RIST TUS

Research Institute for Science & Technology

2020/2021

RIST TUS

Research Institute for Science & Technology

Information and Societal

- Center for Fire Science and Technology
- Research Center for Space Colony
- Atmospheric Science Research Division
- Division of Super Distributed Intelligent
- Division of Intelligent System Engineering
- Division of Advanced Urbanism and
- Statistical Science Research Division
- Department of MOT Strategy & Fintech

Bio and Pharmacy

- Center for Animal Disease Models
- Brain Interdisciplinary Research Division
- Chemical Biology Division Supported by Practical Organic Synthesis
- Academic Detailing Database Division
- Division of Nucleic Acid Drug Development
- Division of Synthetic Biology
- Division of Biological Environment Innovation

Structural Materials

- CAE Advanced Composite Materials and Structures Research Division

Fundamentals

- IR FEL Research Center
- Division of Modern Algebra
- Research Alliance for
- Division of Nano-quantum

Functional Materials

- Photocatalysis International Research Center
- Water Frontier Science & Technology Research Center
- Division of Nanocarbon Research
- Division of Colloid and Interface Science
- Renewable Energy Science & Technology Research Division
- Division of Ambient Devices Research

Center

Funded jointly by TUS and MEXT-Supported Program. Expected to form a strategic research organization after termination.

Division

Funded exclusively by a core of a Center.

Building a better future with

Systems

Architecture

for Social Implementation

and Cooperation with Engineering

Mathematical analysis

Information Science and Technology

TUS and expected to be

Joint Usage / Research Center

A nationally selected organization for joint use / joint research open to public and funded partially by MEXT.

Science

Message from the Director

In a university, education and research are inseparably linked to one another and have a synergistic relationship which contributes to significant growth and development.
Education, in various academic fields, lays the foundation of knowledge in these areas while research transcends the boundaries of these academic areas and contributes to development of applied knowledge and techniques useful for our human society. If education is the longitudinal axis, then research is the horizontal axis.
The Research Institute for Science and Technology plays the role of that horizontal axis within the Tokyo University of Science and is an organization which exists to support outstanding and original research.
On April 1, 2015, a newly reorganized Research Institute for Science and Technology was established. Research within the Institute is carried out by different research divisions, research centers and joint usage research centers which are organized within a full-scale, comprehensive research promotion framework.
The longer term aims of the Research Institute for Science and Technology are to educate highly competent graduate students, equipped with the innovative and creative skills needed for the betterment of the future human societies and economies. The Institute has been striving to transcend the various academic fields and eliminate barriers between academia and industry and society as well as promote international collaboration.
In 2015, Sustainable Development Goals (SDGs) were announced by the United Nations.
The Research Institute of Science and Technology has consistently focused on research in environmental preservation and energy conservation.
Carbon recycling, under the initiative called for by the Japanese Prime Minister' s Office and recently being focused on by the international industrial community, will be one of the main areas of research at the Photocatalysis International Research Center.
The Research Center for Space Colony is conducting research on development of sustainable technologies, that would be essential for long-term survival of humans in extra-terrestrial environments. The reuse and recycling of heat energy, water, air and food production in such closed environments would be technologies that would have varied uses on earth as well.
It is important to develop innovative and integrated technologies that can be used to tackle the unprecedented global issues facing our society.
It is towards this end that we seek to do away with the barriers between research centers and divisions, foster mutual cooperation, create new research clusters and produce new academic trends and results.

Dr.Hideaki Takayanagi
Director
Research Institute for Science and Technology
Tokyo University of Science

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Fundamentals

Only at

The Edge of Cross Disciplines

Research Centers / Research Divisions 2020/2021

TUS

Photocatalysis International Research Center (PIRC)

Established: April 2013

PIRC@rs.tus.ac.jp

Director
Distinguished Professor,
Tokyo University of Science
Akira Fujishima
Ph.D.

Objectives	PIRC conducts photocatalytic researches on self-cleaning, environmental cleanup, and artificial photosynthesis and considers novel applications. PIRC aims R&Ds promoting the photocatalytic technology to the next-stage.
Future Development Goals	PIRC produces original and cutting-edge research results for the photocatalyst market expansion and aims to be the worldwide hub of this field.

There are still various possibilities and chances on photocatalysts and challenging toward these is important. PIRC leads the spread/development of photocatalysts by public relations as well as training for and excellent global people who will take the green innovation.

Establishment of the practical integrated system for environmental cleanup and energy production by deepening photocatalytic technologies

History of PIRC

As a center for strategic R&Ds of an integrated photocatalytic system indispensable for enhancing competitiveness of photocatalysts and related industries, and nurturing excellent global people who will take the green innovation by photocatalysts, the Ministry of Economy, Trade and Industry (METI) selected PIRC for the Innovation Center Establishment Assistant Program. The former division (The Division of Energy and Environment Photocatalyst) was dissolved in favor of PIRC in April 2013.

Application of Photocatalysts and Remaining Problems

Photocatalyst is a Japan-origin technology and Japan has been a leader in this research field. Photocatalyst has been attractive as a promising technology to solve energy/environmental problems. Titanium dioxide (TiO_2) is a representative example of photocatalysts. When ultraviolet (UV) light, which is included in the sunlight, is irradiated, TiO_2 shows "oxidation power" and "superhidrophilicity". Oxidation power is useful for deodorization, sterilization, and antifouling, while superhidrophilicity is useful for antifogging and antifouling (self-cleaning). From a perspective of artificial photosynthesis, complete water splitting producing hydrogen and oxygen in stoichiometric ratio by the Honda-Fujishima effect has been studied aggressively for many years, although its practical use has not been achieved.

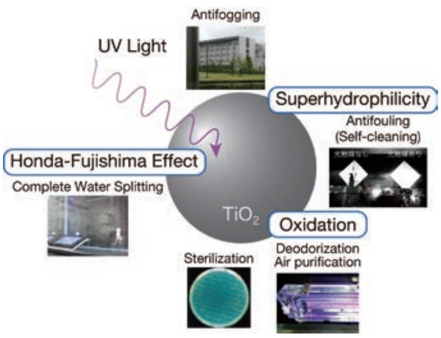


Figure. 1 Photocatalysis and its application

Recently, photocatalysts and its related technologies are applied for housing, purifier, and life/medical filed. An international cooperative project on standardization of photocatalytic evaluation (ISO) is in progress. However, several problems are still remaining. The development of a highly-efficient visible light-active photocatalyst enables to purify the inside of a room under a fluorescent light and the establishment of the sterilization/medical treatment system integrating cell biology/microbiology and photodynamic therapy are examples. Constricting photocatalytic water splitting system producing practical amount of hydrogen has been a big issue since the first discovery of photocatalysis. Furthermore, several tasks such as the establishment of artificial photosynthesis regarding to the reduction of carbon dioxide (CO_2) and its recycling are undertaken at national level.

Aims of PIRC

PIRC aims to overcome the remaining problems on photocatalysts based on our achievements. PIRC also develop an integrated photocatalytic system on practical environmental cleanup/energy production through empirical researches between industry-academia-government collaboration.

Research Organization of PIRC

PIRC not only conducts the latest researches but also aims to create a hub where researchers both inside and outside TUS can join. The feature of PIRC is nurturing human resources and promoting international exchange through the participation of young scientists from both Japan and foreign countries. PIRC also invites research collaborator from other research institutes and industries and widely conducts from basic studies to product/market developments. By utilizing these, PIRC conducts photocatalytic studies.

Although PIRC conveniently divides elemental technologies on photocatalyst in three units, each unit cooperates. By integrating elemental technologies developed at each unit, PIRC creates a high-performance photocatalyst and a novel functionalization. PIRC prepares the system with public institutes and private companies for activation of photocatalytic industries.

Activities at PIRC will launch a new scientific/technological field for energy/environmental problem solution. In addition, obtained results on material development and its fabrication process would bring a ripple effect on a peripheral research field.

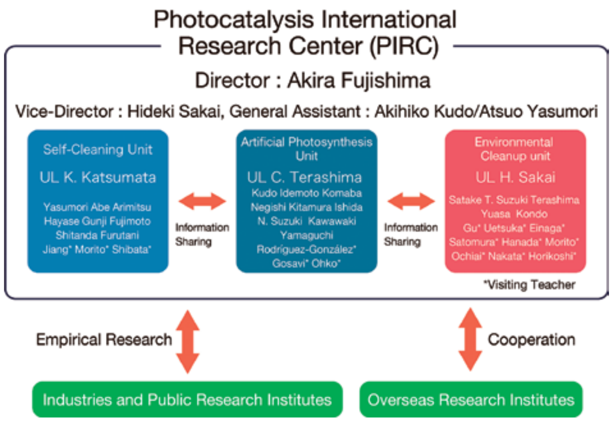


Figure. 2 Organization chart of PIRC

Research theme

Self-Cleaning Unit

Self-cleaning effect of photocatalyst (especially TiO_2) is achieved by using "oxidation power" and "superhydrophilicity" under UV light and widely used in various applications. However, there are several important issues such as a highly durable coating on organic glass/vehicle body and a measure against the change of interior light source (from fluorescent lamp to white LED lamp). This unit studies on self-cleaning materials for interior/exterior and coating technique of photocatalysts. We work on morphological control of photocatalyst particles, coating materials (such as shape processing, survey for inorganic/organic base material), combination with functional materials (such as organic polymer/glass), and survey for visible light-active photocatalysts.

Artificial Photosynthesis Unit

As clean energy-production system, hydrogen-producing technology in which water is split and energy-conversion technology in which hydrocarbons are formed by CO_2 reduction with photocatalyst and solar light are known as an artificial photosynthesis and aggressively studied research fields. Studies on artificial photosynthesis started from the Honda-Fujishima effect reported in Nature in 1972. However, artificial photosynthesis has not practically used because the solar to hydrogen efficiency is still low even now. This unit works on the development of highly efficient novel (electro) photocatalysts for water splitting and CO_2 reduction. We also study an integrated system of electric power generation and its storage for the effective use of solar light.

Environmental Cleanup Unit

It is well known that strong oxidation of photocatalyst shows antibacterial and antivirus effect and photocatalyst-coated tiles are introduced as interior of an operation room in a hospital. This unit conducts basic studies such as an analysis of sterilization mechanism and spore inactivation by photocatalysts. In addition, as biological applications of photocatalysts, we work on the improvement of seed germination and rare sugar production.

Established: November 2016 waterfst@rs.tus.ac.jp

Water Frontier Science & Technology Research Center

Director
Professor,
Department of Chemistry,
Faculty of Science DivisionI

Hiroharu YUI
Ph.D.

Objectives	Development of basic researches and control technologies of water structures, wetting, and flow at the surfaces of various materials that promote regenerative medicine, low-frictional machinery, and so on.
Future Development Goals	As a worldwide research center, we promote the research and education of water on various materials' surfaces by the collaboration with companies, medical center and research institutions in the world.

This center is founded by the research branding program organized by The Ministry of Education, Culture, Sports, Science and Technology (MEXT) Japan. We will push the sciences and technologies of water on materials forward to realize a prosperous longevity and low-energy consumption society by integrating intelligence and powers of the researches and students through worldwide collaborative researches.

Developing sciences of water structures, wetting, and flow on the surfaces of various materials and their application.

Water is ubiquitous and an essential substance that flexibly hydrates various molecules. It plays crucial roles to assist structuring and fulfilling our organs and also brings oxygen molecules and nutrition to every cell in our living bodies. Further, water also exists on the surfaces of materials that surround and assist our ordinal life under ambient conditions with adequate humidity. Although these water molecules are not visible, they crucially affect the maintenances of our living bodies, industrial manufacturing processes utilizing catalysts and machines, and the functions of materials utilized in transport machinery such as cars, ships, and aircrafts and in medical ones such as artificial heart and blood vessels.

However, surfaces of the materials are generally very complicated. For example, they have physical surface roughness beyond the atomic-scale and various chemical functional groups that change according to the environments, and take three dimensional matrix structures in living bodies. It has been difficult issue to selectively measure water molecules on these materials' surfaces and to study them by conventional theoretical approaches and simulations.

To develop novel technologies, it is crucial to understand water structures and dynamics on these complicated surfaces. For the deepening of the basic science of these water molecules, collaborative and interdisciplinary researches are crucial by combining (1) Materials formation with controlled surfaces with nanoscale precision and with chemical functional groups, (2) Selective in-situ measurement techniques with high spatial and temporal resolutions, and (3) Multiscale theoretical approaches and calculations.

Our research center was established on Nov. 2016 by the aid of the research promotion program organized by the MEXT Japan for the purpose of the foundation of an international research center for the water on materials' surfaces. The center address the local structures of water molecules in the vicinities of the materials' surfaces in nanometer scale, and their wetting and flow dynamics ranging from the nanometer to micrometer scales. Our main purpose is to deepen the fundamental science that provides us an integrated view of correlating water structure, wetting and flow dynamics in multiscale on materials surfaces. These basic researches contribute to enhance the functions of the materials' surfaces by controlling water structures and wetting and flow dynamics on them. Based on these science and technologies, we pursue the contribution to the development of healthy, low energy-consuming sustainable future societies through the productions of biocompatible materials for regenerative medicine and low-frictional materials for various machineries.

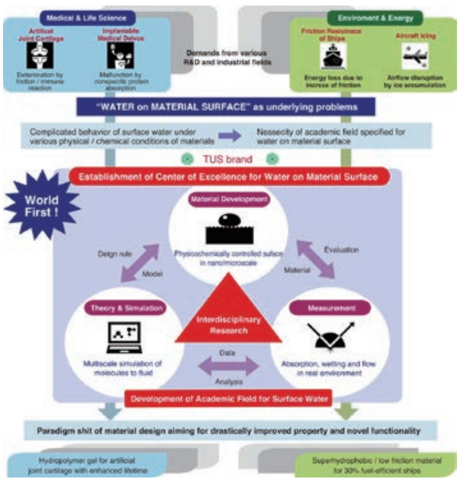


Figure. 1 Background for the establishment, the aim and our collaborative activities, and the future scope of our research center.

W-FST center is composed of 6 groups (G1-G6) as follows, where the member efficiently research and discuss on focused topics.

G1 Materials' Surfaces
G2 Bio-Interfaces
G3 Basic Researches on Wetting and Flow Dynamics
G4 Basic Researches on Theories and Simulations
G5 Measurements and Controls on Flow Dynamics
G6 Analyses and Applications of Aqueous Environments

In each group, researchers collaborate for the productions of materials with nanometer-scale precisions, for the development of specific measurements instruments, and for theoretical and simulative approaches to solve challenging problems. Further, through the inter-group collaborations, we will promote science and technologies of the water on materials surfaces as a world-wide characteristic research center.

G1 and G2 are the groups for the production of materials surfaces finely controlled with nanometer-scale precision. G1 mainly studies materials for energy-saving, such as for low-frictional surfaces and for stable energy storage. G2 develops biocompatible hydropolymers for artificial joint cartridges in regenerative medicine. These groups study on the correlations between the local structures and dynamics of water on materials' surfaces and their various functions. These groups also develop new instruments that enable us to measure local structures and dynamics of water molecules with in-situ conditions.

G3 and G4 are the groups for basic researches of water structures and dynamics on materials' surfaces, which crucially affect their functions. G3 focuses on the wetting and flow dynamics of water on materials surfaces whose hydrophilic and hydrophobic natures are finely controlled. G4 aims to develop integrated theoretical and simulation methods that can address local water structures, and wetting and flow dynamics that correlate with each other in multiscale manner.

G5 develops novel diagnostic and analytical devices that are based on a finely controlled wetting and flow dynamics. G6 develops new analytical methods and reaction schemes based on a characteristic nature of water that hydrates almost every natural molecule. These newly produced devices and analytical methods will contribute to the development of prosperous longevity, low-consumption, and sustainable future societies.

New materials with controlled surfaces produced by G1 & G2 and new devices and analytical methods developed by G5 & G6 provide ideal research targets for G3 & G4. In turn, newly developed fundamental theories and simulations by G3 & G4 will be helpful for advancing the functions of materials (G1 & G2) and for designing novel devices and analytical methods (G5 & G6).

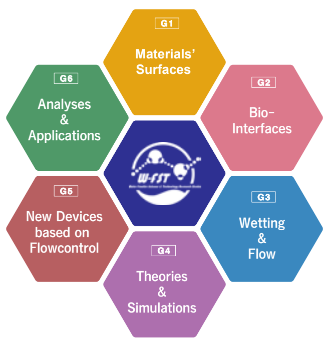


Figure. 2 The roles of 6 research groups in our center and their interdisciplinary collaborative researches.

Established: October 2012 ✉ takahiro@rs.tus.ac.jp

Functional Materials

Division of Nanocarbon Research

Director
Associate Professor
Professor, Department of Physics,
Faculty of Science Division I
Takahiro Yamamoto
Ph.D.

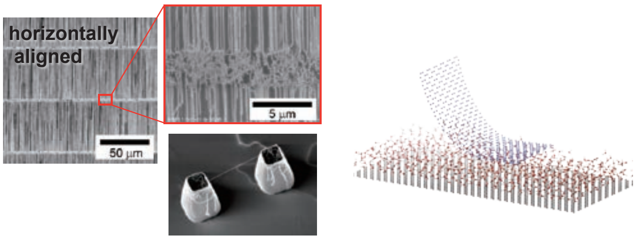
Objectives	To investigate novel properties relating to carbon nanotubes and graphene, and to develop material sciences utilizing the nanospace of nanotubes and the interaction between nanotubes and various molecules.
Future Development Goals	To promote advanced researches on nanocarbons based on tight and highly active collaborations of division members.

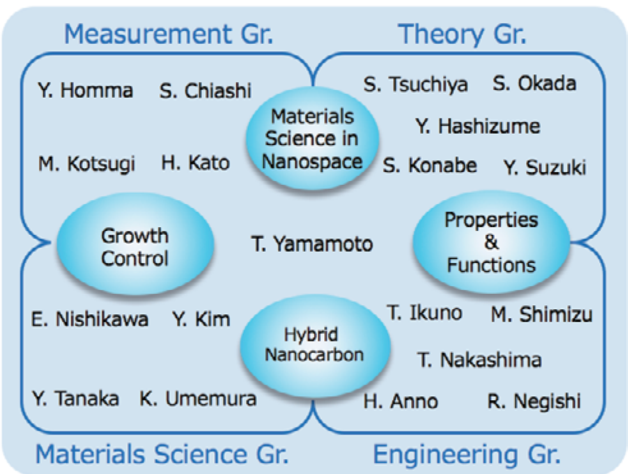
Nanocarbon is an active research field with increasing publications. Our research division is unique in that advanced researchers of nanocarbons are getting together and perform researches with wide scopes. In particular, tight collaborations between theorists and experimentalists are our strength. We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

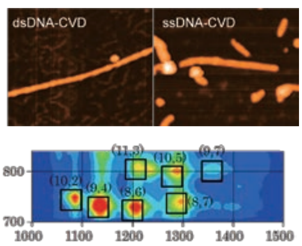
Research and development on carbon nanotubes and graphene.

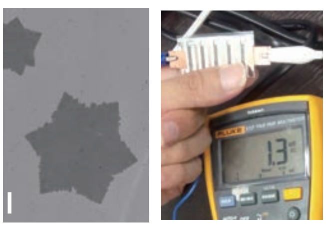
Carbon nanotubes and graphene are low dimensional materials (with linear and flat shapes, respectively) composed of networks of 6-members rings (honeycomb structure). Owing to strong covalent bonds of carbon atoms, they have excellent mechanical strength and chemical stability enough to sustain the monolayered 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-Hybrid Materials

- 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.

Properties and Functions

- We develop the physics of energy conversion based on nanocarbons and its application.
- We establish the basic science for nanocarbon-based paper electronics.

Established: January 1981 hisakai@rs.tus.ac.jp

Functional Materials

Division of Colloid and Interface Science

Director
Professor,
Department of Pure and Applied Chemistry, Faculty of Science and Engineering

Hideki Sakai
Ph.D.

Objectives	To play a leading role in colloid and interface science both in Japan and the world
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".

Research objective of Division of Colloid and Interface Science (DCIS) is to understand various phenomena occurring emerged from restricted spaces at interfaces or boundaries and to develop novel functional interfaces, by collaboration of TUS researches who specialize in chemistry, physics, life science, mechanical engineering, and theoretical science. We sincerely hope that outcomes of our project will contribute to the progress of many research fields and also the improvement of our quality of life (QOL).

Basic and applied researches on phenomena at various interfaces

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^3 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 phenomena and the fuctions at the both interfaces, and hope to achieve the development of novel functional materilas.

Figure 1

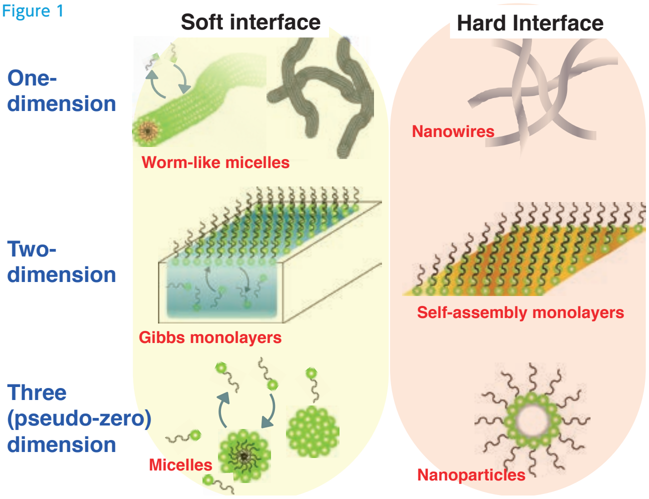
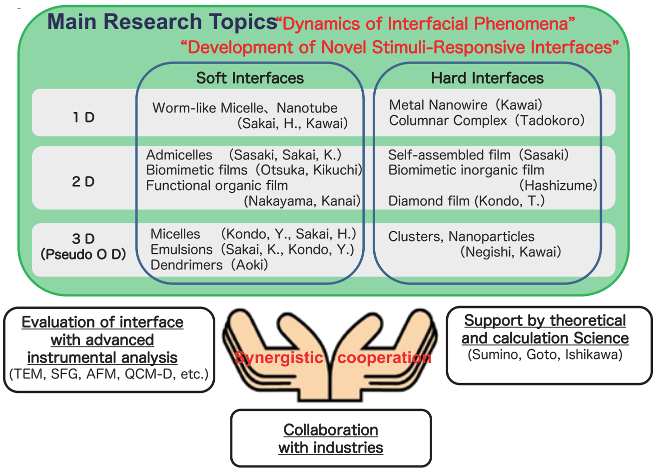


Figure 2



In this project, we are going to investigate intensively the role of water molecules present at interfaces such as solid-iquid, liquid-gas and solid-gas interfaces. It is general known that water molecules at interfaces play a crucail 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.

Functional Materials

Renewable Energy Science & Technology Research Division

Established: April 2020

mutsumi@rs.tus.ac.jp

Director
Professor
Department of Electrical Engineering,
Faculty of Science and Technology

Mutsumi Sugiyama
Ph.D.

Objectives	To propose a foundation for stable and low-cost power supply/management, and to activate and promote research, development and education of renewable energy utilization technology at TUS.
Future Development Goals	Through active interaction among the Division members from different backgrounds, we will promote both internal and external joint research to create novel concepts for renewable energy technology.

In response to the trend of times, this division is created by reorganizing the Photovoltaic Sci & Tech Division established in 2010. We are composed of members from different fields of expertise in various renewable energy devices and systems. We will develop unique renewable energy and integrated systems/infrastructures such as solar-wind-biomass power generation.

Research and development on renewable energy and systems such as solar, wind, biomass etc.

To solve the global warming problem, the biggest issue for humankind in the 21st century, it is necessary to substantially shift the energy sources from fossil energy such as coal, oil and natural gas to renewable energy. With this background, the predecessor Solar Power Generation Technology Division had worked to promote research of the University on solar power generation by disseminating the research results in Japan and worldwide, tackling the global warming problem. Meanwhile, in today world, there is a wide variety of research and development ongoing on "renewable energy" beyond solar, such as wind power, biomass power generation and fuel cells. In addition, at the time of the establishment of the predecessor Division, the power supply was simply based on nuclear power to provide a stable base power and thermal power generation to supplement the fluctuation of demand. However, nowadays many types of renewable energy are connected to the grid and the operation of the system infrastructures for stable power supply has become highly difficult and critical. We have therefore reorganized the Division, which previously focused only on solar, to include the entire "renewable energy", and defined the purpose of the new Division as following:

(i) Development of power generation materials that reduce the installation and operation costs to the same level as power generation by fossil fuels.

(ii) Development of highly efficient management technology for electric power from various power generation methods.

(iii) Development of new materials and new system technologies.

(iv) Collaborations between our research division and external research institutes.

Members of the Division

The Division consists of 15 members listed as follows, who all have different fields of expertise in physics, chemistry, electrical power, electronics, materials and management. We are gathered together to deepen the discussion on the development of renewable energy utilization technology and aim for major developments through synergistic effects.

Table Members of Renewable Energy Science & Technology Research Division

Name	Job title	Affiliation of key role	Main research field
Mutsumi Sugiyama	Professor /Director	Faculty of Science and Engineering Department of Electrical Engineering	Semiconductor material engineering / Thin film solar cell
Zhao Xinwei	Professor	Faculty of Science Division II Department of Physics	Semiconductor nano-material engineering / Thin film photovoltaic cell
Takashi-ro Akitsu	Professor	Faculty of Science Division II Department of Chemistry	Coordination chemistry / Photofunctional fuel cells of organic/ inorganic hybrid materials
Yuzuru Ueda	Professor	Faculty of Engineering Department of Electrical Engineering	Electricity and energy engineering / Photovoltaic system
Morio Nagata	Associate Professor	Faculty of Engineering Department of Industrial Chemistry	Organic photovoltaic cell, Artificial photosynthesis
Junji Kondoh	Associate professor	Faculty of Science and Engineering Department of Electrical Engineering	Photovoltaic and wind power generation / Electric power system
Noboru Katayama	Associate professor	Faculty of Science and Engineering Department of Electrical Engineering	Fuel cells / Hydrogen storage / Diagnosis for energy devices
Takashi Ikuno	Associate professor	Faculty of Industrial Science and Technology, Department of Applied Electronics	Surface and interfaces / Photovoltaic devices / Nanogenerators
Tomoyuki Haraguchi	Assistant Professor	Faculty of Science Division II Department of Chemistry	Coordination chemistry / Dye sensitized solar cell
Satoru Ohnishi	Assistant Professor	Faculty of Science and Engineering Department of Industrial Administration	Energy economics / Low carbon city management
Kim Joonam	Assistant Professor	Faculty of Science and Engineering Department of Electrical Engineering	Semiconductor material engineering / Nano energy harvest
Daisuke Kodaira	Assistant Professor	Faculty of Science and Engineering Department of Electrical Engineering	Smart grid, energy storage system management, PV generation forecasting
Yoichi Hirata	Visiting Professor	Suwa University of Science, Faculty of Engineering	Photovoltaic power generation system / Wind-power generation / Micro grid
Yasuyuki Watanabe	Visiting Professor	Suwa University of Science, Faculty of Engineering	Molecular electronics & Bioelectronics / Photosynthetic engineering
Sho Shirakata	Visiting Professor	Ehime University, Graduate School of Science and Engineering	Semiconductor material engineering / Thin film photovoltaic cell, CIGS solar cell

Research Activities

As a research and development hub for renewable energy technology, we will realize novel renewable energy materials and power generation systems through vertical integration of technologies, as well as educate the next generation of researchers and disseminate the technology to society. Specifically, the following activities will be carried out:

Renewable energy materials group

(i) Proposal of ultra-high efficiency power generation device by tandem configuration of thin film solar cells/thermoelectric generation elements.

(ii) Establishment of hydrogen production technology using solar cell thin films and charging technology such as supercapacitors.

(iii) Development of ultra-low-cost solar and fuel cell materials and manufacturing methods, and examination of their common basic technology.

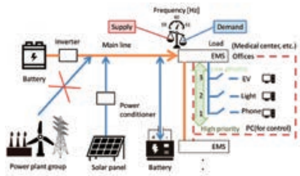
Energy management group

(i) Development of technologies of failure diagnosis, remote diagnosis, power generation prediction and AI utilization for energy loss control.

(ii) Integration of smoothing technology development for wind×solar power generation and power storage technology such as batteries and flywheels.

(iii) Solar matching for agriculture and application of renewable energy technologies to smart houses.

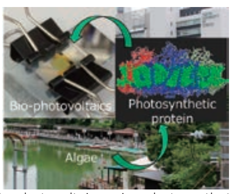
Design and evaluation on renewable energy system utilizing regional characteristics



Renewable energy recovery system assuming a blackout due to a disaster

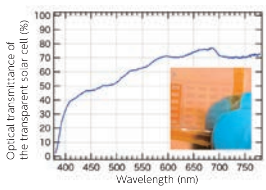
Monitoring of output power from multiple small wind turbines, and a prototype of a flywheel energy storage system

Polymer electrolyte membrane fuel cell and automatic humidity control system for supply air

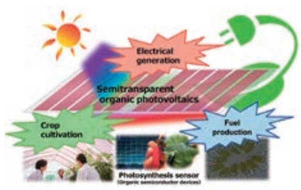


Bio-photovoltaics using photosynthetic proteins from algae

Photofunctional metal complex and catalytic enzyme for biofuel cell



Transparent solar cells fabricated on bio-derived transparent film substrates



Solar matching (Co-developing technology both photovoltaics and photosynthesis)

Figs. Research theme of Renewable Energy Science & Technology Research Division

Established: April 2020

kkinosita@rs.tus.ac.jp

Division of Ambient Devices Research

Director
Associate Professor,
Department of Applied Physics,
Faculty of Science

Kentaro Kinoshita
Ph.D.

Objectives	We aim to create an innovative standalone RFID tag with high-sensitivity sensors consisting of organic or organic/inorganic hybrid semiconductor devices, which are environment-friendly. We also aim to establish new automatic data collection and analysis technology using the data collected.
Future Development Goals	We believe that synergies through collaboration with other departments are indispensable to step through the rugged road to device creation and social implementation.

As a research base of organic or organic/inorganic hybrid devices at Tokyo University of Science, experts who are active in various fields such as physical property experiments and theory, semiconductor devices, organic electronics, energy conversion, etc. We will work on a series of research and development from material research, device application, and to social implementation.

Creation of ambient devices and establishment of technology for collecting and analyzing extracted big data.

Background to establishing the department

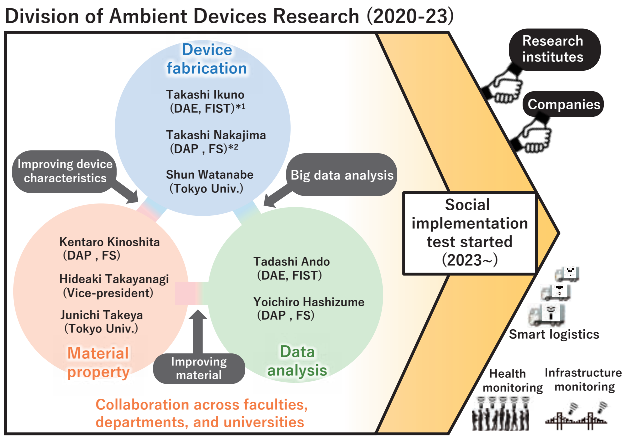
In 2013, the "Trillion sensor concept" was proposed in the United States, in which sensor nodes are attached to all trillions of objects, information is collected, and information science is used to realize a prosperous and safe society. At present, in Japan, "convenience store electronic tag 100 billion pieces declaration" (Ministry of Economy, Trade and Industry) is being promoted to attach electronic tags to all convenience store products by 2025 in order to improve the efficiency of logistics. Such a stick-on type/dispersion type sensor node is called an “ambient device” in the sense that it can be integrated into the environment, and it is expected to form a large market as a post-smartphone. Since the ambient device needs to be lightweight, flexible, and inexpensive, it is necessary to compose all materials including the substrate with organic materials or organic/inorganic hybrid materials. With a view to the mass diffusion of ambient devices, we conduct research on material property control, device creation, and acquired data analysis related to ambient devices, aiming at social implementation.

Contents of our research and development

As an example for the application of an ambient device, we envision a radio frequency identifier (RFID) tag with a sensor for next-generation logistics. With the recent rapid increase in large-scale commercial facilities, expansion of e-commerce, and expansion of logistics services due to globalization, the failure of the conventional logistics system is beginning to become apparent, so there is an urgent need to develop a mechanism for next-generation logistics. There is a wide variety of needs regarding transportation modes, and in order to realize transportation that does not impair the quality and value of food, chemicals, precision equipment, etc., there is an increasing demand for logistics technology in low-temperature and shock-free environments. If an RFID tag with a sensor using an innovative organic semiconductor device is created and a new automatic data collection technology using it is established, a highly efficient, safe and secure logistics service will be realized, and its impact on society will be extremely large. In order to "realize a sensor node with low environmental load and low cost," we construct a sensor node constituent device by precisely controlling the material properties. The devices mounted on the sensor node depend on the purpose, and for example, the sensor node used for future logistics require an acceleration sensor, a temperature sensor, an RF transceiver antenna, a transistor, a memory, and a power supply. A sensor node with low environmental load is realized by constructing the device, including the substrate of each device, with organic materials or organic/inorganic hybrid materials. In addition, the manufacturing cost cannot be ignored for the diffusion of technology. In order to achieve a price of 1/100 of the conventional sensor node (1 yen/sensor node), and we will pursue a low-cost manufacturing process and low-cost material.

System for research and development

Researchers involved in the field of semiconductor devices, functional materials, molecular simulations, and information science who belong to Tokyo University of Science collaborate to realize the concept such as “100 billion tags for convenience store electronic tags” and “1 trillion IoT devices per year” by the creation of innovative ambient devices. Each group actively interacts with each other to search for physical properties, improve device characteristics, and analyze big data. Figure 1 shows the interrelationship among researchers inside and outside Tokyo University of Science and the image of research promotion. In collaboration with the Takeya Group of the University of Tokyo, which possesses the edge technology for producing ultra-thin single-crystal organic semiconductor films that exhibit outstanding device operation speed, we will search physical property from both sides of calculations and experiments, aiming at further improvement of device characteristics. Research can be carried out in the state-of-the-art equipment environment owned by Professor Takeya at The University of Tokyo. Specifically, there are states of the art equipments for forming single crystal organic monomolecular film that is essential to this theme, for forming various organic and inorganic thin film forming devices (both wet and dry processes), for microfabrication (photolithography, laser lithography, wet process), for large screen printing, various electron microscopes, spectroscopes, electrical-, mechanical-, and optical-property analyzers. By using them, we can conduct all the processes for manufacturing ambient devices from organic semiconductor molecule synthesis to device fabrication, evaluation, and large-scale printing process.



*1: Department of Applied Electronics, Faculty of Industrial Science and Technology
*2: Department of Applied Physics, Faculty of Science

Fig1. An image of correlation and research promotion among researchers who belong to Research Division of Ambient Devices inside and outside the Tokyo University of Science.

Established: April 2018

ogihara@rs.tus.ac.jp

CAE Advanced Composite Materials and Structures Research Division

Director
Professor,
Department of Mechanical Engineering, Faculty of Science and Technology

Shinji Ogihara
Ph.D.

Objectives

The main objective of our research division is to create deeper relations between academia and industry and to boost the number of industry-ready CAE engineers significantly through engineering research using CAE technology with a focus on advanced composite materials, including carbon-fiber-reinforced plastic (CFRP) and their structures.

Future Development Goals

The aim is to further the academia–industry partnership through collaborative research on the subject of advanced composite materials and structures conducted individually by our faculty members, while also cultivating more CAE engineers. We also intend to expand this development greatly from the second year onward.

The CAE Advanced Composite Materials and Structures Research Division aims to:

- Conduct research focused on composite materials, which are undeniably the material of the 21st century;
- Build strong relations with industry through engineering research utilizing CAE technology (which has become mainstream in recent years);
- Apply the motto "be equipped" when cultivating CAE engineers, the demand for whom has grown in recent years, and preparing them for industry support.

Engineering research was conducted on advanced composite materials and their structures using computer-aided engineering (CAE) software to achieve partnership between industry and academia

Here at the CAE Advanced Composite Materials and Structures Research Division, we aim to establish strong academic—industry collaboration by effectively utilizing computer-aided engineering (CAE) software to (1) conduct engineering research through the development of materials at the molecular level (via the molecular orbital theory and molecular dynamics method) and (2) design actual structures or execute molding simulations and fracture analysis from destruction simulators (which employ the finite-element method and particle method). Because the members of our research division can cover a wide range of materials and structures, as shown in the figure below, it is possible to increase their suitability for the needs of the industry. In other words, the division will become a major receiver to entrust with and take on collaborative research. Through this research, the division will improve the brand recognition of Tokyo University of Science in Japan by deploying a large number of well-trained, well-equipped CAE engineers for the industry where they will make great contributions.

Until now, CFRP has been primarily used in aerospace applications, but, in recent years, it is starting to become widely incorporated into the automotive industry as well. Our engineering research division aims to provide solutions to the issues/needs of the industry. More specifically, to make CFRP more widely used by the automotive industry, at the very least, the following three points require improvement:

1. Moldability of CFRP: be able to cast parts made from CFRP in 1 min while maintaining its high quality;
2. Impact characteristics of CFRP: doubling its current impact energy absorption;
3. Its unique design: not all metallic parts need to be replaced with CFRP, but, rather, new automotive parts unique to CFRP, while taking its moldability and impact characteristics into account, need to be designed.

However, with the recent advancements in computer capabilities, the use of numerical analysis tools is becoming more familiar. By utilizing CAE software, it has become normal in recent years to reduce the costs of experiments and speed up developments. Our research division makes use of CAE software to approach and solve a variety of research issues, such as the aforementioned improvements to CFRP. One of the major features of our research division is the way in which we cultivate our students so that they are ready to contribute to society right away. This is highlighted by allowing the students to conduct research through their graduate/master's/doctoral theses that meets the needs of the industry. Also, through the work of our experienced, talented alumni, we intend to create a synergistic partnership with industry that allows the Tokyo University of Science to obtain funding from its commissioned research. To educate and conduct research based on a strong relationship with industry is another major characteristic of our research division.

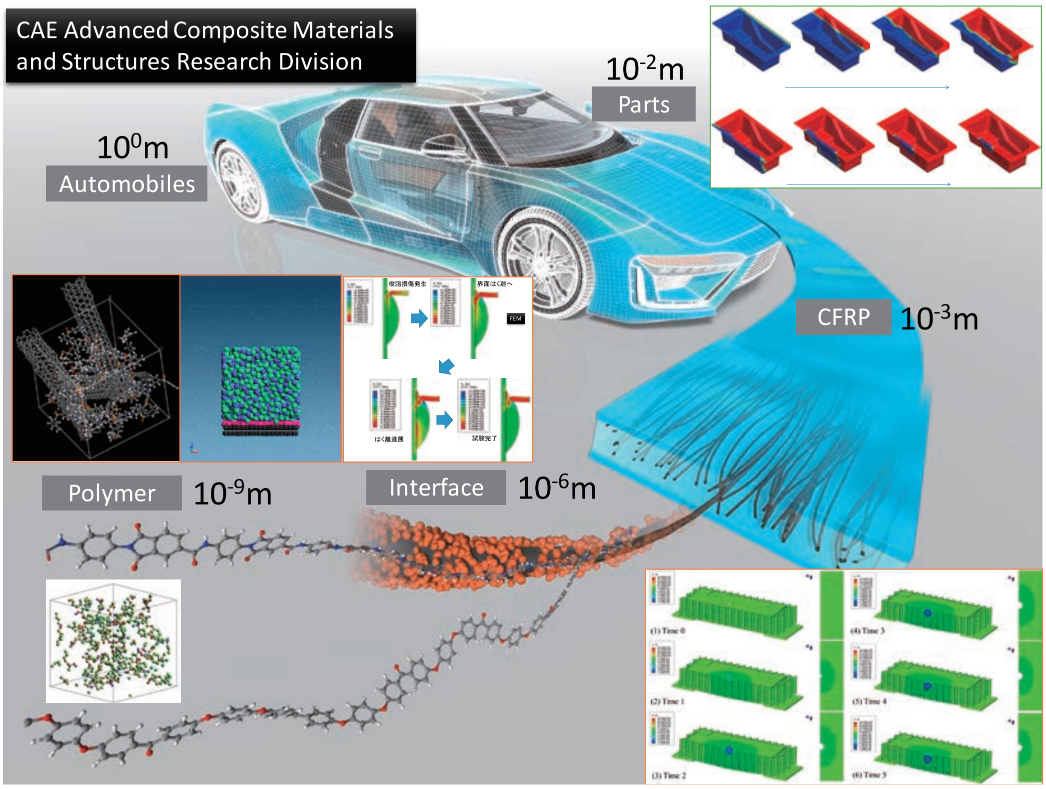


Fig. 1 Overview of research range covered by our group

Established: April, 2013 ✉ iwakura@rs.tus.ac.jp

Center for Animal Disease Models (CADM)

Director
Professor,
Division of Experimental Animal Immunology, Research Institute for Biomedical Sciences

Yoichiro Iwakura
D. Sc.

The homeostasis of our body is maintained through concerted actions 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 collaborations of our research groups.

Objectives	To elucidate pathogenic mechanisms of diseases such as autoimmune, allergic and neurological diseases and tumors, and develop novel therapeutics against these diseases
Future Development Goals	To get more insight into disease pathogenesis and to develop new therapeutics through cross-research field collaboration in Noda area.

Elucidation of disease mechanisms and development of new therapeutics through generation of gene-modified mice.

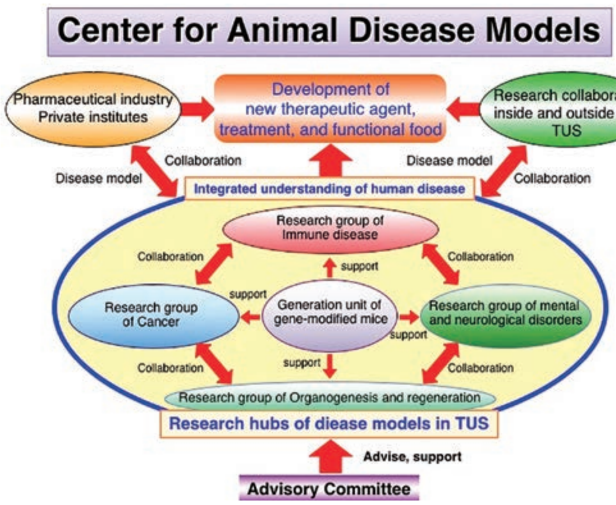
The Aim

Center for Animal Disease Models (CADM), Tokyo University of Science (TUS), was established in 2013, supported by the MEXT Strategic Research Foundation at Private Universities. In April 2018, as a subsequent organization, this center was reorganized for further promotion of research activity. Animal disease models are indispensable for investigation of causes of human diseases and development of therapeutic agent, treatment, and functional food. Animal experiments have made great contribution to the progress of human health and life-science research. Many of them were achieved by using gene-modified mice, and as the researchers who developed the method of generating gene-modified mice have won the 2007 Nobel Prize, gene-modified mice are greatly useful for the analysis of the function of disease related genes.

CADM try to clarify the mutual relationship between gene function and cause of onset for diseases that are a social problem such as autoimmune diseases, allergy, lifestyle diseases, cancer, neurological diseases, and aging by using gene-modified mice of disease related genes. We try to address these big challenges by collaborating with the researchers of biological- and life-science field in TUS. Furthermore, we are aiming to form research hubs of animal model diseases in TUS to develop new therapeutic agent, treatment, and functional food. We are expecting that new therapeutic drugs and therapies will be developed through the activities of this research center.

Research Groups

CADM set up a developmental engineering team to support the generation of gene-modified mice in the center and we will promote the generation and supply of genetically modified mice. Each group in the center promotes cross-sectoral collaborative research by sharing gene-modified mice and analytical methods such as animal disease models.



1. Immune Disease Research Group (Yoichiro Iwakura, Masato Kubo, Daisuke Kitamura, Haruo Kozono, Tomokatsu Ikawa, Shuhei Ogawa, Ce Tang, Soo-Hyun Chung, Sachiko Kubo, Yosuke Harada, Yoichiro Isohama, Chiharu Nishiyama)
Based on the generation and functional analysis of gene-modified mice of the genes such as inflammatory cytokines, innate immunity receptors and signaling factors, we aim to develop novel therapeutic agents and functional foods for autoimmune diseases and allergies.
2. Organogenesis/Regeneration Research Group (Ryo, Goitsuka, Shunsuke Kon, Tomoko Masaike)
This research group analyzes the molecular mechanisms of organogenesis, organ maintenance, and movement of cell organelles by generating gene-modified mice, which have genetic mutation involved in these events. This group also investigates the association between abnormality of these events and carcinogenesis. Finally, we aim at application to cancer therapy.
3. Mental/Neurological Disorder Research Group (Teiichi Furuichi, Takeshi Nakamura)
This group analyzes the mechanism of the onset of mental and neurological disorders by using animal disease models caused by dysfunction of neural circuit formation related gene. This group aims at application to therapy of mental and neurological disorders.
4. Cancer Research Group (Kouji Matsusima, Tatsunobu Mizuta, Naoko Nakano, Satoshi Ueha, Masayuki Sakurai, Yuya Terashima, Masahito Sadaie, Mitsutoshi Tsukimoto, Kazunori Akimoto)
This group investigates the mechanism of cancer development at the molecular, cellular, organ, and individual levels by generation of gene-modified mice involved in the onset of cancer. This group aim to develop anticancer therapy by elucidating the functions of responsible gene.
5. Advisory Committee (Makoto Asashima, Kazuhiko Yamamoto, Ken-ichi Yamamura, Naoko Otani, Kensuke Miyake, Yoshikazu Higami, Shin Aoki)
The member of Advisory Committee "Consisting of experts inside and outside TUS" instructs and advises on the operation of the center, research policy, individual research contents, etc.

Research Supporting Activities (2013-2019)

Generation of Gene Manipulated Mice and Cryopreservation of Embryos

Year	2013	2014	2015	2016	2017	2018	2019	Total
Generation of gene manipulated mice	1	9	10	9	14	2	19	69
Cryopreservation of embryos	25 (3,977)	25 (4,459)	48 (11,689)	28 (8,423)	27 (5,322)	50 (6,651)	23 (3,381)	226 (43,402)
Recovery of mice from frozen embryos	14	7	9	3	13	4	12	62
Microbiological cleaning	16	9	4	10	11	23	26	99

Provision of Gene Manipulated Mice

Year	2013	2014	2015	2016	2017	2018	2019	Total
Japan	36	19	13	23	27	24	20	162
Outside of Japan	65	29	37	29	16	21	14	211

Total 373 lines, to 300 laboratories including 9 pharmaceutical companies.

Brain Interdisciplinary Research Division (“*BIRD*”)

Established: April 2016

tfuruichi@rs.tus.ac.jp

Objectives	We create a collaborative platform for interdisciplinary brain research to develop following areas with a focus on brain cognition: (1) Understanding brain health and disorders and the development of new tools for diagnosis and treatment (2) Analyzing and modeling neural activity, and designing brain-inspired ICT (3) The development of measuring and function-assisting devices
Future Development Goals	Using the emergent research infrastructure created by multidisciplinary integration, we aim to establish an R & D base for brain health, brain measurement, modeling, and for the creation of new devices with designs inspired by the brain function.

Director
Professor,
Department of Applied Biological Science, Faculty of Science and Technology

Teiichi Furuichi
Ph.D.

Healthy brain function is essential for a richness of mind and a better quality of life. In our modern society of high stress and aging communities, the preservation of a healthy brain is becoming evermore important. Furthermore, the brain is a living energy-saving device that can massively parallel processes, learn, store and retrieve a myriad of information by itself. Therefore, we can expect creation of future technologies and devices inspired by the study of the brain.

Creating an R & D infrastructure for the study of the brain, neural information and neural systems.

The Scope of the Brain and Neuroscience Field

The brain and neuroscience field is a life science highly anticipated to show rapid advancements within the 21st century. The maintenance of good brain health is expected to improve the quality of life (QOL) within the current aging population. In addition, innovative information and communications technologies (ICT) can be created by applying the same information processing mechanisms as discovered in the brain. Therefore, the field has had high expectation from both society and industry.

Healthy Brain, Healthy Mind

The brain, responsible for controlling our thoughts and actions, is a system necessary for any person to live as a human being. Throughout the various stages of life, however, people can be confronted with several impairments of brain health. Developmental disorders of brain can cause autism spectrum disorder and has also been linked to an increased risk of schizophrenia. Furthermore, in today’s stressful society, no one is immune to the risk of depression and other stress disorders. With the escalation of aging problem, our society is further burdened with the compounding issues associated with dementia such as Alzheimer’s disease. Impairments of the health of brain and mind are directly linked to the loss of individual’s QOL and thus a significant national health issue. In turn, such health issues are also linked to critical social issues stemming from the burdens placed on patient families and the financial losses...

Information Processing in the Brain

Brain has also been notably compared to a high-level analog computer with high-speed massive parallel processing. Whilst small in size and energy saving, the brain can process information equivalent to that of the supercomputer ‘K’. Technological development is currently underway utilizing brain-inspired computers and brain-machine interfaces (BMI). Despite such advancements, the cognitive systems and computational algorithms of the brain have yet to be completely elucidated.

Goals of the Brain Interdisciplinary Research Division

In order to unravel the complex details of the brain that controls human thought and action, and thus apply this knowledge to emergent development, multi-scaled, multimodal and multidimensional research approaches are required. Informatics that allows such integration becomes essential, and thus the focus and cooperation between the various interdisciplinary fields is also vital. In our University, multimodal and multidimensional research is being advanced within a wide range of fields spanning the natural science, engineering, pharmaceutical and medical sciences. The Brain Interdisciplinary Research Division (BIRD) is creating a research and development (R & D) infrastructure allowing for effective collaboration between researchers belonging to the various disciplines distributed throughout the University (e.g. experimental, information, system and developmental courses). By capitalizing the synergism in this collaborative environment, we aim to create some revolutionary results – filled with the creativity afforded by multidisciplinary integration – regarding the brain, neural information or neural system from Tokyo University of Science.

To confront the challenges ahead, the following three interdisciplinary joint research groups will be established:

(1) Brain Health and Disorders Group

With a focus on cognition, this group aims to elucidate the mechanisms of brain health and disorders (e.g. depression with pessimistic cognitive characteristics; senile dementia that reduces cognitive and memory function; social cognition and communication difficulties caused by autism) and develop therapeutic and diagnostic drug seeds. This will be achieved through multidimensional research studies all aspects from the molecular and neural circuitry to model animals.

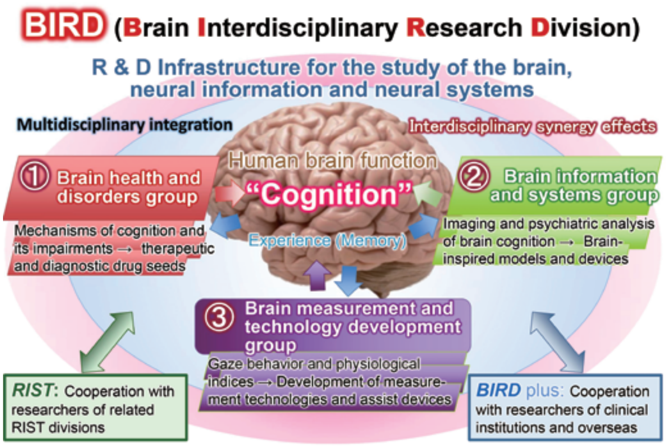
(2) Brain Information and Systems Group

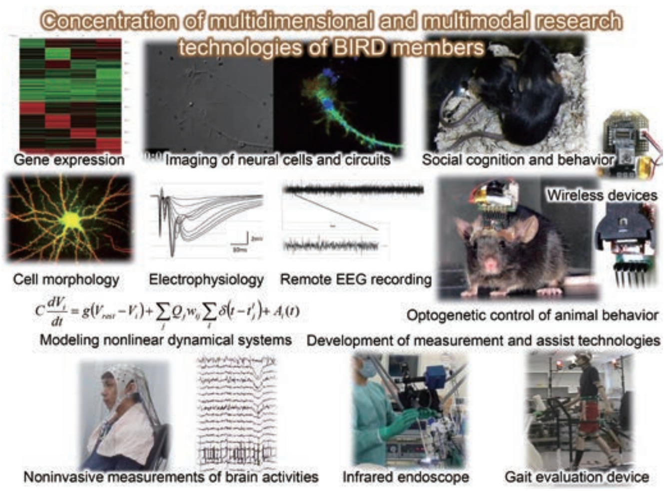
This group aims to elucidate, model and theorize the brain information processing systems with a focus on human visual perception. The group aims to achieve these goals through multidisciplinary studies including brain function imaging, cognitive psychological experiments and brain algorithms.

(3) Brain Measurement and Related Technology Development Group

This group aims to develop measurement and evaluation technologies of brain function and impairment and their assist devices through multidisciplinary study of movement such as gaze behavior and locomotion as well as personality traits and physiological indices which reflect the internal state of the brain.

Researchers (16 members): [Sci. Tech.] T. Furuichi, Y. Sano, Y. Nishiyama, R. Hatano, H. Takemura, H. Ichikawa, [Pharm. Sci.] A. Saitoh, D. Yamada, [Sci. I] O. Araki, T. Urakawa, [Ind. Sci. Tech.] N. Aikawa, H. Natori, E. Segi-Nishida, [Eng.] T. Ikeguchi, [Res. Inst. Biomed. Sci.] T. Nakamura, S. Koinuma
Guest Researchers (2 members): T. Kimura (Kanazawa Univ.), M. Hashimoto (Fukushima Med. Univ.)





Chemical Biology Division Supported by Practical Organic Synthesis

Established: April 2018
shiina@rs.tus.ac.jp

Director
Professor,
Department of Applied Chemistry,
Faculty of Science Division I
Isamu Shiina
Ph.D.

Objectives

Our goals include the efficient production of pharmaceutical products from natural and/or artificial compounds. In our research department, our team will collaborate with researchers within the campus, as well as outside, who have made considerable achievements in the field of molecular biology, thereby completely exploiting synthetic organic technologies from which the representative research can derive its strength.

Future Development Goals

Recently, the discovery of new medicines originating from academia via industry–university collaboration from an industrial viewpoint has attracted a significant amount of attention. Results obtained from such researches provide a methodology for solving various issues associated with the development of drugs derived from natural sources.

In this project, novel biological research will be conducted by completely exploiting organic synthesis technology, referred to as the "total synthesis of naturally occurring products," which has been scarcely used so far for the discovery of new drugs. Synthetic studies based on natural product-derived compounds lead to the production of novel drugs with a unique mechanistic MOA and pave the way for the treatment of intractable diseases that have not been treated thus far.

Structure–Activity Relationship (SAR) and Mode of Action (MOA) Studies Using New Compounds Developed at the Tokyo University of Science

Development of New Synthetic Methods for the Effective Transformations in Organic Chemistry

A majority of the products that are used as medicines by humans comprise carbon-based organic compounds, which are synthesized by combining multiple chemical reactions. However, when it is crucial to perform several reaction steps before achieving the synthesis of the desired compound, considerable time and effort are spent, as well as a considerable amount of waste is generated, thereby adding to the environmental burden.

Our synthetic team is conducting research on reaction methods that can improve the synthetic yield of pharmaceutical products to the maximum. Hence, in 2002, our team developed a new dehydration condensation agent, namely 2-methyl-6-nitrobenzoic anhydride (MNBA), which can drastically enhance the production efficiency of antibiotics and anticancer drugs.

Dehydration condensation is a structural transformation where two hydrogen atoms and one oxygen atom are simultaneously removed from organic molecules, and two compounds are ligated using a reagent such as a dehydrating condensation agent. For decades, dehydration condensation has been employed to construct the basic skeleton of pharmaceuticals. However, as conventional methods require harsh reaction conditions, including the use of an acid catalyst or high temperatures, issues related to the destruction of reagents or compounds that serve as the raw materials were noted.

With the establishment of the Shiina laboratory in 1999, compounds and reaction conditions for the invention of the fastest dehydration condensation reaction in the world were thoroughly analyzed, which finally led to the development of MNBA.

After the establishment of this new technology, MNBA has been widely used to synthesize new antibiotics, molecular target anticancer drugs, and drugs for diabetes treatment, and more than 2000 successful results have been reported worldwide (Please check YouTube using "YouTube MNBA Shiina" as the keyword, (Fig. 1).

Fig. 1 Efficient Synthesis of Various Compounds Using MNBA (The Shiina Research Group) (https://www.youtube.com/watch?v=Dw1ajJchujw)

A New Method for the Inhibition of Cancer Cells (Total Synthesis of Vesicle Protein Transport Blocker, M-COPA)

In this chemical biology division, research on the "Development of New Reactions" and "Total Synthesis of Natural Products" is interconnected as major research topics. Total synthesis involves the artificial synthesis of natural-derived chemical substances with complex molecular structures using a minimum amount of raw materials. For example, some rare chemical compounds extracted from soil-borne bacteria exhibit anticancer properties. If these compounds can be artificially synthesized, not only the stable production of medicines can be achieved but also the chemical structures that are optimum for pharmaceuticals, including the suppression of side effects, can be designed.

In the total synthesis research, MNBA is predominantly used for the synthesis of organic compounds exhibiting anticancer properties.

Our team completed the total synthesis of M-COPA, which limits the function of the Golgi apparatus that is responsible for the transport of intracellular proteins. Both domestic and international research groups have attempted to apply this compound to cancer cells activated by the Golgi apparatus to block transportation pathways and to suppress the growth of cancer (Fig. 2). At the Shiina laboratory, our team has worked toward the development of a large-scale method to prepare M-COPA for use in animal experiments.

Each reaction step was analyzed to ensure gram-scale production, or higher, of M-COPA with seven consecutive stereogenic carbons. Our team established large-scale synthesis by effectively employing organic reactions, such as asymmetric aldol reaction, intramolecular Diels–Alder reaction, and MNBA dehydration condensation reaction. Experiments to verify the effect on cancer cells using M-COPA via total synthesis have been conducted, and even the inhibition of proliferation of cancer, which has been thought to not be cured using the current anticancer drugs, has been observed. In addition, other outstanding achievements have been consistently reported in articles. The design of a synthetic method in the anticipation of the development up to industrial use has played an important role in successfully achieving this objective.

In addition, these results have also been presented on YouTube. These can be viewed on the YouTube handle "YouTube M-COPA Shiina" or "YouTube Shiina Laboratory TUS."

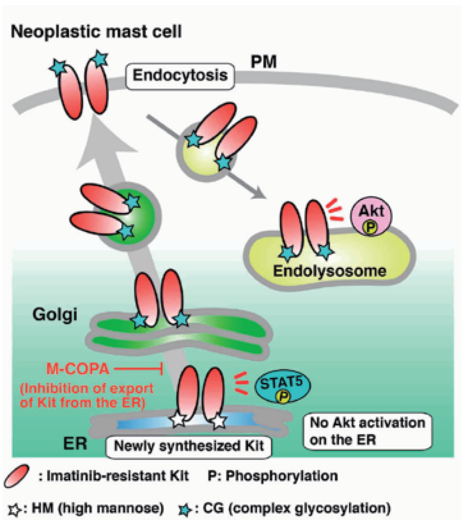


Fig. 2 Proliferation Suppression Mechanism of Cancer Cells Using M-COPA (Fig. 2 was created by Dr. Yuuki Obata who collaborates with Prof. Shiina: *PLOS ONE*, 12(4), e0175514 (2017))

Established: April 2014

t-aoyama@rs.tus.ac.jp

Academic Detailing Database Division

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences
Takao Aoyama
Ph.D.

Objectives
Our aim is to integrate these data in order to develop original diversified Academic Detailing Database. Then we would be able to propose a doctor the most appropriate medicine for a patient by using it.

Future Development Goals
Due to the spread of academic detailing, we will lead to better prescription and contribute to the improvement of medicine treatment quality in Japan.

In this Division, we established in April, 2014. Our pharmacist education program utilizing basic pharmaceutical sciences for patients is still not enough to be a highly qualified clinical pharmacist. Therefore, we focus on utilizing basic pharmaceutical sciences and established division of Academic Detailing Database in our University.

Academic detailing is personalized support for improving both knowledge and clinical decision-making by the latest non-commercial evidence-based data. We will do research about the effectiveness of Academic detailing.

Extension of Academic Detailing and Development of Database

Our pharmacist education program utilizing basic pharmaceutical sciences for patients is still not enough to be a highly qualified clinical pharmacist. Therefore, we focus on utilizing basic pharmaceutical sciences and established division of Academic Detailing Database in our University.

Development of Academic · Detailer Training Program

We will utilize basic pharmacology clinically to train Academic Detailers that can provide fair neutral drug comparison information based on evidence and disseminate Academic Detailing.

Research on Academic Detailing Effect

We will study the influence of academic · detailing to doctor on prescription.

Industry-academia cooperation

We will create academic / detailing support data base with industry-university collaboration and build collaboration with medical science · liaison training.

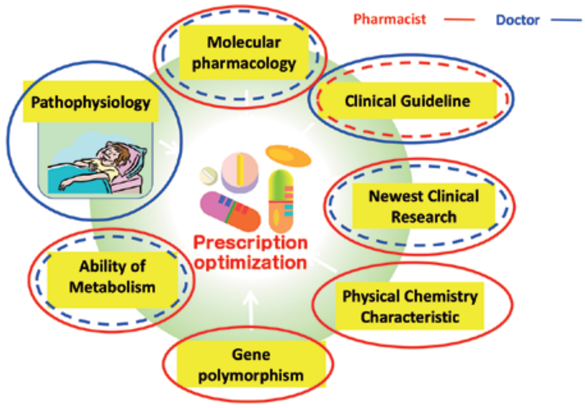


Figure 2. Each point of view for appropriate medicine

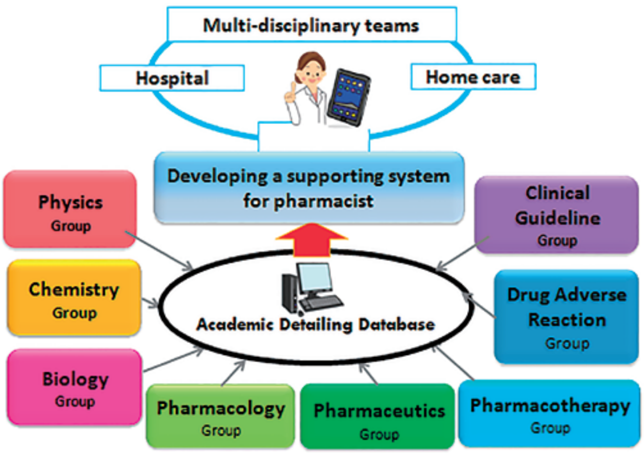


Figure 1. Eight essential fields of the division.

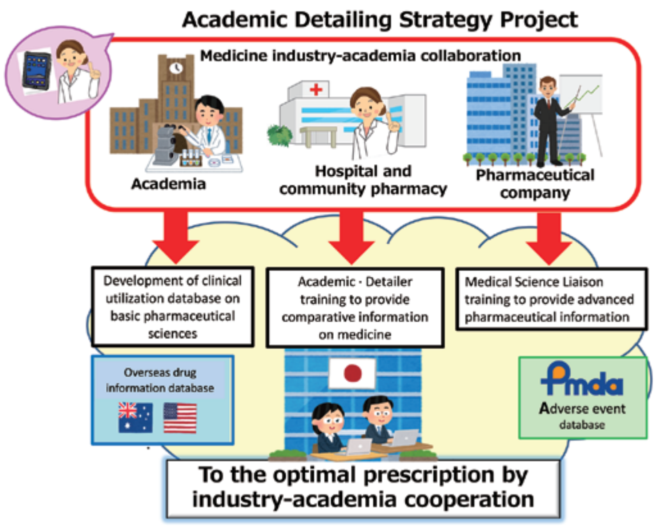


Figure 3. Industry-academia cooperation

Established: April 2019

twada@rs.tus.ac.jp

Division of Nucleic Acid Drug Development

Director
Professor,
Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences

Takeshi Wada
Ph.D.

Objectives	We aim to create nucleic acid drugs to treat unprecedented target diseases through the synthesis of novel chemically-modified nucleic acids and the establishment of DDS and formulation methods
Future Development Goals	Our goal is to make a breakthrough in the field of nucleic acid drugs through the collaboration of in-house researchers

This division was established by the cross-departmental team of in-house researchers working on the nucleic acid or other related research fields. By succession of networks and joint researches created through the activity of the TR center, we aim to develop innovative nucleic acid drugs from TUS.

Development of nucleic acid-based drugs that are expected to be a next-generation drug

History of This Division

The TR (Translational Research) center, which was the former organization of this division and lasted until 2018, got notable results in the field of nucleic acid drug. Also, nucleic acid-based drugs have recently attracted much attention as a next generation type drug. There are a plenty of researchers who work on nucleic acids at TUS, and the most of them took part the activity of TR center. Then, "round-table conference on nucleic acid drugs and DDS" was established in 2017 (representative: Prof. Makiya Nishikawa), and we have active discussions on nucleic acid drugs. Under these circumstances, the Division of Nucleic Acid Drug Development was established as a subsequent organization of TR center in April 2019.

Research Objectives

The development of nucleic acid drugs requires a knowledge from wide range of research field. There are many prominent researchers who work on nucleic acid or related research at TUS, thus innovative and unique results are highly anticipated through their collaborations. In this division, one of our mission is the development of novel nucleic acid derivatives which overwhelm conventional ones in the viewpoint of efficacy, stability and safety. Also, we aim at establishing the cationic molecules and formulation technology which stabilize and improve pharmacokinetics of nucleic acid drugs. We chose immune system, metabolic system related diseases and cancer as targets. As just described, the development of original nucleic acid drugs targeting unique diseases are highly expected by gathering of in-house competent researchers in this division.

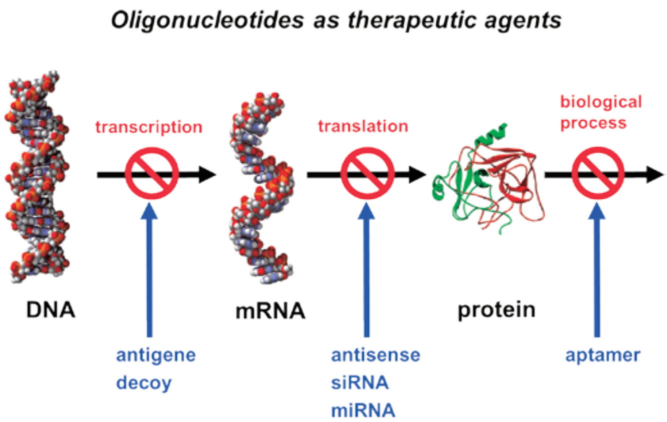


Figure 1.

Members

In-house Members

Faculty of Pharmaceutical Sciences
Takeshi Wada, Kazuki Sato (Organic chemistry)
Makiya Nishikawa, Kosuke Kusamori (Drug delivery system)
Takehisa Hanawa, Yayoi Kawano (Medicinal formulation)
Yoshikazu Higami, Masaki Kobayashi, Ryoma Tagawa
(Molecular pathology and metabolic disease)
Kazunori Akimoto (Molecular Pathology)
Satoru Miyazaki, Yosuke Kondo (Bioinformatics)

Faculty of Science
Hidetaka Torigoe (Biophysical chemistry)

Faculty of Industrial Science and Technology
Chiharu Nishiyama, Takuya Yashiro
(Immunology, allergy and molecular biology)

Research Institute of Biomedical Sciences
Masayuki Sakurai (Biomolecular Chemistry)

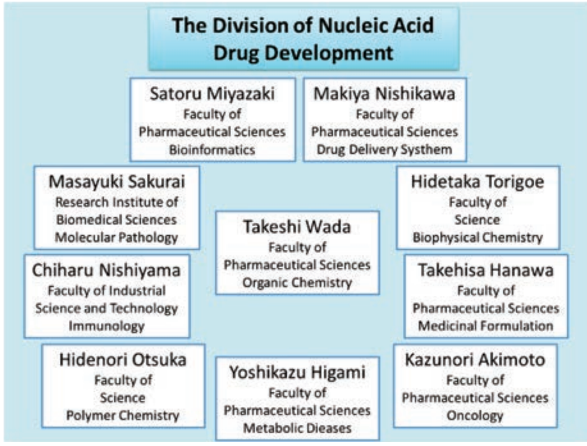


Figure 2.

Current Situation of Nucleic Acid Drugs and Our Research Topics

Nucleic acid-based drugs are anticipated to be an epoch-making remedy for the treatment of intractable hereditary diseases. The global market size of nucleic acid-based drugs is predicted to expand to 19 billion dollars in 2030 from 2 billion dollars in 2018, according to the estimation of Seed Planning Inc., a marketing research and consulting enterprise. Although much efforts have been devoted to the research of nucleic acid-based drugs, only 8 drugs have been approved so far. There are a lot of challenges to overcome for the development of potent nucleic acid drugs, and a break-through is required for the further progress of this area. To address this issue, we are dealing with following topics;

1. Development of an efficient method to synthesize boranophosphate oligonucleotides which is anticipated as an alternative candidate of phosphorothioate
2. Establishment of a scalable synthetic method of artificial cationic oligosaccharides and peptides that bind to and stabilize nucleic acids.
3. Construction of a highly target selective drug delivery system through the elucidation of interaction between nano-structured nucleic acid and cells
4. Development of antisense drugs that target such as wound and bladder cancer remedy
5. Development of a novel formulation method of nucleic acid drug
6. Research on the control of aging, aging related diseases and metabolic abnormalities by nucleic acid drugs
7. Development of nucleic acid drugs which regulate autoimmune response and rejection reaction during an organ transplantation
8. Development of effective breast cancer drugs using novel artificial cationic molecules and siRNAs
9. Establishment of investigation technology via bioinformatics and AI to determine the sequence of a mRNA that codes disease-related protein

Division of Synthetic Biology

Established: April 2019
ikawa@rs.tus.ac.jp

Director
Professor,
Division of Immunology and Allergy
Tomokatsu Ikawa
Ph.D.

Objectives	Using informatics analysis and modern biotechnology such as DNA synthesis, cell fusion, microinjection and microscopic laser technology, we create genetically transplanted cells.
Future Development Goals	Emphasis on ethical, legal and social impacts, we aim to establish genome transplantation technology with sufficient safety measures.

We will promote our synthetic biology projects that create cells with our frontier spirits. This research division can become a platform for joint research, information sharing and technology exchange with synthetic biology researchers.

We create genetically transplanted cells, which will contribute to useful substance production and medical technology.

Synthetic biology is the study to elucidate the biological principle through artificial cells with DNA synthesis. Pet animals such as dogs and cats, horticultural crops such as orchids, livestock such as mules and chickens, and multiple species of agricultural products such as wheat and fruits are hybrids by crosses of related species. Since ancient times, we have created and used such genomic hybrid organisms. Current technological innovations have also enabled crosses and transfer of genomes other than closely related species. In order to create a frontier area from the modern biotechnology, we will promote departmental research. Our research is conducted with strict awareness of ethical, legal and social issues. With a view to the development of useful substance production technology and medical technology in the future, we will promote the following three research subjects with the aim of establishing a genome transfer technology with sufficient safety measures.

Strategy 1: Plant genome transplantation

There are many modules in the plant genome that are not found in animal genome, such as photosynthetic modules, pigment modules, and metabolic pathway modules that produce medicine materials. By transplanting these plant modules into the animal genome, we aim to impart new functions to animal cells. We call artificially photosynthetic animal cells “planimal cells” (Figure 1).

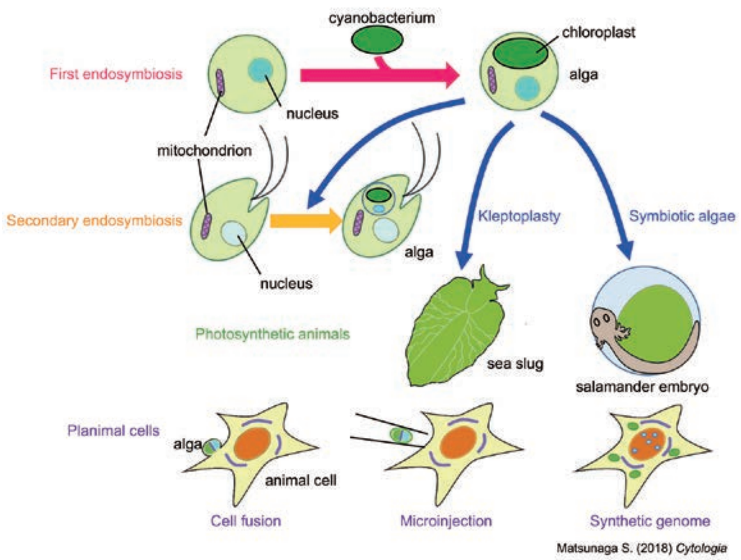
Strategy 2: Genome transfer beyond the species barrier

Even close relatives, there is a "species barrier" in genome crossing between organisms. Therefore, we aim to create ascomycete hybrid cells that enable useful substance production by genome engineering and cell fusion.

Strategy 3: Cell creation leading to regenerative medicine

Methods to control cell proliferation and cell metabolism are needed to promote the production of spheroids and organoids. We aim to develop technologies that can be safely applied to medical technology by incorporating a regulatory system with epigenetic and optogenetic techniques.

Through this department, the fields of biology divided into microbiology, botany, zoology and medical science can be fused to make it possible to elucidate the basic principles of life.



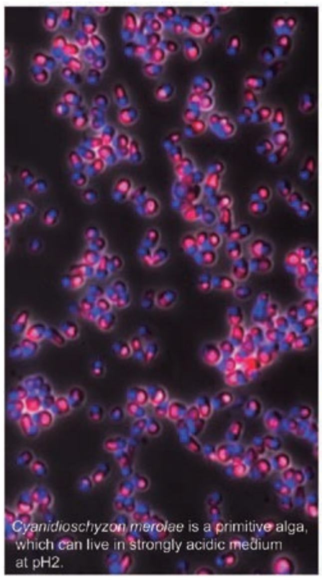


Figure 1 Creation of artificially photosynthetic animal cells “planimal cells”

Established: April 2020

garimura@rs.tus.ac.jp

Bio and Pharmacy

Division of Biological Environment Innovation

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

Gen-ichiro Arimura
Ph.D.

Objectives	We explore the mechanisms by which life adapts and diversifies, and evolution occurs in a rapidly changing habitat environment. Our aim is also to develop technological seeds that contribute to our food and health quality.
Future Development Goals	We will create a new revolutionary academic field that has never existed by fusing individually developed research areas such as environmental biology and ecology.

With the theme of "environment," we will elucidate the environmental adaptability and molecular evolution mechanisms of various species, such as plants, mammals, reptiles, amphibians, fish, insects, and fungi species. We will explore applications of novel discoveries to aid the preservation of natural ecosystems and biological diversity.

Bioenvironmental research with the aim of creation of synergy between academic fields and technological seeds in an environmentally changing society.

Summary

Academic experts in the fields of environmental adaptation, biological interactions, molecular evolution, co-evolution, and ecology of living organisms have formed three subgroups “the section of environmental adaptation”, “the section of molecular evolution, and the “section of nature symbiosis”. In order to create an academic research field that breaks through the classical concepts and barriers of environmental biology, evolutionary science, and ecology, we produce new technological seeds that will contribute to protecting our lives in a global environment that is always changing.

<Section of Environmental Adaption>

We explore to find the mechanisms underlying biological sensing of environmental stress, and develop new technologies including environmental stress-adaptive cultivation systems.

- Elucidation of the mechanisms underlying the evolution and diversity of lives
- Development of significant plant lines adapted for environmental stress tolerance and biologial interaction, leading to the creation of next-generation organic cultivation systems using immunostimulants and companion plants that contribute to reduced pesticide use.

Members: Gen-ichiro Arimura, Hiroaki Shimada, Kazuyuki Kuchitsu, Hisataka Ohta, Yoshitake Desaki, Kenji Hashimoto, Takuya Sakamoto, Sachihiro Matsunaga (Univ. of Tokyo)

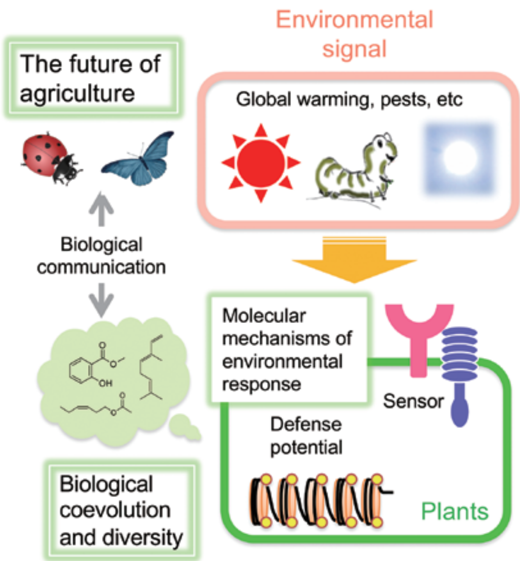


Figure 1

<Section of Molecular Evolution>

We analyze the mechanisms of genomic evolution and biology’s central dogma that enable adaptation and diversification of life from the viewpoint of evolution, which has been overlooked in the past. We also aim to develop new life system technology beyond conventional conceptions.

- Elucidation and utilization of minimum components and the mechanism of biological protein synthesis system of life on Earth
- Development of new life system technology based on RNA technology

Members: Koji Tamura, Toshiki Furuya, Mitsunori Shiroishi, Masayuki Sakurai, Kazunori Okada (Univ. of Tokyo), Akiko Soma (Chiba Univ.)

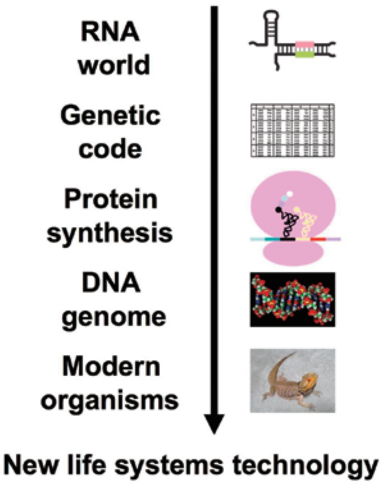


Figure 2

<Section of Nature Symbiosis>

We advance scientific knowledge that contributes to the conservation of ecosystems and biodiversity, and develop technologies for assessing risks of chemical substances to living things and for managing and improving the air, water, and soil environment.

- Elucidation of environmental factors and mechanisms that affect future biological production
- Development of analytical methods for atmospheric molecules and environmental chemicals, and of methods for assessing the effects on living organisms

Members: Shinichi Miyagawa, Shinichi Satake, Yoshitsugu Akiyama, Yuko Komiya, Takuya Saito (NIEFS)

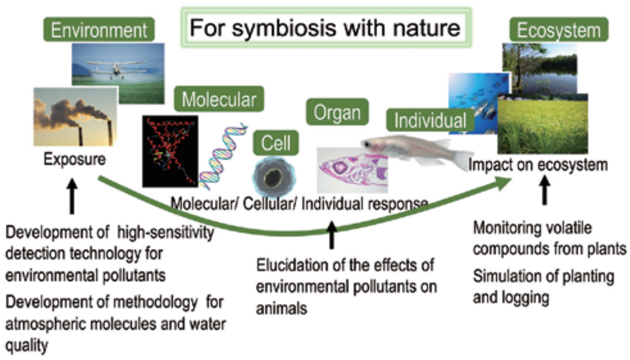


Figure 3

Established: April 2004
ihagiwara@rs.tus.ac.jp

Information and Societal

Center for Fire Science and Technology

Director
Professor,
Research Institute for Science & Technology
Ichiro Hagiwara
Ph.D.

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 contribute to society.

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.

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

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 50 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 record of accomplishment 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 record of accomplishment, 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 Safety Information Center in Asia based on Sharing Expertise-New Fire Safety in Information Society" was started. Fire Safety Information in Asia as a research base that focuses on building a network of networks, and works together to reduce fire risk in Asian cities, we have realized the global development of science, which is an issue for the 21st century.

Since April 2018, it has been playing a role as permanent organization of "Fire Science Research Center", as a center for fire science and fire safety engineering that represents East Asia.

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 (Photo1). 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 fire furnace was added. Other large-scale experimental facilities to be included in the laboratory are composite furnace, fire resistance assessment machines for exterior wall materials, and combustion performance testing facilities, which are needed internationally, to contribute to the advancement of innovative researches.

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 non-life insurance industries) as well as students from Japan and overseas who want to become fire safety 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. The Department of Global Fire Science and Technology is scheduled to be set up in April 2018 under the Graduate School of Science and Technology by reorganization of the Graduate School.

Designated Performance Evaluation

In order to improve fire safety technology and improve reliability at the Fire Science Research Center, the Building Standard Law has been applied to the construction method of buildings as a designated performance evaluation body designated by a designated performance evaluation body of the Ministry of Land, Infrastructure and Transport. Carry out performance evaluations required to obtain Minister of Land, Infrastructure, Transport and Tourism approval.

Performance evaluation is conducted by an evaluator who has expert knowledge of the field of performance evaluation based on the business method approved by the Minister of Land, Infrastructure, Transport and Tourism.

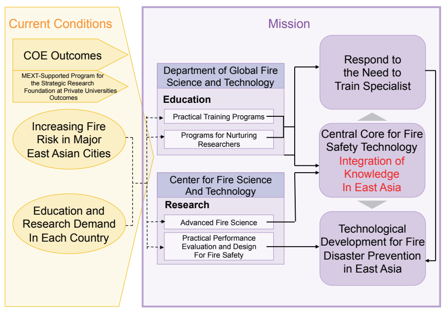


Fig. 1 Perspective of the Center for Fire Science and Technology

Photo 1 Fire Research and Test Laboratory

Fig. 2 Home Page 「Forum on Fire Safety in Asia」
https://gcoe.tus-fire.com/eng/ffsa/

Research Center for Space Colony (RCSC)

Established: November 2017

rcsc@rs.tus.ac.jp

Director
Vice President,
Astronaut,
Tokyo University of Science
Chiaki Mukai
M.D., Ph.D.

Objectives	RCSC gathers space-related technologies and aims for R&D necessary for long-term stay in an extreme closed environment, which is indispensable for frontier expansion of mankind.
Future Development Goals	Through the technology transfer to collaborative private companies, RCSC aims to enhance technologies developed during R&D toward state-of-the-art technologies upgrading lifestyle on the earth as well as usable in space.

RCSC possesses technologies such as component development of the satellite, functional materials, energy creation, construction, IoT, sensor etc. TUS has strength to develop technologies through R&D processes for long term stay of human in an extreme environment. The university that does not have the Department of Aeronautics and Aerospace Engineering aiming to revitalize Japan's space industry through industry-academia collaboration by the idea not caught by the stereotype of conventional space development.

Research Center for Space Colony ~Advancement and Social Implementation of the Space Stay Technology~

History of RCSC

TUS is private university of science and engineering in Japan and has cultivated know-how of interdisciplinary researches.

RCSC gathers TUS's technologies such as component development, functional materials, energy creation, construction, IoT, sensor etc. All of these fields are related to satellite science for spaces exploration. These technologies are extremely important for understanding and development of the universe, which is the frontiers of mankind. RCSC was established for the development of technologies that are necessary for human to stay in a closed environment for a long term in space.

RCSC was launched in November 2017 with the aim to develop technologies through industry-academia-government collaboration. Our goal is to contribute human society through innovative R&D, promote social implementation of the technologies, and human resource development.

Present Problems

To realize a stay in the closed environment (i.e., space colony), which is indispensable for the frontier expansion of human, there are many issued to be solved (e.g., energy supply, water/air recycle, and self-sufficient food production). In order to deal with these problems, we need to take comprehensive measures by gathering the TUS's knowledge and promoting cooperation with private companies.

Aims of RCSC

RCSC aims to develop the sophisticated space-stay technologies also available on the earth. Through the prompt technology transfer to collaborating private companies, RCSC aims to contribute to national resilience by building disaster-resistant houses, enabling long-term stay in the extreme situation caused by disaster, solving food crisis, and revitalizing the very small space industry in Japan. RCSC also focus on education and system development that deals with QOL, agriculture, energy and recycles of waste products in space through industry-academia collaboration.

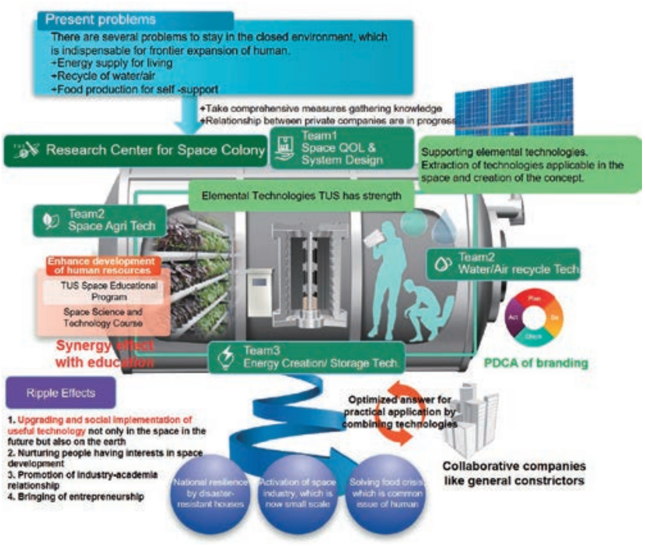


Fig. 1. Outline of the RCSC

Research Organization of RCSC

R&D in RCSC proceeds from the collaboration between four teams. RCSC collects produced technology during R&D and transfers to private companies with the ability to realize, aiming to enable our outcomes to upgrade our lifestyle on the earth as well as usable in space.

Space Colony Demonstration Module

Team-1：Space QOL & System Designing Team

Team-1 supervises the overall project. Assuming that we stays for a long time on the moon, where is a special conditions (e.g., microgravity and low pressure), Team-1 also designs the system for improving the QOL (Quality of Life) and extracts necessary technologies.

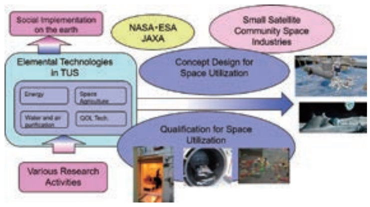


Fig. 2. Mission of Team-1 (Space QOL & System Designing)

Team-2：Space Agri Tech. Team

By using the in-liquid plasma technology and the photocatalysis technology together, Team-2 develops elemental technologies of space agriculture, which is sanitary and enables a self-sufficient in agri products within limited resources and a closed space.

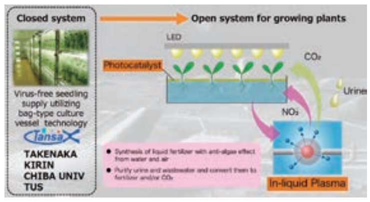


Fig. 3. Mission of Team-2 (Space Agri Tech.)

Team-3：Energy Creation & Storage Tech. Team

Team-3 develops high efficiency and high power solar cells made of materials with excellent cosmic radiation durability, a thermal-to-electric power generation system with indoor and outdoor temperature difference that can generate electricity even at night, and a flywheel type high energy density power storage system cooperating with a solar cell / thermal battery.

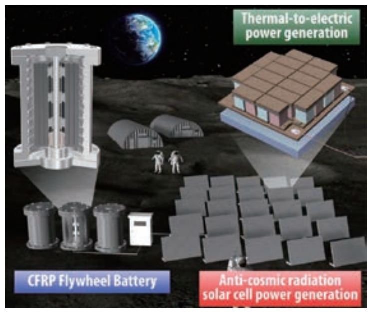


Fig. 4. Mission of Team-3 (Energy Creation & Storage Tech.)

Team-4：Water & Air Recycle Tech. Team

By using functional materials such as highly active photocatalyst, Team-4 develops a system that fully recycles various kinds of water and gases discharged from the human body and equipment.

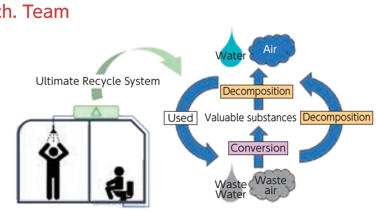


Fig. 5. Mission of Team-4 (Water & Air Recycle Tech.)

Atmospheric Science Research Division (ASRD)

Established: April 2016

miura@rs.tus.ac.jp

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

Kazuhiko Miura
D.Sc

Objectives To clarify the effect of aerosols on air pollution and climate change, the ASRD will observe atmospheric pollutants in the urban, mountain, and maritime atmospheres.

Future Development Goals The ASRD will activate the collaborated research and make the network of Japanese atmosphere observatory.

ASRD is the division to carry out research on air pollution and climate change by observation in the urban air, the ocean air, and the mountain air. We study the processes of new particle formation, particle growth, and cloud formation at the Tokyo Skytree and at the summit of Mt. Fuji. We will study the mixture effects of maritime and urban aerosols by sea and land breeze.

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

ASRD is the division to carry out research on air pollution and climate change by observation in the urban air, the maritime air, the mountain air, and trans-boundary air (Fig. 1). ASRD has twenty members. Their roles and observation sites are shown in Fig. 2.

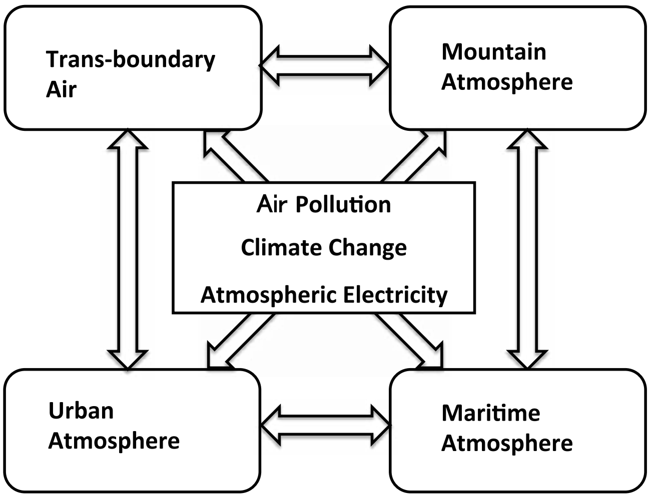


Fig.1. Mutual relationship of the research field.

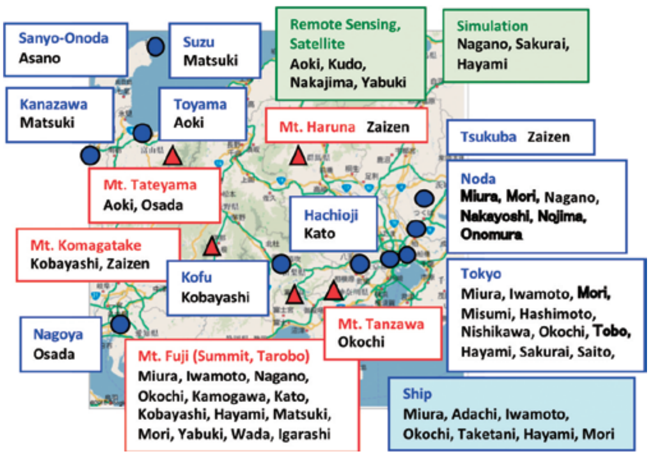


Fig.2. Roles of ASRD members and their observation sites, mountain (red) and surface (blue) sites.

1. High concentration cause of PM2.5 in the Kanto district

Concentration of PM2.5 has decreased by diesel car emission controls considerably in South Kanto, but an achievement of environmental standard rate of PM2.5 is still low. The possibility of the transported pollution is considered as this cause, but PM2.5 occurs not a thing growing only in China anywhere. Because the particles are removed from all over the atmosphere if there is rainfall during transportation, it is thought that the long-range transportation from the continent is performed in the free troposphere. Therefore we get cooperation of the authorized nonprofit organization 'Valid Utilization of Mt. Fuji Weather Station' (http://npo.fuji3776.net/) and observe it at the old Mt. Fuji Weather Station at the summit of Mt. Fuji and study the condition that PM2.5 becomes high concentration. In addition, the hygroscopic aerosol particle can cause the high density of PM2.5. Therefore, by observation using Tokyo Bay or a ship, I investigate the influence of the marine atmosphere aerosol particle.

2. Effects of atmospheric aerosols on climate change

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 (IPCC2013). 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.

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. There are a few papers of new particle production observed in the PBL under a highpressure system. It suggests that particles are produced in the free troposphere (FT).

Because of the altitude, mountain sites are well suited to studying aerosol-cloud interactions. Our station on Mt. Fuji is particularly important, as Fuji is an isolated peak normally situated in the FT. Furthermore, by using the Tokyo Skytree and the research vessel, we investigate the characteristic of aerosol particles in the urban and maritime atmosphere (Fig. 3).

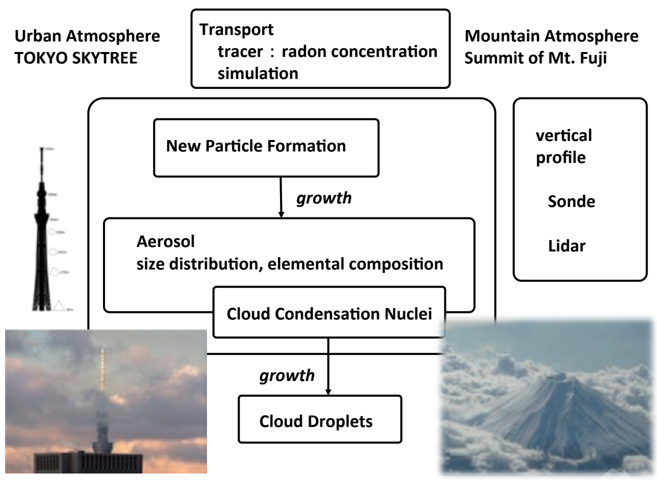


Fig.3. Study on the process of new particle formation and cloud formation in the urban and maritime atmosphere.

Information and Societal

Division of Super Distributed Intelligent Systems

Established: April 2016

mune@rs.tus.ac.jp

Director
Professor,
Department of Information Sciences

Munehiro Takimoto
Ph.D.

Objectives	Development of new parallelizing or distributing techniques in several level, and application of them to several areas including AI.
Future Development Goals	Development of highly parallelized/distributed AI systems that can handle manually processed huge data, and multiple robots for practical missions.

This research division aims to give effective domain specific parallelization/distribution solutions for each system in various levels. The solutions include the design of parallel models inspired from cell signal processing or social insects. We believe that the challenges of this division will open new horizons for parallel or distributed systems.

R&D on highly parallelized/distributed systems and algorithms, and high performance computing tools.

Introduction and Background

In most science areas, which include DNA & molecule designs in micron level and earth environment sciences in macro level, it is so important to extract meaningful information from big data, which is superficially useless data with huge size. The extraction techniques are called data mining. Data mining is so costly that it is difficult to process it in traditional ways. To achieve much more efficient data mining and result in innovative science technologies, we have to enhance parallelization and distribution in algorithms and execution styles.

Division of Next Generation Data Mining Technology, which is the previous division, especially focuses attention to medical and bio-systems, and has developed next generation data mining software together with researchers in artificial intelligence and statistics areas. In the process of that, we have found that we have to enhance parallelization/distribution to achieve new innovative technologies. In Division of Super Distributed Intelligent Systems, we will improve the results of the division of next generation data mining technology, and develop new parallelizing/distributing techniques based on performance issues that the results have exposed. For example, we will enhance execution efficiency in the low level that is related with programming languages, parallel/distributed algorithms, and network protocols. In addition, we will design new parallel/distributed models based on knowledges given by cell signal processing or social insects. Eventually, we will apply these techniques and models to several areas such as image processing, power systems, machine learning, robot systems, software engineering tools and so on, including data mining.

Research Hierarchy

We address the issues of parallelization and distribution in three hierarchical levels, “applications”, “models, and “infrastructures” as follows:

1. Parallel/Distributed Applications
In the application level, considering three applications, “data mining & machine learning”, “image processing” and “distributed robot controls”, their special researchers improve system performance using application-level techniques such as a cloud computing.

2. Parallel/Distributed Infrastructures
In the Infrastructure level, considering “programming languages”, “language processors” and “network protocols”, their special researchers directly improve the parallelization and distribution techniques on various infrastructures.

3. Parallel/Distributed Models
In the model level, considering “evolutionary computation”, “cell communications” and “biological systems”, their special researchers develop models for making infrastructures work more efficiently. Also, they develop new models through which the improvements of infrastructures directly lead to the speedup of applications.

Research topics

Currently, the following three projects are running:

1.Enhancement of milking using a milking robot

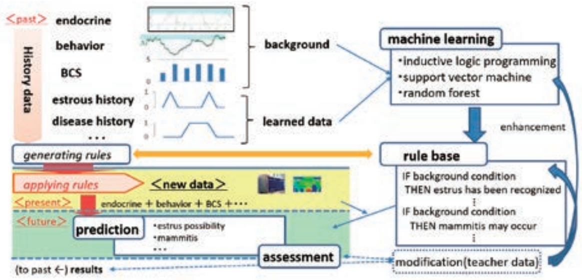


Fig. 1. Relation between a milking robot and A.I.

As shown in Fig.1, the purpose of this project is to generate an endocrine model based on the transition of the ratio of pheromones to milk components automatically given by a milking robot. Precise prediction of the endocrine enables cows to always be enceinte, so that the amount of milk generated by the cows can be kept constant. To generate the endocrine model, we use inductive logic programming, which is one of A.I. methods.

2.Enhancement of traceability of suckled calf and dairy cattle

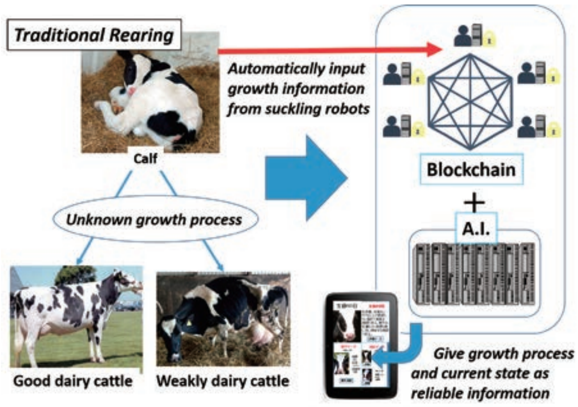


Fig. 2. Traceability of dairy cattle

In this project, as shown in Fig.2, we develop a technique maintaining the information in the process of growth from suckled calf to dairy cattle. Since this maintaining approach of the information is based on blockchain technique, it is difficult to falsify the information. Also, A.I. predicts the amount of milk that a calf will give when it becomes dairy cattle, based on the information.

Information and Societal

Division of Intelligent System Engineering

Established: April 2016 ✉ hyogo@rs.tus.ac.jp

Director
Professor,
Department of Electrical Engineering, Faculty of Science and Technology

Akira Hyogo
Ph.D.

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.

This division reorganized in April 2016, and has been starting to aim at the medical and space applications. In this Division, we will tackle research and development of humanlike 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.

R&D on human-like, human-friendly 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.

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.

○Radio wave 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.

○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 are 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. (see Fig. 1)

○Analog to Digital Converters (ADCs) and Digital to Analog Converters (DACs).

For our intelligent systems novel high performance ADCs and DACs hav been studied and developed.

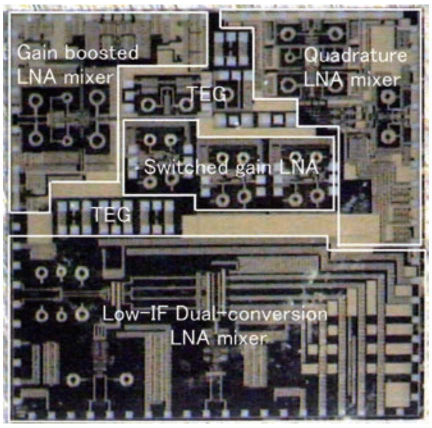


Fig. 1 Microphotograph of the proposed Integrated circuits (5mm×5mm)

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.

Division of Advanced Urbanism and Architecture

Established: April 2014
o.taka@rs.tus.ac.jp

Director
Professor,
Department of Architecture,
Faculty of Engineering
Osamu Takahashi
Dr. Eng.

Objectives	The construction of the city environment plan theory that is sustainable and resilient by updating of modern architecture and urban infrastructure.
Future Development Goals	We will develop regional researches, contributions to local communities, and regional exchanges to the subject area, aiming a modeling of city revitalization plan. And we will generalize to a regional planning, evaluation of a plan, and agreement of a plan. We will also enhance construction and fire safety.

This research division is composed of experts of architecture, city planning and civil engineering. Stuffs belong to Division One and Division Two of Faculty of Engineering and to Faculty of Science and Engineering, and School of International Fire Science. For many years, researchers in this division continue to develop regional researches, contributions to local communities, and regional exchanges with thick accumulation of their researches. We aim to create results to contribute the areal development of Kagurazaka and Sotobori area where is the home of Tokyo University of Science.

City Culture, City Planning, City Performances
Researches on urban and architectural Design, which are composed of three research fields above. We will contribute to urban re-development and re-design for the existing study area, proposing sustainable urban environment by research results and design studies as scientific knowledge.

Characteristics of the Research Division

As for the problems about today's urban environment and urban life, which become highly modernized and industrialized, almost of them are caused by complex and correlative matters. Only results of individual research areas that have been finely specialized and divided, can not solve the problems of necessity of sustainability and resilience for creating, maintaining and managing good human urban environment.

Therefore, our research division aims to the construction of practical integration system of city forming, and it will be reduced to the region as a specific scientific knowledge, helping to build up urban planning policy. From the points of reduction to society of results of academic research and social contribution of the university, and administrative organizations, private companies, NPO, etc. expect to our field of research. And our division has the characteristics that it belongs to social engineering, like civil engineering.

Academic and Social Features

Achievement in each field. Therefore, they are recognized as leaders of each fields of major academic societies, Architectural Institute of Japan, Japan Society of Urban Planning, and Japanese Architecture History Society and others. Comprehensive research by collaboration utilizing the expertise of each researcher and its reduction to society are demands from society and era, and the framework of this study department that specializes in advanced research of urban environment makes it possible to implement elastically and quickly. It is the advantages of the researchers of this division and our team can make full use of the network of each academic society, and it also becomes the social characteristic. As for originality of this research division, one is that we will cooperate and perform the advanced study of each field that primarily affects a building and city planning, and another is that we will analyze the overall issues of modern city in the context of a hronological Edo-Tokyo 400 years to study on designing and planning methodology. Especially, researches of the Outer Moat(Sotobori) surrounding area and Kagurazaka area, where is the home town of TUS, are region with unique characteristics in the points of world city history and of world urban structure.

So, it can be said that this study will gather attention internationally.

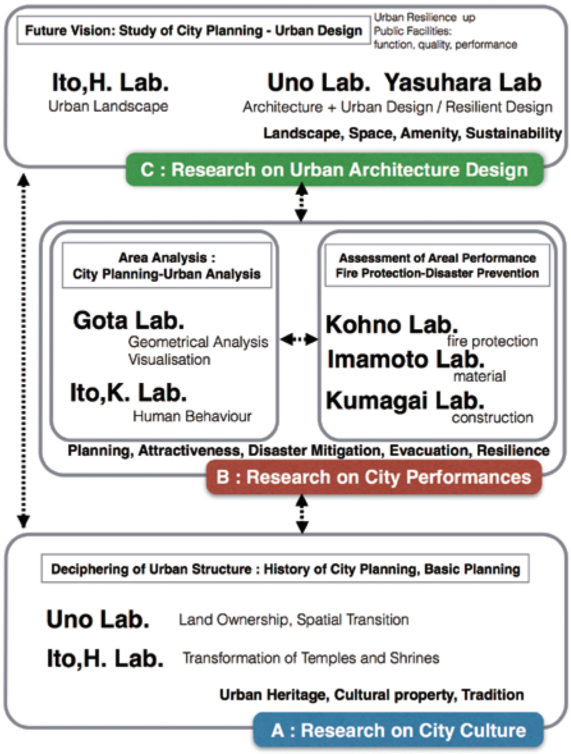
Research Area

Research area is, firstly Sotobori with its outskirts area and Kagurazaka campus area.

Secondly same type area of modernized castle towns (Nagoya, Osaka etc.) inside Japan, thirdly same type area of Asian cities (Seoul, Beijing, Bangkok etc.) that is going to be modernized. We will model urban structure of process of each city and apply graded results of research sequentially and develop to general urban research.

Fig. 1 Historical Changes of Kagurazaka "Outside of Sotobori", Lecture of Professor Akihisa ITO, April 2014

Fig. 2 "Sotobori-Kagurazaka 7 images", CKARD_TUS, April 2014



Tbl. 1 Research field and partners

Fig. 3 "Brought Close between Town and Sotobori" Proposal to connect town and Sotobori with a barrier-free deck, Sotobori Reconstruction Plan Symposium, CKARD_TUS, May 2014

Information and Societal

Statistical Science Research Division

Established: April 2020

seo@rs.tus.ac.jp

Director
Professor,
Department of Applied Mathematics,
Faculty of Science

Takashi Seo

D.Sc.

Objectives	In this research division, the researchers interested in the underlying common theory gather to improve the level of study on essential theories and methods. Additionally, we aim to create new theories in the age of data science and develop new fields.
Future Development Goals	This research division contributes to the study of mathematical data science with the aim of working closely with the Data Science Center, conducting joint research with companies, and becoming a base for the international research on statistical science.

Many professors involved in statistics are enrolled in our university, across campuses and undergraduate departments. In this research division, these professors from the field of statistical science come together and actively interact with each other to conduct a research which is unique to Tokyo University of Science. In the future, we would like to establish a "Statistical Science Research Center" and "AI and Data Science Theory Research Center."

Development of mathematical and applied statistics and their fusion

Background and Purpose of the Research Department

"Statistical science" is a field of study that uses the concept of probability to provide optimality theory and statistical methods to estimate the characteristics of the population behind the data obtained. In the recent years, "data science," which is associated with big data, as well as artificial intelligence (AI), has attracted significant attention. Furthermore, the core of these theories is "statistical science (statistical theory)," which has gained considerable prominence.

Accordingly, our university must build a research system that will lead not only Japan but also the rest of the world in the domain of AI and data science research. However, research in AI and data science is significantly extensive. Tokyo University of Science has been planning to conduct research in this field, intending to make the world proud. The university has many faculty members who specialize in "statistics," and these members are present across all its campuses. In particular, it is no exaggeration to say that our university is the only one in Japan with a huge number of researchers that specialize in mathematical statistics, which handles statistical inference logic mathematically. Tokyo University of Science also has the distinction of being strong in medical statistics, as it used to host a medical statistics program for the working members of society. Therefore, we aim to create a research stronghold where the researchers in these fields can come together and actively interact with members from across all campuses and departments to conduct research "unique to Tokyo University of Science." Furthermore, establishing this department will bring together researchers with specialties in different research topics but with a shared interest in a common theory. Our goal is to increase the level of research on essential theories and methods, and to create new theories and introduce new fields in the era of data science.

Members of Statistical Science Research Division

Name	Job title
HASHIGUCHI Hiroki	Professor, Faculty of Science Division I, Department of Applied Mathematics
MATSUZAKI Takuya	Professor, Faculty of Science Division I, Department of Applied Mathematics
MIYAOKA Etsuo	Professor, Faculty of Science Division II, Department of Mathematics
SEO Takashi *	Professor, Faculty of Science Division I, Department of Applied Mathematics
SOZU Takashi	Professor, Faculty of Engineering, Department of Information and Computer Technology
TOMIZAWA Sadao	Professor, Faculty of Science and Technology, Department of Information Sciences
YABE Hiroshi	Professor, Faculty of Science Division I, Department of Applied Mathematics
KOIZUMI Kazuyuki **	Associate Professor, Yokohama City University, School of Data Science
KUROSAWA Takeshi	Associate Professor, Faculty of Science Division I, Department of Applied Mathematics
MURAKAMI Hidetoshi	Associate Professor, Faculty of Science Division I, Department of Applied Mathematics
NISHIYAMA Takahiro**	Associate Professor, Senshu University, Department of Business Administration
SHIOHAMA Takayuki	Associate Professor, Faculty of Engineering, Department of Information and Computer Technology
TAHATA Kouji	Associate Professor, Faculty of Science and Technology, Department of Information Sciences
WATANABE Yuki	Associate Professor, Organization for Education Advancement, Center for Teacher Education
SHIMOKAWA Asanao	Junior Associate Professor, Faculty of Science Division II, Department of Mathematics
SHINOZAKI Tomohiro	Junior Associate Professor, Faculty of Engineering, Department of Information and Computer Technology
ANDO Shuji	Assistant Professor, Faculty of Engineering, Department of Information and Computer Technology
ISHII Aki	Assistant Professor, Faculty of Science and Technology, Department of Information Sciences
KAWASAKI Tamae	Assistant Professor, Faculty of Science Division I, Department of Applied Mathematics
NAKAGAWA Tomoyuki	Assistant Professor, Faculty of Science and Technology, Department of Information Sciences
TSUCHIDA Jun	Assistant Professor, Faculty of Engineering, Department of Information and Computer Technology
YAGI Ayaka	Assistant Professor, Faculty of Science Division I, Department of Applied Mathematics

*Director, **Visiting Associate Professor

Research Group

This research department is roughly divided into two groups that conducts research in the following fields.

1. Mathematical Statistics Basis Group
(Leader: Hiroki Hashiguchi (Department of Applied Mathematics, Faculty of Science Division I))

The "multivariate analysis group" comprises faculty members from Kagurazaka, Katsushika, and Noda Campuses and visiting associate professors. Focusing on the existing research themes of each faculty member, "multidimensional missing data analysis," "high-dimensional data analysis," "random matrix theory," and "dimension reduction method," we will conduct research with a view to developing the Applied Statistics Research Group. The "statistical model group" comprises faculty members from Kagurazaka and Noda Campuses and conducts research on topics such as "statistical modeling and model selection," "nonparametric methods," and "contingency table analysis." The method, handled by the Mathematical Statistics Basis Group, has a clear theoretical background and acts as a white box. However, the method of solving a "real-world problem" has a black-box aspect, such as in heuristics and deep learning. In constructing the theory of AI and data science, how to clarify the black-box-like solution of the latter using the methodologies of the former, as well as other methodologies, will be asked.

2. Applied Statistics Research Group
(Leader: Takashi Sozu (Department of Information and Computer Technology, Faculty of Engineering))

In the field of "medical statistics (biostatistics)," the faculty members of Katsushika Campus will conduct research activities related to the methodology of research design and data analysis, focusing on medical research. In particular, the Department of Information and Computer Technology, Faculty of Engineering, has an excellent and internationally acclaimed research track record, and new research is expected through intra and inter-group interactions. "Mathematical finance (time-series analysis)" will be studied mainly by the faculty members from Katsushika Campus, and research on the development of educational methods and systems via quantitative analysis in "educational engineering" will be conducted mainly by the faculty members from Kagurazaka Campus. Additionally, in recent years, the field of "sports statistics" has been gaining attention, and the faculty members from Noda Campus and visiting associate professors are actively conducting research in this field. Moreover, we plan to conduct joint research involving student exchange programs. Regarding the "statistical machine learning/mathematical optimization field," research on "natural-language processing that integrates statistical/machine learning and symbolic modeling," "large-scale nonlinear optimization problems related to big-data analysis and machine learning," and "statistical methods for computer-based data mining and pattern recognition" will be conducted mainly by the faculty members from Kagurazaka Campus.

Moreover, regarding one of the objectives of this research department, "collaboration with external institutions, such as companies, through a Data Science Center," a "data analysis team," which comprises research coordinators appropriate for each research content, will be formed, and joint research will be conducted.

Information and Societal

Established: April 2020

wakabayashi.hideki@rs.tus.ac.jp

Department of MOT Strategy & Fintech for Social Implementation

Director
Professor,
Department of Management of Technology, Graduate School of Management
Hideki Wakabayashi
Master of Engineering

Objectives	Contribute to systemization and database construction, social implementation, selection of research themes, and investment in venture companies. Do this with the tacit knowledge accumulated in MOT and TUSIM but not yet utilized, such as case studies and know-how in innovation, management, and venture business.
Future Development Goals	Creation of a database on know-how in evaluation will make it possible to increase the success rate of research theme selection, new business creation, M&As, and investment in venture companies.

There will be a coming together of top economists, top analysts, and venture capitalists who have conducted field surveys for many years in the fields of macro, semi-macro, and micro for the purpose of fusing technology with finance, and social science approaches with science and engineering approaches. They will transform the tacit knowledge of their analysis know-how into explicit knowledge using the latest technologies such as AI. In other words, the approach of professional specialists will be implemented in society using AI.

Implement the practical knowledge accumulated in Management of Technology (MOT) in society by utilizing the theory of financial engineering.

Think Tank" with technology and management, theory and practice, MOT and Innovation Capital

The purpose of this project is for MOT—which conducts practical education fusing theory with practice in technology management—and TUS Innovation Capital—which leads financial engineering—to interact with each other including the networks surrounding their organizations and personal connections, and to try various theoretical tools. The aim is to develop products utilizing advanced technologies and knowledge information, to conduct empirical research on new services, and to implement them in society. This can be called a think tank for the new Reiwa era, "TUS Research Institute."

In Management of Technology (MOT), many theoretical studies and case studies relating to innovation have been accumulated from large enterprises to venture companies. Various kinds of know-how, such as successful and failed cases of such technology strategies and investments in venture companies, are hidden as tacit knowledge in the field, including MOT, TUSIM, and VB investment track records of TUS. Some of them have been identified as case studies in papers and reports, although they are superficial, not transformed into explicit knowledge or practical knowledge, and nor are they related. They will become useful only when experts' knowledge is available. However, such know-how has not been passed on to the next generation, nor has it been shared within TUS and society. On the macro side, on the other hand, not only statistical data but also a lot of big data will be accumulated in the future. However, such macro data is explicit knowledge and is not linked to tacit knowledge and practical knowledge on a micro basis that is the background to making decisions in management strategy and conducting evaluations in VB investment. This may be due to the vertical division of expertise in each field, as well as insufficient exchange between macro and micro experts, technical and financial experts, and academic and business experts. In the future, many documents and kinds of know-how will be digitized and patterned by the development of AI. In addition, Center for Data Science of TUS has been established to enable knowledge sharing. Utilizing such AI, fintech, and ICT technologies, it will become possible to share and digitize kinds of know-how, accumulated at the micro level such as those within MOT and IM, link with macro statistical data, and fuse them.

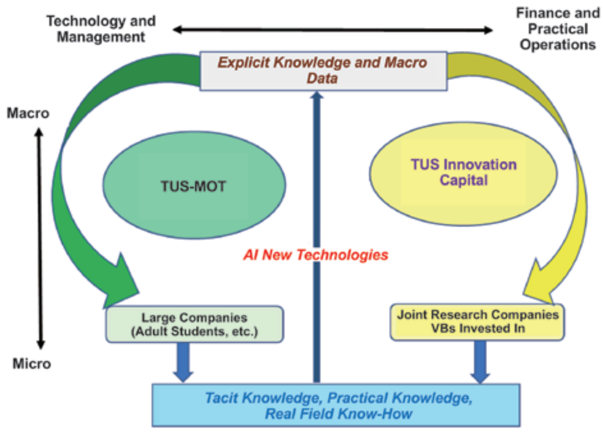
In-depth learning of tacit knowledge accumulated in hop, KPI extraction in step, and digitization in jump

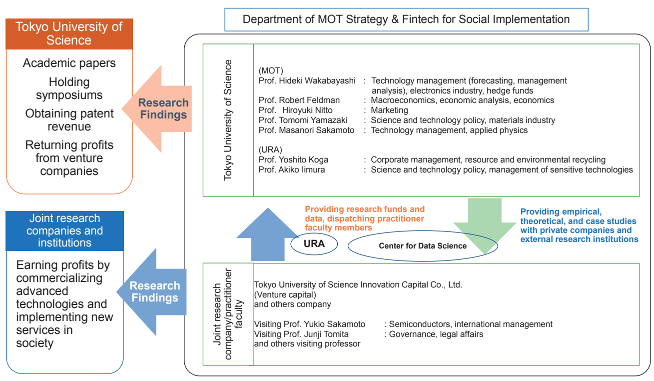
The first step is to extract keywords and KPIs that have been selected to the extent possible with respect to past MOT papers, and success/failure of published technical strategies and VB investments. Analysis is then performed on the relationship between these keywords/KPIs and data published externally, such as macro statistical data and annual securities reports. For example, we will analyze the correlation among the age and background of the manager, the mobility of employees, technology strategy, earnings, and VB investment.

As the second step, we will conduct interviews with corporate managers and VB investors who have many successful cases. In this way, we will analyze what are the key points for evaluation and investment decisions, and what decisions are made based on explanatory materials and questions and answers; and if necessary, we will conduct a questionnaire survey. We will then examine the relationship between this and the sample analysis described above.

For the third step, we will extract KPIs and keywords using AI, analyze the correlation with the macro-statistical data and the published data of annual securities reports, expand N, and make a database.

The figure shows the correlation analysis and mutual feedback between the real field know-how and practical knowledge of enterprises and VB investments at the micro level and macro statistical data. The horizontal axis shows the sharing of the cases and corporate strategies in MOT and the know-how in IM as a VC. On the Management of Technology side, it will become science and technology policy at the macro level while corporate strategy at the micro level; and on the IM and financial side, it will become portfolio construction in GPIF and policy of public and private funds at the macro level, while criteria for individual VCs to decide at the micro level.





It has been pointed out for a long time that innovation and the start-up of new businesses are stagnant processes in Japan, particularly lagging behind in the areas of big data analysis, deep learning and AI.

This may be due to overserious business practices, a fixed industrial structure, a highly mature working-age population structure, and other micro and macro conditions peculiar to Japan. Although from another perspective, it can be said that resources remain for high-quality growth. There is a possibility of creating a new industry by exploiting the opportunities for efficient use of abundant, highly useful data that have been kept idle in enterprises, although this can be achieved only through academic knowledge backed by practical experience. Collaborations with enterprises, external research institutes, and venture capital firms will be accumulated as research findings, and passed on to not only joint research partners but also widely to society.

Established: April 1999 fel-tus@rs.noda.tus.ac.jp

IR FEL Research Center

Director
Professor,
Department of Chemistry,
Faculty of Science Division I
Koichi Tsukiyama
Ph.D.

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 as a laser center equipped with mid-infrared and THz free electron laser, ultra-short pulse laser. and frequency tunable dye laser, etc.

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.

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

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 the high-frequency electron gun has its energy spread regulated by the α-magnet, and is forced toward the linear accelerator. The electron beam, now accelerated to a maximum 40 MeV, passes through a deflecting magnet and is led toward 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 the 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 1 mm-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, FELTUS 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 ~10 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. The peak power of micropulses is several MW, corresponding to a high photon density of 1026 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 a 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, MALDITOFMS, 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. However, due to deterioration of the hardware including the accelerator, difficulty of raising funds for operation, recent development of the wavelength conversion technique, rise of solid state MIR laser involving quantum cascade lasers and a new infrared free electron laser at KEK under construction, it is extremely difficult to maintain the standard of research activities as the center of free electron laser community. FEL-TUS will be closed at the end of March in 2021.

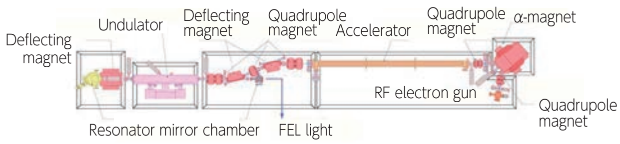


Fig. 1 Schematic outline of FEL-TUS

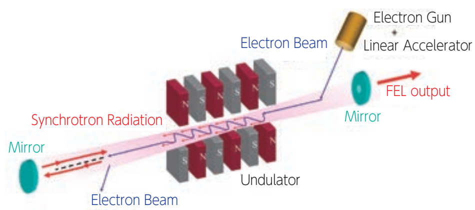


Fig. 2 Structure of undulator

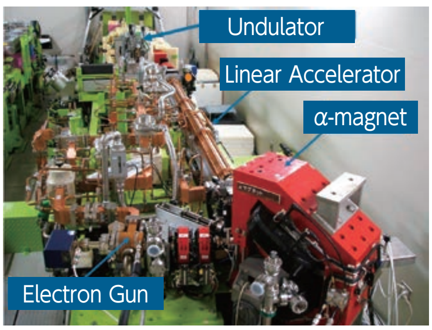


Photo Main body of the infrared free electron laser

Established: October 2016 ito_hiroyuki@rs.tus.ac.jp

Division of Modern Algebra and Cooperation with Engineering

Director
Professor,
Department of mathematics,
Faculty of Science and Technology
Hiroyuki Ito
Doctor of Science

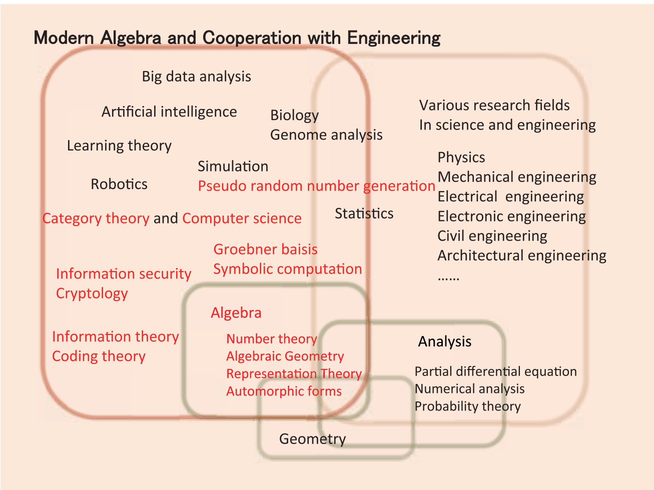
Objectives	To research and develop algebra itself and algebra based engineering, also to find new engineering fields cooperation with algebra, thereby making a contribution to mathematics and engineering.
Future Development Goals	To make contribution to mathematics and engineering, and to make the center of research on algebra and its applications to engineering.

This division do research from purely theoretical mathematics to experimental engineering, and make cooperative environment between mathematicians and researchers in algebra based engineering. Furthermore, the division will contribute to find new cooperative research fields between algebra and engineering which make mathematical innovation.

Theoretical research on algebra and its applications on engineering

Background and purpose of the division

It is important for mathematics, which has more than 2000 years history for research, to interact with other research fields outside mathematics. Research area of pure mathematics is roughly divided into three parts, algebra, geometry and analysis. One can think that algebra and analysis are two wheels of a cart, via geometry and geometric objects. In its long history, analysis, which treat mainly continuous objects, has been developed in interaction with various engineering technology. On the other hand, algebra, which treat mainly discrete objects, has been started to make interaction with information science, information technology, electrical and mechanical engineering, etc., after 20th century, and produce many useful results and effects which are indispensable for modern human life. Our division based on algebra are going to cooperate with another division "Mathematical modeling and its Mathematical analysis", and are going to be a basis of science and technology to cooperate with various research areas. And finally, to be a center of research on algebra and algebra based engineering.



Research on Modern Algebra and Cooperation with Engineering

The division consists of various researchers inside Tokyo University of Science, whose research fields are number theory, arithmetic geometry, algebraic geometry, commutative algebra, representation theory, automorphic forms, algebraic topology, discrete mathematics, combinatorial design, computational mathematics, computer algebra, cryptology, information security, coding theory, and applied algebra. In the past, these researchers have cooperated with each other in the occasion of seminars, workshops and international meetings. As an activity of this division, we pursue further cooperative relationship not only inside the division, but also outside the division, and we are going to produce many cooperative research between pure mathematics and engineering.

More precisely, the division consists of three groups for purely mathematical research and three groups for applied research. Pure mathematics groups are managed by holding seminars, workshops and symposiums on algebra, algebraic geometry, number theory, and so on. Engineering groups are also managed by making a place for engagement of researchers of pure mathematics and engineering, and by proposing and developing many research plans for both sides, mathematics and engineering.

There are three special features of this division. 1) The generations of researchers are widely distributed. 2) They have enough experiences of joint research not only for domestic but also for international. 3) The researchers have been managed continuously various seminars and symposiums inside Tokyo University of Science.

About the Future of Modern Algebra and Cooperation with Engineering

The first step is to make relationship between person and person in various research fields, which has already done. The second step is expanding the relationship between person and person to person and group. Final step is expanding the relationship to group and group, and developing a new cooperative research fields based on algebra.

Affiliation	Job title	Name	Academic degree	Main research field
Department of Mathematics Faculty of Science and Technology	Professor	Hiroyuki Ito	Doctor(Science)	Algebraic geometry Applied algebra
Department of Mathematics Faculty of Science Division I	Professor	Katsunori Sanada	Doctor of Science	Ring theory
Department of Mathematics Faculty of Science Division I	Professor	Masanari Kida	Ph.D	Number theory
Department of Mathematics Faculty of Science Division I	Professor	Naoko Kunugi	Doctor(Science)	Representation theory
Department of Applied Mathematics Faculty of Science Division I	Professor	Yosuke Sato	Ph.D	Computer algebra
Department of Applied Mathematics Faculty of Science Division I	Professor	Hiroshi Sekigawa	Doctor (Mathematical Science)	Computational Mathematics
Department of Information Sciences Faculty of Science and Technology	Professor	Nobuko Miyamoto	Ph.D (Management Science and Engineering Course)	Discrete mathematics Combinatorial designs and their applications
Department of Mathematics Faculty of Science Division II	Associate professor	Takaoh Sato	Doctor (Mathematical Science)	Algebra, Geometry
Department of Mathematics Faculty of Science and Technology	Associate professor	Hiroki Aoki	Doctor(Science)	Automorphic forms
Department of Mathematics Faculty of Science and Technology	Associate professor	Hisanori Ohashi	Doctor(Science)	Algebraic geometry
Department of Mathematics Faculty of Science and Technology	Associate professor	Toru Komatsu	Doctor(Science)	Number theory
Department of Mathematics Faculty of Science and Technology	Associate professor	Yoshitaka Hachimori	Doctor (Mathematical Science)	Algebra Number theory
College of General Education Faculty of Science and Technology	Associate professor	Takashi Nakamura	Doctor (MathematicalScience)	Analytic number theory
Department of Mathematics Faculty of Science and Technology	Associate professor	Tomokazu Kashio	Doctor(Science)	Number theory
Department of Electrical Engineering Faculty of Science and Technology	Associate professor	Yasutaka Igarashi	Doctor(Philosophy)	Information security Cryptanalysis
Department of Mathematics Faculty of Science Division II	Assistant Professor	Jiro Nomura	Doctor(Science)	Algebraic Number Theory
Department of Mathematics Faculty of Science and Technology	Assistant Professor	Enokizono Makoto	Doctor (Science)	Algebraic Geometry
Department of Mathematics Faculty of Science and Technology	Assistant Professor	Yuya Matsumoto	Doctor (Mathematical Science)	Algebraic Geometry

Established: April 2020 kato@rs.tus.ac.jp

Research Alliance for Mathematical analysis

Director
Professor,
Department of Mathematics,
Faculty of Science
Keiichi Kato
Mathematical Sciences

Objectives	To make interdisciplinary researches with researchers of mathematical analysis, numerical analysis, physics, chemistry, biology and engineering
Future Development Goals	We make research alliance with other divisions in our research institute and institutes outside the university

This division has been established on the April of 2020, as the succession of Division of Mathematical modeling and mathematical analysis. Our aim is to make interdisciplinary researches between mathematical analysis, numerical analysis, physics, chemistry, biology and technology. The members of our division are willing to cooperate to those who need to techniques of mathematical analysis, numerical analysis or theoretical physics.

Interdisciplinary researches between mathematical analysis, science and engineering

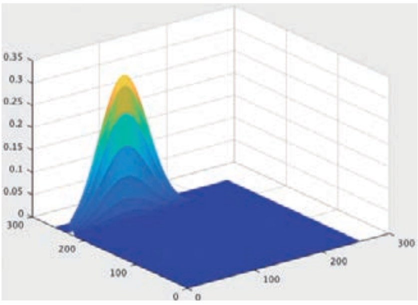
This division has been established on the April of 2020, as the succession of Division of Mathematical modeling and mathematical analysis. The aim of our division is to make alliance research over mathematical analysis, numerical analysis, physics, chemistry, biology and engineering.

Alliance inside the division

We make research alliance based on Three groups(Group of mathematical physics, Group of mathematical biology and Group of mathematical engineering).

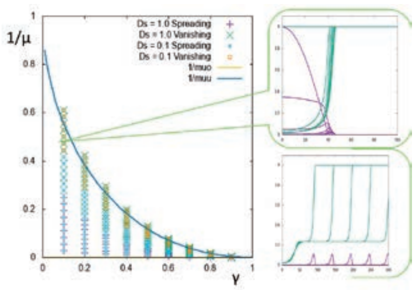
・Group of mathematical physics

The aim of the group is to establish original numerical method for Schrödinger equations based on representation of solutions via wave packet transform due to K. Kato and apply it to condensed matter physics. We have succeeded to establish original numerical method and are applying it to compute numerical solutions of Schrödinger equations.



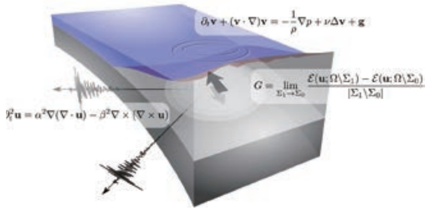
・Group of mathematical biology

We investigate asymptotic behavior of solutions of mathematical models including epidemiological models and Keller-Segel system for cancer invasion. One of our study is a free boundary problem that describes the spatial propagation of a transmitted disease. By a joint work among E. Ishiwata, T. Ushijima, Y. Enatsu, we have obtained a new result for existence and nonexistence of a traveling wave solution (a solution propagating in a direction with the same profile and the same speed). Starting February 2018, we have organized regular seminars relating to infectious diseases in Kagurazaka campus. In the seminar, talks on infectious diseases are given by researchers in the field of mathematics, biology, medical science.



・Group of mathematical engineering

This is a research group focused on mathematical analysis of various phenomena in continuum mechanics and applying to inverse problems. Especially, we study fracture phenomena for elastic structures, motion of vortex filaments, faulting rupture in seismology and so on. As regards inverse problems, we deal with reconstruction problems for discontinuity embedded in a medium, such as cracks, cavities, inclusions and obstacles, from observed data, which are arising from non-invasive tests for a living body, non-destructive tests in engineering and inversion of source process in seismology. The aim of the group is to provide theoretical foundations and their numerical implementation.



Alliance with other divisions in RIST

From the beginning of the 21st century, the importance of mathematics has been known more and more even in our country. In the research institute for Science and technology(RIST), we have two mathematical division: this division and the division of modern algebra and cooperation of engineering(DMACE). We will make research alliance with other divisions such as divisions of condensed matter physics, divisions of chemistry, divisions of biology and divisions of engineering with cooperation of DMACE.

Alliance with other institutes

On the January of 2020, we have concluded the agreement for research alliance between RIST and Research Alliance Center for Mathematical Sciences(RACMaS) in Tohoku University. We will promote research alliance between this division and RACMaS based on the agreement. We also try to make research alliance with other institutes.

Division of Nano-quantum Information Science and Technology

Established: April 2020

h-taka@rs.tus.ac.jp
takayanagi.h@gmail.com

Director
Professor,
Director General
Research Institute for Science and Technology

Hideaki Takayanagi
Ph.D.

Objectives	Our research division aims at optimization of the operation condition for superconducting, optical and spin qubits.
Future Development Goals	This division will contribute to the practical realization of the quantum computer thirty years later.

The research of quantum computer has been very active during the recent years. One of the reasons of the rapid progress is the improvement in coherence time of the qubit due to the advancement of nanotechnology. However, the current status of the quantum circuit is still far from the real implementation. We must accelerate the pace of research and development toward the truly fault-tolerant quantum computer.

Nanotechnology and its applications to quantum information and electronics

Background

A Canadian company D-wave Systems commercialized a superconducting quantum annealing machine in 2011. This sensational announcement has triggered the activation of quantum computer research and development in the world. The machine by D-wave Systems is not a universal quantum computer but a specialized machine for annealing which is designed for solving optimization problems. In contrast, there exist a universal quantum computer architecture based on a gate model. Recently, Google announced that they have achieved quantum supremacy demonstration by using a gate-type quantum computer. The big news made many researchers, institutes, and governments (including Japan's) reaffirm the importance of the research and development of gate-type quantum computer.

Our targets

Our division mainly investigate the superconducting qubit. Qubit cause errors like ordinary classical semiconductor circuits. Malfunction of the qubit also would come from the breakdown of the quantum superposition state. Such phenomenon is called decoherence. The fault-tolerant quantum computer would be realized by employing a quantum error correction procedure, and it would deliver truly practical applications. The division plans to carry out research of several kinds of fault-tolerant quantum circuits with superconducting qubits. It is expected that the fault-tolerant quantum computer would appear by 2050, and we would try to contribute to its realization.

Superconducting qubit is considered as the most suitable platform for the quantum computers. However, it also has its problems. The coherence time of superconducting qubit is still short, for example. Beside the superconducting qubit, qubits based on other physical systems, like photon, ion, atom and electron spin in quantum dot have been investigated earlier. In our division, spin qubit and optical qubit will also be investigated, along with the superconducting qubit.

Collaboration with the University of Tokyo

Other research activity of the division is the collaborated one with the University of Tokyo. The partner organizations are the Institute for Nano Quantum Information Electronics (NanoQuine) and Quantum Innovation Co-creation Center. The research subject is quantum optics utilizing single photon.

Members

affiliation	name
Tokyo University of Science	Hideaki Takayanagi
Tokyo University of Science	Jaw-Shen Tsai
Tokyo University of Science	Kaoru Sanaka
Tokyo University of Science	Mark Paul Sadgrove
Tokyo University of Science	Shohei Watabe
Tokyo University of Science	Noboru Watanabe
Tokyo University of Science	Satoshi Iriyama
Tokyo University of Science	Takeo Kamizawa
Tokyo University of Science	Yoichiro Hashizume
The University of Tokyo	Yasuhiko Arakawa
Riken	Seigo Tarucha
NEC	Tsuyoshi Yamamoto
NICT	Koichi Semba
NTT	Shiro Saito

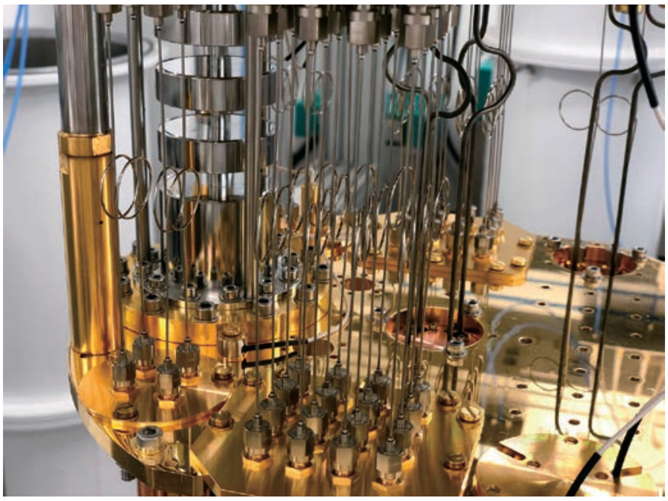


Fig. 1 Heart of the dilution refrigerator for superconducting qubits' evaluation. Multiple wideband signal lines can be seen.

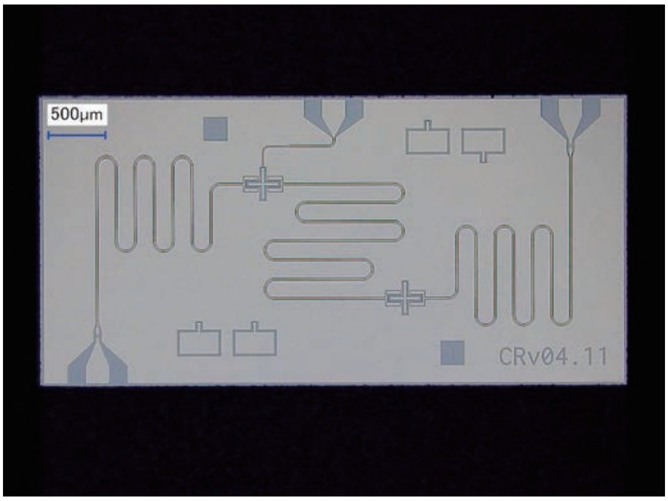


Fig. 2 2-bit quantum logic gate. Two transmon-type qubits (cross-shaped structures) are connected by a superconducting resonator.

(Tokyo University of Science, Tsai Laboratory)

Joint Usage/Research Center

Research Center for Fire Safety Science

Established: July 2009 ✉ kasaianzen-ml@tusml.tus.ac.jp

Director
Professor,
Research Institute for Science and Technology
Ichiro Hagiwara
Ph.D.

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.

Open Call 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

[General Category, A~F]

A. Fundamental research on building fire safety
(Examples from the past)

- An experimental study on measurement method and estimation algorithm of radiant heat flux from large scale facade fire

B. Fundamental research on material combustion science

- Measures for controlling fire propagation at the surface of wooden linings
- An investigation of the measurement methods of lateral flame spread rate over wall lining materials
- FT-IR/Thermal Decomposition Analysis of Surface Combustion Characteristics in Flame Retardant Cross-Laminated Timber with Intumescent Nano-Clay Composites

C. Fundamental research on fire safety and disaster prevention

- An Experimental Study on Fire Prevention Effect with High Viscosity Liquid on A Wood Board

D. Fundamental research on large-scale fire

E. Research on technology and measures pertaining to fire safety

F. R & D issues that can be expected for technological innovation to reduce fire risk

[Emphasis Category, G] (※)

G. Experimental Research on Building Structural Fire Resistance

(※) Large-scale experimental challenge to use Structural Fire Resistance Furnace, or Multiple Full-scale Furnace

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 10 members (5 from inside and 5 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)

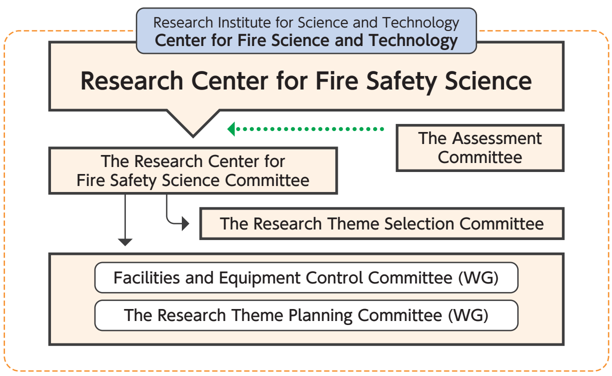
This committee (WG) is primarily involved in the operation planning of the full-scale experimental facilities. It is also responsible for the maintenance of facilities and equipment installed in the institution. In addition, it gives users instruction on how to use these facilities and equipment and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

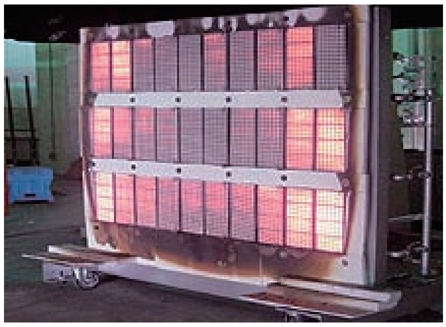
Example of Available Facilities/Equipment

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.

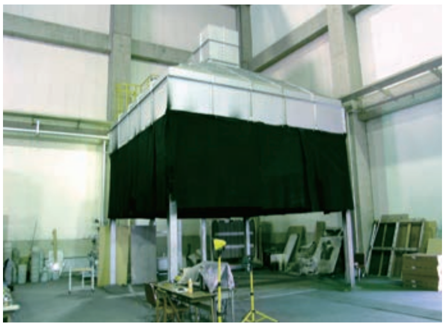
FTIR Gas Analyzer

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.



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-tatamimat 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.

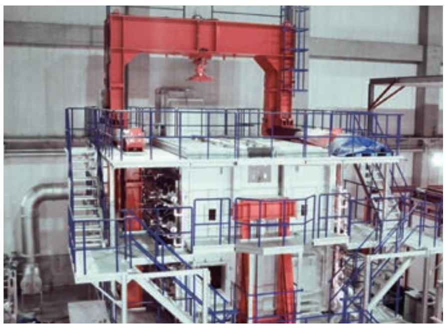
In addition, flashover experiments can be performed with this unit by recreating fires that spread to entire rooms in a short time period, and then combustible gas concentration and temperature distribution data can be collected. The development of the fire can be captured by video camera.

Structural Fire Testing Furnace (Medium scale)

This unit is used to evaluate the fire-resistive 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.

Structural Fire Testing Furnace (Large scale, for Walls)

This unit is used to evaluate the fire-resistive 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.



Multiple Full-scale Furnace

This device is used to measure the fire-resistive duration of horizontal materials of buildings including beams, floors and roofs by using the standard heating test (ISO834). Fire-resistive 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.

Joint Usage/Research Center

Photocatalysis International Research Center (PIRC)

Established: April 2015　PIRC@rs.tus.ac.jp

Director
Distinguished Professor
Akira Fujishima
Ph.D.

Objectives
PIRC aims to be a core institute of photocatalytic researches by opening our facilities enable to evaluate photocatalytic performance, and promoting to create a community of researchers via collaborate research.

Future Development Goals
PIRC aims to realize 1) energy-saving and eco-friendly society, 2) safe, secure, and healthy society, and 3) comfortable space through the implementation of photocatalysts.

The 21st century is called the "environmental century". We are now facing several problems such as global warming, depletion of resources, and air/water pollution. Photocatalyst is an "environmental technology" having various potentials. We would like to make PIRC a hub for photocatalytic researches, develop a photocatalytic research field by promoting worldwide collaborative researches, and then contribute to solve various problems.

By utilizing unique facilities in PIRC, we deepen a photocatalytic science for social implementation.

Background of photocatalysts

The development of photocatalysts has been attractive in these years. Photocatalysts have been not only studied in various research fields including especially environmental and energy-related fields but also used in a variety of products.

Followed by the epoch-making report on water splitting by Fujishima and Honda in 1972, the photocatalytic properties have been used to convert solar energy into chemical energy to obtain useful materials including hydrogen and hydrocarbons by oxidizing or reducing materials and to remove pollutants and bacteria on the wall surfaces and in air/water.

Among various photocatalysts, TiO_2 has been the most widely studied and used in many applications because of its superior properties such as strong oxidizing abilities to decompose organic pollutants, superhydrophilicity, chemical stability, long durability, nontoxicity, low cost, and transparency to visible light. The photocatalytic properties of TiO_2 are derived from the formation of photogenerated charge carriers (i.e., holes and electrons) induced by absorbing ultraviolet (UV) light of which energy is equal or greater than the band gap energy of TiO_2. The photogenerated holes/electrons in the valence/conduction band diffuse to the TiO_2 surface and oxidation/reduction is occurred and active species such as radicals are frequently formed. To give an example, electrons in the conduction band typically react with molecular oxygen in the air to produce superoxide radical anions ($O_2^{\cdot-}$). Formed active species attract organic pollutants/bacteria and decompose/sterilize them.

In addition, TiO_2 surfaces become superhydrophilic with a contact angle less than 5° under UV-light irradiation. The superhydrophilicity is originated from the change of chemical conformation on the surface. The majority of the holes are subsequently consumed by reacting directly with adsorbed organic species/water. However, a small proportion of the holes is trapped at lattice oxygen sites and may react with TiO_2 itself, which weakens the bonds between the lattice titanium and oxygen ions. Then, water molecules can interrupt these bonds, forming new hydroxyl groups. The singly coordinated OH groups produced by UV-light irradiation are thermodynamically less stable and have high surface energy, which leads to the formation of a superhydrophilic surface. Superhydrophilicity is used for anti-fogging and self-cleaning of the surface.

By utilizing above features, materials and applications involving TiO_2 have a potential to improve our lives from a perspective of energy production and environmental cleanup.

History of PIRC

To be a hub of the photocatalytic research network for an accelerative research progress and the development/spread of the technology, PIRC opens facilities for photocatalytic studies and collaborates with various researchers. PIRC was selected as a "Program for Promotion of Joint Research Centers" by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and started from April 2015. In 2018, MEXT decided to enforce PIRC as Joint Usage/Research Center.

Purpose of PIRC

Tokyo University of Science (TUS) holds up "Building a Better Future with Science" as our slogan and aims to be a global university with the international competitiveness, envisioning ourselves not only as TUS of Japan but also TUS of the world. PIRC aims to be a hub for photocatalytic researches by opening our unique apparatus and promoting collaborations with outstanding researchers.

Photocatalyst is a Japan-origin technology, starting from the Honda-Fujishima effect, and Japan has been a leader since its discovery. PIRC advertises this fact and guides the further development of photocatalytic study through inevitable collaborative researches.

Features of PIRC

Although photocatalysis industry is developed to 100 billion JPY, society still demands many kind of highly-developed applications. PIRC promotes GENUINE researches creating clean environment and energy through air/water purification by self-cleaning effect and strong oxidation ability and solar-driven material conversion (artificial photosynthesis), respectively.

PIRC promotes the use of JIS and ISO-based facilities for photocatalytic performance evaluation. Furthermore, PIRC support the development of photocatalyst based on a novel synthesis technique such as state-of-the-art plasma process. PIRC also promotes academic researches toward social implementation by opening our facilities to public and collaborative researches. As examples of the social implementation of photocatalyst, PIRC aims to realize 1) energy-saving and eco-friendly society, 2) safe, secure and healthy society, and 3) comfortable space.

Figure 1 Board of PIRC as Joint Usage/Research Center

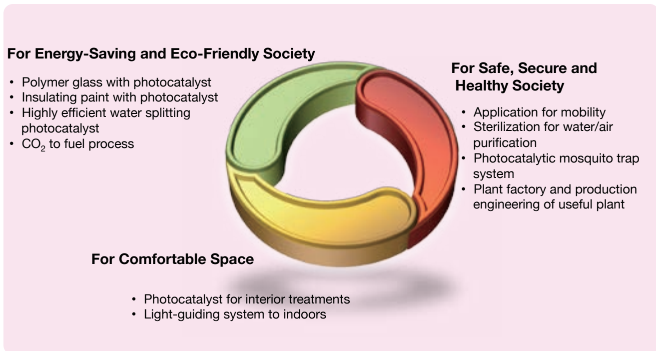


Figure 2 Researches at PIRC

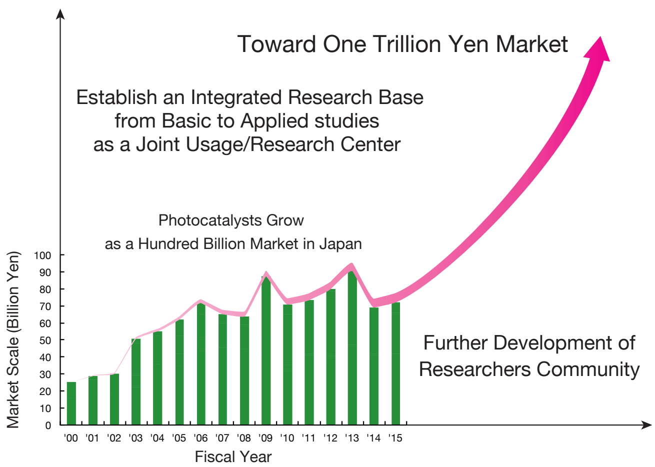


Figure 3 Goal of PIRC

Rist Organization Chart

- Chairman of the Board of Governors
  - President
    - Organization for Research Advancement
      - Research Institute for Science & Technology
        - Research Institute for Science & Technology Steering Committee

Research Institute for Science & Technology

Research Divisions

- Atmospheric Science Research Division
- Division of Super Distributed Intelligent Systems
- Brain Interdisciplinary Research Division
- Division of Intelligent System Engineering
- Division of Modern Algebra and Cooperation with Engineering
- Division of Nanocarbon Research
- Division of Colloid and Interface Science
- Chemical Biology Division Supported by Practical Organic Synthesis
- CAE Advanced Composite Materials and Structures Research Division
- Academic Detailing Database Division
- Division of Nucleic Acid Drug Development
- Division of Advanced Urbanism and Architecture
- Division of Synthetic Biology
- Renewable Energy Science & Technology Research Division
- Division of Ambient Devices Research
- Division of Biological Environment Innovation
- Statistical Science Research Division
- Department of MOT Strategy & Fintech for Social Implementation
- Research Alliance for Mathematical analysis
- Division of Nano-quantum Information Science and Technology

Research Centers

- Center for Fire Science and Technology
- IR FEL Research Center
- Photocatalysis International Research Center
- Water Frontier Science & Technology Research Center
- Research Center for Space Colony
- Center for Animal Disease Models

Joint Usage / Research Center

- Research Center for Fire Safety Science
- Photocatalysis International Research Center

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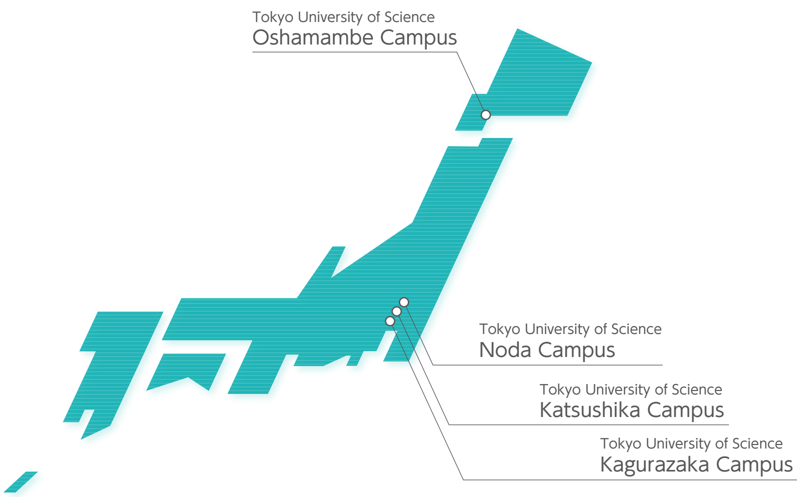
Campus Map



Tokyo University of Science
Research Support Division

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Katsushika Campus 6-3-1, Niijuku, Katsushika-ku, Tokyo, 125-8585 JAPAN

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Tokyo University of Science

2020/2021

RIST creates new directions in science and technology achievable "only at TUS".