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https://park.itc.u-tokyo.ac.jp/createthefuture

東京大学工学部
FACULTY OF ENGINEERING
THE UNIVERSITY OF TOKYO

Editor's Note

In this issue, we asked people who are studying various disciplines of engineering to reflect on and talk about what their high school days mean to them today. We hope that everyone who reads this brochure will feel the connection between what they learn in high school and engineering, and will develop an interest in engineering. In addition, at the end of the brochure, we feature several objets d'art located near the Faculty of Engineering Square, which you will see on the left side after entering from the main gate. Please check them out when you visit Hongo Campus.
This is the first issue produced under the new system. We were busy preparing for the May Festival, where we planned dialogues with current students of the Faculty of Engineering, but we were able to complete this brochure thanks to all the professors and students whom we interviewed, as well as everyone who was involved in preparing the brochure. Thank you very much. We will continue to do our best to show you what the Faculty of Engineering has to offer, so please continue to read Ttime!

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SUMMER 2022

Ttime!

Looking Ahead to Engineering

FACULTY OF ENGINEERING
THE UNIVERSITY OF TOKYO

Looking Ahead to Engineering

The theme of this issue is “Looking Ahead to Engineering.”
Learning at university is based on high school subjects, such as mathematics, physics, chemistry, and biology. However, few students in high school or the first year of university have a clear idea of how these subjects will lead to engineering research. Therefore, we interviewed teachers and students in various fields of engineering and asked them about their current research and high school days.
We tend to think that only science-related subjects lead to engineering, but during our interviews we came to understand the importance of broadening our horizons in an integrated manner by looking at social studies and other humanities subjects as well.
We hope these articles will serve as an opportunity for high school students and Komaba students who are preparing to enter higher education to “look ahead to engineering.”
In publishing the valuable stories of teachers and students, we have broadly divided engineering into four fields. You are free to read from the beginning or from the areas that interest you.
At the end of the brochure, we also introduce some statues and objets d’art related to the Faculty of Engineering. As you experience the atmosphere of the Faculty of Engineering, the University of Tokyo, please stop to think about the history of engineering in the Faculty and in Japan.

Written by Ayako Masuno, Mizuki Noguchi, and Yuki Tsuji.

Creating Physical Properties that Open Up the Future

Studying the microscopic world offers endless possibilities.
Studying the characteristics of materials at the microscopic scale, so small that they are invisible to the eye, allows for a deeper understanding of materials. By using those characteristics, we can not only improve the properties of materials, but also design materials with new, unexpected properties.
In addition, the laws of physics around us do not apply to nano-sized objects such as atoms and molecules, or even smaller sizes. Instead, the laws of the world at the ultra-small scale, called quantum, which has the properties of both particles and waves, apply. The laws of the quantum world are highly mysterious, but they are actually the foundation of our world. One of the applications of quantum mechanics, which are the principles of quantum behavior, is the quantum computer.
A variety of digital technologies are now being used to realize the society of the future, and these information technologies and sophisticated devices are supported by literally invisible technologies.

Written by **Ayako Masuno**

First year, Master's course, Department of Applied Physics, School of Engineering, The University of Tokyo

Kazuma TAKAHASHI

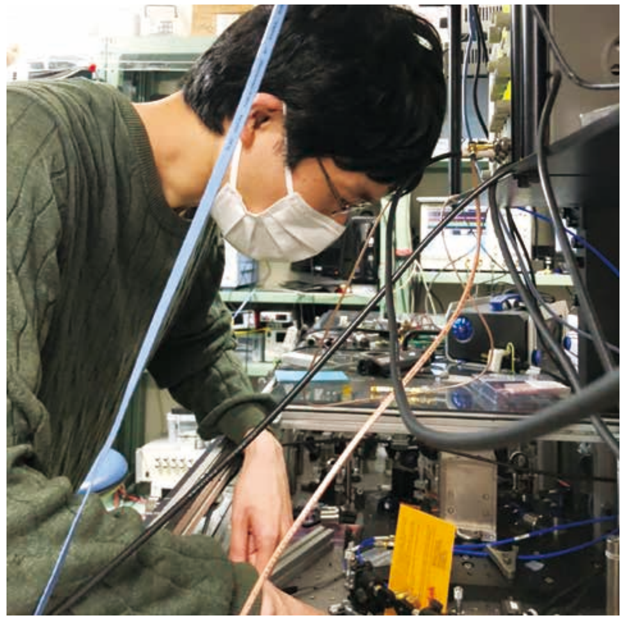
Research on the Realization of Quantum Computers

I am currently working on research on quantum computers. While conventional computers use zeros and ones in their calculations, quantum computers use superposition states of zeros and ones, which has the advantage of solving certain problems faster. There are several types of quantum computers. Among them, my laboratory is particularly interested in quantum computers using light ("optical quantum computers").
Current computers have a clock speed (an indicator of how many calculations can be performed per second) of about 2 to 5 GHz, but optical quantum computers are expected to achieve up to several tens of THz, which would significantly improve the calculation performance. Such a high computational performance with a clock speed of several tens of THz can be attained by using light with a wavelength of 1,550 nm. This wavelength is in a wavelength band called the communication wavelength band, and since optical communication and optical cables in widespread use today use light in this wavelength band, there is an advantage that existing modules※2 and products can be used. Until a few years ago, we had been using a different wavelength band, but the development of a photodetector※1 (photon measuring instrument) that uses superconductivity has made it possible to conduct experiments in this wavelength band.
In my graduation research, I studied photodetectors using superconductivity. Ideally, it would be possible to count the number of photons as 0, 1, 2, ..., but ordinary detectors are not so accurate. Therefore, I investigated the accuracy of the device by changing its parameters, and finally verified that changing certain parameters changes the maximum number of photons that can be identified.

※1 : Photodetector: A device that detects the number of photons (light particles) and converts it into the magnitude of an electric current corresponding to the number.
※2 : Module: A replaceable component.

Relationship between High School Subjects and Career Choices / Research

I am glad that I studied hard what I learned in high school classes.
This is just my personal opinion, but when it comes to studying, I think it is enough to study the subjects for the exam. Of course, those who want to learn more are encouraged to study beyond the high school scope. On the other hand, those who have only vague dreams for the future should focus on high school studies because they contain important material. For those aspiring to be researchers, the harder you learn high school mathematics, physics, chemistry, and English, the easier it will be to understand university lectures. In particular, high school mathematics is directly linked to physics, which is why I studied mathematics in order to study physics at university. If you want to study physics at university, you should definitely study high school mathematics. In addition, all English language skills, that is, reading, writing, listening, and speaking, are necessary. When I was in high school, I thought I could get by with translation tools, but I was wrong.
I also feel that having a wide range of interests, even if shallow, will broaden your options. Especially when it comes to research, it is important to know what research fields exist in the world in order to know what subject you would like or are interested in. In my case, I didn' t particularly like physics in high school, but was just interested in the stories my physics-loving friend would tell me. After that, while I was interested in learning, I happened to get into my current field. In this sense, I think it is important to study any subject, including humanities subjects, until you know whether you like it or not. It is also good to read books that interest you. I think having even a rough idea of what you like and what you don' t like will help you in your future career choices.
As an aside, I also feel that I should have taken my club activities more seriously. I used to play table tennis, and although I didn' t expect to continue playing after high school, I still play from time to time to get some exercise and refresh myself. It' s more fun if you' re good at it.



Scene of experiment

Written by **Atsushi Narita**

Research Theme

Research on Semiconductor Devices for High-Efficiency Power Conversion

Professor, Department of Advanced Materials Science,
Graduate School of Frontier Sciences, The University of Tokyo, and Department of Materials Engineering,
Faculty of Engineering, The University of Tokyo

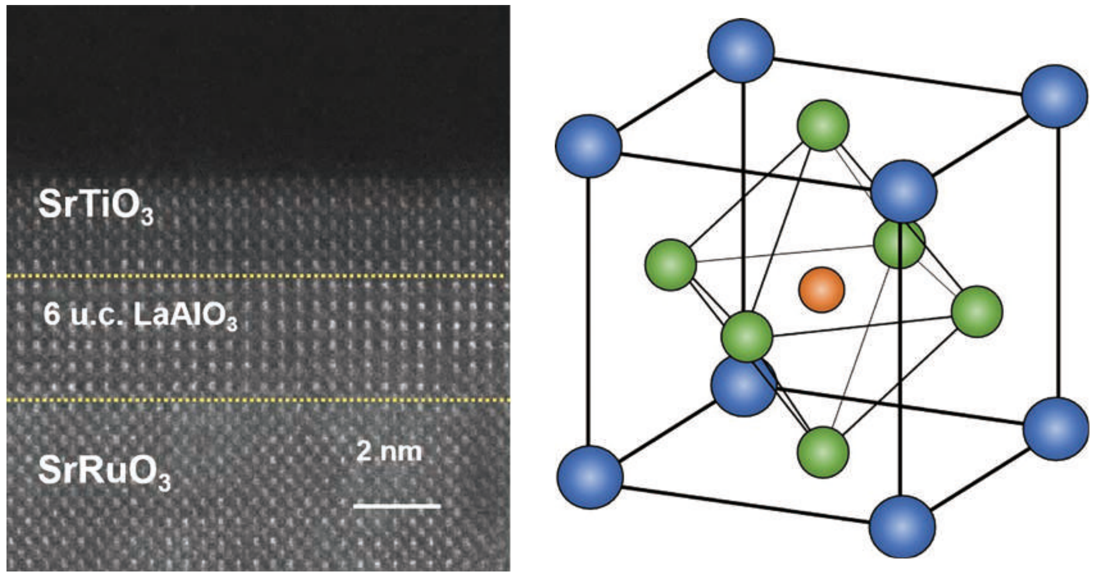
Koji KITA

Research on New Power Device Materials to Replace Conventional Si

A power device is an element (a component of an electric circuit) used to convert electric power. When switching on and off a current of hundreds of amperes flowing through the element at high speed, a certain percentage of the energy is lost. To reduce this loss, we are conducting research to dramatically improve performance by replacing the conventional silicon (Si) material with a new material called SiC.

The performance of SiC as a power device is limited by a part of the transistor※1 called channel. The channel is made by bonding an insulator such as SiO_2 to SiC, and electric charge is accumulated by applying a voltage to the bonded interface. SiC is about 350 μm thick, but this function is performed in a tiny region only about 10 nm from the surface. In other words, the performance of a power device depends on the properties of the nanometer-order space near the interface. Therefore, we are studying the manufacturing process, principles, and physics of how to control this interface to achieve the desired properties in the nano-region.

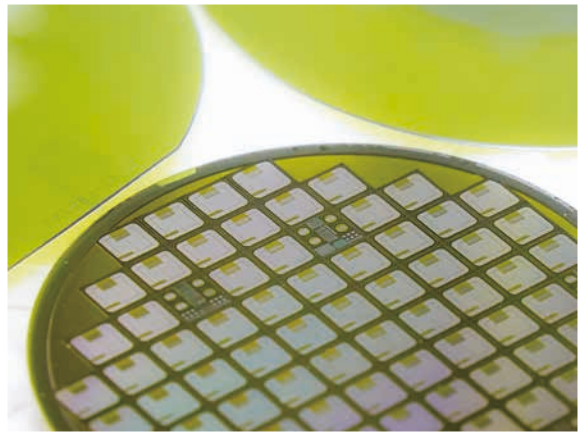
※1 : A structure that controls electric current by amplifying electrical signals or turning on and off electricity in an electrical circuit.



Stacked structure of perovskite oxide nano-films (observed by transmission electron microscopy) and schematic diagram of the crystal structure.

Looking beyond Conventional Si Devices

Until now, research on the operating principles, physics, and other aspects of electronic devices has been conducted assuming the use of Si as the semiconducting material. However, with the emergence of a new material, SiC, behavior that cannot be explained by conventional Si physics has come to be observed. This is where chemistry is helpful, as it can explain what reactions are taking place at the interface. For example, let' s consider a situation where you think you are using only SiC and SiO_2, but in fact you need to check for the formation of unintended compounds due to unexpected chemical reactions. At this point, if you have a correct understanding of chemical thermodynamics, you can predict what reactions will occur at what temperatures and pressures. In addition, although it is beyond the scope of high school subjects, from the viewpoint of material engineering, strain exists at the interface. Since strain affects the electronic properties of SiC devices, it is necessary to investigate how much strain is present. In order to develop a broad understanding of materials in general, it is necessary to have a broad knowledge of chemistry as well as physics among high school subjects.

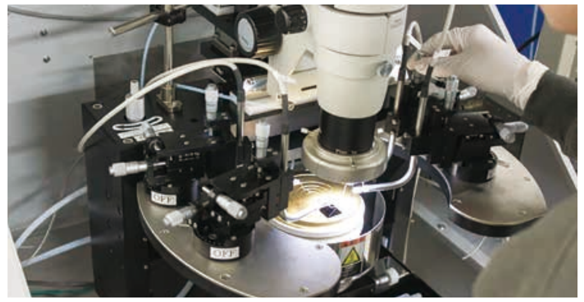


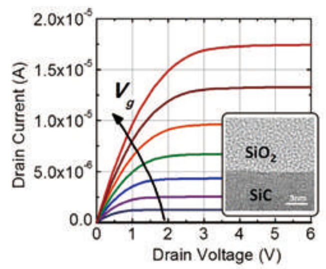
A wafer※2 made of SiC which is attracting attention as a next-generation power device material

※2 : A thin, disk-shaped plate made of semiconductor crystals used to fabricate semiconductor substrates and devices.

To Learn Cutting-edge Technology

Research in the field of device technology requires the ability to apply knowledge of Si physics in order to understand phenomena. However, this alone is not enough. In fields where modern science is struggling to develop technology, research results already exist in areas that can be understood by existing disciplines. To go one step further and pursue novelty, you will need to advance your research by integrating academic disciplines, for example, examining the subject from the perspective of specialized chemistry in addition to physics. In order to quickly acquire knowledge in fields other than your own specialty when needed, you must have a good understanding of the underlying academic disciplines. At the forefront of research, the ability to foresee phenomena based on an understanding of many disciplines is required. For this reason, I recommend that high school students study a wide range of subjects rather than focusing on just one.





Measurement of the prototype SiC MOS transistor and the voltage-current characteristics obtained

Developing the Ability to Relate to Society

I was particularly interested in environmental issues among social problems, partly because I had learned about the pollution problems that occurred in Japan in the 1970s from textbooks at elementary and junior high schools. When I later entered the Faculty of Engineering at the University of Tokyo, I wanted to do research on themes that would contribute to environmental issues, and that led to my current research on developing devices with low energy loss.

In my case, environmental issues were the trigger for my research, but I hope everyone will keep considering, not limited to the environmental issues, how they want to contribute to society in the future. This may sound difficult, but I believe that social studies subjects such as geography, history, and civics provide the opportunity to form antennas that can receive social information with high sensitivity. I believe that a person' s sense of interest and concern for society is formed through learning and studying, and I myself became interested in environmental issues through what I was taught at school.

The sense that you developed as a student will surely be reflected in your actions when you are in your 40s or 50s and in a position to influence the society. Some of you may become researchers, some will work as public servants, and some will work in the private sector. There are many ways to interact with society, but no matter which career path you choose, the sensitivity that you developed during school years will be reflected in how you contribute to society. I hope that all high school and Komaba students will study society carefully and value their sense of what they are interested in and what they perceive as problems in society.

Written by **Yuki Tsuji**

Improving Performance through Design

Raise your head a little and look around. You will see various products. For example, the clothes you wear, the bag you carry, plastic bottles, smartphones, cars, computers, home appliances, airplanes ... all of these products around us are made because someone designed them.

Even if materials of the same size and weight are used, the properties will differ greatly if the shapes are different. Even a small change in structure can make the product stronger, more beautiful, and perform better. Also, there are many aspects of performance, and products and systems are created by considering a wide variety of things. It is difficult to come up with the optimal design that satisfies all requirements, such as to be easy to use for everyone, to be safe, not to break down, and to be friendly to people and the environment, but it is the most exciting part of design.

What were the intentions behind the design of the things around you? If you observe while thinking, you may make an unexpected discovery.

Written by **Ayako Masuno**

First year, Master's course, Department of Mechanical Engineering, School of Engineering, The University of Tokyo

koyo HORIE

Aiming to Improve the Fuel Efficiency of Hybrid Vehicles by Analyzing Real Driving Data

I am conducting research to analyze the factors that deteriorate the fuel efficiency of hybrid vehicles based on real driving data in order to optimize automotive powertrain※1 control.

The fuel efficiency of automobiles has been improved year by year through performance tests with strict standards. However, the fuel efficiency perceived by consumers is not always as good as in performance tests. This is because cars are driven in different situations by different people, and the environment, traffic flow※2, and other conditions are also different each time. The actual environment and traffic flow cannot be reproduced by conventional performance tests, which are conducted by placing vehicles on something like a belt conveyor to simulate the actual driving conditions. There is a discrepancy in the degree of improvement in fuel efficiency between conventional performance tests and actual driving, in which the accelerator and steering wheel are operated based on information sensed by the driver.

For this reason, my research focuses on real driving data. Information about the vehicle, such as speed, is measured together with information about the surrounding environment, such as temperature and road gradient. From the data obtained, we investigate what kinds of driving situations particularly deteriorate fuel efficiency, and analyze the factors that worsen fuel efficiency in those driving situations. The results of these analyses are then used to control the output of the motor and engine in hybrid vehicles, such as how to switch between the motor and engine, with the aim of optimizing powertrain control.

※1 : Powertrain : Mechanism required to transfer rotational energy produced by the engine to the drive wheels. It includes the engine, clutch, and transmission.
※2 : Traffic flow : Aggregate flow of vehicles driving on the road.

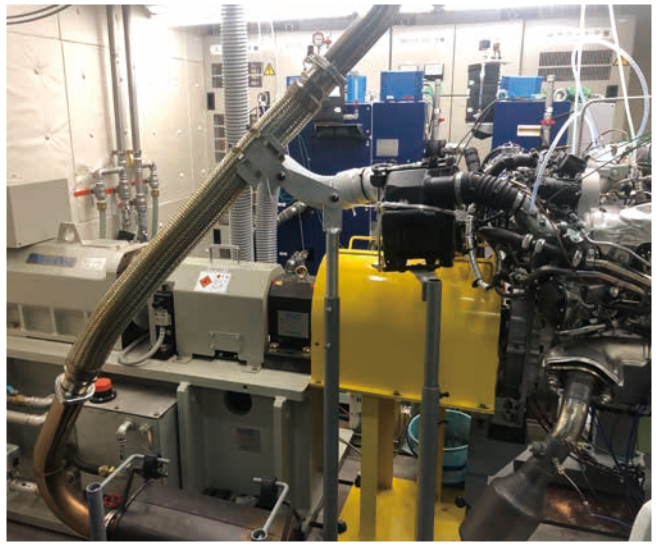
The Relationship between Research and High School Subjects

Physics and mathematics are closely related. For example, knowledge of mechanics is necessary to calculate motor output and understand the motion of pistons, which are engine components. Thermodynamics is related to how the heat energy produced by burning fuel in the engine is converted into kinetic energy, and fluid mechanics, an application of wave motion, is related to how the burned fuel is discharged. Also, electromagnetics is used for data measurement and power consumption calculations. Mathematics is necessary to learn physics, and in high school mathematics, calculus and complex numbers are closely related to physics.

The mathematics and physics studied in university are applications of those studied in high school, so at first I struggled with the transition from high school to university. However, the way of thinking is the same as what I learned in high school, and so I was able to cope thanks to having studied hard in high school.

In addition, although not directly related to my research theme, I wish I had studied English harder in high school and overcome my inferiority complex about the language. I have opportunities to give research presentations in English, so I should have practiced speaking more, which tends to be neglected when studying English for entrance exams. Also, many of the papers I read in my research are written in English, and I sometimes struggle to read them because they contain technical terms that I first saw in my research and I' m not sure I understand them even in Japanese.

Beside classes, I also wish I had been more aware of world affairs in high school. For example, the EU is shifting from gasoline-powered to electric vehicles to attain carbon neutrality, and so some domestic companies have declared that they will no longer develop internal combustion engines. However, even amid such a trend, some believe that internal combustion engine vehicles will not disappear anytime soon, so we are currently conducting research on improving fuel efficiency.

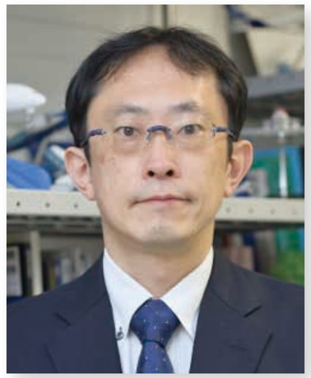


Gasoline engine in the laboratory

Written by **Mizuki Noguchi**

Research Theme

Fluid Analysis Program, Shape-changing Wings, and Noise



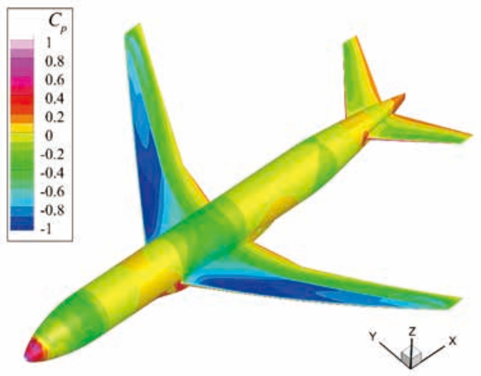
Associate Professor, Department of Aeronautics and Astronautics, School of Engineering, The University of Tokyo

Taro IMAMURA

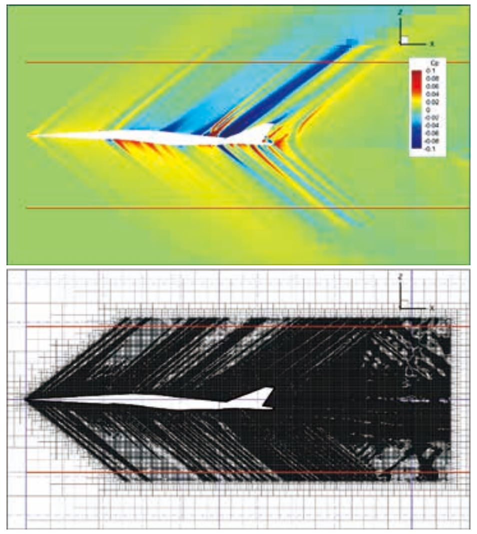
Improving Aircraft Design

Safety, environmental compatibility, and convenience are required for aircraft. Environmental compatibility includes fuel efficiency and low cost, and convenience includes high speed and punctuality. We are conducting research to design an aircraft that enhances these characteristics.

The major difference between aircraft and other vehicles is that aircraft fly in the sky. To do this, it must efficiently receive force from the air around the airframe, and therefore the exterior shape of the airframe is the key. We are developing a computational fluid dynamics (CFD) program called UTCart to accurately simulate how airflow varies with the shape of the airframe. The CFD program divides the space into small lattices and calculates physical quantities such as density, pressure, and direction of air flow in each lattice. However, it is often difficult to create the lattices and divide the space in the software, so it is not always possible to perform the fluid calculations. Therefore, we developed software from scratch that automates all of these processes and makes it easy to perform fluid analysis, and we are using it to perform fluid simulations. Simulations are performed on a variety of subjects, including not only airflow, but also pressure distribution on the outside of aircraft, noise, and shock waves generated during supersonic flight.



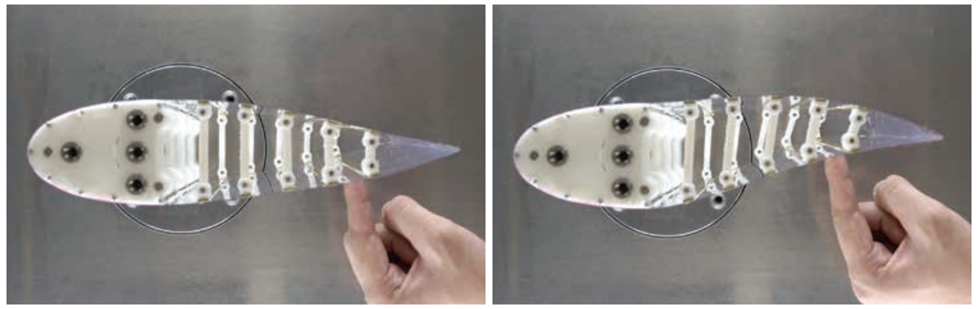
Analysis around transport aircraft using UTCart



Analysis around supersonic aircraft using UTCart (solution-adaptive approach)

We are also researching entirely new aerodynamic devices. Although ordinary aircraft wings also deflect and deform slightly, we believe that we can actively improve aerodynamic performance by daring to make them softer. We are currently studying a wing called a morphing wing, which can deform against the force of air to increase lift. With a view toward practical use in future, we are repeatedly conducting wind tunnel experiments to verify whether such soft wings are actually effective.

We are also studying aircraft noise, simulating the noise around the airport that occurs during takeoff and landing. Currently, a joint research project with a group from JAXA has been started to measure the noise level during landing at Narita Airport.



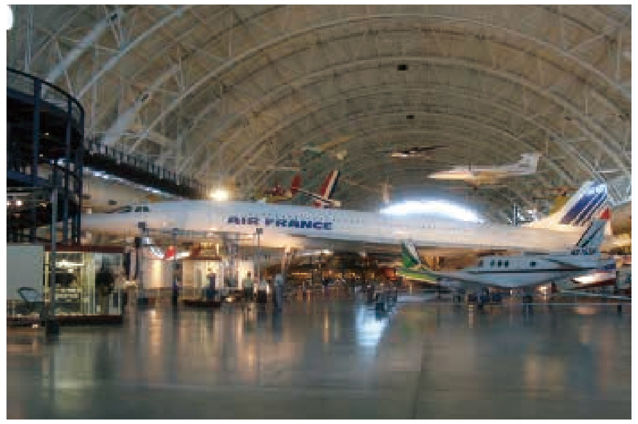
Deformation of a morphing wing

Focusing on Mass Points or the Continuum

When designing an aircraft, an understanding of fluid mechanics is necessary to perform fluid simulations. Although fluid mechanics may sound difficult, it is based solely on the mechanics and thermodynamics learned in high school. The laws of physics learned in high school physics, such as the laws of conservation of mass, conservation of momentum, and conservation of energy, also apply to fluid mechanics. Using these as the governing laws, fluid mechanics extends the object of interest to a fluid (a type of continuum) rather than mass points. The mathematics required to deal with fluids must be learned at university, but studying mechanics and thermodynamics will help you understand fluid mechanics more easily. Also, if you are going to make presentations overseas or read foreign papers as a researcher, of course English is important.

Touching the Real Thing

I think there are few opportunities to see airplanes in everyday life. Even if you do see them, you only see them flying far way, not up close in detail. Therefore, I recommend that you visit an airport, watch rocket launches on site, and create opportunities to see aircraft and spacecraft up close. It' s worth visiting the aerospace museum in Narita or Nagoya, or joining a tour of an airline maintenance factory.These days, you can look up anything on the Internet, but it' s a pity that you feel like you know something just by looking it up, rather than really knowing it. Once you touch the real thing you are interested in, you will notice fascinating new things that cannot be seen only from information on the Internet.



Exhibition at the Smithsonian Institution

Japanese Language Skills as a Researcher (for Japanese student)

English, mathematics, and science are of course important, but Japanese is also surprisingly important. When writing a paper, it is necessary to construct a logical structure properly and write sentences that accurately convey experimental results and the outline of graphs. Moreover, you must do it in English at university. Obviously, if you cannot write a paper in Japanese it is impossible to do so in English. When I was a high school student, I received essay corrections in preparation for the University of Tokyo entrance exam, and in retrospect, I think this helped me develop the habit of being aware of how to construct sentences and acquire expressive ability. In particular, my logical composition skills are useful not only when I write, but also when I think about the logic for assembling my research. And if you are unable to convey what you want to say at an academic conference, it is important to grasp how the other party interprets your words, which also requires linguistic competence. It may seem too obvious to mention, but I think Japanese language skills are just as important as English, mathematics, and science.

Written by **Anna Sasaki**

Designing the Space

The term “space” does not refer only to the inside of a room.
When building a new building, simulations are used to verify how it will change the ambient temperature and sunlight. Other simulations contribute to urban infrastructure development by examining the cost of maintaining and managing roads. In addition, information about town facilities may be analyzed to identify the characteristics of each community. In fact, these are all important elements in designing a “space.”
In the following research themes, you will see how “space” relates to physics, mathematics, information, geography, and political economy. Engineering tends to be thought of as a science-related field, but the “spaces” that support our daily lives have a strong relationship with society and cannot be considered without considering the elements of humanities subjects.
Isn’t it exciting to hear that many subjects will be equally useful when designing a “space” without being biased toward either the humanities or the sciences? How about trying to find the connection between “space” and the subjects you like or are good at?

Written by **Mizuki Yamada**

First year, Master’s course, Department of Civil Engineering, School of Engineering, The University of Tokyo

Jotaro ITO

Toward Better Road Maintenance

I am examining methods for public-private partnerships (cooperation between municipalities and businesses) for the maintenance and management of general roads. The majority of roads are maintained by municipalities using taxes. The municipality decides when to repair or renew a road and orders the work to contractors. In order to streamline operations, the municipality is motivated to outsource its operations, including scheduling of repairs and renewal, to contractors. However, outsourcing comes with financial problems. The municipality pays the contractor that manages the road, but if the amount is too small, the contractor may cut corners in road management, or no company may accept the contract. On the contrary, excessive payment will increase the expenditure of the municipality, putting pressure on finances. Therefore, a good payment method is needed.
I examined a payment method for a municipality to outsource the maintenance of a bridge to a contractor. Bridges are required by national standards to be inspected once every five years. One possible method would be to vary the amount to be paid to the contractor entrusted with the maintenance and management according to the results of this inspection. However, there are various possible ways of determining the difference in the amount to be paid between when the results are good and bad. In addition, the uncertainty of whether the bridge will collapse must also be taken into account. Considering these, I have examined appropriate payment methods through simulations.
Let me explain an ingenious aspect of my research. Initially, I used a linear function to connect the bridge condition value to the amount of payment. However, if a bridge is in poor condition, the risk of collapse generally increases, so both citizens and local governments are very reluctant to pay. Therefore, I tried a method that significantly lowers the payment amount if the bridge is in poor condition by using a curvilinear function, which improved the simulation results. I am exploring a better method by repeating this cycle of ingenuity and simulation.

Connections between High School Experiences and the Present

I believe that the study of geography is deeply related to the present. When I was in high school, my teacher encouraged me to participate in the Scientific Geography Olympiad. This is a competition in which high school students from all over Japan compete in their knowledge of geography. That was where I learned about the relationship between humans and nature, which led me to join the Department of Civil Engineering. After joining, I was able to use my knowledge of geography to gain a deeper understanding of transportation theory and natural disaster theory.
I also belonged to a quiz club, which helped me learn about things I didn’ t learn deeply in high school classes. For example, I participated in a quiz competition called “Economics Koshien” which included financial and economic questions. That gave me the opportunity to learn about finance and economics and broadened my interests. As a result, I took several economics classes after entering the University of Tokyo, and my current research is deeply related to economics.
Looking back, I wish I had participated more in the Science Olympiad and other programs for high school students beside geography. If I had ventured out of school more, I might have gained more insight. But I didn’ t have the time to think about such things at the time. When I was in high school, I spent my time focused on studying for entrance exams first and foremost. Nevertheless, I have no regrets because I am who I am today as a result.
I recommend that high school students try to venture outside of school while studying their subjects well. If you broaden your insight outside of school, you may find something that interests you, which may help you achieve self - actualization in the future.

At the school gate in high school

Written by **Toki Kobayashi**

Research Theme

Spatial Information Analysis

Professor, The University of Tokyo Interfaculty Initiative in Information Studies

Yukio SADAHIRO

Map Visualization

My major in a broader sense is the spatial information science. Spatial information is the locational information of spatial objects and phenomena. Spatial information science is the discipline that provides the methods for collecting, managing, visualizing, and analyzing spatial data. Google Map and car navigation systems are based on the technology developed in spatial information science. I am specialized in the development of the methodology of spatial analysis. Visual analysis of spatial information is a naïve but effective tool for understanding spatial phenomena. John Snow' s map is a famous example that indicated the effectiveness of visualization, when the causes and properties of chorela was unknown. Chorela cases were clustered around a specific water well, which clearly indicated that the well is the cause. The well was closed, which ceased the expansion of cholera. The term "cluster" has long been used in spatial analysis, and we were surprised that this term suddenly became popular in the era ot COVID-19.

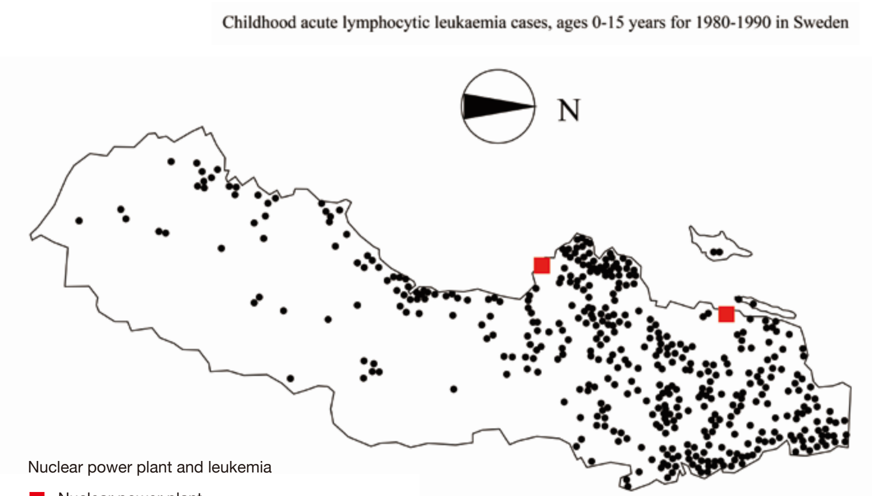
Cholera map

■ Well

◆ People who died of disease

Objective Analysis Using Numerical Values

The next map indicates the location of nuclear power plants and leukemia cases. The latter seems to gather around the former, though we cannot say it with confidence. Visual analysis is easy and effective, but it tends to be subjective to some extent. Geography taught at high school covers the visualization of spatial data. Spatial information science taght at colleges and universities gives more objective and quantitative methods of data analysis, which include statistical analysis and mathematical models. We discuss the locational relationship between nuclear power plants and leukemia cases from a statistical perspective, i.e., whether the relationship is statistically significant.



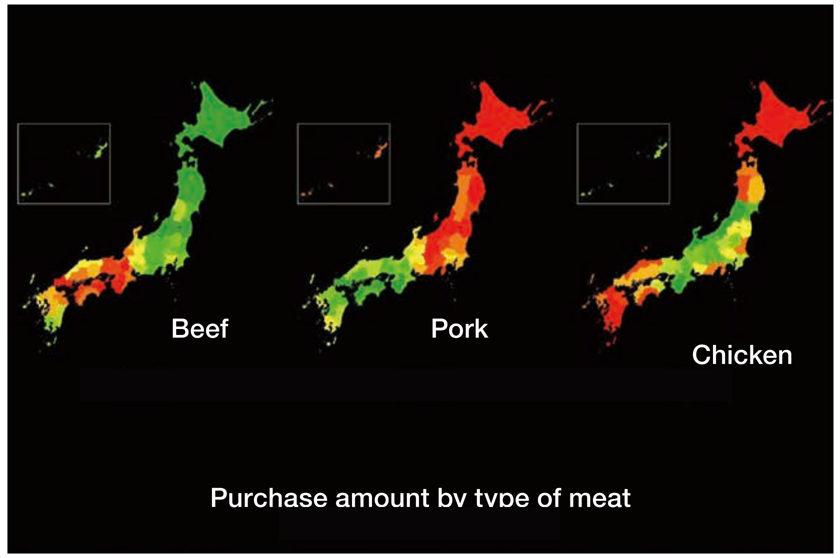
Nuclear power plant and leukemia

■ Nuclear power plant

● Patient with acute childhood leukemia

The Fascination of Geography Seen in Data Visualization

The next maps shows the purchase amounts of beef, pork, and chicken meats in each prefacture. The maps clearly reveal the spatial variation in the purchase amounts. Beef is populat in Kansai region, while pork and chicken are popular in Tohoku and Kyushu regions, respectively. Comparison of different maps gives us further spatial patterns. The map of chicken purchase is similar to that of shochu purchase. The maps of salt and sugar purchases are also similar. The distibution of the names of ramen restaurants tells us the regional variation in the names such as "-ya (屋)," "-ya (家)," and "-ken (軒)." Mapping is a useful tool for understanding the spatial pattern of objects and phenomena, and considering its underlying structure. Geography may seem boring that put more emphasis on learning rather than thinking. However, geography gives us an effective approach for grasping spatial phenomena.



Meat purchases in each prefecture

Learning from the Past

I always regret that I didn' t study world history well in high school. Since joining Natural Sciences I at the University of Tokyo, I have been on the path of science, but every time I speak with a foreigner, I am keenly aware of the importance of understanding world history. Then, at the age of 40, I made a big decision and got into the habit of reading, which I had rarely done before, and learned a lot about world history. It was a real eye-opener and gave me a better understanding of the background of world affairs today. For example, you have to study history to understand why Kyiv is so important to Russia in the current situation in Ukraine. Liberal arts and general education may not be immediately useful, but they are indispensable for understanding how the world works. This has nothing to do with whether you are in the sciences or humanities, but I think that those in the sciences, who tend to avoid social subjects from university, should study them in high school without considering just immediate benefits.

Written by **Takaaki Miyake**

Research Theme

Simulating Architecture

Project Associate Professor, Department of Architecture, School of Engineering, The University of Tokyo

Keiichiro TANIGUCHI

High School Subjects as a Basis for Simulation

My research is in the field of architectural environmental engineering, which deals with the environment around us, such as the temperature and brightness of the places where we live. This research leads to how to design building facilities or how to operate buildings after they are built.

In particular, I am researching how to simulate what the environment will be like after the building is actually built in the design phase. By simulation, it is possible to avoid a poor environment, such as too cold or too dark, after the building is built.

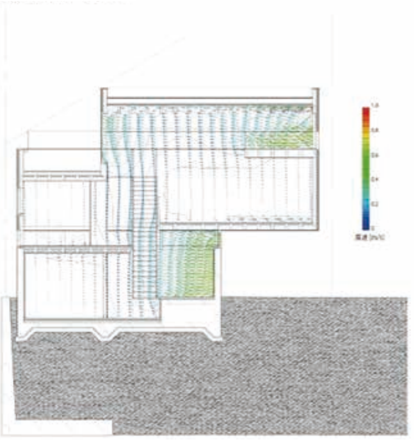
In my lectures, I have students work on architectural design using simulations, which deal with the basic matters learned in high school physics, such as light, wind, and temperature.

For example, CFD analysis※1 is used to simulate wind movement. In this analysis, the space is virtually divided into small lattices, and the relationship between the lattices is solved using the law of conservation of momentum to simulate the movement of wind in a certain space. This process is performed using a computer because it would be too laborious by hand, but the basis of these simulations is what we learn in high school physics, and we use it without even knowing it.

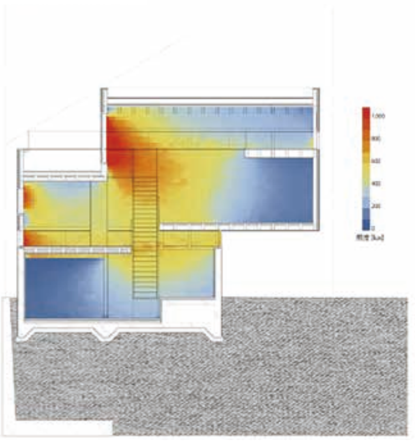
However, if the simulation is set up incorrectly, the results will also be wrong, so sometimes it is necessary to approximate the results manually and compare them with the results of the simulation to check whether the simulation is correct. Even in such cases, a background in physics learned in high school is still required.

※1 : CFD analysis : Computational Fluid Dynamics analysis. A numerical analysis and simulation technique that observes flow by using a computer to solve equations related to the motion of fluids using numerical solutions of partial differential equations.

Wind environment diagram



Light environment diagram



Simulation examples

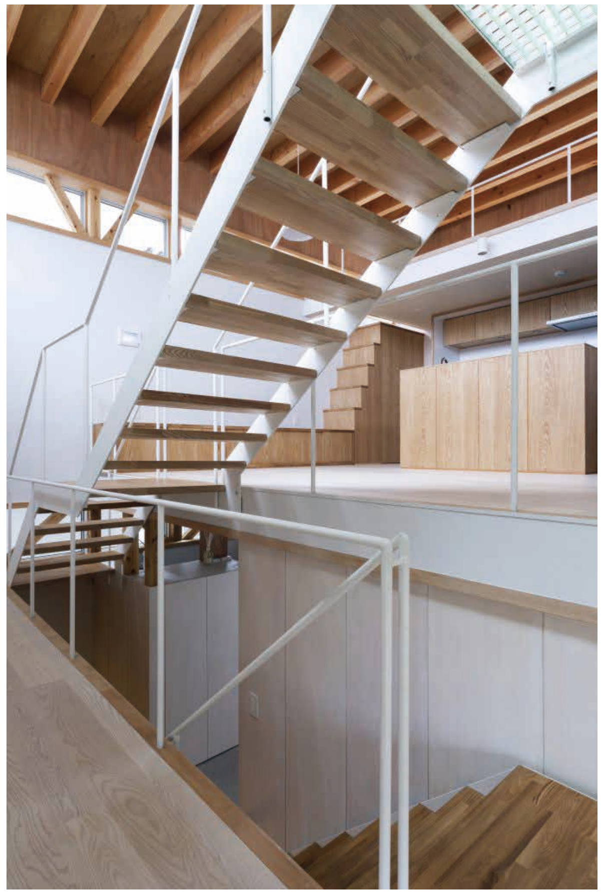
We also use mathematics as well as physics in our research and design. Since buildings are naturally built on the earth, the movement of the sun is important in the simulation. Fundamentally, the simulation examines how much solar radiation enters the building from what angle and at what time of day and season, and the trigonometric functions learned from the first year of high school are used to determine the position and altitude of the sun. Of course, we use various other areas of high school mathematics, but trigonometric functions are especially frequently used.

Knowing the Background of Information

In today' s world of the Internet and social media, it is easy to obtain information you want to know. However, looking at my students, they are not very aware of where the information is coming from. Therefore, in addition to not being deceived by false information, it is important to be aware of who is providing the information and on what basis, and to explore more about the sources of the information. This will expand your knowledge because you will then learn the motivation for the information being disseminated. The knowledge gained in this way will help you find out what you want to do in the future and what you are interested in.

I myself learned about the existence of the profession of an architect from a book I read in high school, which led me to pursue a career in architecture. Until then, I didn' t even know there was such a profession.

Also, I think there are some high school students and those in their first semester who already aspire to major in architecture, and I think it is good for them to visit and experience various architectural structures around the world if they have time. When you actually see an architectural structure, I encourage you to think about why you think the space is cool or comfortable, and conversely, if you don' t like it, think about the reasons why not, and accumulate many such spatial experiences for yourself. The experience you gain in this way will surely be useful when thinking about your own designs.



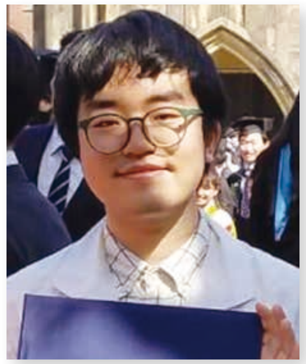
His works

Written by **Shuichiro Koga**

Pursuing Sustainability

In response to the spread of climate change and poverty issues, there is growing global demand for the realization of a sustainable society. The term “SDGs” appears on television and in newspapers almost every day, and has become very familiar in daily life. Also in the field of engineering, many studies are focusing on sustainability by using the latest knowledge and technology. With the aim of saving energy and reusing resources, new technologies are being integrated and developed from multiple perspectives, including chemistry, physics, and biology.
Furthermore, although the SDGs tend to focus on environmental issues, engineering is also closely related to technological innovation for providing quality education and improving sanitary environments in poor areas.
The sustainability of society is an issue that our generation, which is responsible for the future of the world, must think about without turning our eyes away. As you continue your studies and think about your own career path, we encourage you to think about what you can do to help.

Written by **Yu Ajimi**



Second year, Master's course, Department of Applied Chemistry, School of Engineering, The University of Tokyo

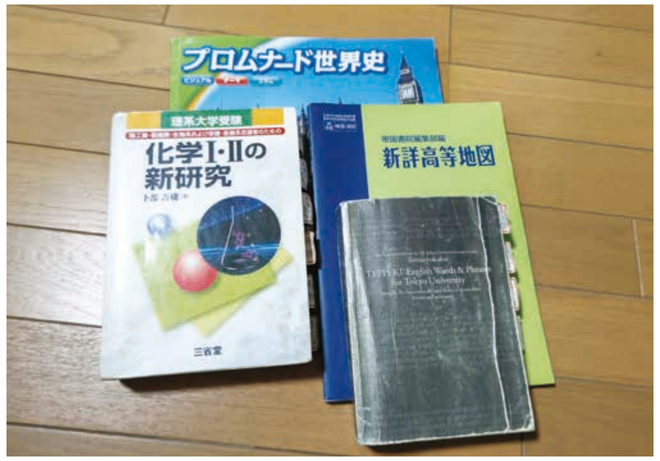
Tomohiro HOJO

Developing Catalysts that Convert Carbon Dioxide into Useful Substances

I’m researching catalysts that hydrogenate carbon dioxide and convert it into useful substances.
Global warming caused by carbon dioxide has various adverse effects, including on the climate, ecosystems, and various human activities. Nowadays, the SDGs and carbon neutrality initiatives are being carried out worldwide to address these issues, and so there is the need to convert emitted carbon dioxide into other useful substances.
Carbon dioxide is a relatively stable substance consisting of carbon and oxygen strongly bound by double bonds. Therefore, it is difficult to convert carbon dioxide alone into another substance; it is useful to react it with hydrogen, which is more reactive. However, simply mixing carbon dioxide and hydrogen does not cause the reaction to proceed, so a catalyst is added to help the reaction. Hydrogen is currently made from fossil resources, but in the future, if hydrogen can be produced by electrolyzing water using renewable energy, it will be possible to react it with carbon dioxide in a more environmentally friendly manner.
Through these reactions with hydrogen, carbon dioxide is converted into a variety of useful substances, including fuels, raw materials for chemical products, and alcohols. In particular, research and development on producing substances containing a single carbon atom, such as methane, has progressed worldwide, and it has become relatively inexpensive and efficient, and is on the verge of commercialization. On the other hand, substances containing two or more carbon atoms, such as ethanol, are difficult to produce because it is difficult to form bonds between carbon atoms. Therefore, although various reaction mechanisms have been proposed, research is still under way. That’s why I’m researching catalyst development to improve the efficiency of existing reaction mechanisms and to propose new ones.

The Relationship between Research and High School Subjects

Needless to say, high school chemistry is closely related to research, and the knowledge of chemistry learned in high school and the experimental techniques acquired through student experiments form the basis for research activities. However, since it is difficult to fully understand chemistry, high school chemistry is explained simply, omitting some parts. Therefore, there is a slight gap between the chemistry you learn at university and high school chemistry. However, high school chemistry is a good stepping stone to university chemistry, as advanced topics cannot be understood without knowing the basics.
Geography is also useful. Consider, for example, which countries produce which resources. The main source of carbon dioxide emissions is fossil fuels, which are produced in the Middle East and the United States. In South America, large amounts of sugarcane and corn are produced, and there are cars that run on bioethanol made from these crops, but bioethanol is not common in Japan. Such geographical differences between countries will lead to differences in national needs regarding resource issues. Knowing needs is very important when considering what kind of research and development is needed to enrich people’ s lives.
In addition to geography, keeping an eye on the political and economic situations in the world will also be useful for your research. People in the sciences tend to neglect social studies, but I was reminded of their importance in the course of my research.
Also, I wish I had studied English harder in high school. This is because all four language skills are required in conducting research: reading papers written in English, speaking with international students, making presentations at conferences in English, and writing papers in English.
You have opportunities to learn English immediately after entering university, but in the second and third years, you will have almost no chance to come into contact with English unless you learn English independently. When you are assigned to a laboratory in the fourth year, you will suddenly have to use English. I realize now that I should have built a solid foundation in English at high school so that I would be more comfortable with English and be able to maintain a good knowledge of English.



Reference books from high school that I still look back on and study

Written by **Mizuki Noguchi**

Research Theme

Investigating the Physicochemical Properties of Lipids and Using That Knowledge to Create Products

Lecturer, Department of Chemical System Engineering, School of Engineering, The University of Tokyo

Kaori SUGIHARA

Applying Functionalized Lipids

Our laboratory conducts research on biophysical engineering,※1 and specializes in lipids. Controlling the environment around lipids can create a variety of forms with different functions. In our laboratory, we are creating lipid nanostructures with various functions and investigating what they can be applied to.

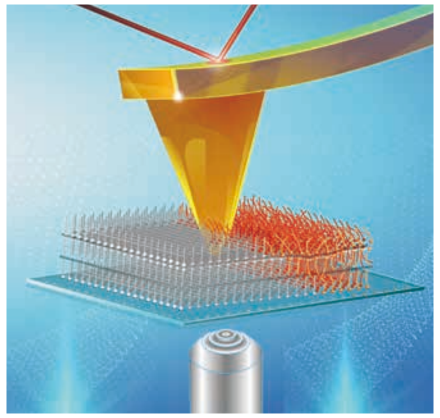
For example, we are creating a mechanochromic polymer,※2 which is a polymer bound with many crosslinked lipids. This polymer is originally blue, but turns red when pressed and also emits fluorescent light, so we are aiming to use it to create biosensors. For example, by adding a function to emit light when COVID-19 antibodies adhere to it, we may be able to create a test kit that is inexpensive, simple, and sensitive compared to the ones currently available in drugstores.

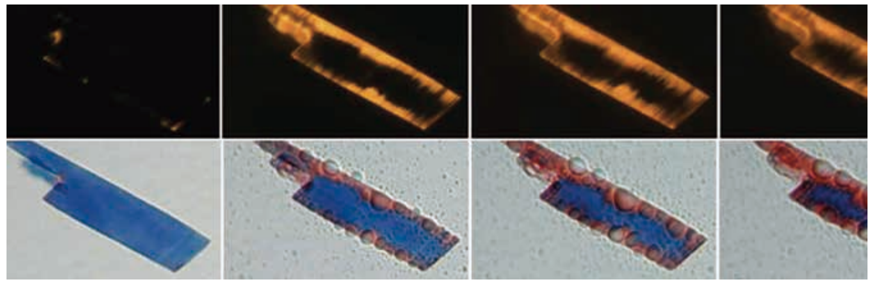
Furthermore, our laboratory is developing new drugs using peptides that interact with lipids. Antibiotics have freed the world from various deadly diseases, but recently bacteria that are resistant to antibiotics have emerged, and drug-resistant tuberculosis is slowly becoming an epidemic. Fearing that a worse pandemic will follow COVID-19 if this trend continues, alternatives to antibiotics are being explored all over the world. One candidate is an antimicrobial peptide that our bodies produce as part of our immune system when we are infected with bacteria. This tiny peptide can puncture bacterial cell membranes, destroy them, and kill them. Therefore, we are aiming to develop drugs that enhance the existing functions of our bodies.

Moreover, there is a cooperative effect, which increases the bactericidal ability when two peptides are mixed, but our laboratory discovered a phenomenon called a double cooperative effect, which in addition reduces their toxicity to human cells. If this can be put into practical use, it may be possible to create an antibacterial drug that kills many bacteria simply by mixing and has fewer side effects. So we are conducting basic research to elucidate the principle and to develop drugs.

※1 : A study that applies the devices and methodologies used in physics and physical chemistry to study biological materials and life phenomena handled by biology.

※2 : A molecule formed by combining many of the same molecules or a substance composed of them.





Mechanochromic polymer that glows when pressed, Macromolecules 2020, 53 (15), 6489-6475.

The Relationship between Research Topics and High School Subjects

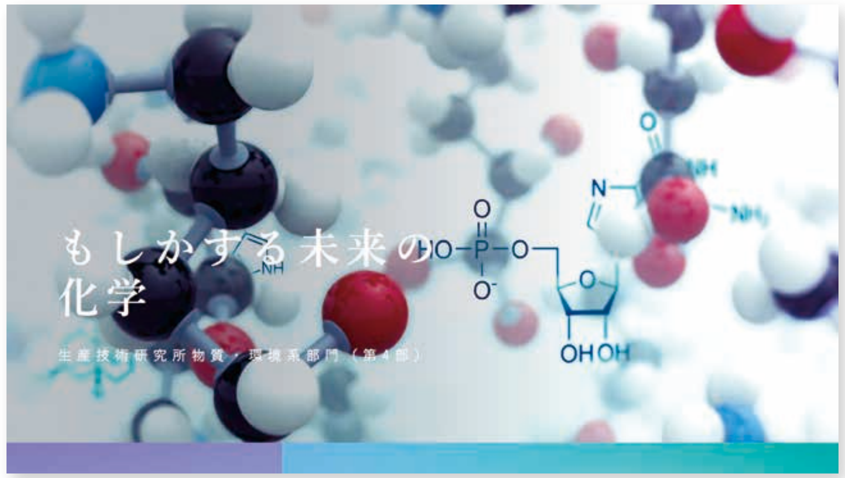
I believe all high school subjects are related to research topics. Even though we study individual subjects in school, real social problems are too complex to be solved by just one subject. COVID-19 is a good example. Solving problems in research requires the ability to quickly relearn and use what is necessary. Therefore, it is very important to study with a wide range of interests before it is too late.

On the other hand, I originally specialized in physics, so I tend to take a physics approach and thinking when looking at lipids and cells, which is an advantage. It is beneficial to work hard at one thing you are good at and make it your own, and to get into the habit of seeing the world with that sense of value.

Advice for High School Students Interested in the Faculty of Engineering

I believe what is most important is to dive in when you find something interesting. If you want to go abroad, go; if you want to do research in this field, do it. That' s it. When academia was still in its infancy, it was possible to get to the cutting edge in about ten years by studying previous works by great scientists in chronological order. But now there is an enormous amount to learn, and if you try to build it up from scratch in order, you will die before you reach the cutting edge. Nowadays, it is mainstream to try what you want to do even if you don' t know it first, and then relearn what you need. Therefore, I think it is important for high school students to get into the habit of pursuing their interests and studying what they need.

I also encourage you to participate in events held by the university. For example, the Institute of Industrial Science, to which I belong, is running a series called "The Perhaps Chemistry of the Future," which introduces the research conducted at the Institute of Industrial Science mainly to junior high and high school students so that they can imagine how their current studies will be useful in research and in society in the future. I hope that through these events, students will have the opportunity to think about what they want to do in the future beyond their studies.



"The Perhaps Chemistry of the Future"
Please scan the QR code below to access the web page.

Learning in High School Leads to the Present

When I was in high school, I was working hard on things I liked and ignoring things I didn' t like. I liked physics, and disliked geography and history, but I regret that I didn' t take them seriously, especially history. For example, I might have been able to understand the current situation in Ukraine better if I had listened carefully to my history class. Please realize that some subjects that you think are uninteresting now may actually be very useful. Be careful!

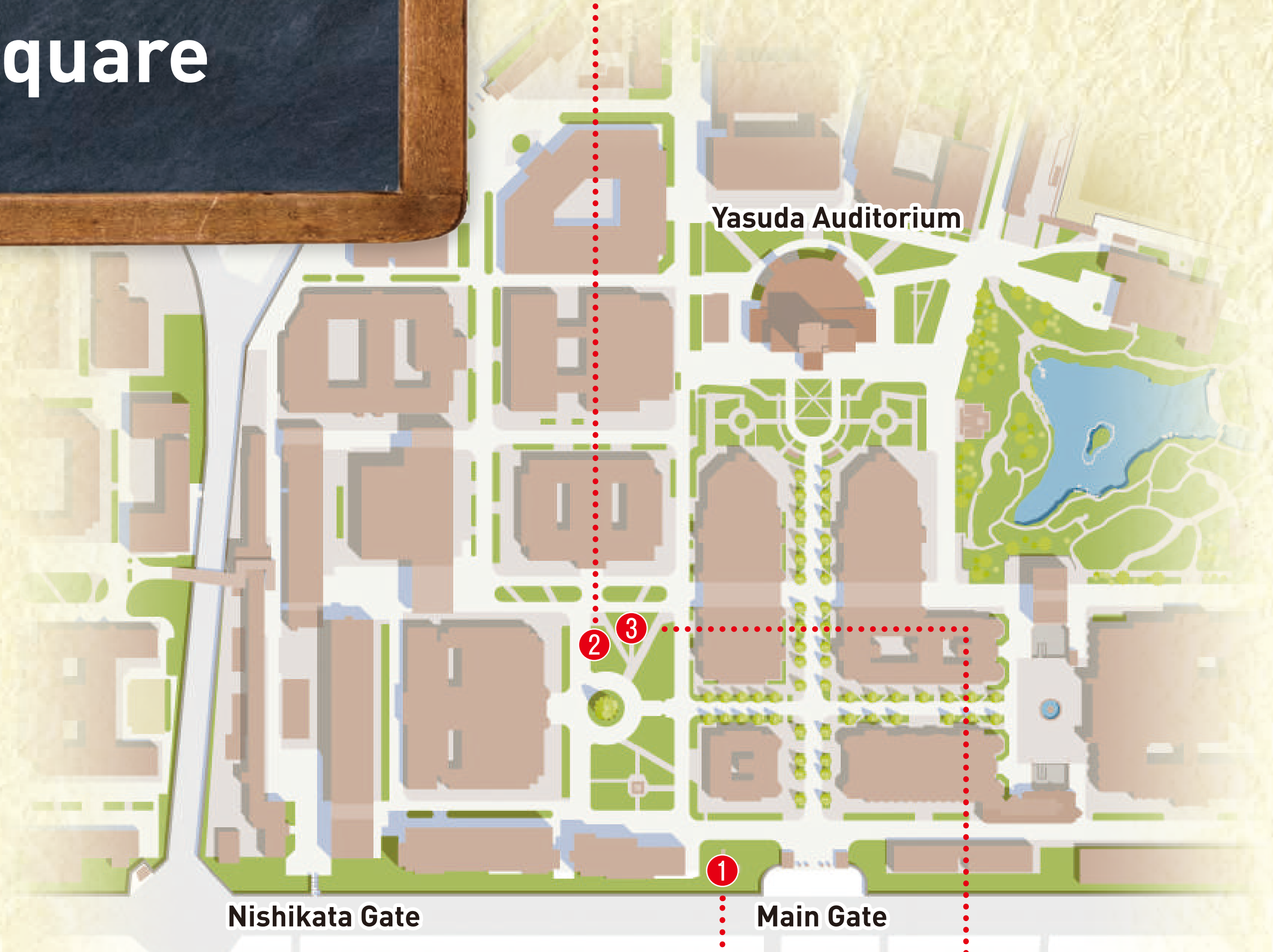
In addition, I' ve been studying abroad in Switzerland since my doctoral course, and I studied abroad in Canada for a month when I was in high school. Although the stay in Canada was short, the confidence I gained from being able to speak and live there enabled me to suddenly go to Switzerland as a doctoral student. I think it is a good idea to actively take such opportunities.

Written by **Shiho Sakuma**

Objets d'Art in the Faculty of Engineering Square

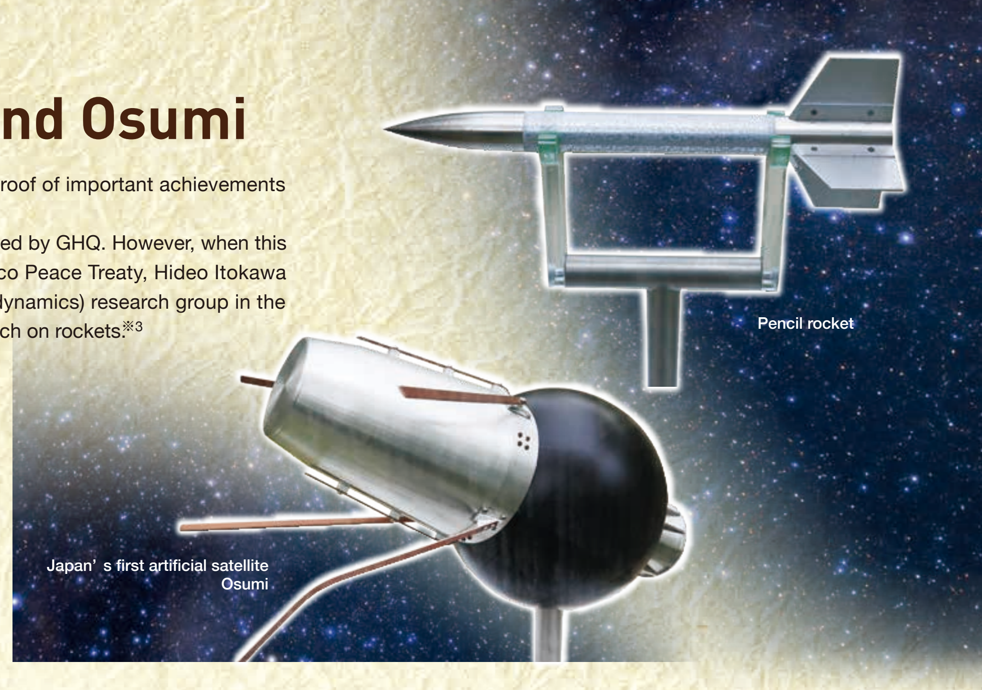
There are many objets d'art and statues related to the University of Tokyo on the Hongo Campus. Among them, there are many monuments around the Faculty of Engineering that commemorate people and products that played epoch-making roles in the development of engineering in Japan. This issue spotlights such objets d'art and statues, particularly those around the Faculty of Engineering Square. Let's enjoy the history of the Faculty of Engineering that resides in the objets d'art and statues, as well as the depth of history of the development of engineering in Japan.

Written by **Kouki Kameda** and **Isami Dainichi**



2 Pencil Rocket and Osumi

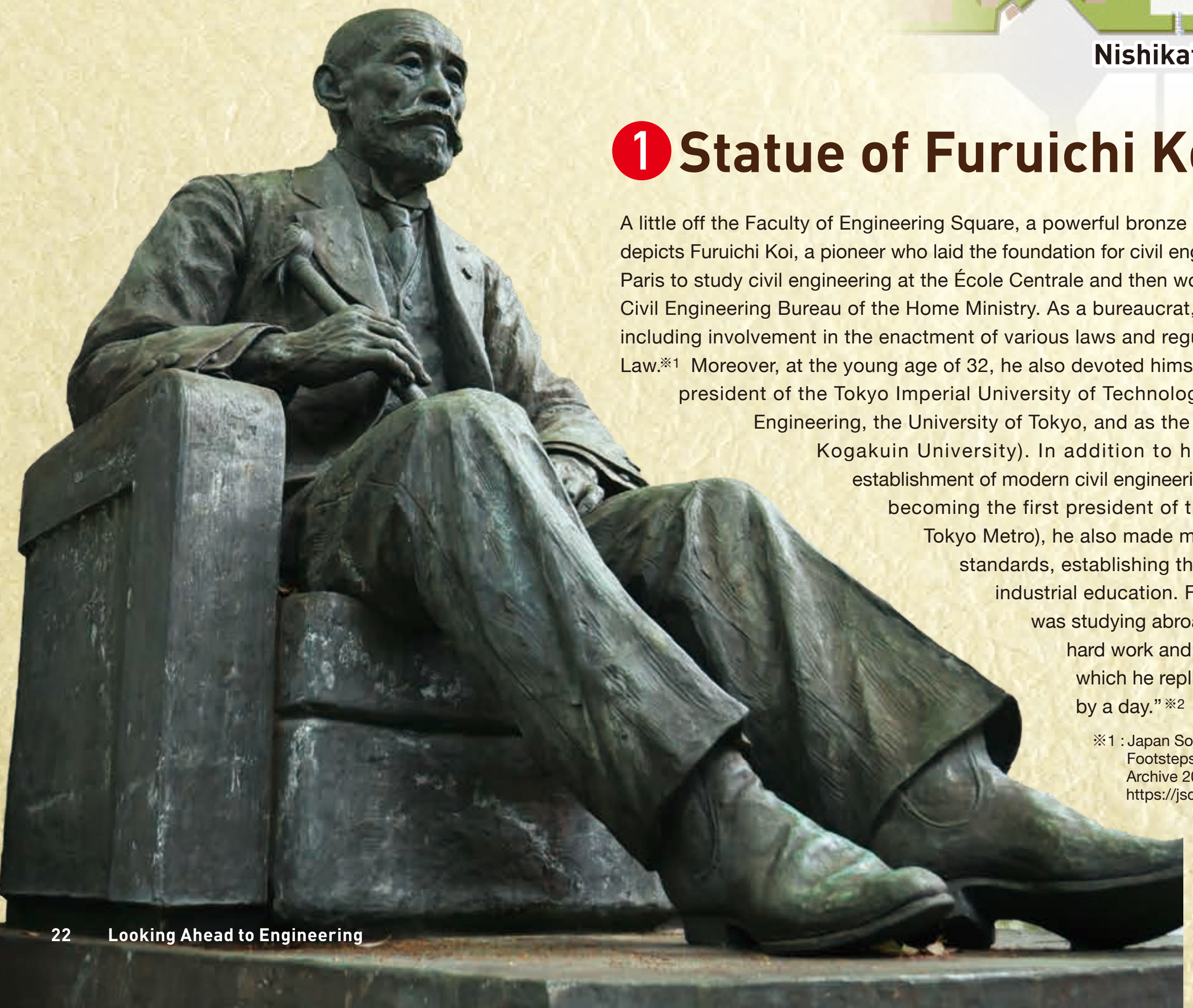
Although these objets d' art are very small, they are proof of important achievements in the history of Japanese aerospace research.
Just after the war, aviation research in Japan was banned by GHQ. However, when this ban was lifted with the conclusion of the San Francisco Peace Treaty, Hideo Itokawa established the AVSA (Avionics and Supersonic Aerodynamics) research group in the Institute of Industrial Science in 1954 and began research on rockets.※3


Pencil rocket

Japan' s first artificial satellite Osumi

In 1955, a horizontal launch test of a pencil rocket measuring 1.8 cm in diameter, 23 cm in length, and weighing 200 g was carried out. Starting with the success of this experiment, rockets were developed and gradually grew in size into the Baby Rocket and the Kappa Rocket. In 1960, the rocket reached a launch altitude of 190 km and successfully measured ion density for the first time in the world.
In 1970, the Institute of Space and Aeronautical Science of the University of Tokyo launched Japan' s first artificial satellite by the Lambda rocket L-4S-5. This is "Osumi." The name comes from the Osumi Peninsula in Kagoshima Prefecture, where the launch base is located.
Fifteen years after the horizontal launch test of the pencil rocket, Japan became the fourth country in the world to launch its own satellites after the former Soviet Union, the United States, and France. It was a rare example in the world of a university research institute successfully developing a satellite for non-military purposes as part of its academic research.
Incidentally, the Institute of Space and Aeronautical Science of the University of Tokyo was later separated from the University of Tokyo and became the Institute of Space and Astronautical Science under the direct control of the Ministry of Education, Science and Culture, and is now part of the Japan Aerospace Exploration Agency (JAXA). There is still a connection with the University of Tokyo, and some students from the Graduate School of Engineering commute to the laboratory on the JAXA Sagamihara Campus.

※3 : Institute of Space and Astronautical Science, "The 100th Birth Anniversary Site of Hideo Itokawa, the Father of Japanese Space Development," ISAS Special Report/Report & Column 2012-7-20. https://www.isas.jaxa.jp/j/special/2012/prof.itokawa/. (Reference 2022-05-17)



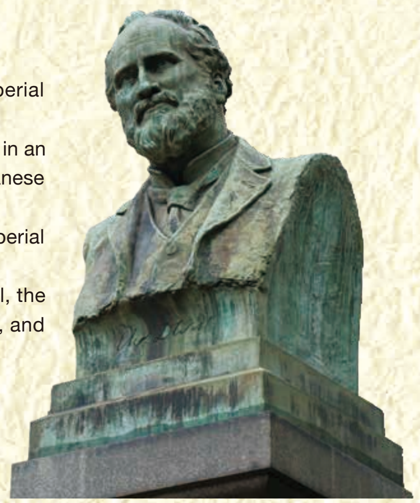
1 Statue of Furuichi Koi

A little off the Faculty of Engineering Square, a powerful bronze statue about twice the size of an adult depicts Furuichi Koi, a pioneer who laid the foundation for civil engineering in Japan. Furuichi Koi went to Paris to study civil engineering at the École Centrale and then worked as a bureaucratic engineer in the Civil Engineering Bureau of the Home Ministry. As a bureaucrat, he left behind brilliant achievements, including involvement in the enactment of various laws and regulations, such as the Civil Engineering Law.※1 Moreover, at the young age of 32, he also devoted himself to educational activities as the first president of the Tokyo Imperial University of Technology, the predecessor of the Faculty of Engineering, the University of Tokyo, and as the superintendent of Koshu Gakko (now Kogakuin University). In addition to his many other contributions to the establishment of modern civil engineering from various perspectives, including becoming the first president of the Tokyo Underground Railway (now Tokyo Metro), he also made many achievements in setting industrial standards, establishing the metric system, and institutionalizing industrial education. Furuichi has an anecdote that when he was studying abroad, the landlady of his lodgings saw his hard work and expressed concern about his health, to which he replied "If I rest a day, Japan will fall behind by a day."※2

※1 : Japan Society of Civil Engineers, "The True Face and Footsteps of Furuichi Koi," JSCE 100th Anniversary Project Archive 2021-03-31. (Reference 2022-05-17) https://jsce100.com/furuichi/history.html.

※2 : Ryotaro Shiba, "Kono Kuni no Katachi (The Shape of This Country) III"

3 Statue of Charles West



Charles Dickinson West (1847–1908) was a hired foreigner※4 from Dublin, Ireland. He was a teacher at the Imperial College of Engineering, one of the predecessors of the Faculty of Engineering, the University of Tokyo.
West studied mechanical engineering at the University of Dublin and gained knowledge of shipbuilding while working in an iron mill in Great Britain after graduation. With this background, he contributed greatly to the modernization of Japanese industry as a teacher of shipbuilding as well as mechanical engineering at the Imperial College of Engineering.※5
The pedestal for this statue was designed by his close friend, Josiah Conder. Conder was also a teacher at the Imperial College of Engineering, specializing in architecture.
The bust was created by a sculptor named Kazuo Numata. If you look at the sculptures embedded in the pedestal, the front, right, back, and left of the statue are each decorated with motifs of drafting instruments, iron mill, shipyard, and engines, making it relatively fashionable among the many bronze statues in the University of Tokyo.

※4 : Experts from advanced Western countries who were invited or employed by public, private, and educational institutions from the end of the Edo period to the Meiji period in order to introduce Western technology, scholarship, and institutions.

※5 : Libraries for Engineering and Information Science & Technology, The University of Tokyo, "Life of Charles Dickinson West, a Hired Foreigner," Libraries for Engineering and Information Science & Technology, The University of Tokyo News. 2021-2-18 https://library.t.u-tokyo.ac.jp/news/20210217_westdetail.html. (Reference 2022-05-17)


Four panels on the pedestal of the statue