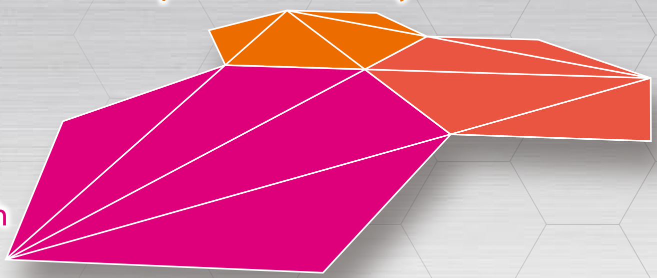
TOKYO TECH RESEARCH 2019-2020

東京工業大学
Tokyo Institute of Technology

Research at Tokyo Tech

Since its founding in 1881, Tokyo Tech has stood at the front line of research as one of the world's leading universities in science and engineering. Building upon the Institute's long-standing philosophy of *monotsukuri*, or technical ingenuity and innovation, Tokyo Tech consistently produces high-impact research across numerous science and technology fields, including physics, chemistry, mechanical engineering, materials science, environmental engineering, and life sciences.

Three Crucial Engagements in Research



From President Masu

As a national designated university corporation where the world's highest pedigree of education and research is expected, Tokyo Tech seeks new potential among science and technology and aspires to pioneer a new era in discourse with society. This pamphlet presents the essence of our institution's research from three perspectives: creation of innovative science and technology; search for truth and acquisition of new wisdom; and deployment of wisdom in society. I would be pleased, if the reader gains a sense of the future from the many research efforts at Tokyo Tech, a lens from which new alliances between industry and academia could emerge. The diversity groomed in a university setting provides opportunities to conduct exciting and intriguing research under fast-paced decision-making and execution. As we challenge ourselves to pursue research that will contribute to society, I ask you to look forward to the research prowess at Tokyo Tech.

President
Kazuya MASU

Staff/Students

Faculty
1,489 (International: 129) — % International 8.7%

Research Staff
290

Administrative Staff
595 (Female: 254) — % Female 42.7%

Students
10,212 (Female: 1,600) (International: 1,431) — % Female: 15.7% — % International: 14.0%

Bachelor's
4,828 (Female: 637) (International: 249)

Master's
3,947 (Female: 679) (International: 659)

Doctoral
1,437 (Female: 284) (International: 523)

Awards

Nobel Prize **Yoshinori Ohsumi, Honorary Professor, 2016 Nobel Prize in Physiology or Medicine**
"Elucidating the Molecular Mechanisms and Physiological Significance of Autophagy, a Cellular Adaptive System to Environment"
Hideki Shirakawa, PhD, 2000 Nobel Prize in Chemistry
"For the Discovery and Development of Conductive Polymers"

Japan Prize **Hideo Hosono, Professor, 2016**
"Creation of Unconventional Inorganic Materials with Novel Electronic Functions based on Nano-Structure Engineering"
Yasuharu Suematsu, Honorary Professor, 2014
"Pioneering Research on Semiconductor Lasers for High-Capacity Long-Distance Optical Fiber Communication"

Publications

Total 12,464 — Top 1% 170 — % International Co-Authorships 38.8%

Industry Collaboration

Patent Income
280 million yen(2017)

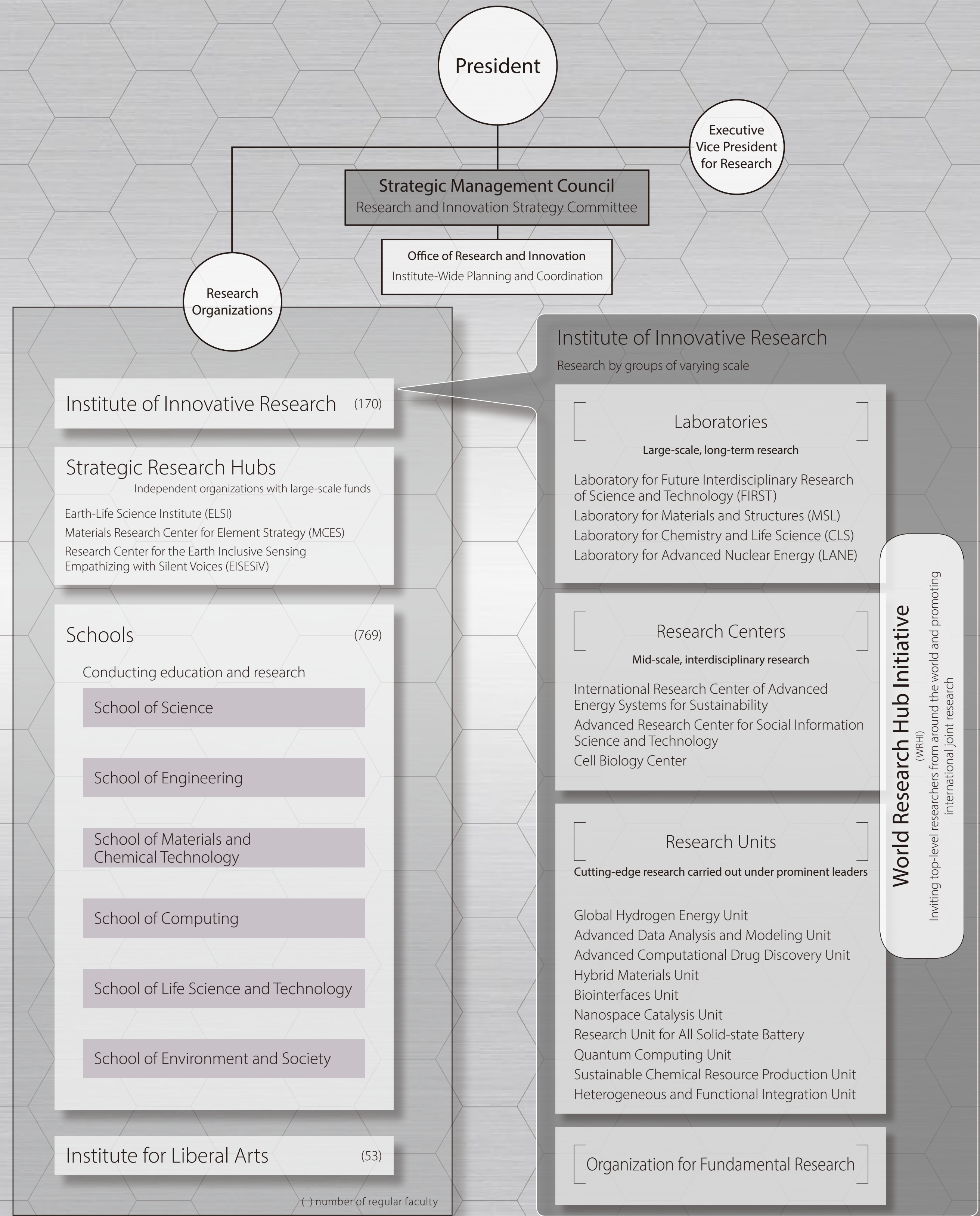
Tokyo Tech Ventures
92 companies (As of December 2018)

Income/Expenses

46.02 billion yen

(Personnel data as of May 2018; Publications, Top 1%; 2013-2017, 5-year span, Web of Science; International Co-Authorship; 2017, Web of Science; Income/Expenses; estimated for fiscal year 2018)

Research Structure



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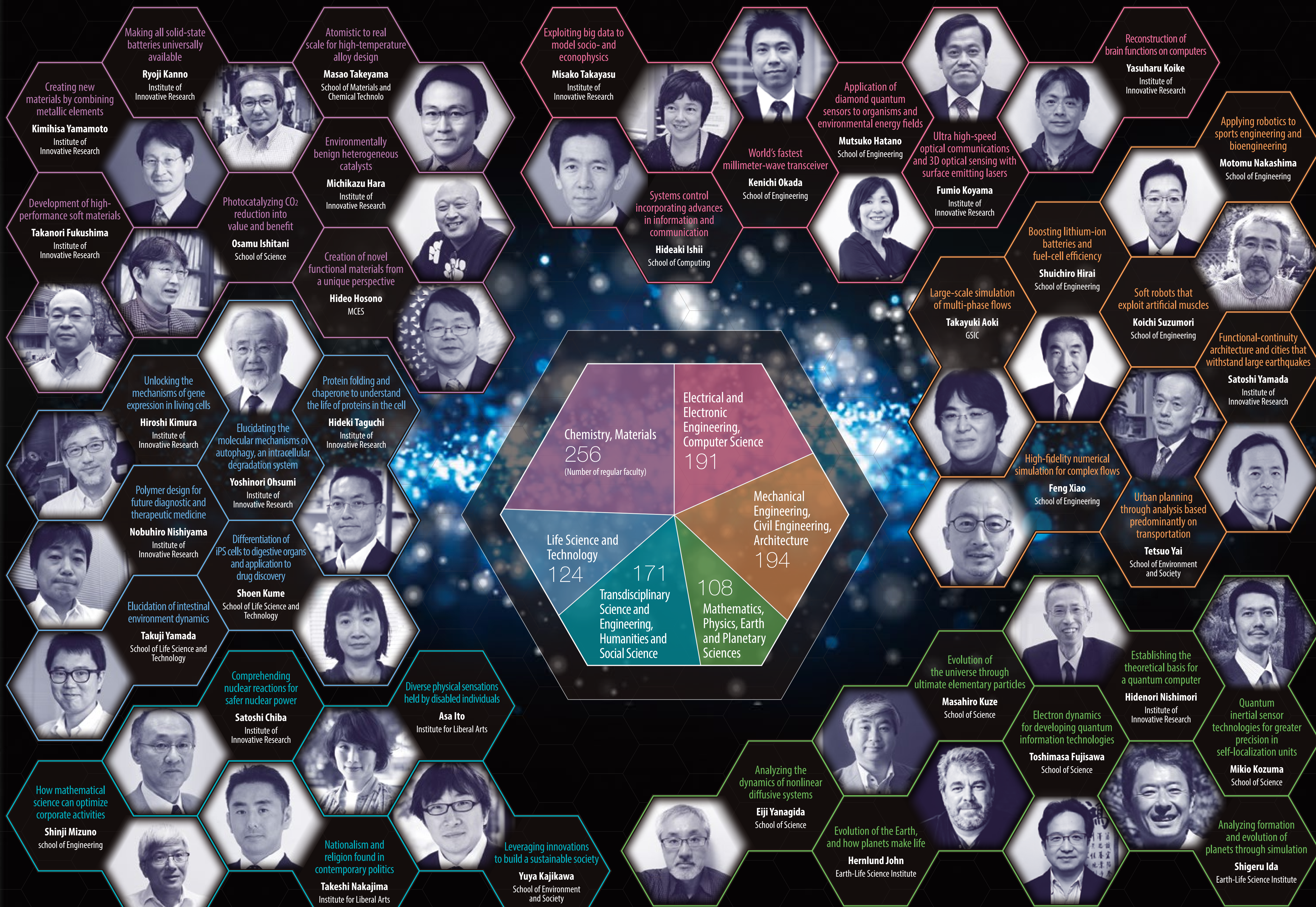
TOKYO TECH RESEARCH MAP 2019-2020



MCES: Materials Research Center for Element Strategy GSIC: Global Scientific Information and Computing Center

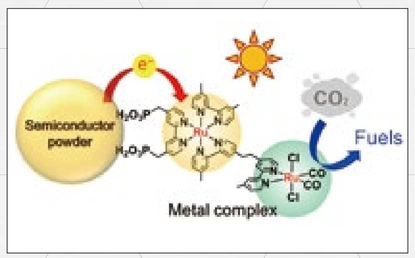
For the betterment of society

Global Environment and Energy

A photocatalyst that recycles CO_2

Osamu Ishitani, Kazuhiko Maeda
School of Science

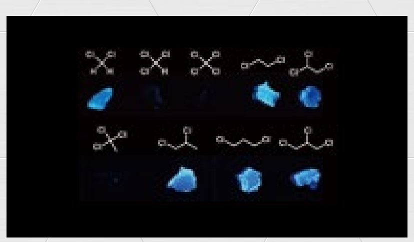
A hybrid material constructed with two completely different substance groups, a metal complex and semiconductor, is used to achieve CO_2 fixation at ambient temperatures and pressures. It has attracted global attention as a new artificial photosynthesis technique and has led to the creation of an unprecedented interdisciplinary field. Since 2013, relevant publications have been cited more than 700 times. Further developments are expected to produce breakthrough results that contribute to solving future energy and environmental problems.



A polymer gel for simple detection of specific environmental pollutants

Gen-ichi Konishi
School of Materials and Chemical Technology

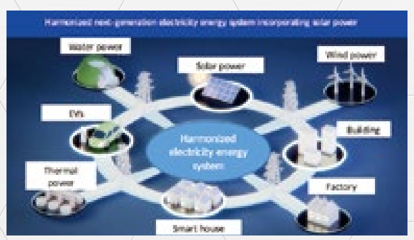
Konishi discovered that a blue-fluorescent dialkylaminonaphthalene dye can act as a bifunctional sensor for trihalomethane (an environmental pollutant). When the molecule is irradiated with UV light, fluorescence quenching and degradation occur. Using this photo-trigger molecule as a cross-linker, he designed a polymer gel sensor for trihalomethane. The polymer gel can detect a small amount of trihalomethane under black light (UV) irradiation via two processes, fluorescence quenching and degradation of the gel into liquid.



Development of a solar power-focused next-generation electrical energy system

Jun-ichi Imura
School of Engineering

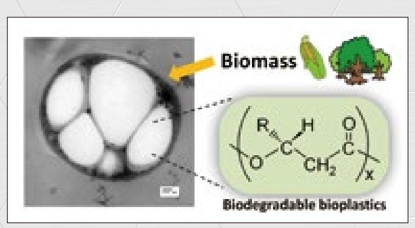
We are conducting joint research and development for a power system control method which utilizes photovoltaic power predictions to achieve harmonized and stable supply of electricity power even when a large amount of photovoltaic power generation has been implemented. The joint research is being conducted by researchers at 17 domestic universities and research centers (76 researchers) and 8 foreign universities. It is extremely difficult to predict photovoltaic power output. Furthermore, in the case of photovoltaic power, its generation is only possible during limited time periods. Therefore, we are working to comprehensively develop an energy management method which assumes that major discrepancies with predictions will occur, and which utilizes storage battery control and electricity market mechanisms. Based on this development, we seek to construct a next generation energy system that will serve as the foundation of a super-smart society.



Microbial synthesis of eco-friendly plastics

Toshiaki Fukui
School of Life Science and Technology

Although plastics are essential materials for the modern society, most existing plastics are synthesized from fossil resources. As such, their production and waste treatment have various impacts on the environment. Polyhydroxyalkanoates, which are polyesters synthesized and accumulated within microbial cells as storage compounds, are eco-friendly bioplastics because they can be produced from renewable biomass



resources and are easily degraded by environmental microbes after use. We constructed recombinant microbial strains than can efficiently produce polyesters exhibiting practical properties using genetic and metabolic engineering. The use of such bioplastics are expected to contribute to establishing a sustainable society.

Energy and environmental research from a global perspective

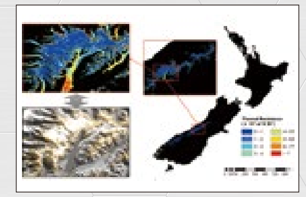
Mika Goto, Jeffrey S. Cross
School of Environment and Society

Goto studies energy and environment issues from a corporate management and innovation perspective. She uses a variety of data to analyze productivity improvements and the promotion of technological progress taking into account the social dimension of companies such as dealing with environmental protection and leveraging human resources, conducting research on future corporate management in a sustainable society.
Cross conducts research on future energy policy and educational technology in fields such as sustainable energy, biofuels, and engineering education. He is also actively engaged in the development and production of massive open online courses (MOOCs), as well as research in the field of online learning analytics.

Designing the future earth environment

Manabu Kanda, Shinjiro Kanae
School of Environment and Society

Kanda applies cutting-edge technology in the study of urban meteorology. He uses supercomputer-driven urban weather forecast technology, the world's only outdoor urban test facility, and advanced environmental observation technology to understand city-specific weather such as heat islands, heatstroke, torrential rain, and atmospheric pollution on a global scale.
Kanae is broadly engaged in research on water cycles and water resources. With "Earth the water planet" as his research theme, his investigations extend from counter-measures for heavy rain and floods in Japan to exploring the sustainability of water resources, food, and renewable energy on a global scale 100 years down the road.

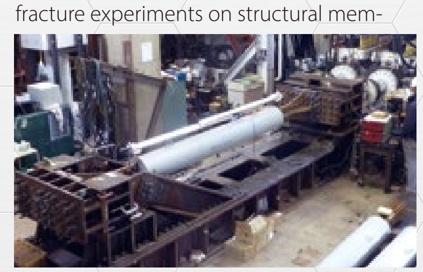


Earthquake and Disaster Mitigation

Seismic resistant technology for steel building structures

Satoshi Yamada
Institute of Innovative Research

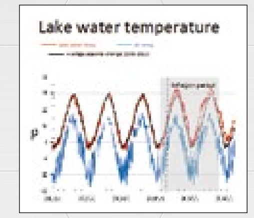
In order to mitigate seismic damage, Yamada develops seismic isolation and passive control technology as well as seismic resistant renovation technology for steel buildings such as high-rises and gymnasiums. To evaluate to the full extent seismic performance of steel building structures under extreme severe earthquakes, he investigates a broad range of research topics, including seismic response analysis of steel structures based on the realistic hysteretic behavior of structural components, fracture experiments on structural members, and evaluation of energy input due to earthquake. He is also conducting research on whole-scale safety improvements for buildings, including non-structural components and equipment.



Multidisciplinary monitoring of Kusatsu-Shirane volcano by integrating geophysics and geochemistry

Kenji Nogami, Akihiko Terada, Wataru Kanda, Yasuo Ogawa
School of Science

Kusatsu-Shirane volcano in the northwest corner of Gunma is one of Japan's 111 active volcanoes. Tokyo Tech has been continuing observational research at the volcano for over half a century. The Kusatsu-Shirane Volcano Observatory was established in 1986 in Kusatsu town, and continues observational research and forecasting of phreatic eruptions. Phreatic eruptions have extremely faint precursors, so eruption forecasting remains a challenge. However since March 2014, researchers have tracked how Kusatsu-Shirane has become active with regards to ground deformations, seismic activity, total magnetic intensity, and compositions of crater-lake water and fumarolic gas. These results have led to disaster countermeasures by the Japan Meteorological Agency and the Kusatsu-Shirane Volcanic Disaster Prevention Council.

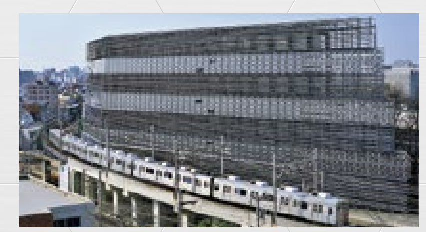


Architecture and Transportation

Challenges for creating a safe low-carbon society

Toru Takeuchi, Yoshiharu Tsukamoto
School of Environment and Society
Manabu Ihara
School of Materials and Chemical Technology

Takeuchi, Tsukamoto, and Ihara oversaw the architectural design of the Environmental Energy Initiative (EEI) Building, a globally unique building with an energy system that supplies nearly 100% of the power consumed within, reducing carbon dioxide emissions by over 60%.
Takeuchi engages in research to create "elegant and tough" architecture with a focus on spatial steel structures such as space trusses and tension structures, as well as response control technologies, based on the concept that buildings must be resistant to natural disasters, but should also be beautiful.

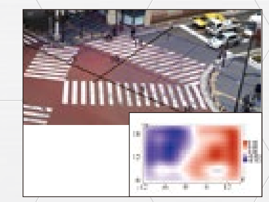


Tsukamoto is exploring better inter-relationships between architectural composition, the "behavior" of people and nature, and social frameworks for systems through research on and engineering of architectural design, based on the ethnographical wisdom of architecture responding to the local climate and their ecology of livelihood.
Ihara oversees the design of energy systems for the EEI Building, developing and evaluating the smart energy system Ene-Swallow that controls 1.4 MW of solar cells, fuel cells, gas engines, and batteries on campus, and also works on future energy system and scenario research using big data.

Intensive research on transport, cities, and the environment

Yasuo Asakura, Tetsuo Yai, Shinya Hanaoka, Yasunori Muromachi, Daisuke Fukuda
School of Environment and Society

The Transport Studies Unit (TSU) is conducting research for planning, operation, system design, and other elements of transportation systems for realizing a safe and high-quality lifestyle. Asakura is using IT technology to observe and analyze the movement of people and automobiles, and is researching transport management in the event of emergencies. Yai is researching human-centered infrastructure planning spanning from the formulation process of transport plans, citizen participation, and air traffic control to transport policies for railways, roads, and bicycles. Hanaoka is conducting transport development studies for solving the problems to prevent the growth of developing and emerging countries. Based on the keywords of urban planning and transport planning, Muromachi is researching urban planning such as compact cities, climate change in urban and transport sector, and real-time transport modelling and safety measures. Fukuda is utilizing big data to conduct analytical and applied economic research on a wide range of mobility from national scale transport to pedestrian movement.



Health, Medicine, and Supporting People with Disabilities

Creating new materials that are people- and environment-friendly

Hideki Hosoda
Institute of Innovative Research

Hosoda conducts research and

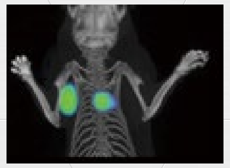
development on new shape-memory and superelastic materials using alloy design, working with virtually all elements on the periodic table. Being both safe and ductile, these materials allow for easy X-ray and MRI photography, and are expected to progressively improve vascular disease therapy instruments for heart disease and strokes. In addition, he develops complex materials using magnetic shape-memory alloys, as well as conducting research on actuators remotely controlled with a magnetic field. These research results are attracting attention both for functions surpassing conventional materials and as new technologies to benefit both people and the environment.


Stents from gold-based superelastic alloys

Shedding light on cancer treatment by focusing on hypoxia

Shinae Kondoh
School of Life Science and Technology

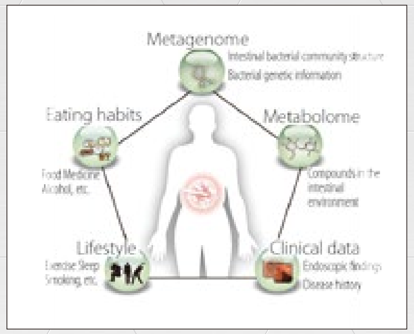
We have been developing novel anti-cancer strategies that focuses on tumor microenvironments (especially hypoxia). For example, to identify new therapeutic target, we are working on hypoxia inducible factors (HIF), important transcription factors in malignant progression, and immunosuppressive cells. Furthermore, in order to visualize therapeutic targets and evaluate the therapeutic effect of developed drugs, we are developing mouse models using *in vivo* optical imaging and developing world-leading imaging technologies and imaging probes. In the future, we will further develop therapeutic methods targeting tumor microenvironment and promote the development of new diagnostic equipment and imaging probes using light by enhancing interdisciplinary integrated research in Tokyo Tech.



Multidimensional analysis for the human gut environment

Takuji Yamada
School of Life Science and Technology

Yamada conducts research to elucidate how the human intestinal environment affects health, with a focus on the intestinal microbiome. He cooperates closely with clinical doctors, collecting multidimensional data for the human intestinal environment, such as intestinal microbiome, metabolites, lifestyles, eating habits, or endoscopic data. One of the main purpose of this project is to identify intestinal environment factors causing colorectal cancer. The current focus is on colorectal cancer, but data and insights from this project will certainly be used for a variety of other diseases.



Information and Communication Technology (ICT) in Education

Development of learning support systems using ICT

Masao Murota
Institute for Liberal Arts

Nowadays everyone carries a network-connected device such as a smartphone or tablet. Leveraging this type of environment, Murota researches learning support systems for enabling collaborative study, rather than just individual study, in a variety of locations such as classrooms, homes, and destinations outside the home. Specifically, he develops support systems for English speaking, outdoor disaster preparedness education, and peer review using video, as well as computer test systems using tablet devices. Taking a research approach to educational technology, he develops learning support systems with novel functions and collects data to demonstrate their effectiveness.

Social Science

Making social contributions through "participation-based studies"

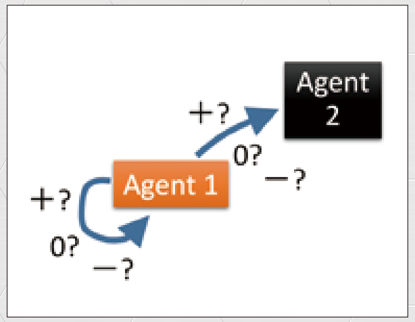
Tatsuya Yumiyama
Institute for Liberal Arts

Yumiyama engages in efforts to connect academicism, the religious world, and civil society. Following the 2011 Tohoku earthquake and tsunami, he organized community-based logistic support and student volunteers, and continues to be personally involved in local recovery efforts. Based on this practical experience, he advocates "participation-based studies" organized around collaboration with and closer proximity to subjects of study, as opposed to traditional research methods based on detachment from the subject. These efforts extend not only to research on disaster-affected areas, but also to social contributions through education (especially life education) and religion (particularly those to end poverty), as well as exploring the social contributions of research.

Integrating game theory and social network theory

Takehiro Inohara
Institute for Liberal Arts

By integrating game theory and social network theory, Inohara has developed a framework for simultaneous analysis of interests between agents and relationships within groups and society, analyses which were previously performed separately. He applies this framework to the analysis of decision-making and consensus-building. Employing quantitatively developed theories, he integrates the time needed for the formation of associations (cliques and party factions) and decision-making into a framework, with the goal of extending it to conflict resolution, cross-cultural understanding, and organizational development in groups and in society.

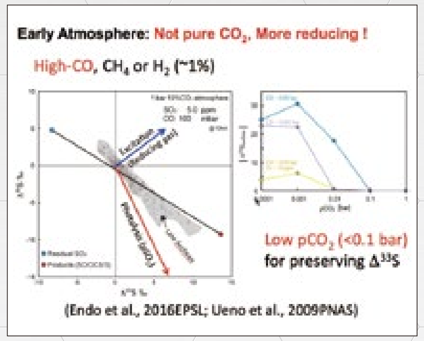


Origin of the Earth, Universe and Life

Carbon monoxide in the early Earth atmosphere

Yuichiro Ueno
School of Science

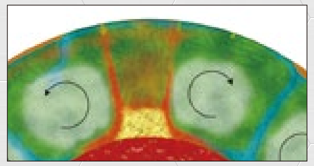
An isotopic anomaly of sulfur was found in Earth rocks that were more than 2.5 billion years old. The cause was thought to be ultraviolet rays striking Earth's early atmosphere, which was virtually devoid of oxygen. But that is only one of the leading theories. Ueno's group was able to recreate this scenario in the lab and show that the amount of carbon dioxide was less than previously thought. This has led to new insight that Earth's early atmosphere instead had a high concentration of carbon monoxide.



Proposing the "conveyor belt model" as a new theory for general circulation of the Earth's mantle

Maxim D. Ballmer, Kei Hirose et al.
Earth-Life Science Institute

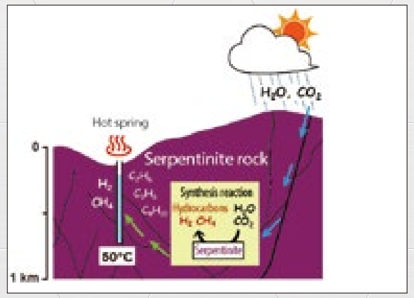
By examining the convection agitation motion of the mantle, we added a high-viscosity substance rich in silicon dioxide to the numerical simulation of mantle convection. As a result, after the significant reversal in the stratified structure which was assigned as an initial condition, the mantle assumes a large roll-shaped convective cell structure. In this state, the fragile rock which possesses a small amount of silicon dioxide accumulates in the upper area. In the bottom of the mantle, there is a solid block containing a large amount of silicon dioxide. We observed that circulation occurs around this block like a giant belt conveyor. Although most plates sink, the existence of this solid range explains why some plates do not sink to the bottom of the mantle, instead of stagnating at an intermediate depth. For many years, the reason why ancient rock remains in the convecting mantle was a mystery to most scientists. However, it may be possible to explain this mystery as the result of a lack of mixing between solid rock possessing large amounts of silicon dioxide and a mantle which is depleted of silicon dioxide and is much more brittle.



Estimating the formation process of hydrocarbons on early Earth before the emergence of life

Naohiro Yoshida, Shigenori Maruyama, Ken Kurokawa
(currently at the National Institute of Genetics)
Yuichiro Ueno
Earth-Life Science Institute

The rock known as serpentinite is only slightly exposed on today's Earth surface, but it was the most common rock on the seafloor immediately following the formation of Earth. This rock reacts with water to form high-concentration hydrogen gas, which may have promoted the formation of energy and organic matter needed for the emergence of life. A study of hot springs in the Hakuba region of Nagano Prefecture revealed that the methane in this hot spring gas contains the same level of deuterium as hot spring water. In other words, the hydrocarbons of hot springs were synthesized from the water there. This discovery that hydrocarbons (from which life arose) were formed by a previously unknown inorganic chemical reaction hints at one possibility of how life emerged on early Earth.



Formation of hydrocarbons on the serpentinite surface

The search for extrasolar planets

Bunei Sato
School of Science
Exoplanet Observation Research Center

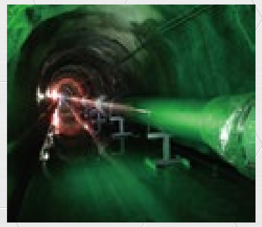
We have learned that there are many planets in the universe orbiting stars other than the Sun. They are called extrasolar planets or "exoplanets". The Center was founded in 2017 with the goal of revealing what the diverse exoplanets in the universe are like through astronomical observation, and shedding light on the formation and evolution processes of planetary systems, including our solar system. The research group leads in the search for planets revolving around stars even larger than the sun, called giant stars. Roughly 30 exoplanets have been discovered, and in 2016 two very strange exoplanets which potentially orbit one another in reverse were discovered by nearly nine years of observations using large telescopes in Japan and abroad. The group is aiming to discover many more exoplanets and contribute to transforming humankind's view of the cosmos.


Star HD47366 around which a new exoplanet was discovered (National Astronomical Observatory of Japan)

Developing a gravitational wave detector

Kentaro Somiya
School of Science

The first observation of gravitational waves, ripples in space-time predicted by Einstein, was made by the LIGO detector in the US in 2015. LIGO observed two black holes of about 30 solar masses orbiting each other and finally merging into a larger black hole. In Japan, a research team with many institutes including Tokyo Tech is developing a gravitational wave telescope KAGRA at a fevered pitch. KAGRA is a state-of-the-art gravitational wave telescope with several cutting-edge technologies not implemented in other detectors. Somiya's laboratory has been a core member of the KAGRA collaboration since 2011, right after the beginning of its construction, and has mainly contributed to developing methods of reducing quantum noise. KAGRA is scheduled for completion around 2020 and they anticipate to join the international gravitational wave observation network together with the LIGO in the US and Virgo in Europe.

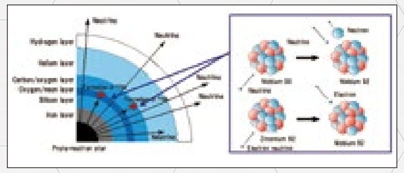


Nuclear Power and the Universe

Driving innovation in nuclear power systems using nuclear data research

Satoshi Chiba
Institute of Innovative Research

The pressing challenges for nuclear power are the pursuit of safety, as well as efficient use driven by the high burnup of nuclear fuel, and establishing a nuclear transmutation disposal method for long-lived radioactive waste within used fuel. There are still many unknowns involved in the nuclear reactions and decay properties of unstable nuclei needed to develop innovative nuclear power systems, but Chiba is performing theoretical research to elucidate them. He is using this technology to study the origin of heavy elements in the universe and the evolution of the universe.

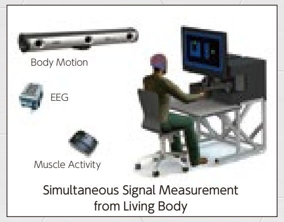


Life Science, Cell Biology

Modeling and result of brain motion control and learning mechanisms

Yasuharu Koike
Institute of Innovative Research

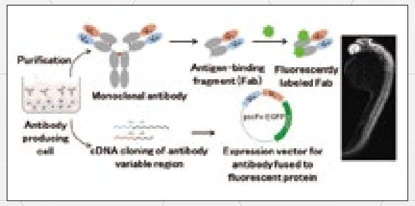
This research seeks to clarify how the brain expresses physical exercise and how it solves the control problems, and to establish a new scientific field so called a "computational method for brain-body imaging" to decipher computational models of brain based on brain waves and other physical signals during tasks and exercises. From the time of being born, human beings acquire knowledge through autonomous interaction with the environment. For instance, human beings become to move their arms and legs freely, start to use tools, and begin to speak without being taught by anyone. Something acquired inside the brain seems to result in such behaviors of human beings. We are going to learn these functions of the human brain and to make a computer to replicate the functions.
We are conducting research to achieve a society in which quality of life can be ensured, and people can live with safety and peace of mind, even when people age or have some kind of disability. We also hope to establish new rehabilitation methods and auxiliary equipment that can be integrated with the human body.



Dynamics of gene regulation in living cells

Hiroshi Kimura
Institute of Innovative Research

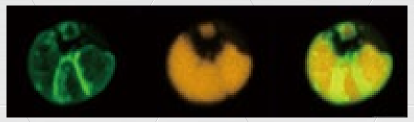
All cells in multicellular organisms have the same genetic information, but genes expressed in individual cells vary, and each shows a particular morphology and properties. To figure out the mechanisms of how genes are regulated, Kimura uses antibody-derived probes to analyze the dynamics of posttranslational modifications of histones and RNA polymerase in living cells. He also takes part in joint research with overseas institutions such as the International Human Epigenome Consortium.



Unlocking the evolution of photosynthetic organisms and lipid production through lipid research with plants and algae

Hiroyuki Ohta
School of Life Science and Technology

Ohta has had early success in the field of plant lipid research. He was the first to identify the gene for biosynthesis of the main glycolipid of plant chloroplasts, the most abundant biomembrane lipid on Earth, and also determined both its necessity during photosynthesis and its function during phosphorus deficiency response. In recent years, he has made notable discoveries involving algae, such as decoding the genome of charophytes considered the algal phylum most closely related to terrestrial plants, and demonstrating that charophytes have lipid components like wax on the cell surface despite being algae. He continues to produce innovative results such as uncovering the oil accumulation mechanism of algae with high oil productivity, and developing basic technology for manipulation of oil synthesis.



Development of functional materials using protein assemblies

Takafumi Ueno
School of Life Science and Technology

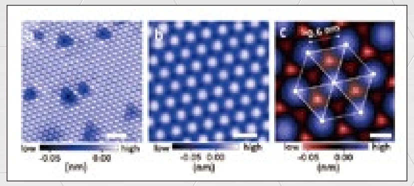
We are developing a functionalization method for new protein assemblies. Specifically, we are investigating understanding and control of chemical reactions inside cells and creating biomaterials by using protein assemblies, such as caged structures, needle shaped assemblies, and protein crystals, with making use of synthetic chemistry, protein engineering and various measurements. In recent years, we focused on protein crystals formed inside of cells and succeeded in synthesizing protein crystals that played the role of enzyme armor and molecular filter. In addition, we are creating functional materials by complexation of metal compounds and proteins. We are disseminating research results covering a wide range of fields from bio-related chemistry and material science.

New Materials

Observing atoms of spinel oxide surfaces

Taro Hitosugi
School of Materials and Chemical Technology

The group led by Hitosugi investigated the atomic arrangements and electronic states on the surface of spinel oxide $LiTi_2O_4$, known as a superconductor and a battery material. They figured out how the titanium atoms are arranged on the surface, and revealed that the surface superconductivity is different from that in the bulk interior. These findings were made possible by the development of an instrument that connects a scanning tunneling microscope (STM) and a thin-film deposition method called pulsed laser deposition (PLD). These studies lead to the deeper understandings on the origin of superconductivity and the properties of the electrode surface of lithium-ion batteries.



Venturing the unexplored through molecular technology

Takanori Fukushima
Institute of Innovative Research

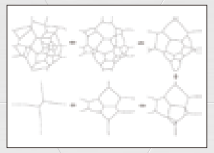
Fukushima's group is creating organic and polymeric materials using strategic designs in molecular geometry, electronic structure, and functional groups. They are also developing new methodologies of molecular assembly to achieve a highly ordered structure at a size regime ranging from the nano to macroscopic scales. Through these research efforts, they are exploring new phenomena and functions in a wide variety of material forms, including single molecules, two-dimensional thin films, and three-dimensional macroscopic materials. They aim to establish next-generation molecular technology to address problems that cannot be solved with existing methods.

Mathematics, Mathematical Science

Mathematical analysis of interfaces moving by surface tension

Yoshihiro Tonegawa
School of Science

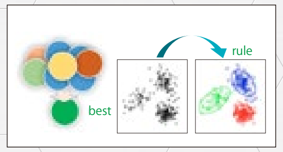
Tonegawa has established a fundamental existence and regularity theory for a general solution for the so-called mean curvature flow problem, in which interfaces of arbitrary dimensions and configurations such as networks with singularity move due to surface tension. In recent years he has given intensive courses on mean curvature flow at the world's top-notch research centers, and has attracted attention for a series of findings. The mean curvature flow of interfaces is a model problem of grain boundary motion. It is a research topic of high academic significance related to wide-ranging fields such as differential geometry, the calculus of variations, materials science, and image processing.


Mean curvature flow of networks

Mathematics for making computers think

Yoshiyuki Kabashima, Makoto Yamashita
School of Computing

Find the best strategy from vast possibilities. Analyze data and extract underlying rules. Until recently, computers have struggled with these types of "thinking" problems. However, as symbolized by extraordinary performances in shogi and go, computers based on recent artificial intelligence technology are posting remarkable results even with thinking problems. To promote this dramatic development in technology, they research methods to make computers think from a mathematical perspective.



Design and Art

Exploring technology, art, and design in an interdisciplinary manner

Kayoko Nohara, Haruyuki Fujii
School of Environment and Society

Nohara and Fujii conduct world-leading research in the design field, integrating art, design, and technology.
Nohara uses linguistics, semiotics, and communication theory to perform and provide transdisciplinary research and education, with the key word being "translation". To translate is to express something in a different medium, creating new value. When science is expressed with sensitivity, new art and logic can be born. Integrating art ideas also brings science to the next level. She creates new places and ideas connecting science with art and design by collaborating internationally with artists, designers, editors, journalists, museums, and companies.
Fujii conducts research in the fields of design science and basic theories and principles in architectural planning. Based on research questions such as what is design and what is a design mindset like, he conducts practical activities with experts from cognitive science, intelligent informatics, design, art, and philosophy. He explores methods of science concerned with the act of design, and methods to cultivate a design mindset.

Investigating the "viewpoint" of the blind

Asa Ito
Institute for Liberal Arts

The world "seen" by the blind using hearing, taste, and language is completely different from the world perceived with sight by seeing people. Ito researches its deeper nature based on interviews with blind people, and has written works such as "How do blind people see the world?" She also applies those findings to the domains of art and sports. She organized a workshop called "Let's design a country without sense of vision", and works to reevaluate the world from the perspective of not being able to see, rather than from the humanitarian perspective of supporting the blind.


Photo: Shinichiro Mikuriya
Provided by: Mori Art Museum

Politics and Religion

Nationalism and religion in modern politics

Takeshi Nakajima
Institute for Liberal Arts

In recent years, there has been a surge in xenophobic nationalism and a rise in religious fundamentalism across the world. Nakajima sheds light on the logic, mechanisms, and historical background of these synchronic phenomena, exploring what a new inclusive society may look like. His past research has examined (1) Hindu nationalism in modern India, (2) ultranationalism in modern Japan, and (3) modern Japan's drift to the right, based on the former two themes. He continues to debate the relationship of spiritual and identity issues of "belief" and "patriotism" with politics.

Big Data, AI

Super computer technology for supporting next-generation big data.

Toshio Endo
School of Computing

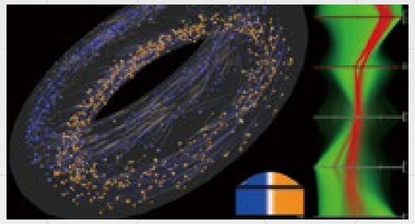
We are conducting research and development for fundamental software technology used in high-performance computing (HPC). Examples include massively parallel algorithms, memory layer utilization technology for next-generation big data, and efforts to achieve high-speed and large-scale machine learning. The importance of advanced super computing technology for the growth of scientific technology will continue to increase in the future. Related technologies include large-scale processing of genome analysis, earth observation image analysis using satellites, and simulations of molecules and weather.

The world's top-ranking supercomputer in energy efficiency, TSUBAME 3.0

Platform software and algorithms for next-generation supercomputers

Rio Yokota
School of Computing

Yokota's research group is developing fast algorithms for the next generation of supercomputers. They are designing highly parallel computing algorithms with high arithmetic intensity that operate efficiently on GPUs installed in Tokyo Tech's TSUBAME 3.0 supercomputer. The hierarchical low rank approximation method, used for large-scale fluid and molecular simulations, as well as mixed precision arithmetic can be applied to the recently popular deep learning computation. As such, Yokota's group is active in both of scientific computation and deep learning.



Application to scientific computation

Emotional experience design: Building desirable interaction between systems and people

Hiroyuki Umemuro
School of Engineering

As robots, AI, and other systems grow even more intelligent, human beings increasingly treat these systems as "agents" with intentions and personality during interaction. When using tools or machines, human beings mainly engage in rational thinking and evaluation. However, as systems grow more intelligent and display greater personality, affective experiences such as trust and affection become increasingly important during interaction with systems. In western nations, it is already commonplace for engineers to collaborate with expert psychologists when researching interaction with robots and information systems. However, in Japan, the majority of engineers design interaction by using themselves as a point of reference or by imagining other human beings. As a team of experts on the psychological characteristics of human beings, our

team contributes to technical design for an even better affective experience.

Realization of a quantum computer based on the theory of quantum annealing

Hidetoshi Nishimori
Institute of Innovative Research

Quantum annealing, proposed by Nishimori and his student Kadowaki, is a basic principle for solving problems known as combinatorial optimization problems. In artificial intelligence, many of the tasks for machine learning are optimization problems, and quantum annealing is attracting a great deal of attention as a next-generation information processing technology to further promote the development of machine learning and artificial intelligence. The Canadian startup company D-Wave Systems Inc. has implemented quantum annealing as hardware, and Google, NASA, and others have introduced it or have begun using it for cloud services. With unique quantum annealing machine development by Google and as part of a large-scale national project in the United States, a large flow originating from the research at Tokyo Tech is driving the world.

Electronics and Communication

Transparent oxide semiconductor for organic EL displays

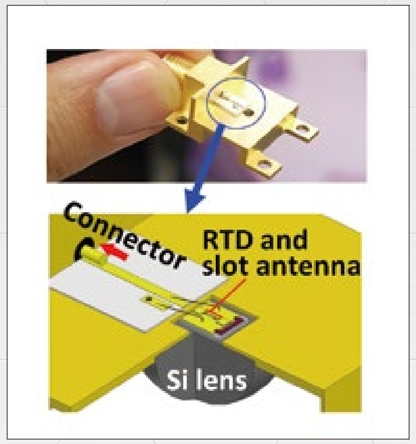
Hideo Hosono
Material Research Center for Element Strategy

In order to improve the performance and lifespan of organic EL displays as a replacement for liquid crystal displays, electrons from a cathode must be steadily injected and transported to the light emitting layer at high speed and with high transparency. This is achieved with two newly developed transparent oxide semiconductors; amorphous C12A7:e which are stable electrides in the air (substances where electrons act as anions) and $ZnO\text{-}SiO_2$. The transparent oxide semiconductor IGZO thin film transistor invented at this laboratory is now used not only for liquid crystal displays but also for driving large organic EL televisions. These new semiconductor materials will help make organic EL displays as common as liquid crystal displays.

Designing a microminiature semiconductor terahertz light source that operates at room temperature

Masahiro Asada
Institute of Innovative Research

Asada developed a compact semiconductor terahertz light source that operates at room temperature using resonant tunneling diodes (RTDs), which are a type of nanostructure, in order to apply electromagnetic waves of about 0.1 to 10 THz (between radio waves and light) to ultra-high-speed wireless communication, imaging, and spectroscopic analysis. He successfully achieved the world's highest frequency of 1.92 THz for an electronic device at room temperature, and demonstrated THz wireless communication at 56 Gbit/s. He is optimizing the structure of the antenna and RTD, and is developing high-frequency, high-power, and variable frequency light sources for practical applications.



Developing a flexible terahertz scanner

Yukio Kawano
Institute of Innovative Research

Kawano and colleagues have developed a terahertz scanner that can detect electromagnetic waves from 0.1 to 30 THz with high sensitivity and at high resolution. By increasing the response sensitivity of carbon nanotube detectors for photovoltaic power and integrating a large number of the detectors in a curved array, they have made it possible to measure objects of any shape from any direction. They plan to demonstrate its use in non-destructive, contactless inspection of medical instruments and drug tablets of various shape.

High-precision indoor positioning with low model dependency using "ellipsoid features"

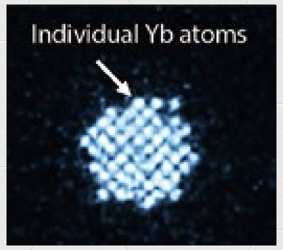
Masamichi Shimosaka
School of Computing

Although positional information is becoming more important due to various services and its usefulness in the field of ubiquitous computing, it is difficult to achieve high-quality positioning with conventional indoor positioning technology due to hardware and other differences. To resolve this issue, Shimosaka research group focused on "ellipsoid features" using the difference in radio wave intensity obtained from multiple access points. He found that there is less dependency on the model, and the position of the terminal to be located can be narrowed down to a smaller area than with existing methods.

Quantum simulation and quantum sensors using ultra-cold atoms

Mikio Kozuma
School of Science

The world's first ytterbium quantum gas microscope, developed by Kozuma's laboratory, is expected to be used as a quantum simulator for understanding the mystery of high-temperature superconductivity. The copper oxide superconductor, discovered in 1986, achieves superconductivity at a high temperature that cannot be explained by the traditional BCS theory. Its microscopic mechanism is still not fully understood even 30 years after the phenomenon was discovered. They simulate high-temperature superconductivity quantitatively using ultra-cold atoms instead of electrons, and using an optical lattice with lasers instead of an ionic lattice, with the goal of understanding this mystery and revealing the conditions for room-temperature superconductivity. When entering the Mott insulator state, which is a phenomenon in the stage prior to achieving high-temperature superconductivity, electrons occupy each site in



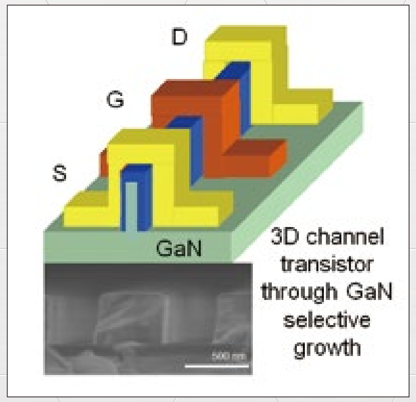
the lattice one by one, not randomly. The figure shows the Mott insulator state in the optical lattice, and a microscopic observation of each atom. Kozuma's group is also conducting research to realize ultra-sensitive inertial sensors using the properties of ultra-cold atoms as waves.

New Materials

Expanding the limits of semiconductors with new materials and process technologies

Kazuo Tsutsui
Institute of Innovative Research

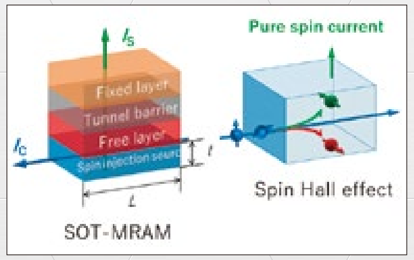
In recent years, Tsutui has been struggling to overcome the limits of Moore's law governing the semiconductor industry and working to push the limits of existing materials and process technologies used for devices. By going back to basic physical mechanisms, he is developing device structure technologies as well as materials and fabrication processes that could be applied in future electronics. Development is mainly focused on the field of next-generation power semiconductor devices, which are essential for an energy-saving society, and on creating the foundation for the progress of future society.



Development of ultra-low power consumption SOT-MRAM using topological insulators

PHAN NAM HAI
School of Engineering

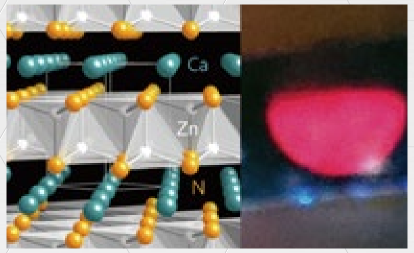
In recent years, there has been active development of nonvolatile memory with low power consumption. There are particularly high expectations for magnetoresistive random-access memory (MRAM). In addition to being nonvolatile, MRAM has extremely outstanding characteristics such as high-speed operation in the 10 ns class and superior durability (more than 10^{16} writing operations). Research and development was conducted for a spin-injection magnetization reversal method as writing technology for second-generation MRAM which is currently being commercialized. This technology has been used in products since around 2012. However, the spin-injection magnetization reversal method has the significant drawback of high power consumption for writing operations. In order to achieve third-generation SOT-MRAM with small power consumption during writing operations, we conducted research on a pure spin injection source which displays high electrical conductivity and a strong spin Hall effect. Our research succeeded in developing the world's first topological insulators that display high electrical conductivity and a strong spin Hall effect. Compared to second-generation MRAM technology, we were able to reduce writing electrical current by one order of magnitude and writing electrical power by two orders of magnitude. Moving forward, we seek commercialization through joint development with corporations. If successful, we anticipate the first industrial application of topological insulators.



Discovery of a nitride semiconductor that emits red light

Fumiyasu Oba, Hidenori Hiramatsu, Hideo Hosono
Materials Research Center for Element Strategy

Oba, Hiramatsu, and Hosono have discovered a new nitride semiconductor that is expected to have applications for devices that emit red light and solar cells. Nitrides have properties suitable for application as semiconductors, but nitride semiconductors currently in use contain rare-elements. The newly identified material uses only earth-abundant elements and has properties that differ from conventional nitride semiconductors, widening the range of applications. This discovery is the result of the application of materials informatics, which is a blend of materials science, computational science, and data science.



New molecular assemblies with functional nanospaces

Michito Yoshizawa
Institute of Innovative Research

Yoshizawa's group is creating new molecular assemblies with functional nano-sized spaces through the rational use of various chemical bonds and interactions. For example, a capsule-shaped assembly bearing a 1 nm-sized cavity can efficiently encapsulate molecules with the complementary size and shape. The captured molecules exhibit unique properties and reactivity that are not observed outside the cavity. Recently, it was revealed that the capsule binds D-sucrose, which is the main component of sugar, in water from a mixture of natural sugars with 100% selectivity. Further development of functional nanospaces will lead to industrial and bio-medical applications.

Development of an immobilized rhodium catalyst with extremely high activity

Ken Motokura
School of Materials and Chemical Technology

Precious metal catalysts are used industrially in the hydrosilylation reaction, which is a silicone synthesis method used for various applications such as water repellents and paints. Motokura has developed an immobilized rhodium catalyst that demonstrates extremely high activity in this reaction. The catalyst turnover number (the number of times one molecule of the catalyst progresses to the desired reaction) reached 1.9 million times, an order of magnitude higher than in the past. This will greatly reduce the amount of precious metal catalysts used and contribute to the stable production of silicone.

Comparison of activity between the catalyst developed in this study and published reports

	Reaction time	Catalyst turnover number
SiO_2/Rh-NEt_2	24	1,900,000
MOF-Rh (Paper *1)	72	820,000
SiO_2/Rh (Paper *2)	10*3	200,000

*1 Sawano, T.; Lin, Z.; Boures, D.; An, B.; Wang, C.; Lin, W. J. Am. Chem. Soc. 2016, 138, 9783-9786.
*2 Szubert, K.; Marciniec, B.; Dutkiewicz, M.; Potrzebowski, M. J.; Maciejewski, H. J. Mol. Catal. A Chem. 2014, 391, 150-157.
*3 10 cycles of 1-hour catalytic reactions

Development of peptides "aligned" on the surface of 2D nanosheets

Yuhei Hayamizu
School of Materials and Chemical Technology

Hayamizu and collaborators have developed peptides, types of small proteins, that spontaneously form nanostructures on the surface of 2D nanosheets with a nanometer thickness, such as graphene and molybdenum disulfide. These peptides specifically modulate the electrical conductivity of single-layer graphene and molybdenum disulfide. Their work has opened the door to develop future biosensors with new mechanisms using peptides and nanosheets.

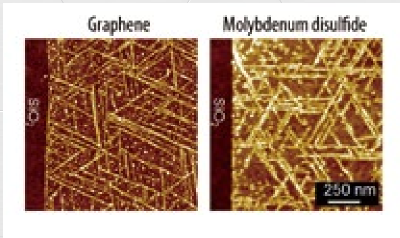


Figure: Self-assembled peptide nanowires on the surface of single-layer graphene (left) and single-layer molybdenum disulfide (right) on a silicon substrate

Environment and Energy Technology

Solid-state lithium batteries

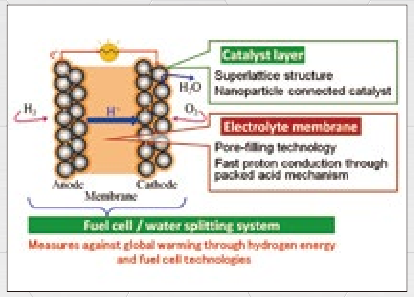
Ryoji Kanno
Institute of Innovative Research

In conventional lithium batteries, a liquid is used as the electrolyte for flowing ionic current. However, Kanno demonstrated the possibility of using a solid electrolyte in defiance of conventional wisdom. Solidification reduces flammability and also improves stability. It can operate in a wide temperature range, and it is easy for the current to flow and become powerful. It also enables rapid charging and discharging, providing many advantages as a battery. In the future, Kanno and colleagues plan to tackle issues such as cost reduction for further practical application.

Design and development of fuel cell and water splinting materials and functional membranes

Takeo Yamaguchi
Institute of Innovative Research

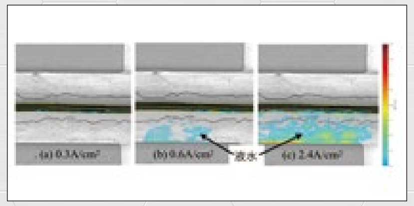
Although traditional material development is based on trial and error, Yamaguchi is systematically designing and developing functional materials from the molecular level to the device level. Through a systematic material design approach, he successfully developed novel materials, such as electrolyte membranes, electro-catalysts and systems for fuel cells and water splitting applications. He also developed functional membranes for water treatment and disease diagnosis through the same approach.



Measuring liquid water inside of fuel cells and seeking high efficiency

Shuichiro Hirai, Takashi Sasabe, Manabu Kodama
School of Engineering

Fuel cells are the power source for next-generation zero emission automobiles. These clean automobiles only emit water when driving. However, there are cases in which that water has an adverse effect on high efficiency and low cost. This is because the water generated by fuel cells can interfere with the supply of the oxygen required for fuel cells. This creates the need to control water and ensure smooth discharge from the fuel cell. By using X-ray technology, we succeeded in measuring the incessantly changing status of liquid water behavior inside of solid fuel cells that do not transmit light. The diagram shows how water is generated and behaves when the electrical current of a fuel cell has increased. Utilizing this measuring technology makes it possible to evaluate the effect of newly-developed materials on liquid water behavior. This contributes significantly to the advancement of fuel cell technology.

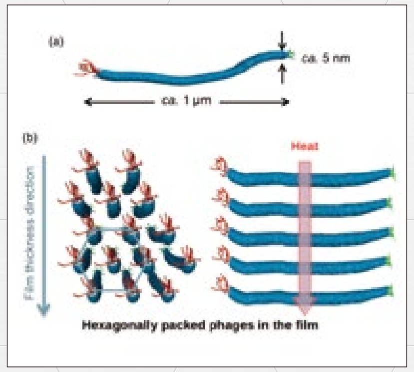


For industry and innovation

Thermal conductive film composed of viruses

Toshiki Sawada, Takeshi Serizawa
School of Materials and Chemical Technology

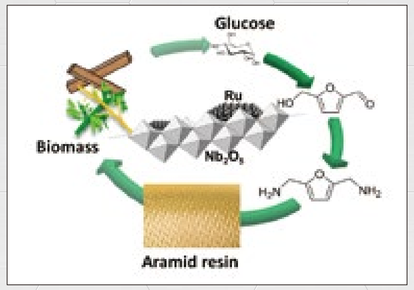
Because organic polymers are generally regarded as thermal insulators due to the low thermal conductivity, they have not been considered suitable for heat dissipation materials for electrical or electronic devices. However, we prepared thermal conductive films composed of liquid crystalline filamentous viruses, which are polymeric assemblies of proteins and nucleic acids. Importantly, the film can be prepared by a simple flow-induced method using a glass substrate circularly patterned with hydrophobic polymers. We expect that our development will contribute to the establishment of a preparation method for organic polymeric materials with high thermal conductivity, as well as to the clarification of novel heat conductive mechanisms on the materials.



Solid catalyst for solving industrial and environmental problems

Michikazu Hara
Institute of Innovative Research

When the functions of liquid catalysts are transferred to a solid, it becomes easier to separate it from the product, making it possible for the catalyst to be reused. Carbon solid catalysts developed from coal have already been successfully put to practical use, and their performance far surpasses that of conventional sulfuric acid catalysts. Hara has also succeeded in producing biofuels and resins such as ethanol from plants and other biomaterials using solid oxide catalysts. His aim is to resolve environmental problems and contribute to industry by replacing conventional catalysts with new materials to efficiently produce target chemical compounds.

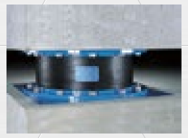


Earthquake and Disaster Mitigation

Vibration control and seismic isolation technology using laminated rubber and many other materials

Kazuhiko Kasai
Institute of Innovative Research
Akira Wada
Professor Emeritus

Kasai and Wada are overturning conventional building structure concepts by engaging in cutting-edge research of seismic isolation technology. One of the isolators uses laminated rubber. It can move horizontally and isolates the building from seismic ground motion, while sustaining the enormous weight of the building. They are also leading research on vibration control technology which uses dampers to absorb vibration energy of the building and dissipate it as heat. A variety of types of dampers are now available in Japan.

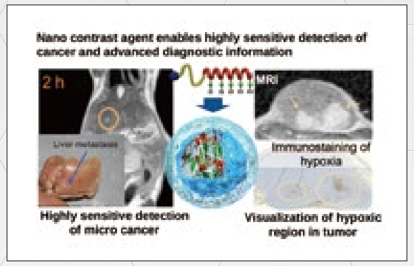


Health, Medicine, and Supporting People with Disabilities

Next-generation diagnostic and therapeutic drugs using macromolecular design

Nobuhiro Nishiyama
Institute of Innovative Research

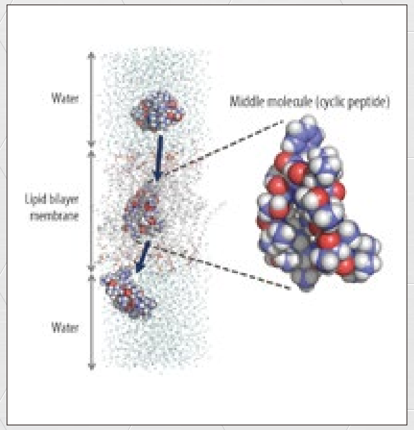
Nishiyama is aiming to develop diagnostic and therapeutic systems for diseases that exhibit advanced functions in vivo by integrating smart functionalities such as targetability and environmental responsiveness into a platform of synthetic polymers. Specifically, his goal is to realize effective but less toxic anticancer treatment, practical application of biopharmaceuticals including nucleic acid medicines, and highly sensitive bioimaging and minimally invasive treatments in combination with medical equipment. Some systems have already progressed to clinical trials, and his research is expected to lead to innovations in medicine, society, and industry.



Middle molecule IT-based drug discovery through collaboration with chemistry and biology researchers

Yutaka Akiyama, Masahito Ohue
School of Computing

While middle molecules can be chemically synthesized inexpensively, they possess various advantages similar to large macromolecules and are expected to take on a new leading role in drug discovery. Development time can be drastically reduced through intelligent support using IT. Examples include molecular simulation and machine learning to determine drug targeting molecules and predict cell membrane permeability, plasma stability, and toxicity among other aspects, making fast industrial development of new drugs possible. Akiyama and Ohue are working on innovative middle molecule drug discovery research in collaboration with faculty members from the School of Life Science and Technology as well as other areas.



Developing artificial hearts using micro maglev technology

Tadahiko Shinshi
Institute of Innovative Research

Shinshi is developing implantable and disposable artificial hearts using micro magnetic levitation technology. The impellers of centrifugal blood pumps are suspended and rotated by electromagnetic force. Non-contact support of the impellers can greatly reduce red blood cell destruction and blood clotting. In animal experiments, extracorporeal disposable maglev centrifugal blood pumps successfully supported blood circulation for two months without any clot formation inside the pumps or organ damage. He is working on practical application through a joint venture between Tokyo Tech and Tokyo Medical and Dental University.


Implantable artificial heart using magnetic levitation

Soft robotics

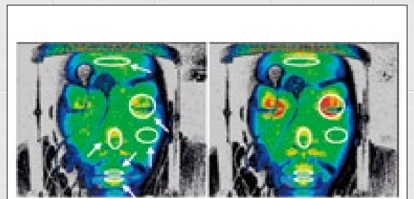
Koichi Suzumori, Hiroyuki Nabae, Hiroto Tanaka
School of Engineering
Tosinori Fujie
School of Life Science and Technology

Conventional robotics has focused on speed, power, accuracy, and reliability. Although these efforts have yielded outstanding results in industry, today's robots still have difficulty engaging in soft movement which is so easy for living creatures. One example of such movement is using the appropriate amount of strength to hold a baby. In recent years, there is a new trend towards softness in various fields such as mechanical and electronic engineering, information processing, materials science, and biology. By fusing these fields from a broad perspective, our research seeks to create new robotics based on biological system values such as flexibility, adaptation, and appropriate force. We are advancing research on soft bodies, supple movement, and adaptable intelligence in an effort to develop robots for medical care, nursing care, and a human-robot symbiotic society.

Human measurement through physiology: determining taste and emotion from facial blood flow response

Naoyuki Hayashi
Institute for Liberal Arts

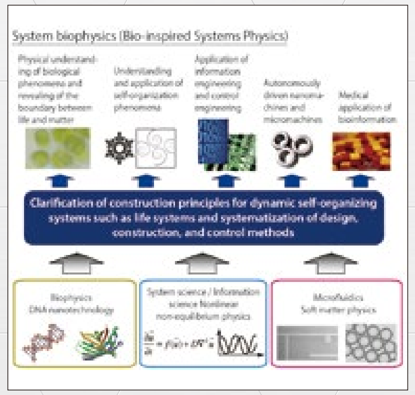
Darwin described that changes in facial expression related to taste are universal, regardless of time, culture, and region. In 2011, it was discovered that basic taste preferences are related to changes in blood flow in the face. For example, blood flow in the eyelids increases when we taste something good. Later, Hayashi reported a similar result related to the influence of complex taste, and he is now applying this to various tastes through an industry-academia partnership. In addition, he discovered that facial blood flow increases only at the site where a massage roller was used. Based on his physiological knowledge of the circulatory system, he is contributing to industrial fields such as food and cosmetics.


Facial blood flow before (left) and after (right) favorite sweet taste stimulus (Kashima and Hayashi, PLoS ONE, 2011).

Construction of molecular computers, artificial cells, and molecular robots

Masahiro Takinoue
School of Computing

In living systems, DNA and RNA are involved in information retention and transmission, and proteins act as expression of biological function. By utilizing these biomolecules, Takinoue and colleagues are striving to develop molecular robots with autonomous information processing mechanisms. They use those biomolecules not only from the view point of actual biological properties in living systems, but also from a wider physicochemical point of view as material science. In the future, molecular robots are expected to be applied to molecular computers and cell controllers in nano/microspaces such as the inside of a cell, health condition monitors inside our body, and machines to deliver medicine to a disease site.



Institute of Innovative Research (IIR)

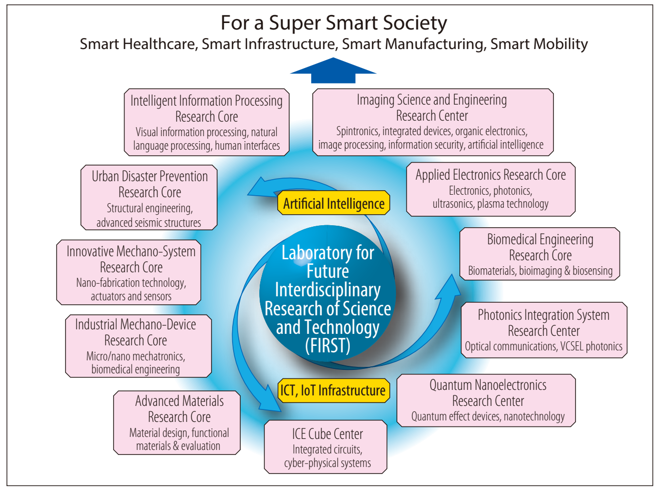
Creating true innovation at the front line of science and technology
Taking a leading role in the advancement of basic and applied research

The mission of the IIR is twofold — to promote active cooperation within and beyond the organization by providing an open research environment, and to continuously improve this environment so that researchers can focus fully on their work and make the most of their abilities. By accomplishing this mission, the IIR can create new research areas and new technologies that address existing problems in society and lay the foundations of future industry. In the long run, the IIR aims to become a leading global innovation center.

DATA	As of December, 2018
Faculty/International	320/47
Research staff/International	107/26
Graduate Students/ International Graduate Students	981/249

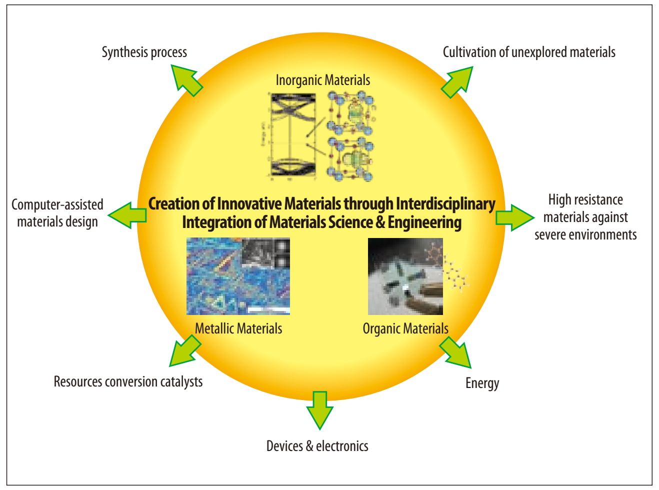
Laboratory for Future Interdisciplinary Research of Science and Technology (FIRST)

FIRST creates innovative industrial technologies that meet the needs of society through a fusion of various research fields such as mechanical engineering, electrical and electronic engineering, materials science, information engineering, environmental engineering, disaster prevention engineering, and social engineering to realize a prosperous future for all.



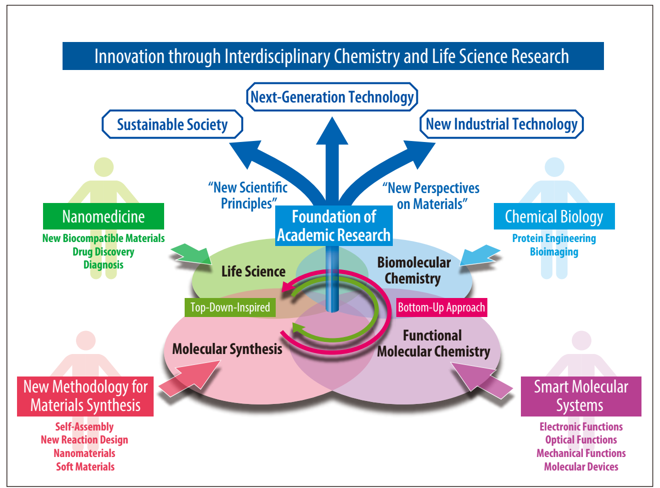
Laboratory for Materials and Structures (MSL)

MSL creates innovative materials with unique properties and functions based on inorganic materials via interdisciplinary materials science. These materials offer wide flexibility, as they can be designed using almost all the elements in the periodic table. They also utilize a wide range of other materials such as metals and organic materials. MSL works to contribute to solutions for social issues, such as environmental and energy problems, by pursuing new unconventional materials.



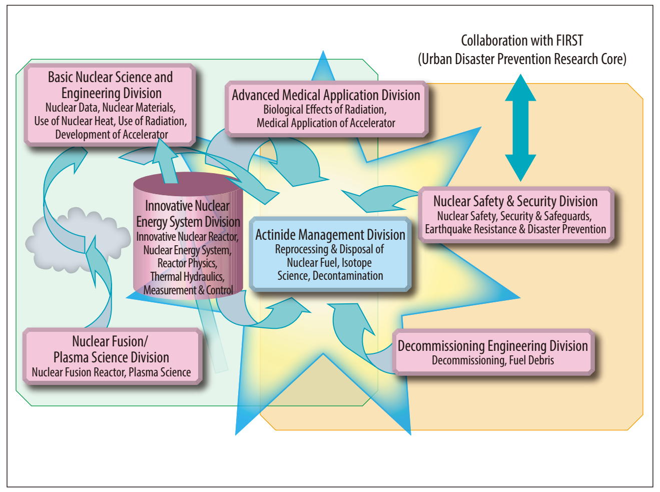
Laboratory for Chemistry and Life Science (CLS)

The CLS aims to create new scientific principles as well as next-generation technology through the deepening and development of fundamental and applied research on molecular-based chemistry and life science, thereby contributing to the advancement of civilization and the realization of a more prosperous and sustainable society.



Laboratory for Advanced Nuclear Energy (LANE)

LANE aims to contribute to sustainable global development through the establishment of nuclear energy systems that harmonize with society. They also work to propose effective solutions to issues related to natural resources, energy, and global environments, utilizing the fruits of science and engineering research conducted for the responsible use of nuclear energy and the development of advanced radiation technologies to support society.



Research Centers

International Research Center of Advanced Energy Systems for Sustainability (AES Center)

The AES Center and partner entities pursue development of fundamental next-generation energy technology. They aim to realize "smart communities" that fully incorporate renewable energy sources and energy-conservation, practices which are central to achieving a low-carbon society.

Center Director: Institute Professor Takao Kashiwagi

Advanced Research Center for Social Information Science and Technology (ASIST)

ASIST develops safe and secure social information distribution infrastructures that allow individuals to acquire, confirm, and utilize personal information managed by public administrations and medical institutions. They are also engaged in research and development of systems that provide one-stop service by public administrations and life-long individual health management.

Center Director: Professor Nagaaki Ohyama

Cell Biology Center

This Center investigates various aspects of cells through observation, manipulation, and creation of unique cells. They seek to understand molecular mechanisms, from gene expression and editing to synthesis, modification, and the resolution of proteins, and to elucidate the dynamics of cellular functions with applications in next-generation cell engineering.

Center Director: Honorary Professor Yoshinori Ohsumi

Research Units

Research Units carry out work in prioritized areas under the leadership of prominent scientists. Each Unit has an initial 5-year term to deliver results. Tokyo Tech provides Research Units with a wide range of support, including research resources.

Global Hydrogen Energy Unit

Identifies issues in the development of elemental technology and systems, and industrial and social structures; evaluates these from a subjective and objective perspective; and conducts necessary research and development to realize a hydrogen energy society

Unit Leader: Institute Professor Ken Okazaki

Nanospace Catalysis Unit

Creates nanospace catalysts and develops processes that make efficient use of carbon resources to contribute to the greening of chemical production

Unit Leader: Assistant Professor Toshiyuki Yokoi

Advanced Data Analysis and Modeling Unit

Studies a wide range of phenomena and risks in society from a scientific perspective utilizing big data that includes extremely detailed and comprehensive records of human behaviors to build a sustainable and resilient society

Unit Leader: Professor Misako Takayasu

Research Unit for All Solid-state Battery

Develops the unique solid electrolyte materials including superionic conductors as the key technologies for implementing all-solid-state batteries, which are expected to be the first choice of the next generation batteries.

Unit Leader: Professor Ryoji Kanno

Advanced Computational Drug Discovery Unit

Pursues development and utilization of an open, innovative, and effective drug discovery platform through the integration of IT and biochemical experimentation

Unit Leader: Associate Professor Masakazu Sekijima

Quantum Computing Unit

Basic theory of quantum annealing is our main topic of research. We have been leading the world in this field since our first proposal of quantum annealing in 1998.

Unit Leader: Professor Hidetoshi Nishimori

Hybrid Materials Unit

Creates new materials based on the precision synthesis of sub-nano metal particles using original dendritic polymers; works to open up a frontier field of science for the next generation of functional materials

Unit Leader: Professor Kimihisa Yamamoto

Sustainable Chemical Resource Production Unit

Seeks to establish sustainable production methods for indispensable chemical resources to human society without using petroleum resources, and to establish a new industry.

Unit Leader: Professor Michikazu Hara

Biointerfaces Unit

Performs research to understand how the brain controls the body and develop devices that can be controlled by thought alone; also creates new methodologies and instruments to evaluate organ status for early detection of diseases

Unit leader: Professor Yasuharu Koike

Heterogeneous and Functional Integration Unit

The development of large scale 3D integration technology for Tera-byte memory, ultra-small system module, bio-devices, and functional sensor to recognize thoughts of plant are being conducted by research platform in cooperation with industries, so-called WOW Alliance.

Unit leader: Professor Takayuki Ohba

Strategic Research Hubs

Promotes cutting-edge global research supported by large-scale government funding

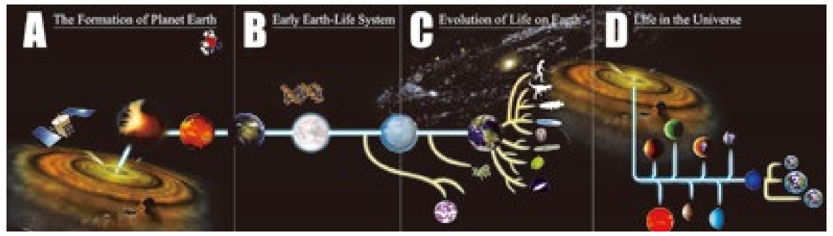
Earth-Life Science Institute (ELSI)

Director: Kei Hirose

ELSI is a unique research institute that seeks to discover the "origins of the Earth and life" by bringing together world-class researchers in geoscience, life science, and planetary science from both Japan and overseas. With about half of its nearly 60 researchers coming from abroad, English is the official language of ELSI. The administration office has a dedicated staff to provide daily-life support for non-Japanese researchers. They also provide weekly Japanese classes. ELSI was selected by the MEXT World Premier International Research Center Initiative (WPI).
(Established in 2012)
http://www.elsi.jp/


New ELSI building


Open space AGORA



ELSI research topics

Materials Research Center for Element Strategy (MCES)

Director: Hideo Hosono

The MCES creates useful innovative materials from abundant elements such as gravel and cement. The only center for electronic materials in Japan, it was adopted by the MEXT Element Strategy Initiative Project (Core Research Center Formation). (Established in 2012)
http://www.mces.titech.ac.jp/

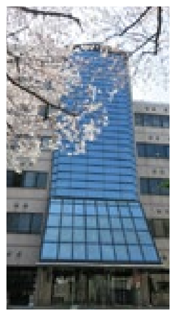

Genso Cube is a new research facility with 18 windows at each floor, the same number of elements in a row of the periodic table


Atomic resolution analytical electron microscope

Research Center for the Earth Inclusive Sensing Empathizing with Silent Voices (EISESiV)

This research center is handling sensing and AI/IoT edge technologies to solve social and environmental issues for a co-existence of human race with nature of the Earth. Our technologies perform for phenomenon, which were not previously recognized or measured, in four categorized fields of the Earth, "satoyama" (border zone between mountain foothills and arable flat land), human society and beings. Sensed information are going to be provided for us as beneficial knowledges empathizing among nature and human beings. Through these activities to encourage the people to take proactive behaviors, this center targets to achieve a cooperative society of mutual assistance, as well as co-existence and co-prosperity in the global environments.

Selected as a Center of Innovation (COI) by the Ministry of Education, Culture, Sports, Science and Technology



EISESiV
Research Center for the Earth Inclusive Sensing Empathizing with Silent Voices

School of Science

Exploring and creating knowledge

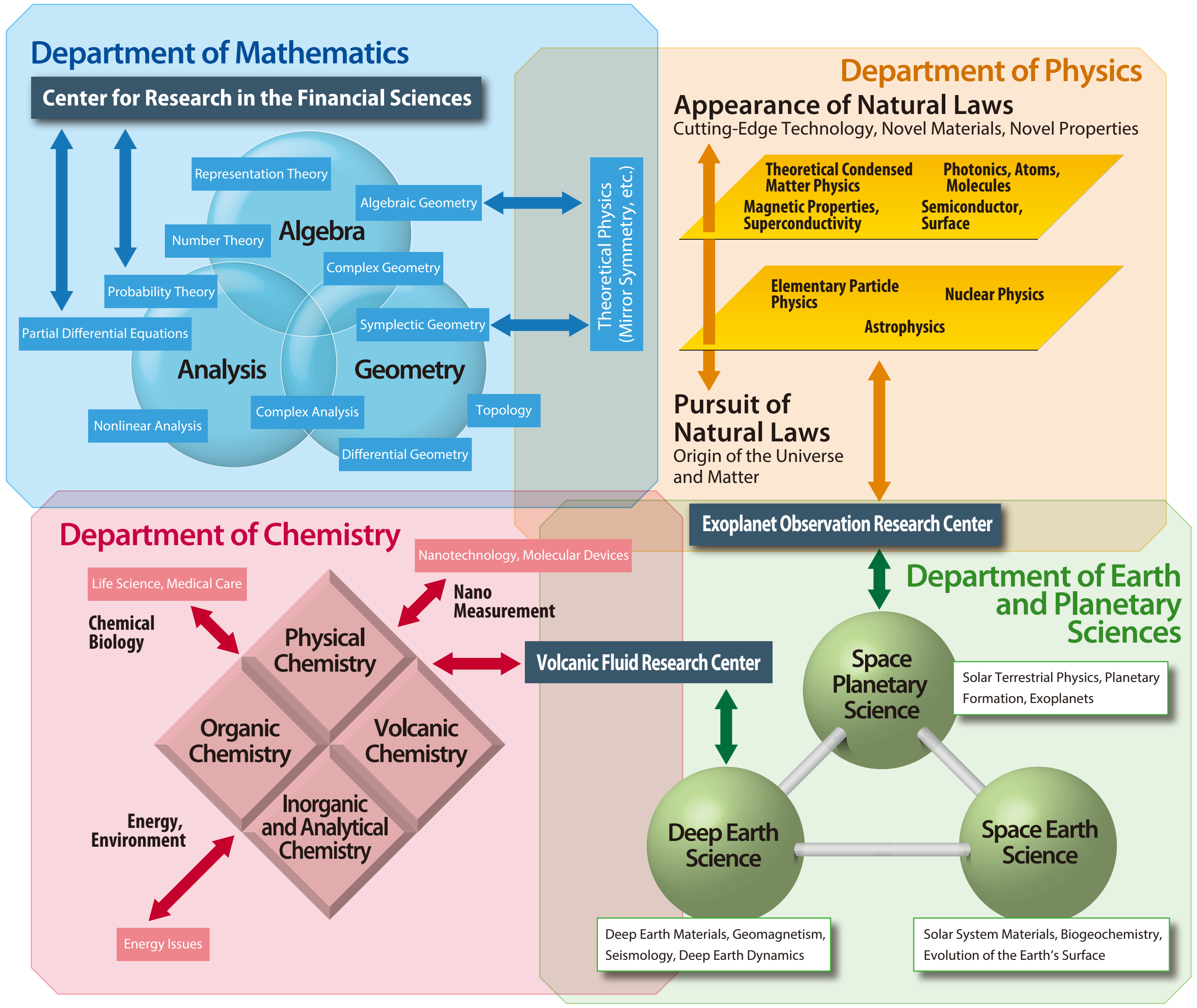
The School of Science comprises four departments, the Departments of Mathematics, Physics, Chemistry, and Earth and Planetary Sciences. The School is committed to advancing science as the culture and knowledge of humankind and to taking a leading role in research and exploration at the frontiers of the natural sciences. While scientific research is independent of immediate applications, the concepts developed and the knowledge obtained through scientific activities have not only enriched the culture of human beings but also, eventually after ten or more years, contributed to solving the problems society and nature were facing.

DATA	As of May 1, 2018
Faculty/International	170/10
Research staff	23
Total Students/International Students	760/36
Students in Bachelor's Program/ International Students	296/9
Students in Master's Program/ International Students	346/11
Students in Doctor's Program/ International Students	118/16

Structure and Research Fields

Department of Mathematics	■ Analysis ■ Geometry ■ Algebra
Department of Physics	■ Elementary Particle Physics ■ Nuclear Physics ■ Astrophysics ■ Theoretical and Experimental Condensed Matter Physics
Department of Chemistry	■ Physical Chemistry ■ Organic Chemistry ■ Inorganic Chemistry ■ Analytical Chemistry ■ Volcanic Chemistry
Department of Earth and Planetary Sciences	■ Earth and Space Science ■ Space Planetary Science ■ Earth Internal Science

Approaches to Research



School of Engineering

Creating new industries and advancing civilization

The School of Engineering comprises the Departments of Mechanical Engineering, Systems and Control Engineering, Electrical and Electronic Engineering, Information and Communications Engineering, and Industrial Engineering and Economics. We promote basic research aiming to expand the subjects in each technological field and promote interdisciplinary research through the establishment of cross-sectional groups with a focus on issues related to future society.

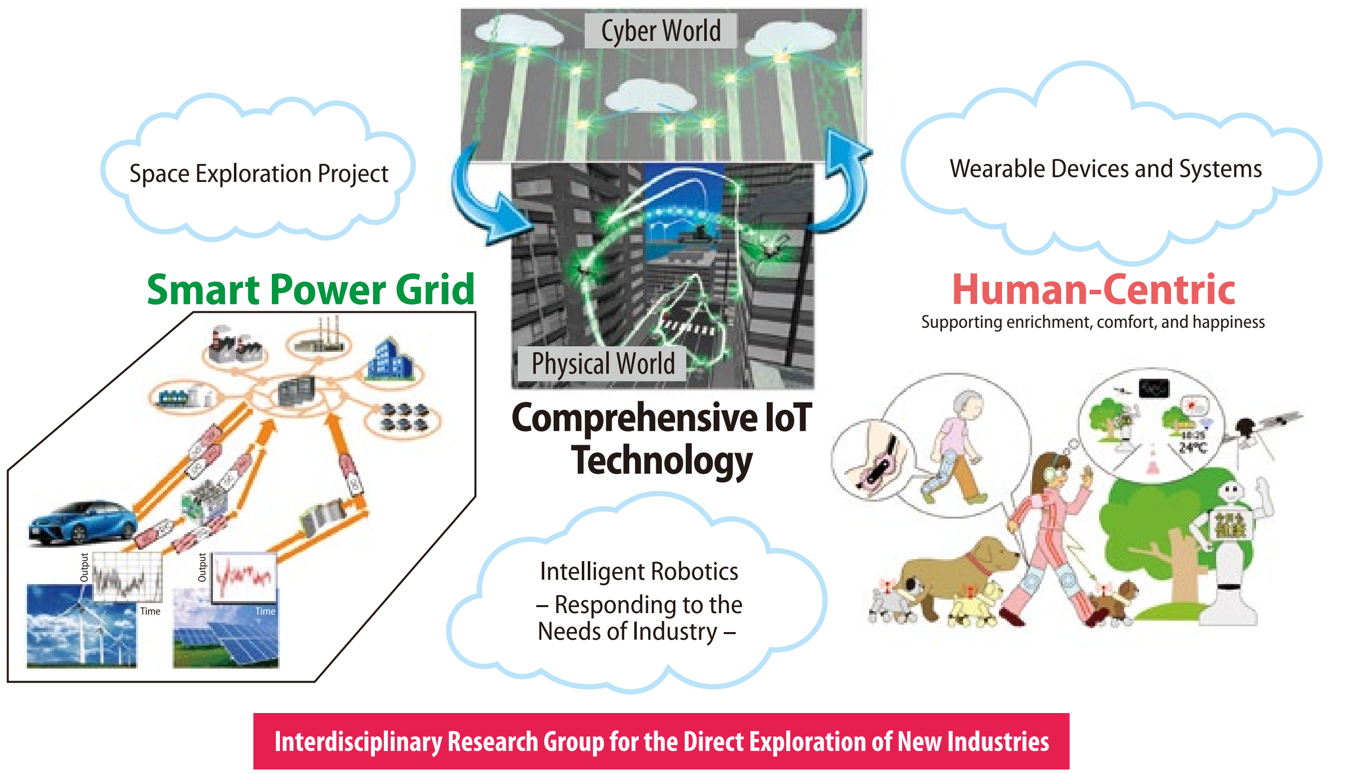
The School of Engineering Industry-University Cooperation Office organizes research teams made up of the best faculty members for each issue to respond to specific needs from industries. Through these systems, we advance technical development to identify solutions for a wide range of social issues and explore new industries such as renewable energy and energy saving technology, diversified spatial temporal system management, innovative interface devices and information networks that make use of the five senses.

DATA	As of May 1, 2018
Faculty/International	252/16
Research staff	25
Total Students/ International Students	2,230/375
Students in Bachelor's Programs/ International Students	782/37
Students in Master's Programs/ International Students	1,190/219
Students in Doctor's Programs/ International Students	258/119

Structure and Research Fields

Department of Mechanical Engineering	■ Energy ■ Fuel Cell ■ Micro- and Nano-Fluids ■ Turbulence and Combustion ■ Processing Technology ■ Functional Materials ■ Strength and Integrity ■ Mechanical Systems ■ Robotics ■ Actuators ■ Vibration and Noise ■ Medical and Welfare Equipment ■ Perceptual Engineering ■ Aerospace Engineering
Department of Systems and Control Engineering	■ Control Theory ■ Measurement Theory ■ Computer Vision ■ Ultrasonic Measurement ■ Network Control ■ Bio-Machine Hybrid Systems ■ Sports Science and Engineering ■ Energy Conversion Control
Department of Electrical and Electronic Engineering	■ Electronic Devices ■ Electronic Materials and Properties ■ Wave Communications ■ Circuit System ■ Electric Power Energy ■ Power Conversion Device ■ Electromagnetic Actuators ■ Quantum Sensors ■ Biosensors ■ Spintronics ■ Green Devices ■ Photonics ■ Integrated Circuits ■ Plasma ■ Antennas
Department of Information and Communications Engineering	■ Telecommunication ■ Signal Processing ■ VLSI and Computation ■ Human Informatics ■ Telecommunications Networks and Security ■ Wireless Power Supply ■ Autonomously Distributed Network ■ Cloud Computing ■ Human Cooperative AI ■ Machine Learning ■ Big Data Analysis ■ Sensory Sensing
Department of Industrial Engineering and Economics	■ Industrial Systems ■ Human-Oriented Systems ■ Operations and Management ■ OR ■ Mathematical Information Technology ■ Corporate Governance ■ Management Strategy and Marketing ■ Humanomics ■ Cliometrics ■ Game Theory and Experimental Economics ■ Macro Economics and Econometrics

Approaches to Research



School of Materials and Chemical Technology

Creating a civilization in which all living things can prosper

The School of Materials and Chemical Technology comprises two departments, Materials Science and Engineering, and Chemical Science and Engineering. It is dedicated to creating new functions based on a solid understanding of the structures and properties of matter. It also aims to nurture researchers and engineers capable of discovering principles and methods for controlling the dynamic chemical processes of substances. This is a place for top-level researchers to interact and cooperate, and for the education of young people interested in exploring solutions to issues related to the environment, energy, resources, safety, and health through the application of various materials.

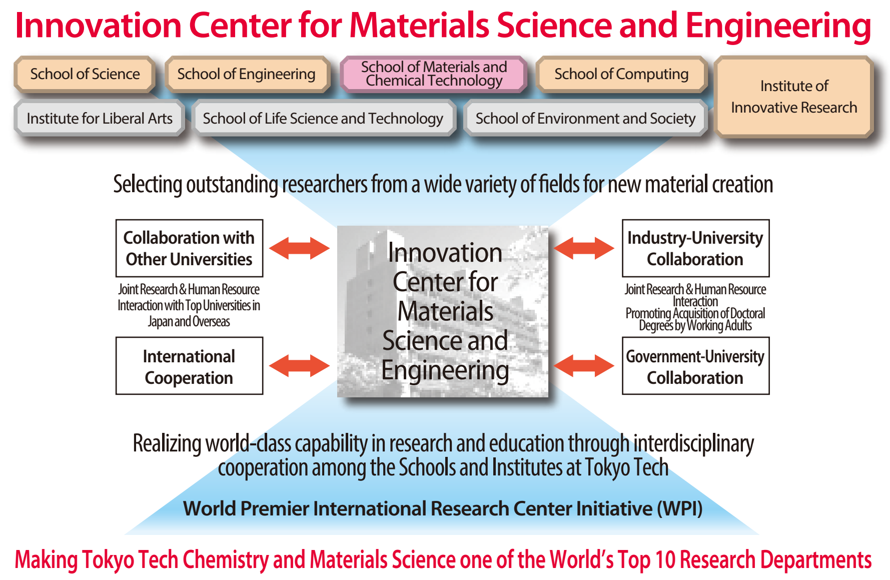
DATA	As of May 1, 2018
Faculty/International	181/11
Research Staff	33
Total Students/ International Students	1,456/197
Students in Bachelor's Programs/ International Students	387/11
Students in Master's Programs/ International Students	847/102
Students in Doctor's Programs/ International Students	222/84

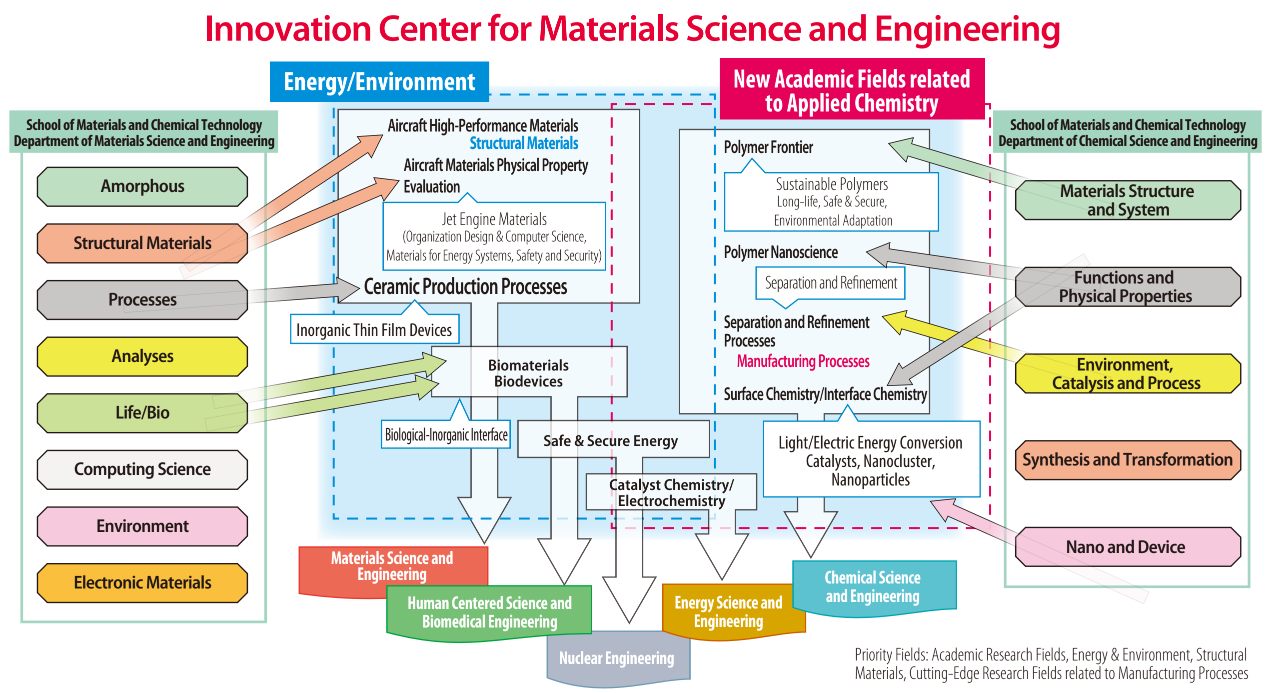
Structure and Research Fields

Department of Materials Sciences and Engineering	■ Metallurgy and Surface Science ■ Organic and Poymeric Materials ■ Inorganic Materials ■ Energy Science and Engineering ■ Human Centered Science and Biomedical ■ Nuclear Engineering
Department of Chemical Science and Engineering	■ Materials Structure and System ■ Functions and Physical Properties ■ Environment, Catalysis and Process ■ Synthesis and Transformation ■ Nano and Device ■ Energy Science and Engineering ■ Human Centered Science and Biomedical ■ Nuclear Engineering

Approaches to Research

The School of Materials and Chemical Technology comprises of two departments, Materials Science and Engineering, and Chemical Science and Engineering. They play a central role in research and education for extremely powerful and essential substances, and materials for future Japanese industries. We also established Innovation Center for Materials Science and Engineering, a new organization inside the School to promote cross-sectional research and projects between the two departments. These include collaborative industry-university education, collaborative industry-university research, international education and research, and joint interdisciplinary research; and staff from our faculty are assigned to advance Tokyo Tech's new education system and research activities.





Priority Fields: Academic Research Fields, Energy & Environment, Structural Materials, Cutting-Edge Research Fields related to Manufacturing Processes

School of Computing

Creating a future information society

"Information" is a vague entity. In order to see, analyze, and turn information into something usable, research on advanced mathematical theory, high-performance computing technology, and artificial intelligence is essential. While information can now be processed by computers to enable more efficient application, there are still many theories that have yet to be proven and technologies that have yet to be developed to realize the true potential of information and understand how to make even better use of it. There must be potentially vast applications of information that have yet to be imagined, and the School of Computing is engaged in the establishment of advanced theories of information and the creation of cutting-edge technologies from the perspectives of both science and engineering to fully explore this vast potential. We are working to gain a deeper understanding of what information really is and can be used, and to develop innovative technologies through the application of this knowledge. We are continuously in pursuit of information science and technology that contribute to society.

DATA	As of May 1, 2018
Faculty/International	105/8
Research staff	18
Total Students/International Students	661/113
Students in Bachelor's Program/ International Students	211/9
Students in Master's Program/ International Students	361/78
Students in Doctor's Program/ International Students	89/26

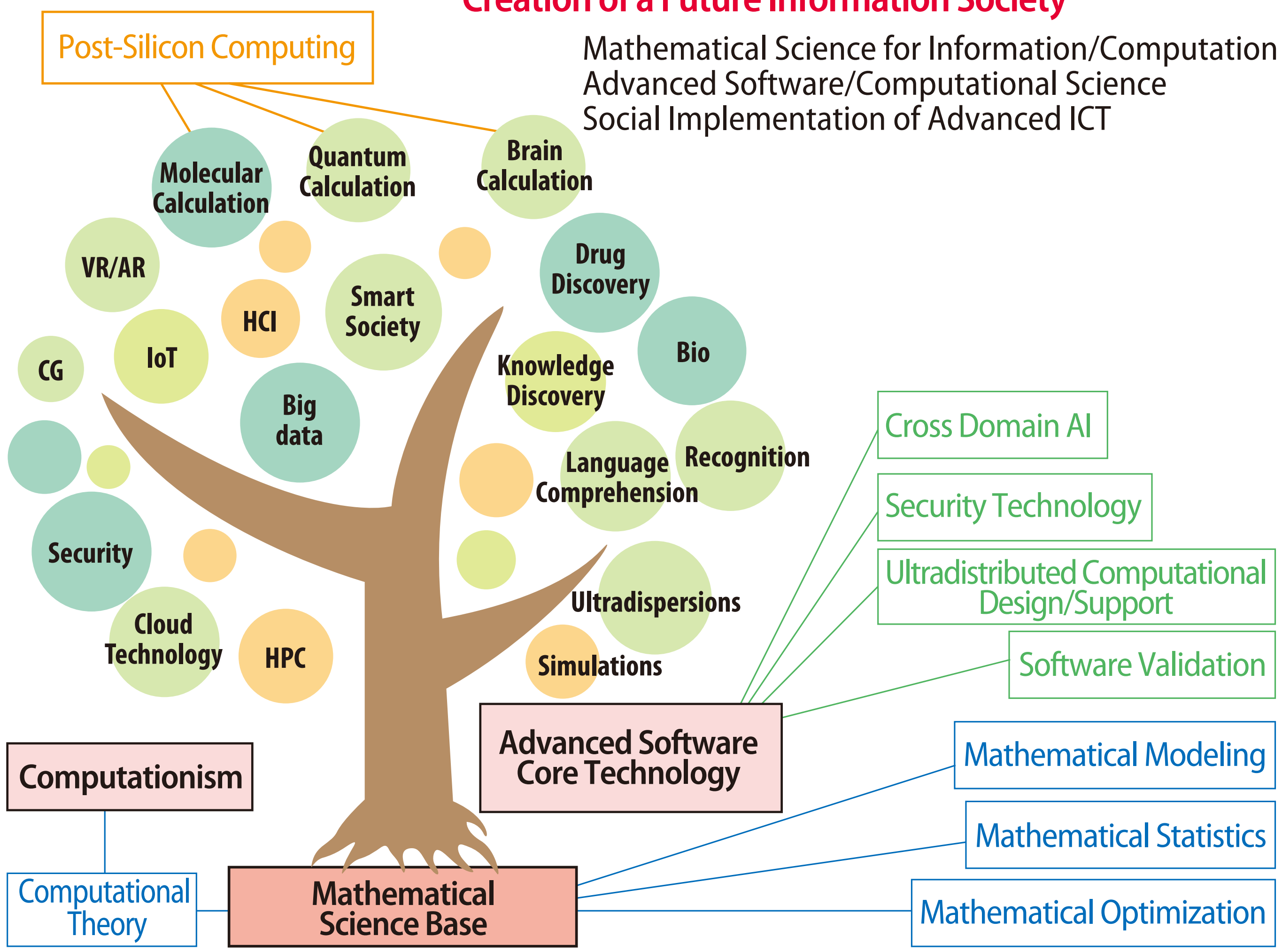
Structure and Research Fields

Department of Mathematical and Computing Science	■ Mathematical modeling ■ Mathematical Statistics ■ Algorithm design ■ Programming languages ■ Blockchain ■ Software Development Environment ■ High Performance Computing ■ Cybersecurity ■ Mathematical Optimization ■ Information Visualization ■ Distributed Systems ■ Topology ■ Partial Differential Equation
Department of Computer Science	■ Artificial Intelligence ■ Natural Language Processing ■ Speech/ Image Recognition ■ System Control ■ Data Mining ■ Molecular Simulation ■ Parallel Computing ■ Human Interface ■ Virtual Reality ■ Database ■ IoT ■ Bioinformatics

Approaches to Research

Broad Research Fields Contributing to the Creation of a Future Information Society

Mathematical Science for Information/Computation
Advanced Software/Computational Science
Social Implementation of Advanced ICT



School of Life Science and Technology

SmartBio – promoting the integration of life science and biotechnology to become a knowledge creation base for life innovation

The realization of a super smart society (The 5th Science and Technology Basic Plan of Japan) requires the establishment of biotechnology that responds to social needs, through the expansion of life science research. This is what we call smart biotechnology (SmartBio). The School of Life Science and Technology promotes research and education for the creation of new smart biotechnology through the integration of biomolecular science, bioengineering, and bioinformatics based on solid basic research in life science to fulfill its function as a knowledge creation base for life innovation through social collaboration.

DATA	As of May 1, 2018
Faculty/International	92/1
Research staff	26
Total Students/International Students	786/83
Students in Bachelor's Program/ International Students	287/5
Students in Master's Program/ International Students	385/49
Students in Doctor's Program/ International Students	114/29

Structure and Research Fields

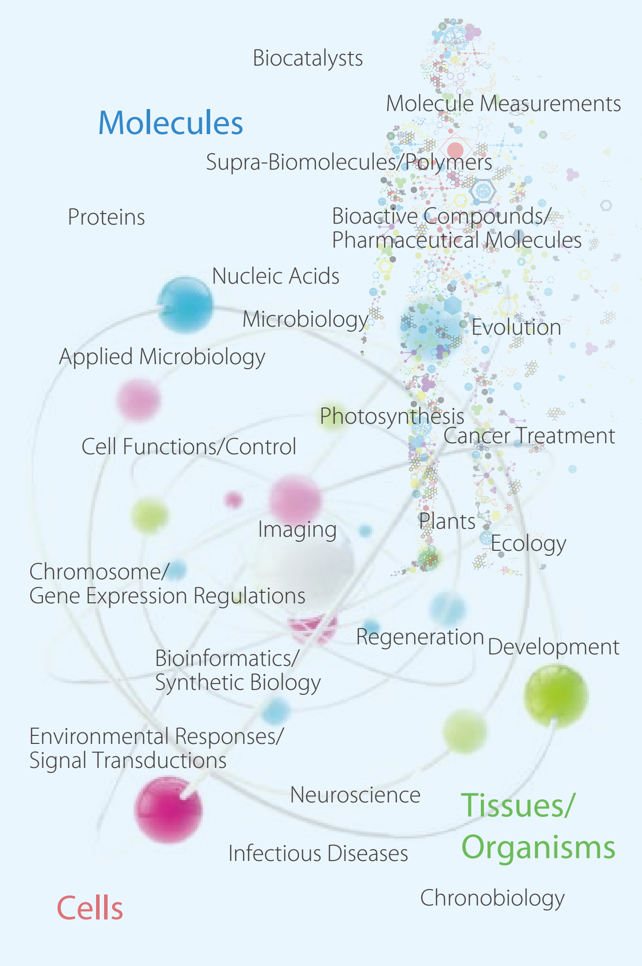
Department of Life Science and Technology	■ Biopolymer ■ Medicinal Chemistry ■ Chemical Biology ■ Clarification/Control Technology of Cell Functions ■ Disease Mechanism/Development of New Therapeutic Technology ■ Biomarker ■ Development/Regeneration ■ Brain Science/Neuroscience ■ Bioimaging ■ Bioinformatics ■ Biomolecular Devices ■ Genetic Engineering ■ Protein Engineering ■ Microbial Engineering ■ Biomaterials ■ Biosensors ■ Biomolecule Analysis Technology ■ Biocatalysts ■ Plant Science ■ Biomass Technology ■ Biological Evolution

Approaches to Research

Promotion of Research

We promote a broad range of activities in both basic and applied life science and technology to advance fundamental and innovative research.

The following chart shows our faculty's areas of research.



Promotion of Industry-University Collaboration & Social Collaboration

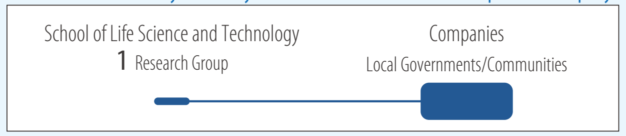
Supporting interdisciplinary integration and collaboration as the knowledge base for life innovation

Life Science and Technology Open Innovation Hub (LiHub)

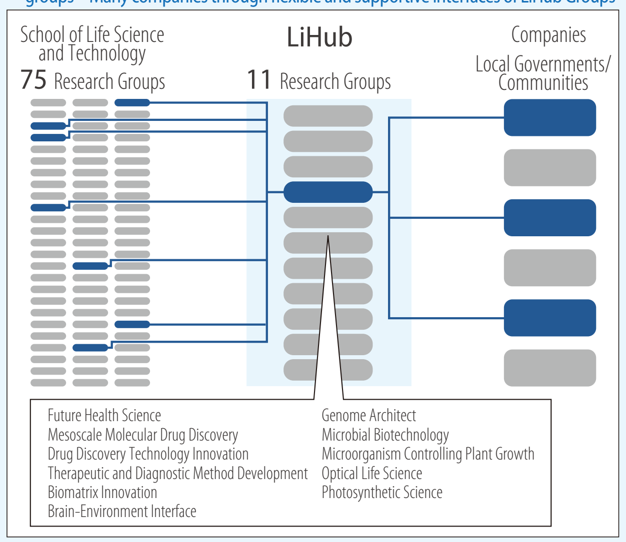
Advantages for Collaboration with LiHub

- Access to information on the cutting-edge of international trends in life science bio-industries
- Recruitment of young talents in life science and technology
- Research and screening for new business seeds
- Networking to many different experts in academia and industrial sectors
- Support to establish core competences

■ Conventional Industry-University Collaboration: One Research Group – One Company



■ LiHub-produced innovative structure for university-industry collaboration: Many research groups – Many companies through flexible and supportive interfaces of LiHub Groups



School of Environment and Society

Solving complex social issues through the integration of humanities and science for inclusive and sustainable global development

The sustainable development of humanity and society requires that the institute's students absorb a broad range of humanities and social science knowledge while they learn science and engineering concepts. Furthermore, we expect our students to become individuals capable of applying and developing knowledge to create new technologies and academic fields. To make this happen, in addition to the Department of Architecture and Building Engineering, Civil and Environmental Engineering, and Transdisciplinary Science and Engineering, the School of Environment and Society has established the Department of Social and Human Sciences and the Department of Innovation Science, as well as the Technology and Innovation Management Professional Master's Degree Program for graduate-level studies. By integrating the humanities and science, we aim to cultivate leading scientists and engineers truly capable of contributing to the global society.

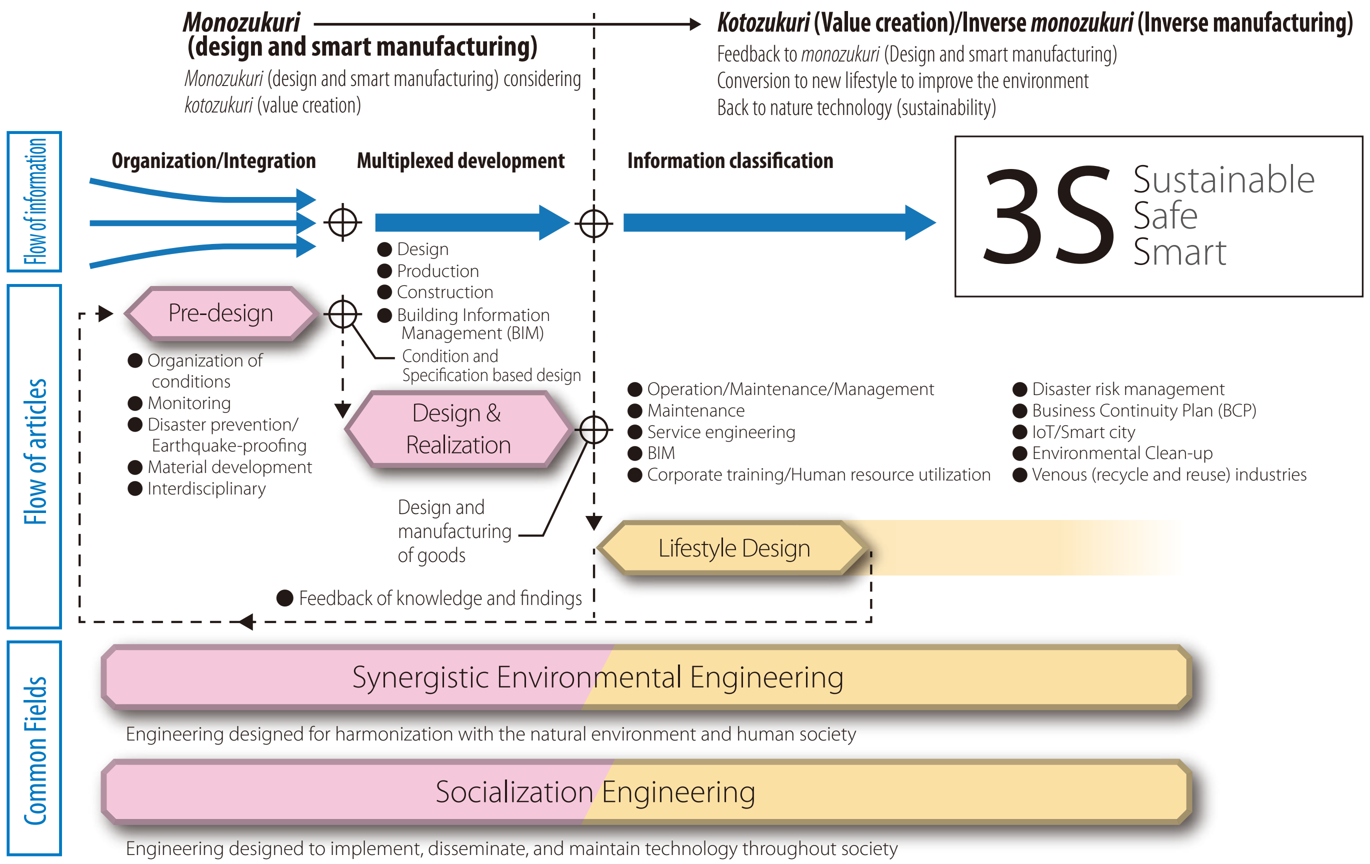
DATA	As of May 1, 2018
Faculty/International	187/12
Research staff	22
Total Students/International Students	1,289/357
Students in Bachelor's Program/International Students	300/61
Students in Master's Program/International Students	772/196
Students in Doctoral Program/International Students	217/100

Structure and Research Fields

Department of Architecture and Building Engineering	■ Architectural Design ■ Sustainable Architecture ■ Architecture Engineering ■ Architecture Project Management ■ Urban Space Management
Department of Civil and Environmental Engineering	■ Next-Generation Infrastructure and Space Management ■ System for Sustainable Society ■ Social Safety System ■ Urban Space Management
Department of Transdisciplinary Science and Engineering	■ Human – Societal System ■ Environment – Natural System ■ Expert and Artificial System ■ Integration – Harmonization System
Department of Innovation Science	■ Intellectual and Technological Value Creation ■ Economic Value Creation ■ Social and Public Value Creation

Approaches to Research

In order to contribute to inclusive and sustainable global growth, we are expanding engineering design to promote harmonization between the natural environment and human society, and engineering designed to implement, disseminate, and maintain technology throughout society. We also promote comprehensive research activities including *monozukuri* (manufacturing), *kotozukuri* (value creation), and techno-logical development to reintegrate manmade objects back into nature (regenerative design).



Institute for Liberal Arts

Envisioning an alternate future through the fundamental and ethical integration of knowledge in science and engineering, and the utilization of logos, pathos, and ethos from the liberal arts

The Institute for Liberal Arts (ILA) carries out interdisciplinary research centering on the fields of humanity and social science. We seek to truly understand what we are and what the world is to discover new bases of intellect and knowledge to enhance lifestyles.

At the same time, the ILA also plays a role as a think tank to implement science and engineering knowledge into society, which contributes to large-scale research projects developed by Tokyo Tech.

DATA	As of May 1, 2018
Faculty/International	56/5

Structure and Research Fields

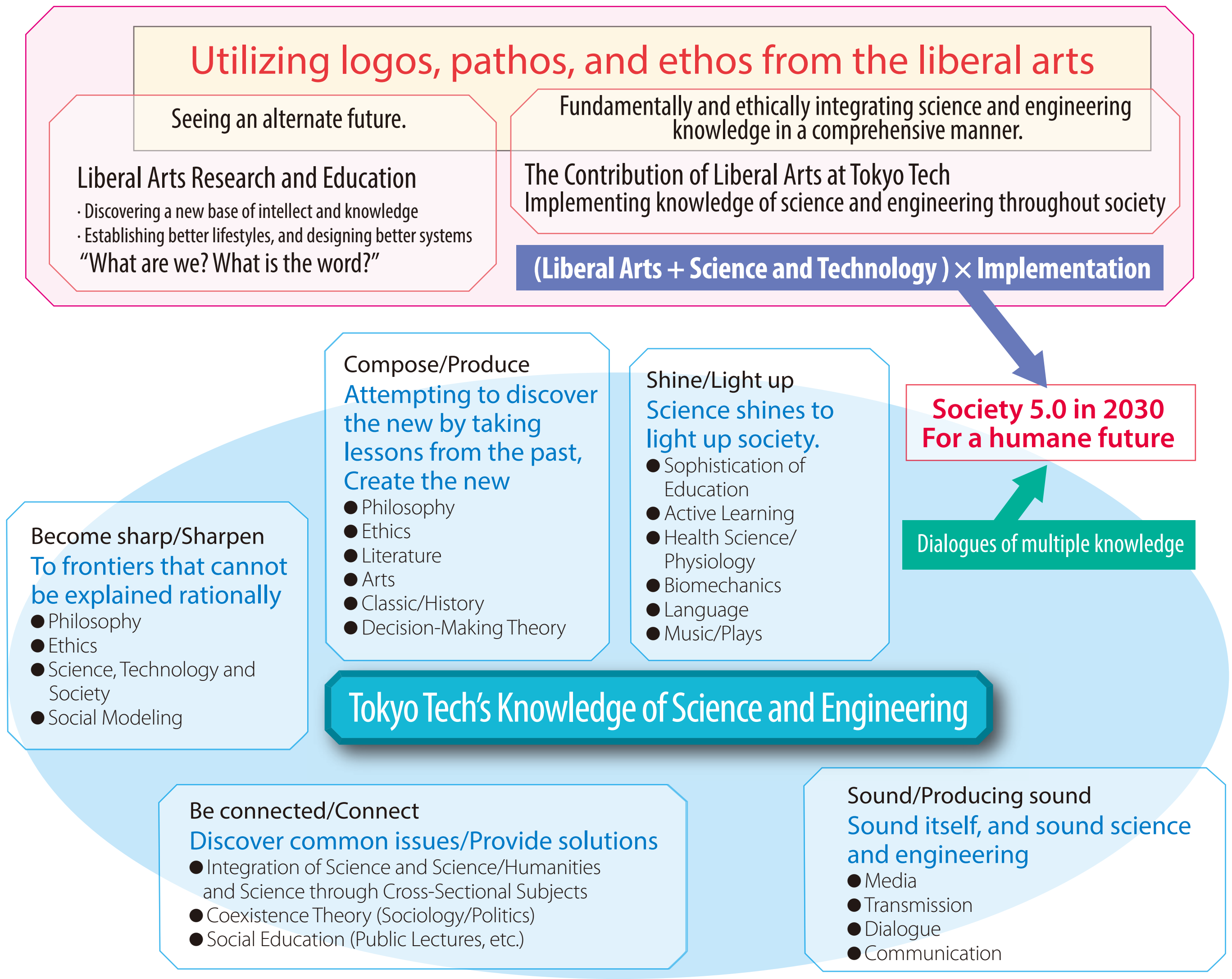
The ILA provides liberal arts education to all Tokyo Tech students. The ILA provides different courses in the Humanities and Social Science, English Language, Second Foreign language, Wellness, Japanese Language and Culture, and Teacher Education. The ILA also provides initial education immediately after enrollment, leadership education given in master's programs, and interdisciplinary research and education related to social issues given in doctoral programs, all beyond the boundary of specialization.

The ILA offers opportunities to conduct research in a wide variety of fields that cover an extensive range of research themes. For example, instruc-tors in charge of language carry out research on art, or instructors in charge of humanities and social science handle mathematical models. Please see the table for the research fields of individual instructors.

The ILA oversees knowledge in science, engineering and society, and has come to play a role as a bridge to building better lifestyles.

Approaches to Research

— Future Vision —

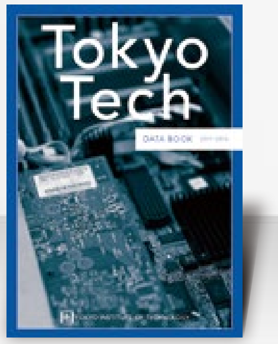


Publications

J Japanese E English J/E Japanese and English

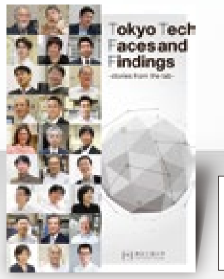
Tokyo Tech Overview J E

Data Book J E



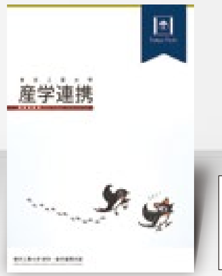
Admissions 2019 J

Tokyo Tech Faces Findings J E

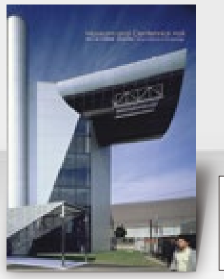


Tokyo Tech Research 2019-2020 J E

Industry Liaison J E



Museum and Centennial Hall J E



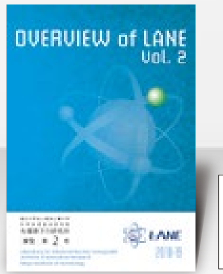
Institute of Innovative Research J/E

FIRST 2018 Laboratory for Future Interdisciplinary Research of Science and Technology J/E

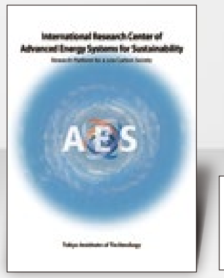
Laboratory for Materials and Structures 2018 J/E

2018-2019 Laboratory for Chemistry and Life Science J

Overview of LANE Laboratory for Advanced Nuclear Energy J/E

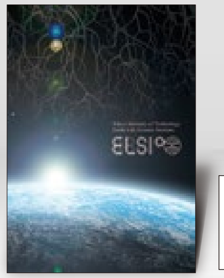


International Research Center of Advanced Energy Systems for Sustainability J E



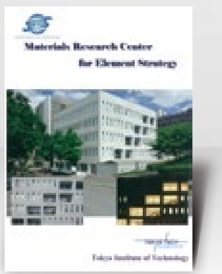
Research Unit J E

Earth-Life Science Institute ELSI J E

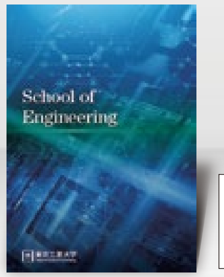


ELSI: Search for the origin of Earth and life J E

Materials Research Center for Element Strategy E



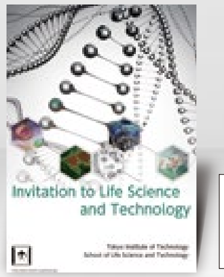
School of Engineering J



Professor Profiles 2017 School of Materials and Chemical Technology J E

School of Computing 2018 J

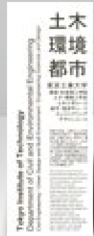
Invitation to Life Science and Technology J E



Institute for Liberal Arts J

Architecture and Building Engineering J

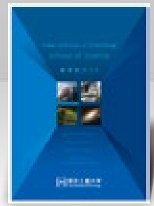
Department of Civil and Environmental Engineering J



Undergraduate Major in Transdisciplinary Science and Engineering J/E

Department of Innovation Science J

School of Science J



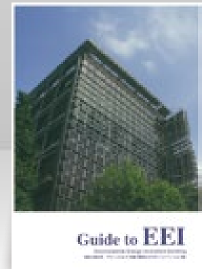
Department of Mathematics J

Department of Chemistry J

Department of Earth and Planetary Sciences J

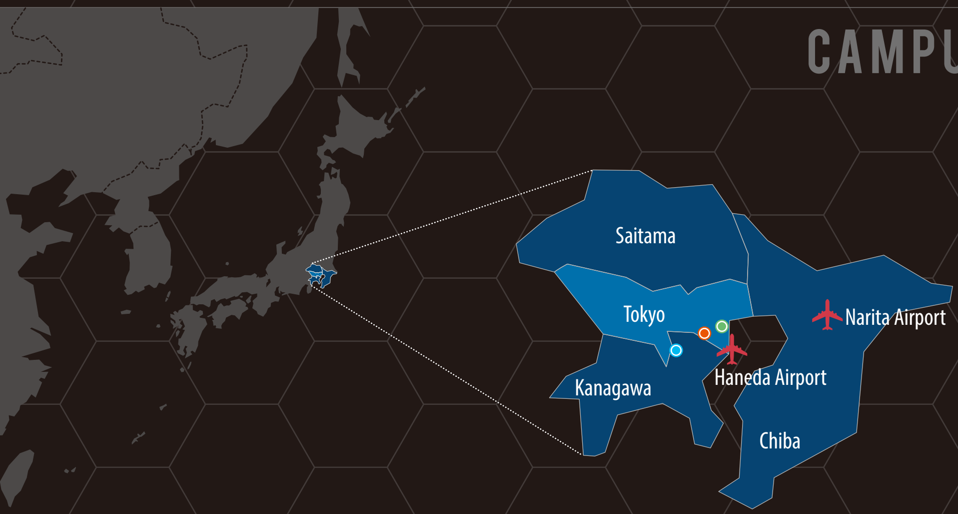
Global Scientific Information and Computing Center J E

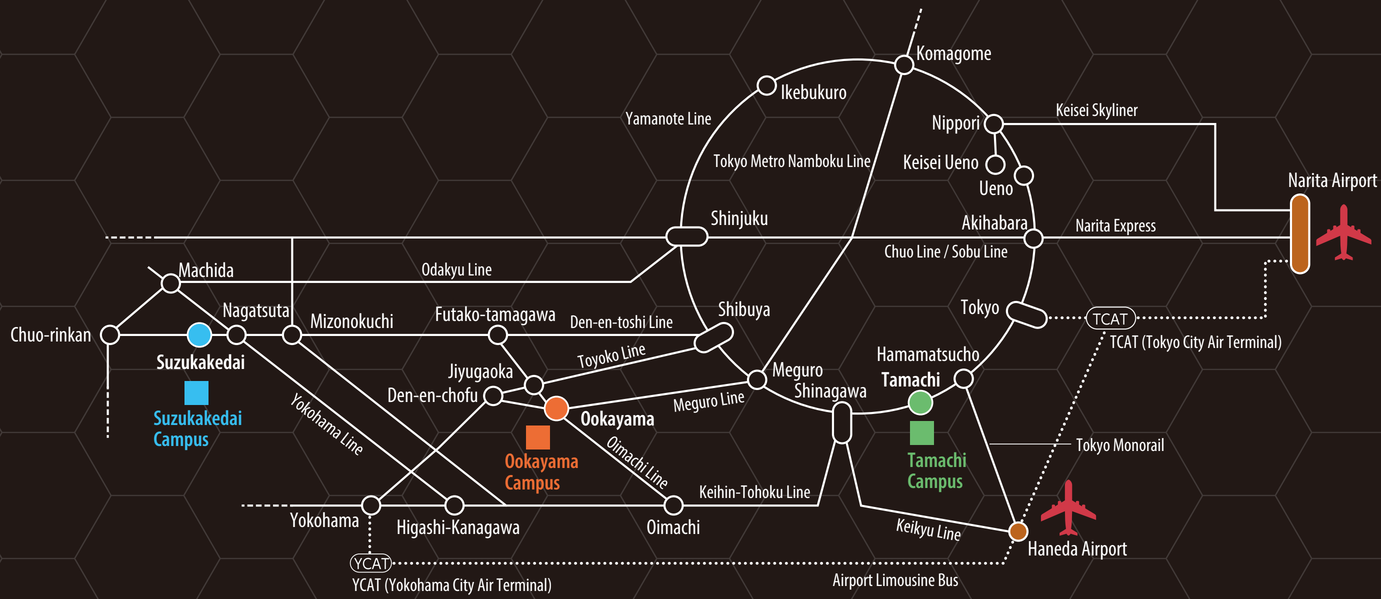
Guide to EEI Environmental Energy Innovation Building J E



Innovative Research Initiatives J

CAMPUS LOCATION & ACCESS





Suzukakedai Campus
4259 Nagatsuta-cho, Midori-ku, Yokohama, Kanagawa 226-8503 JAPAN

- 5-minute walk from Suzukakedai Station on the Tokyu Den-en-toshi Line
- 70 minutes from Haneda Airport
- 130 minutess from Narita Airport

Ookayama Campus
2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550 JAPAN

- 1-minute walk from Ookayama Station on the Tokyu Oimachi & Tokyu Meguro Lines
- 45 minutes from Haneda Airport
- 85 minutes from Narita Airport

Tamachi Campus
3-3-6 Shibaura, Minato-ku, Tokyo 108-0023 JAPAN

- 2-minute walk from Tamachi Station on the JR Yamanote Line & Keihin-Tohoku Line
- 25 minutes from Haneda Airport
- 65 minutes from Narita Airport

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