micropulses is several MW, corresponding to a high photon density of 10^{26} photons per second.

By drawing on these characteristics of FEL light, we are able to conduct different types of new experiments that would not have been possible with conventional light sources. Our Research Center is promoting the following, in particular, as priority tasks:

(1) Tracing the physical and chemical processes such as photodissociation and isomerization induced of molecules by multiple photon process.

(2) Tracing the chemical reactions of vibrationally excited molecules using pump-and-probe method.

When molecules are irradiated with light, they normally absorb single photons. But cases such as FEL, in which the output power is high, they induce the phenomenon of multi-photon absorption, in which several photons are absorbed at a time. If the sum total of all the photon energy absorbed exceeds the energy of chemical bonds, these bonds may be broken (dissociated). FEL is capable of exciting specific vibrational modes in molecules, and is therefore expected to be able to induce selective dissociation of bonds and reactive processes. Understanding the details of this in macroscopic terms is the target of (1) above. Protein aggregates such as the amyloid fibrils are in many instances associated with serious diseases including amyloidosis. Those aggregates contain many β-sheet structures which are formed by intermolecular hydrogen bonds of peptide backbones. Although the fibril structure is so robust in a physiological solution, FEL tuned to the amide I band (6.0 μm) can dissociate the amyloid fibrils which are formed by lysozyme, insulin, and calcitonin peptide fragment into each native monomeric form. The effect of FEL on the refolding of amyloid fibrils can be analyzed by using electron microscopy, MALDI-TOFMS, and FTIR following the FEL irradiation. As a mechanism, it can be suggested that non-covalent bonds between β-sheet structures can be affected by the FEL irradiation tuned to the amide band. As for (2), vibrationally excited molecules are known to cause specific reactions, and the aim is to elucidate microscopically, i.e. via molecular science, what properties of molecules cause this specificity. "Pump-and-probe" is a technique of first generating vibrationally excited molecules via FEL (pumping), then tracing the behavior of these molecules using a separate laser light (probing). By introducing a second laser light, not only are we able to identify reaction products, but also to completely define the direction and speed of their movement as well as their quantum state distribution, etc.

This research center has been financially supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) from 2007, which promoted active use of IR FEL for basic and applied research by external users. At present, ~10 research groups including companies and national institutions are carrying out their original experiments. Because FEL is simply a light source in the mid infrared region, it is absolutely necessary to combine FEL radiation with suitable detection techniques in order to perform highly sophisticated spectroscopic measurements. We hope that researchers with a variety of scientific background and unique experimental skills make use of FEL radiation and that our center develops as a research base for a variety of fundamental research fields.

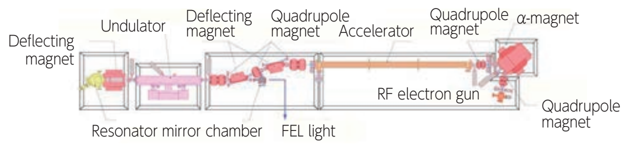

Fig. 1 Schematic outline of FEL-TUS

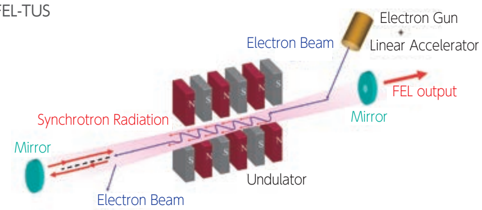

Fig. 2 Structure of undulator

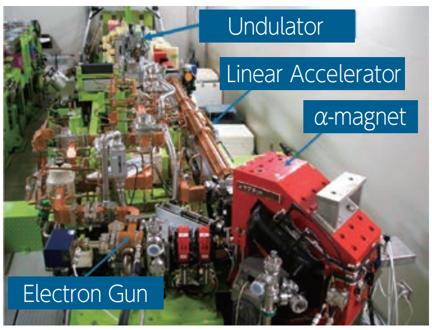

Photo 1 Main body of the infrared free electron laser

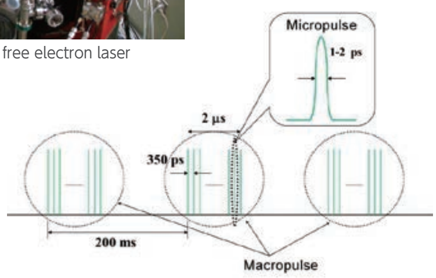

Fig. 3 Pulse time structure of FEL-TUS output

Koichi Tsukiyama

FEL-TUS occupies an extremely specific position in global terms as a variable frequency pulsed light source in the mid-infrared region. We are currently promoting basic research in molecular science and spectroscopy as a priority research task, with a view to making maximum use of its characteristics. We will continue our efforts for the further development of our Center as a research base for molecular science.

Fundamentals | Established: April 2011

Leading-Edge Holography Technologies Research and Development Center

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Manabu Yamamoto

Research Content

The Center focuses on the development of next-generation holography-based recordable media manufacturing technologies and 4D fluid measurement techniques.

Objectives

The Center's primary objective is the creation of next-generation high-capacity recordable media (ROM) using holography-based technologies, and the establishment of technologies for 4D measurement of fluid behavior in the vicinity of phase boundaries.

Future Development Goals

To realize our goals of using holography in next-generation high-capacity recordable media and in technologies for 4D measurement of fluid behavior in the vicinity of phase boundaries, a complete redesign of simulations and redevelopment of associated equipment will be required.

Overview of the Center and its projects

The name of the project at the Leading-Edge Holography Technologies Research and Development Center is "the development of next-generation holography-based recordable media manufacturing technologies and 4D fluid measurement technologies." This overview focuses on two groups, the Holographic Memory Structuring Group, which is researching the manufacture, duplication, recording, and playback of holographic recordable media, and the Holography Instrumentation Group, which focuses on 4D fluid measurements. The first group aims to create high-precision ROM media by electron beam lithography capable of nanoscale shaping, and to establish mass production methods for duplicating the resulting forms into plastics. The second group aims to establish measurement technologies that utilize waveguide holograms to observe fluid behavior in the vicinity of phase boundaries. Such measurements will use light emitted through a waveguide onto media from a perpendicularly incident laser, making phase boundary observations possible.

Background and goals of the project

Many years have passed since the invention of holography in 1947, yet even today there are few areas where it has been put into practical use, or developed into technologies that are useful in actual applications. The creation of silver holographic decals to prevent forgery of banknotes and credit cards is one of the few examples of current practical applications, but research into holography is being actively conducted to develop as-yet unrealized applications, such as 3D displays, optical elements for head-mounted displays, holographic memory, and holographic measurement instrumentation. A further issue is the relatively small number of researchers worldwide engaged in the study of such applications. One possible reason is the relatively difficulty of such research as compared with research on standard optical disks, owing to the phase information contained in holographs. Although applied holography research is difficult, the potential rewards of new technologies and applications are great if we can persevere in this endeavor.

The goals of this project are as follows.

- *Development of technologies for holographic memory*

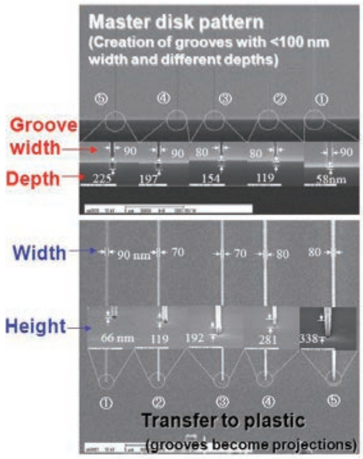
  We aim at raising holographic memory technologies to a level where they can be usefully applied. In particular, this project focuses on the establishment of technologies related to mass production of high-capacity ROM media that can be realized using only optics technology.
- *Development of technologies for the application of holography to fluid measurement*

  The project aims at verifying poorly understood fluid behavior at phase boundaries, in particular, describing resin flow with high precision.

Overview of the Holographic Memory Structuring Group

Examples of high-capacity ROMs currently in use include DVD and Blu-ray discs. Recent applications such as 3D television and film, however, have created demand for storage media with even higher recording densities. Holographic memory is one technology that may make this possible, but increasing the storage density of ROM media will require the development of new microfabrication techniques. Furthermore, pattern formation on ROM discs requires the creation of patterns in the direction of their rotation. Holography involves large amounts of information, with pattern widths and heights that require fabrication with nanoscale precision, but techniques and devices for achieving such high levels of control in a rotation pattern do not yet exist. The theme of this research will therefore be the creation of ROM media through electron beam lithography in vacuum, performed upon a rotating disk.

Nanoscale patterns can be formed using electron beam lithography. The upper part of the figure below shows an image of an actual electron beam lithography pattern, specifically, an example pattern with differing depths of less than 100 nm line width. While technologies required for the creation of holographic masters exist, methods are still lacking for forming these patterns on a disk, as well as for disk duplication and mass production. We therefore plan to pursue the following areas of research.



1. Playback of recorded holographs and calculation of the patterns to be written to disk
2. Fabrication stages related to in-vacuum disk revolution and creation of grooves through electron beam lithography
3. Duplication of created grooves in plastic
4. Hologram playback of the transferred pattern and operation verification

Overview of the Holography Instrumentation Group

Many of the fluid flows seen in the natural world and in industrial applications are accompanied by heat and material transport phenomena, dominated by the formation of vortices that spatially expand. Understanding such flow characteristics is vital to understanding their underlying physical mechanisms, developing numeric prediction models, and constructing artificial control techniques. One method for measuring such flows is particle image velocimetry (PIV), in which fine particles that will not interfere with fluid movement are introduced and tracked, and their behavior imaged. A shortcoming of this method, however, is that it only delivers two-dimensional information. One technique for overcoming this limitation is holography-based PIV—such techniques have already been successfully used to track the three-dimensional movement of fluids at micrometer scales. Research by this group will focus on the development of measurement technologies using holography to measure fluid behavior in the vicinity of phase boundaries.

Conclusion

The Center will continue the work of the Next-Generation Photonics Application Research Division, which developed the world's first technologies for creating write-once holographs. Creation of the Center will allow us to work toward the development of more complex new technologies, as well as to pursue our research with added synergistic effects arising from cooperation between our two groups.

Manabu Yamamoto

Optical technologies have already become an indispensible element in twenty-first century information and measurement devices. Holography technologies incorporating optical phase information are the best-suited techniques for further advancement toward increased functionality and precision. To that end, the Center is pursuing next-generation high-capacity write-once media (ROM) using holography-based technologies, and the establishment of technologies for 4D fluid measurements in the vicinity of phase boundaries.

Fundamentals | Established: April 2011

Quantum Bio-Informatics Research Division

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Masanori Ohya

Research Content

Research for new paradigm on information science and life science on the bases of quantum theory.

Objectives

To return to the basics of bio-information and quantum information and to focus on the relation between the two for new development.

Future Development Goals

To seriously attempt mutual interaction between bio-information and quantum information, thereby creating a new field that could be called "quantum bio-informatics".

The purpose of this Research Division is to return to the starting point of bio-informatics and quantum information, fields that are growing rapidly at present, and to seriously attempt mutual interaction between the two, with a view to enumerating and solving the many fundamental problems they entail. In our view, there is no other research effort in the world that has such attempts.

The immensely long DNA sequence consisting of four bases in the genome contains information on life, and decoding or changing this sequence is involved in the expression and control of life. In quantum information, meanwhile, we produce various "information" by sequences of two quantum states, and think of ways of processing, communicating and controlling them. It is expected that the problems we can process in time "T" using a conventional computer can be processed in time nearly "log T" using a quantum computer. However, the transmission and processing of information in the living body might be much faster than those of quantum information. Seen from this very basic viewpoint, developing the mathematical principles that have been found in quantum information should be useful in constructing mathematical principles for life sciences, which have not been established yet. The mechanism of processing information in life is also expected to be useful for the further growth of quantum information.

To bring this project to fruition, we plan to bring together Japanese and overseas researchers from various fields including quantum information, quantum probability, bio-informatics, structural biology, stochastic analysis, and solid-state physics, and to hold frequent exchanges between them (visits, invitations, conferences).

Here, we will list some of the basic problems that currently concern us in the separate fields of bio-informatics and quantum information, and will explain our efforts to tackle them.

(1) While the genomes of various living organisms have already been determined, how this information of genome should be understood or processed, and how they are related to the emergence of life, are more or less completely unknown at the moment. In some respects, this problem is connected to the question of how the transmission and change of information is involved in the "shape" of life. Meanwhile, the base sequence of the genome is called the primary structure, and in research related to life from the genome we first need to align the sequences in order to compare several different genes or amino acid sequences. But if the number of sequences being compared becomes too large, this alignment takes very long time. Therefore, we have made an attempt to establish this alignment using quantum algorithms. This has been done recently for some cases. Moreover we develop a high quality alignment algorithm by means of the concept of entanglement. In future, we plan to use our findings in research on classification and change in living organisms such as HIV, and to link it to the introduction of markers for observing changes in disease progression (see for trials along this line). In addition, we will elucidate the dynamics of change and control of bio-information, i.e., how information of life can be read from the base sequence of the genome and how the information is expressed through the intervention of amino acids and proteins, based on the theory of information transmission and processing in quantum information. In this vein, we could succeed to classify HIV and influenza virus.

(2) To establish the Heisenberg uncertainty principle (one of fundamental concepts of quantum mechanics) and to make it possible to describe phase transition and the creation and annihilation of elementary particles, and so on, quantum mechanics have to be described by an infinite dimensional Hilbert space. Therefore quantum information should be incorporated with the essential nature of quantum mechanics and it has to be constituted in an infinite-dimensional Hilbert space, too. The only theory in which such attempts have been completely established is that of quantum entropy which expresses the amount of information. Most of other problems are still incompletely established: (a) The state describing phenomena specific to quantum dynamics (such as quantum interference) is called the "quantum-entangled state". In various aspects of research on quantum information we need to judge whether or not a quantum state is "entangled". However, the method of making this judgment has only been established in a few cases such that the Hilbert space is 2- or 3- dimensional, but in other cases it is very incomplete. (b) We need to establish the mathematics of information communication in infinite-dimensional Hilbert spaces (quantum teleportation, quantum coding).

Infinite systems are also necessary for a physically precise discussion of the genome, since the world of the genome has an overwhelmingly large degree of freedom as the world of physics. Therefore, we will study to what extent the mathematical principles of quantum information in an infinite system are used in understanding changes and transmission of information in Life.

(3) In quantum information theory, the two signals "0" and "1" are expressed by two quantum states, and the changes of information are described in quantum dynamics. As an example, in quantum computation, logical calculations are represented by unitary dynamics. However, actual physical processes are dissipative processes, and unitary processes are merely ideal. Therefore, to make unitary computation suffice for quantum computation is merely idealization, and this causes difficulty to make a real quantum computer. In a first stage of our research in this division, we have constructed a theory of quantum computation incorporating dissipative processes, and introduced a generalized quantum Turing machine, by which we solved the outstanding problem "P=NP". Based on this study, we tried to construct new quantum algorithms for "bio-information". For instance, a quantum algorithm for multiple sequence alignment of amino acids is the efficient algorithm which can solve the multiple alignment problems in polynomial time of input length. Recently, we found some incompleteness for the proofs of the complexity in the Shor quantum algorithm for prime factorization which is published in 1994. In our paper, we showed that Shor's reduction is not achieved in some cases, namely the computational complexity is not in polynomial. Moreover, we proposed a new quantum algorithm to solve the factorization problem in a polynomial time.

Associated with our research of quantum information, we found a new cryptography based on non-commutative mathematics as a byproduct. This new cryptography is faster, lighter and secure than all of present cryptographies. We showed that this cryptography passed all statistical tests, U01-TESTS provided by NIST, and its velocity for data encryption is faster than AES.

(4) While a given sequence of the amino acids designates a protein, the three-dimensional structure of the protein has not been clearly understood yet. With current methods (e.g. molecular dynamics), the mechanism (e.g. "folding") whereby this three-dimensional structure is produced cannot be simulated even by super-parallel computers, as the complexity of computation is far too large. Our conceivable approach would be, firstly, to write this mechanism down by quantum algorithm, secondly, to attempt simulation using a parallel computer when the bit-count is small, and then to consider improving the algorithm on this basis.

(5) Genome information expressed by extremely long sequences of four bases is far more complex than that expressed in sequences of two quantum states. Besides, the speed of transmission and processing of information in life must be even faster than that of quantum information processing, which it self is incredibly fast. Therefore, we will attempt to incorporate the mechanism of bio-information, which is far more complex than that of quantum information, into the mathematical structure of quantum information.

(6) Recently, one faces a fundamental problem appearing in many experiments, particularly in biology, psychology and so on. It is the breaking of total probability law. We have studied this problem and we found a mathematical treatment solving this problem in terms of the concepts of liftings and adaptive dynamics. This new mathematics is one of the non-Kolmogorovian probability theory. We have lots of rooms to develop the theory. In particular, we generalized in a natural way the classical Bayesian inference and studied a mathematical formulation of the non-Bayesian inference which can not be described in Kolmogorovian probability theory. We succeeded to explain the irrational inferences that have been discussed in cognitive psychology. Moreover, we pointed out that the experimental data in Escherichia coli's metabolism violate the total probability law in classical probability, and proposed how to compute the non-Kolmogorovian probabilities in such phenomena.

Masanori Ohya

Our primary goal is to solve fundamental problems by causing a mutual interaction between bio-informatics and quantum information, two areas that appear quite different at first sight. While this in itself is by no means easy, we firmly believe that this kind of basic understanding will be extremely useful in making the new fields of bio-informatics and quantum information truly "fundamental and practical".

Fundamentals | Established: October 2011

Imaging Frontier Research Division

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Akira Suda

Research Content

R&D on leading-edge imaging technologies such as *in vivo* FRET imaging and near-infrared *in vivo* imaging.

Objectives

To develop advanced non-invasive *in vivo* imaging technologies beneficial for research in various fields of life science.

Future Development Goals

To develop novel *in vivo* imaging technologies and demonstrate their useful applications to observe living cells and biomolecules.

Establishment of the Division

Imaging is a key technology of the 21st century in the field of basic science and medical/industrial applications. TUS has a large variety of research specialists; this is a great advantage for producing innovative imaging devices, materials, and techniques by interdisciplinary collaborations. Thus, in 2010, we set up a Noda Imaging Alliance for the purposes of (i) the promotion of collaborative research by exchange of information about mutual studies and (ii) the enlightenment of young scientists and students. Based on the activities of this Alliance, now we have launched the Imaging Frontier Research Division to build a base for creating cutting-edge core technologies for imaging. In this Division, we will execute a close feedback between the technical development by researchers in physics, chemistry, and engineering and the verification studies by life scientists in order to develop novel imaging technologies which have a large spillover effect on basic and applied sciences.

Research Content

"Seeing is believing." When we perform life sciences, bioimaging technology supplies much information in biological mechanisms. Our purpose is to produce innovative "novel *in vivo* imaging" technology through interdisciplinary sciences. We will try to develop breakthrough technologies that contribute to advances in various fields of life sciences including medical, environmental and agricultural applications.

1.Enhancement of functionality of *in vivo* FRET imaging

Fluorescence resonance energy transfer (FRET) is a powerful technique for studying molecular interactions inside living cells (Fig. 1). *In vivo* FRET imaging with improved fluorescence proteins will give high spatial and temporal resolution and sensitivity. Moreover, our developed phase control method by ultrashort pulse laser will prevent photobleaching and keep its velocity. Our innovated next-generation FRET technology will be available for a wide range of biological applications including live-cell imaging for drug screening and Ca^{2+} imaging within brains.

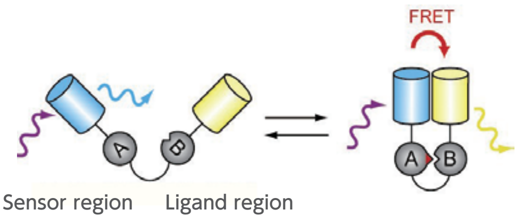

Fig. 1 Schematic representation of a FRET biosensor

2.Development of near-infrared *in vivo* imaging system

The application of near-infrared (NIR) fluorescence to bioimaging can provide low-scattering and non-invasive observations with low autofluorescence. *In vivo* fluorescence bioimaging (IFBI) in a long-wavelength-range over 1000 nm (OTN) is an unprecedented technology. The original technology from TUS attracts scientific attention as a next-generation technology (Fig. 2). The development will bring a non-invasive and multi-wavelength imaging system for various biological systems including animals and plants and their organs into reality. It includes the research on novel fluorescent probes made from ceramic nanoparticles doped with rare-earth elements as a suitable probe in the imaging system. The system development will be followed by applications such as a disease diagnosis without abdominal operation, monitoring of plant responses against environmental stresses, pathogenic microorganisms and pests.

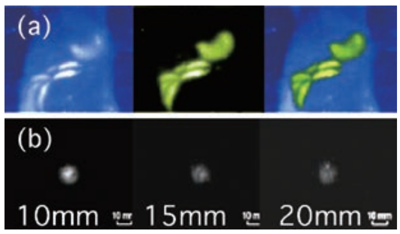

Fig. 2 OTN-NIR-IFBI with 1550-nm fluorescence of (a) digestive tube of a mouse and (b) phosphor tablet under muscular tissue of a swine with several-cm thickness

Research Organization

The Division aims to create a responsible imaging technology to meet demands of specialists of various fields of life sciences as imaging users. For achieving the aims, we are attempting close communications among specialists from various scientific and engineering research fields and those from life sciences. Accordingly, the Division consists of both of the users and designers of bioimaging technologies. The Division expects close interdisciplinary collaboration for the enhancement of the development of the key technologies such as *in vivo* FRET imaging and NIR *in vivo* imaging. Collaboration among the members of other divisions or centers in the RIBS, as potential users or designers, is also encouraged. The members will also collaborate with researchers in other universities or institutes not only for cutting-edge research but also to organize workshops or training courses on bioimaging, which will promote the development of a center of excellence of the bioimaging in TUS.

Expected Outcome and Spreading Effect

Now that the whole genome information for various species of organisms has been analyzed, *in vivo* imaging technology, with which dynamics of biomolecules and their interactions inside living cells can be studied, is essential to a broad range of research and development in life sciences. In this Division, fully integrated interdisciplinary research, including laser technology, innovative fluorescence probe technology and live-imaging of various organisms including animals and plants, will be undertaken to develop innovative imaging technologies for use worldwide. We expect breakthroughs to be made in the life sciences using innovative imaging technologies, such as next generation *in vivo* FRET and NIR *in vivo* imaging technologies. TUS offers this potential methodology to the world community, and will contribute to the training of forward-looking young scientists and students to gain a broad knowledge in both material and life sciences and technology.

Akira Suda

In vivo imaging is a key technology for making progress in various fields of life science research. TUS has a good research system where a wide range of specialists can collaborate in this interdisciplinary field. In this Division we will develop innovative *in vivo* imaging technologies towards the next-generation of life sciences.

Research Equipment Center (REC)

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Yasushi Idemoto

In 1967, the groundwork was laid for the establishment of the Research Equipment Center (REC) at the Tokyo University of Science (TUS), when a steering committee was formed under the direction of the University President to guide the purchase, use, and joint operation of research equipment, which was advanced, sophisticated, large in size, and too expensive for individual researchers. Next came a steering committee for the Center for Analytical Instruments in 1985, which was finally reincarnated into the Research Equipment Center as a technical division of Research Institute for Science and Technologies (RIST), in October 2006.

The Aims of the Research Equipment Center (REC) at the TUS

The aims of this center are summarized as follows:

1. To enhance the research system at the TUS
2. To create an environment to foster the world's highest levels of research at the TUS by introducing the most advanced equipment
3. To unify the research system at the TUS
4. To promote the effective and efficient operation of research equipment
5. To promote the effective and efficient use of research resources at the TUS
6. To provide educational support for the research programs of graduate students
7. To provide administrative equipment-operation that reflects the will of the researchers at the TUS
8. To provide repair, maintenance, and operational jurisdiction of the equipment
9. To purchase strategic equipment for future research at the TUS

Present status of the Research Equipment Center at the TUS

The total number of equipment registered to the REC is in the 99s. Equipment is classified into 4 groups: centrally administrated (21), collectively managed (44), dispersion-managed (30), and utility (4). Furthermore, the kind of equipment has 13 classifications: mass spectrometers (10), nuclear magnetic resonance spectrometers (13), X-ray analysis instruments (9), X-ray fluorescence spectrometers (3), scanning electron microscopes (6), transmission electron microscopes (5), atomic force microscopes (4), laser system (1), spectrophotometers (10), other analysis equipment (9), biological analysis (16), other special analysis (9), and utility (4). Pictures of these instruments are shown in Figures 1-4.

The future of the research equipment center (REC) at the TUS

The most important task at this center, as mentioned above, is to efficiently manage the budget. As a first stage of reform, maintenance contracts of some NMR and MS spectrometers were packaged and rationalized. Operators and engineers at the REC professionally rationalize the administrative operation of equipment, and teach the operation techniques to graduate students in their research projects. This will increase the quality of the measurement data, and will enable the effective use of research resources at the TUS. Licensed students will be able to operate most of the equipment of the REC after reservation through a corresponding web site. Repair, maintenance, and operational jurisdiction of the equipment are important affairs at the REC, and strategic equipment should be purchased for the future of research at the TUS. Furthermore, it is desirable that the REC make a social contribution to the community by allowing the use of some of the equipment.

- Web Site of REC http://www.tus.ac.jp/labo/kiki/
- Web Site of Request System for Analysis http://www.frcam-fw.tus.ac.jp/
- Web Site of Reservation System for Equipment http://www.rec.tus.ac.jp/cgi-bin/cbag/ag.cgi

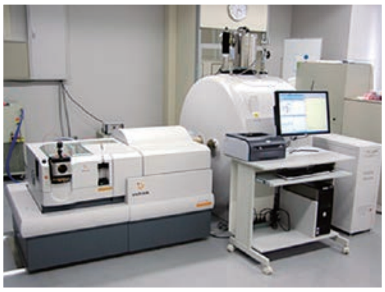

Fig. 1 Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FT-MS) (Registration No. 1077)

Fig. 2 High-Resolution Nuclear Magnetic Resonance Spectrometer (FT-NMR) (Registration No. 1073)

Fig. 3 Powder X-Ray Diffractometer (XRD) (Registration No. 1058)

Fig. 4 Transmission Electron Microscope (TEM) (Registration No. 1103)

Established: July 2009

Research Center for Fire Safety Science

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Makoto Tsujimoto

Objective

Research Center for Fire Safety Science is currently promoting formation of research and education center, and produced two major outcomes, one is the development of "theory" pertaining to performance-based fire safety design, and the other is the development in "practice" through experimental research utilizing the full-scale experimental facilities. Upon these two pillars, the Center will further research and deepen our knowledge of how to control the potential fire risks that are increasing along with the emergence of new spatial configurations (high-rise or underground) and use of new materials (e.g. aluminum and plastics). These are inevitable changes brought about by modernization, industrialization and increased need of energy conservation.

Recruitment Schedule

The Center invites and accepts research plans from public basically once a year Research activities of the selected plans start at the beginning of each academic year. However, research of urgency may be accepted at any point of an academic year as needed.

The rough schedule of the application is as follows:

- Announcement of the theme :early February
- Application period :February to mid-March
- Notification of acceptance :March to April
- Conducting collaborative research :April to next March
- Briefing report of achievement :by next April

Reference Research Theme

A. Experimental Study on Fire Prevention/Resistance and Evacuation Countermeasures of Buildings

- Fire Resistance of steel structures damaged by preceding earthquakes
- A study on modeling of burning behavior of combustibles in compartment
- Experimental Study on Behaviors of Fie Spread between Compartment Rooms in a Building
- Study on boundary layer thickness and Gaussian characteristic thickness of ceiling jet

B. Integration of Architecture and Civil Engineering to Study Fires in Particular Space

- Pure research into fire load for the fire safety measures of nuclear plant
- Study on composites of PS / Kenaf / non-halogen flame retardant

C. Other Experiments and Research Activities

- Terahertz imaging and hazardous gas detection through fire and smoke
- Research of the safety measures about fire protection of institution

D. Researches by Younger Researchers with Unique Viewpoints

E. Fundamental research on large-scale fire

Management Structure and Assessment Procedure

The Research Center for Fire Safety Science Committee ("the Committee"), playing the central role in the Center, consists of a chairperson and twelve members (six from inside and six from outside of TUS).

The Committee is the supreme decision-making body of the Center that develops a research and operation policy, formulates a management policy (including budget drafting), and plans research projects such as deciding a theme to call for entries.

Aiming to support smooth operation of the Center, the Research Theme Selection Committee and two special committees (called Working Groups or WG) are placed under the Committee. The Research Theme Selection Committee and two special committees function as follows respectively:

The Research Theme Selection Committee

This committee makes judgment on acceptance or rejection of applications received. Judgment will be made considering whether the research objective is defined clearly, the plan and the methodology are appropriate, proposed budget is reasonable, and whether the research outcome has potential for further development.

Facilities and Equipment Control Committee (WG)

This committee (WG) is primarily involved in the operation planning of the full-scale experimental facilities. It is also responsible for the maintenance of facilities and equipment installed in the institution. In addition, it gives users instruction on how to use these facilities and equipment and on safety control.

The Research Theme Planning Committee (WG)

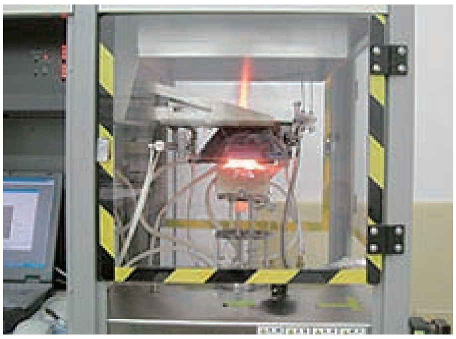
This committee (WG) draws out research themes and projects that are appropriate for the collaborative use or research and that serve the purpose of the Center and fulfill a social need.

The Assessment Committee

This committee functions as an assessing body of the Center by providing interim and ex-post evaluation on the progress and outcome of research projects.

(Management Structure)

Example of Available Facilities/Equipment

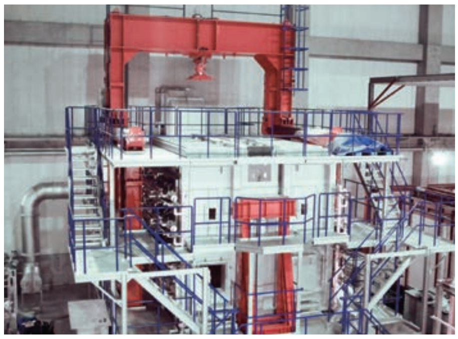


Cone Calorimeter Testing Device (ISO 5660)

This device is used to examine ignitability and the exothermal properties of construction materials using thermal radiation. A test object is placed under the conical-shape electric heater which controls the thermal radiation to the object, and a pilot flame is applied to the object 10mm from its surface. The ignition time and the heat release rate can be measured per thermal radiation that can be set in the range of 0 to 50 kW/m^2.

Structural Fire Testing Furnace (Medium scale)

This unit is used to evaluate the fireproof performance of various structural members such as columns, beams, floors and walls. The unit can control the heat to the standard heating temperature and furnace pressure set by ISO 834. The heating furnace, with dimensions of 1.5 m (W) × 1.5 m (D) × 1.5 m (H), can also provide immediate heating.



Multiple Full-scale Furnace

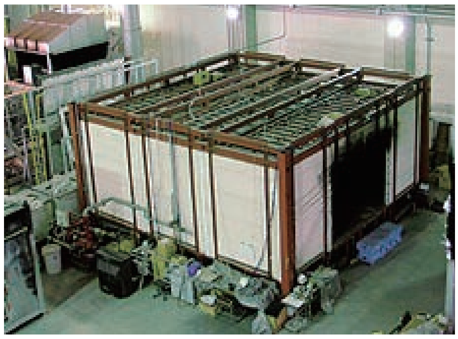
This device is used to measure the fireproof duration of horizontal materials of buildings including beams, floors and roofs by using the standard heating test (ISO834). Fireproof performance of any kind of horizontal materials can be evaluated by the heating test using this device. Put a full-scale model of 3 m (W) × 4 m (D) on the top the heater like covering it and then turn on the burner to heat the model from beneath.

Structural Fire Testing Furnace (Large scale, for Walls)

This unit is used to evaluate the fireproof performance of an exterior wall under fire and can control the heat to the standard heating temperature and furnace pressure set by ISO 834. There are 20 burners on the lateral side, and this can heat up to a 3.5 m × 3.5 m area. The unit is also suitable for performing heat tests.

Calorimetry Hoods (5 m × 5 m)

This unit is used to analyze the burning characteristics of furniture and equipment in a room by burning them and collecting the burning gas. The duct is equipped with devices for flow measurement and sampling. The design heat release rate is 2 MW at maximum, and the smoke suction power is 600 m^3/min at maximum. A movable unit (4 m × 4 m) is also available.



Full-Scale Compartment for Fire Experiment (with Water Pump)

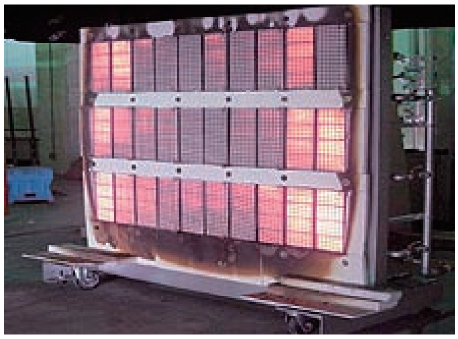
This fire compartment is 6 m (W) × 6 m (D) × 2.7 m (H) in actual size, and the sprinkler system can be attached to the ceiling. The compartment is mainly used to evaluate the fire extinguishing performance of sprinkler systems and also has used for experiments on smoke movement during sprinkler system activation.

Room Corner Testing Unit (ISO 9705)

This unit is comprised of a space of 2.4 m (W) × 3.6 m (D) × 2.4 m (H) (approximately, the size of a 6-tatami-mat room) and an opening 0.8 m (W) × 2 m (H). It can be used to recreate a fire in a room with furniture and dry walls, which can be developed into a fully developed fire. In addition, flashover experiments can be performed with this unit by recreating fires that spread to entire rooms in a short time period, and then combustible gas concentration and temperature distribution data can be collected. The development of the fire can be captured by video camera.

FTIR Gas Analyzer

This unit is designed to be connected to the combustion and smoke generation tester and enables high-speed and continuous analysis of combustion gas. A measured value can be updated at short intervals (five to ten seconds). This unit specializes in measuring certain types of gas that is result from combustion in fire.



ICAL Testing Unit (Heat Radiation Panel)

This unit is designed to elucidate the burning behavior of combustible materials under the condition where a certain heat flux was given through radiative heat transfer. The unit can also be used to investigate the behavior of members exposed to radiative heat. The panel heater has a heating area of 1.75 m (W) × 1.38 m (H). Members can be exposed experimentally to surface temperatures up to 950 and a heat flux of 50 kW/m^2.

Cooperation with Research Institute for Biomedical Sciences(RIBS)

Center for Animal Disease Models

Director Professor, Research Institute for Biomedical Sciences (RIBS)

Yoichiro Iwakura

Research Content

Functional analysis of disease-related genes and development of new therapeutics using gene-targeted mice.

Objectives

To develop novel therapeutics and regenerative medicine for autoimmune diseases, allergic diseases, neurological diseases, life style-related diseases, age-related diseases and tooth and hairloss.

Future Development Goals

To get more insight into disease pathogenesis and to develop new therapeutics through cross-research field collaboration in Noda area.

Message

The homeostasis of our body is maintained through concerted action of many genes. Therefore, it is critically important to elucidate gene functions in order to develop new therapeutics. I believe that we will be able to develop novel drugs and therapeutics through the activities of our research group.

1 The Aim

Abnormality of gene functions is implicated in many diseases. For example, abnormality of cell growth control genes causes development of tumors and that of cytokines, regulators of the immune system, cause autoimmunity such as rheumatoid arthritis and psoriasis. Therefore, to develop new drugs and therapeutics, we have to know which gene is involved in the pathogenesis and what is the function of the gene. Then, we can develop drugs targeting these genes or their gene products. To elucidate the function of a gene in a body, gene targeted mice are most useful, because you can easily know the roles of the gene by the phenotypic abnormalities of the mutant animal. Because of this contribution, the researchers who developed this method were awarded a Nobel Prize in 2007. In this project, the researchers in biological and biomedical field in the Noda area including those in the RIBS, Faculty of Pharmaceutical Sciences, Faculty of Science and Technology, and Faculty of Industrial Science and Technology, will get together and collaborate to elucidate mechanisms of diseases such as autoimmune diseases, allergic diseases, neurological diseases, life style-related diseases, age-related diseases and hair and tooth loss and develop medicine to treat these diseases and regenerate organs by systematically generating gene targeted mice of the genes related to the pathogenesis of these diseases.

2 The Task and Importance of the Project

Now, the ratio of the papers in which gene manipulated mice are used has reached 1/3~2/3 of total publications in Cell and Nature Medicine, leading journals in biological and biomedical fields, 30 years after the development of this technique, suggesting the importance of gene manipulated mice in biological and biomedical researches. Accordingly, the Japan Science Council recommends to strengthen this research field in the future. In the Noda area of the Tokyo University of Science, there are so many researchers in biological and biomedical research fields including immunology, neurobiology, developmental biology, aging, metabolism, and regenerative medicine. In this research project, by collecting and organizing researchers in different fields through establishing the research center that enables us to generate various types of gene manipulated mice and carry out various kinds of animal experiments, we want to improve and accelerate our research significantly. Because the elderly population is gradually increasing in Japan, the development of effective therapeutics for diseases such as autoimmune diseases, allergic diseases, tumors, life style-related diseases, depression, and Alzheimer's disease that become a growing threat of our society, is eagerly needed. The establishment of this research center and accumulation of our knowledge in this field will bring us a clue to develop effective therapeutics for the treatment of these diseases and contribute to promote the welfare of our society.

3 The Research Groups

To facilitate and support generating gene manipulated mice, the embryo manipulation unit is established in RIBS. Each research group in the center will collaborate each other beyond their research fields by sharing gene manipulated mice and analytical tools.

1.Immunological Disease Reseach Group

Iwakura, Kubo, Kitamura, Ogawa, Nakano, Kozono (RIBS)

This group attempts to develop new drugs and functional foods for the treatment and prevention of autoimmune and allergic diseases by analyzing the functions of disease-related genes, such as genes for inflammatory cytokines, cell surface innate immune receptors, and intracellular signaling molecules, through generation of gene-targeted mice.

2.Organ Regeneration Research Group

Tsuji (Research Institute for Science and Technology), Saito (Tohoku University School of Medicine), Goitsuka (RIBS), Wada (Faculty of Science and Technology)

This group is studying the mechanisms of regeneration of hair and teeth as well as the mechanisms of organogenesis and age-dependent involution of the spleen and thymus by generating gene manipulated mice, and will try to regenerate the organs.

3.Mental/Neurological Disorder Research Group

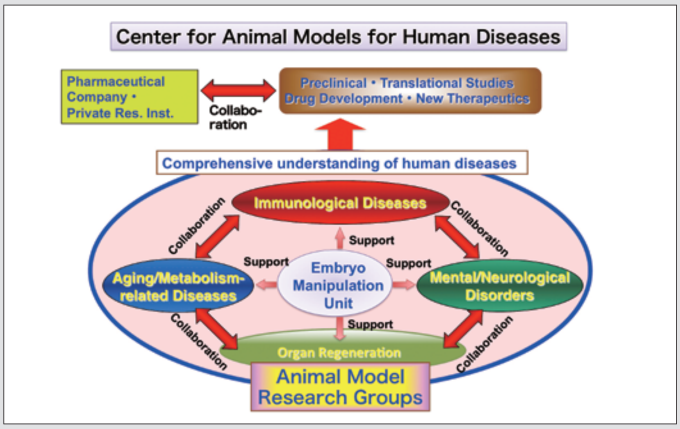
Furuichi (Faculty of Science and Technology), Nakamura (RIBS)

This group is trying to develop new therapeutics to treat mental and neurological disorders by generating gene targeted mice of the genes of the neural network.

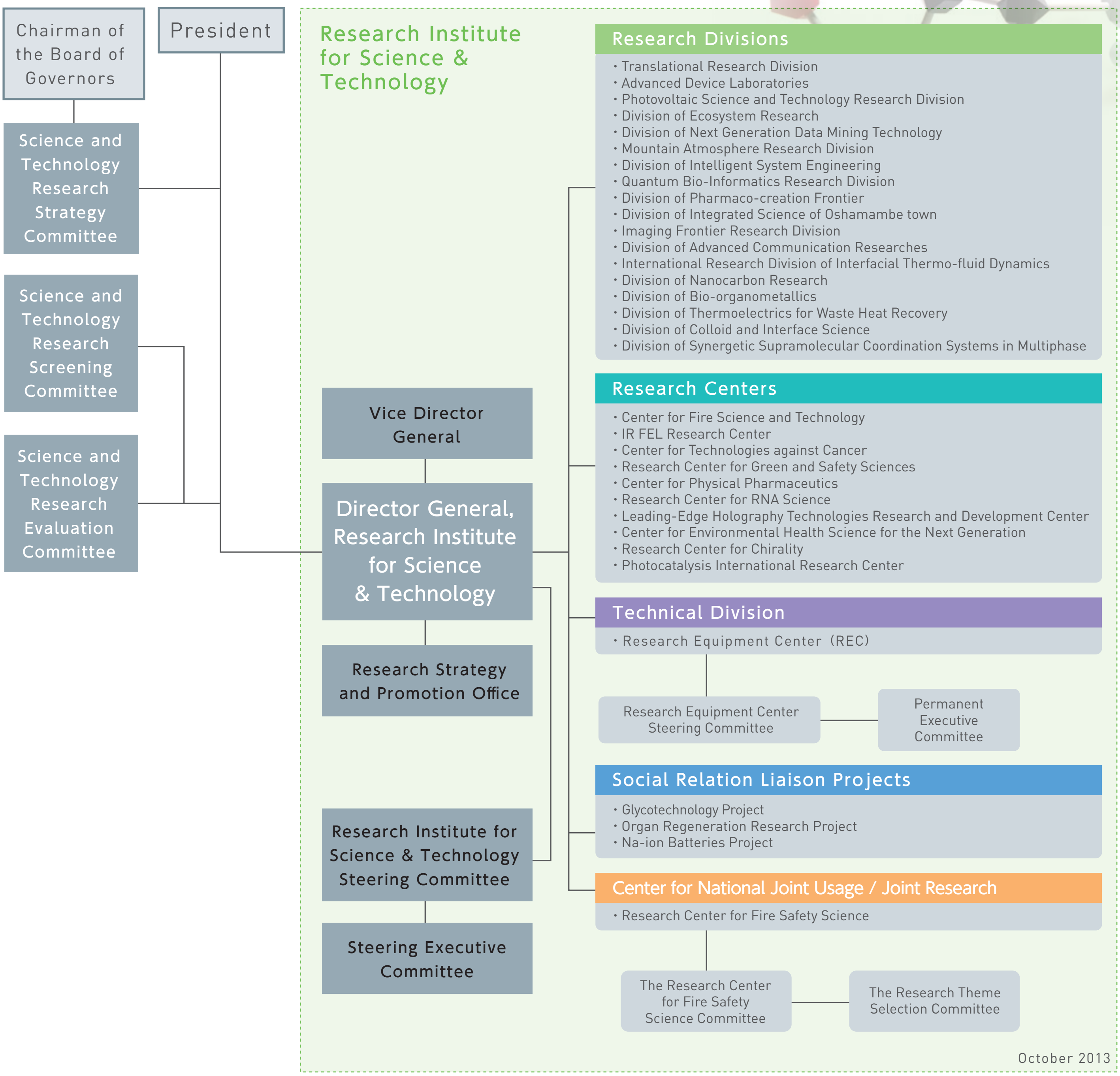
4.Aging/Metabolism-Related Disease Research Group

Higami (Faculty of Pharmaceutical Sciences), Mizuta (RIBS)

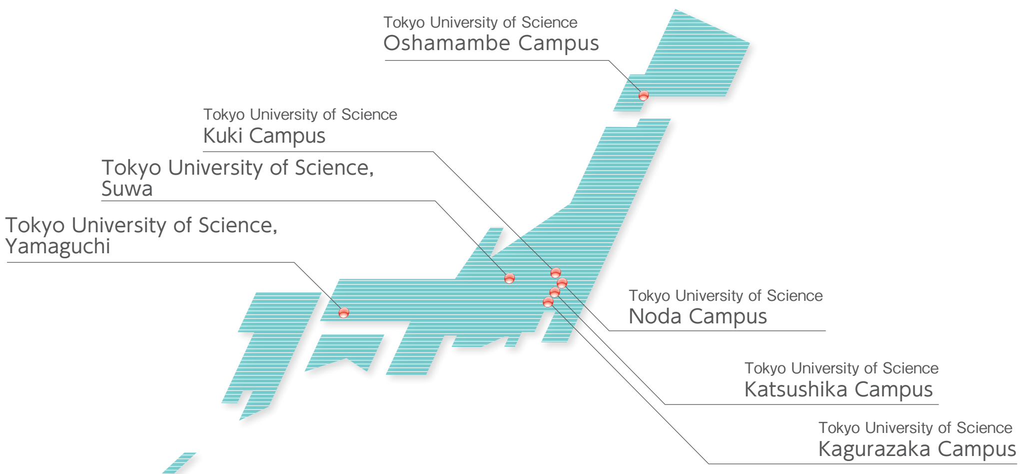
This group is searching for the genes involved in aging, energy metabolism, and oxidative stress, and by generating gene targeted mice of these genes, the group will elucidate the function of these genes and find ways to prevent aging.



Rist Organization Chart



Campus Map



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