Molecular Frontiers Symposium 2017

Science For Tomorrow

MOLECULAR FRONTIERS

東京工業大学
Tokyo Institute of Technology

Molecular Frontiers Symposium 2017

Dr. Bengt Nordén

Dr. Hideki Shirakawa

Dr. Ada Yonath

Dr. Tim Hunt

Dr. Joseph L. Kirschvink

Dr. Yoshinori Ohsumi

Science For Tomorrow

Overview of Molecular Frontiers Foundation

Molecular events underpin much of what happens in our daily lives and on our planet. Everything from storage of memories in our brains to medical diagnostics and climate change all depends on molecular actions. Aiming to raise the appreciation of science and technology, Molecular Frontiers presents in a new- way the roles of molecules in various exciting contexts, especially catering to young people.

Molecular Frontiers started as non-profit foundation registered in the state of Massachusetts, USA in 2006. In 2007, a second branch was founded by the Royal Swedish Academy of Sciences in Stockholm, Sweden. Working globally, Molecular Frontiers also has hubs in Africa and Asia. The organization operates with a small staff and relies extensively on volunteer contributions and support from governments, industry, and other non-profits.

The Scientific Advisory Board, a group of eminent scientists including many Nobel Prize laureates, plays a key role in Molecular Frontiers. Representing expertise from a wide range of molecular science disciplines, they define the scientific focal points of symposia, interact with the young audience, and select the winners of the Molecular Frontiers Inquiry Prize.

Greeting from President Yoshinao Mishima

On behalf of Tokyo Institute of Technology (Tokyo Tech), it is my great pleasure to welcome you to Molecular Frontiers Symposium (MFS) 2017. We are honored to host the second MFS held in Japan and to bring an accomplished group of world-leading researchers together with the young generation who will lead the research breakthroughs of tomorrow.

We have organized MFS 2017 at Tokyo Tech around the theme "Science for Tomorrow." I expect this symposium has attracted those who have a strong curiosity to learn more about the world in which we live, who seek answers to fundamental questions, and who are unafraid of pushing conventional boundaries.

Tokyo Tech is the ideal venue in which to have these conversations—it is what we do every day in our classrooms, lecture halls, laboratories, and offices. With a history of over 135 years, Tokyo Tech has consistently been at the forefront of education and research in science and technology. We are an institute whose organization and members continue to innovate.

The awarding of the Nobel Prize in Physiology or Medicine to Honorary Professor Yoshinori Ohsumi was a strong validation of the excellent education and research at Tokyo Tech. Professor Ohsumi's message highlights the importance of conducting fundamental research that addresses the important basic questions of life. In his words, "the nature of fundamental research is such that it develops in ways that are sometimes not initially anticipated but have an immense and beneficial impact on society."

All of us at Tokyo Tech take seriously our duty to nurture scientists, like Professor Ohsumi and the other speakers participating in the MFS, who conduct the basic research without which applied research would not be possible. We also recognize our duty to nurture those whose applied research can provide the advanced technologies required by society to address urgent global challenges.

We have organized this symposium to provide opportunities specifically for high school students to engage directly with eminent scientists through lectures, group work activities, and laboratory workshops in hopes that their personal stories of addressing seemingly unanswerable questions and challenges will inspire the scientist in each of you.

Finally, we hope that you will return to your schools and communities with messages about the intriguing possibilities of "Science for Tomorrow."

Theme of MFS2017 in Tokyo

Masayuki Takahashi

Specially Appointed Professor, School of Life Science and Technology, Tokyo Institute of Technology
Member of the Organizational Committee of MFS2017 in Tokyo
Tokyo Institute of Technology

Molecular Frontiers Symposia bring together leading scientists including Nobel Prize laureates, and the public, in particular young high school students. The scientists will present their most recent discoveries and share their perspectives, and talk about science with the students. We believe that these meetings are important because, as Molecular Frontiers Founder Professor Bengt Nordén remarked, "it is essential for our survival that young people take an interest in molecular science and see it as a gateway to the future." Molecular events underpin much of what happens in our daily lives. Medical diagnosis, storage of memories in our brains, and climate change all depend on molecular actions.

The theme of the MF2017 is "Science for Tomorrow." We will see how the scientists in attendance at this symposium have contributed the landscape of scientific fields today. We will contemplate what science might bring about in the future.

Professor Ada Yonath determined the 3-D structure of the ribosome, a cellular machine at which protein synthesis occurs. I listened to her describing her project when I was a student, almost 40 years ago. Scientists at the time thought of her ideas as absurd. It was difficult enough to determine the structure of even small proteins. It was, therefore, considered impossible to determine the structure of the ribosome, which is made of many proteins and RNA. Although it took her more than 20 years of hard work and dedication, she was able to achieve her goal and prove them wrong. This was made possible thanks to the previously unimaginable advancements in detection machines and computing systems, and the discovery of much more stable and easily crystallizable proteins from bacteria living in environments of very high temperatures. Her work clarified the mechanism of protein synthesis and now helps in designing new antibiotics.

Professor Hideki Shirakawa invented conductive plastics, which nobody at the time imagined could be possible. The idea that plastic could conduct electricity was considered ludicrous. But his work ultimately led to the development of organic light-emitting diodes (OLED), which are now used in television screens, computer monitors, mobile phones, and more.

Professor Tim Hunt discovered the cyclin protein, which regulates cell division. Understanding the mechanism of such regulation is important for life as diseases such as cancer form due to improper regulation of cell division. Interestingly, Professor Hunt did not discover the protein in humans, but in sea urchins by using their eggs as a model organism in experimentation. Although the urchin is a very different species, a similar protein with the same functions exists in humans.

Professor Yoshinori Ohsumi studied the function of vacuole, a substructure in yeast cell. Vacuole was considered a cabbage of cell. Only few people interested in it. He showed that it is the place of autophagy, the process of degradation and recycling of old cell components and important for survival. He discovered the proteins that were involved in the process. Thanks to his research, we now know that the autophagy occur in a similar way in humans and that defects in its regulation cause several diseases, including cancer.

Professor Bengt Nordén studies the physico-chemical characteristics of DNA. To many biologists, DNA is just a molecule containing genetic information. However, DNA is first of all a chemical molecule. Professor Nordén found that some fundamental biological functions of DNA, such as replication, translation, and others, may be related to its chemical and physical features.

Professor Joseph Kirschvink showed that the earth was completely covered in ice several times in Earth history. This 'Snowball Earth' event is thought to be related to the large evolution of organisms such as the appearance of eukaryotes and multicellular animals. He is also known for a new theory of the origin of earth's life.

These and other amazing scientists have opened up a new world for us through their excellence in and devotion to their fields, although their idea was not always considered interesting at the beginning. What difference have they made? Are advances in science always beneficial? Will technologies such as artificial intelligence, for example, be helpful or harmful in the long run? These are some of the questions that we will address.

We have divided the high school students into small groups, each of which one scientist will join. Each group will talk about what they think the "Science for Tomorrow" is or will be, or perform experiments relating to the Nobel Prize work of one of our prominent scientists. Each group will then present a summary of their discussion or experiment.

We hope that you will enjoy the symposium and feel inspired to contribute to the "Science for Tomorrow."

DAY 1

/ SATURDAY, OCTOBER 21

Master of Ceremonies / **Tom Hope,** Associate Professor, Tokyo Institute of Technology

13:30 - 14:00 **Opening Ceremony**

Remarks

Yoshinao Mishima, President, Tokyo Institute of Technology

Bengt Nordén, Founder & Chairman, Molecular Frontiers Foundation

Masayuki Takahashi, Specially Appointed Professor, School of Life Science and Technology, Tokyo Institute of Technology

14:00 - 18:00 **Lecture Program**

14:00 - 14:45 **"Next generation environmental friendly antibiotics"**

Ada E. Yonath,
2009 Nobel laureate in Chemistry
Professor, Weizmann Institute for Science

14:45 - 15:30 **"My Life As A Scientist"**

Tim Hunt,
2001 Nobel laureate in Physiology or Medicine
Visiting Researcher, Okinawa Institute of Science and Technology

15:30 - 15:45 ***Fika,*** Swedish-style Coffee Break

15:45 - 16:30 **"Discovery of a stretched conformation of DNA – could it have a biological role?"**

Bengt Nordén,
Founder and Chairman, Molecular Frontiers Foundation

16:30 - 17:15 **"Earth's Magnetic Biosphere"**

Joseph L. Kirschvink,
Principal Investigator, Earth-Life Science Institute, Tokyo Institute of Technology
Professor, California Institute of Technology

17:15 - 18:00 **"What is autophagy? A dynamic cellular recycling process"**

Yoshinori Ohsumi,
2016 Nobel laureate in Physiology or Medicine
Honorary Professor, Tokyo Institute of Technology

DAY 2

/ SUNDAY, OCTOBER 22

09:00 - 12:00 **Laboratory Workshop (2 Groups)**

- **Yoshinori Ohsumi**
- **Hideki Shirakawa**
  2000 Nobel Laureate in Chemistry
  Emeritus Professor, University of Tsukuba

10:15 - 12:00 **Group Work (4 Groups)**

- **Ada E. Yonath** ■ **Tim Hunt** ■ **Bengt Nordén** ■ **Joseph L. Kirschvink** (9:00 - 12:00)

(12:00 - 13:45 **Preparation for the presentation and Lunch Break**)

14:00 - 16:00 **Presentations by High School Students**

14:00 - 14:20 **Ohsumi team** (Laboratory Workshop)

14:20 - 14:40 **Shirakawa team** (Laboratory Workshop)

14:40 - 15:00 **Yonath team** (Group Work)

15:00 - 15:20 **Hunt team** (Group Work)

15:20 - 15:40 **Nordén team** (Group Work)

15:40 - 16:00 **Kirschvink team** (Group Work)

16:00 - 16:30 **Wrap Up**

Bengt Nordén, Founder & Chairman, Molecular Frontiers Foundation

Masayuki Takahashi, Specially Appointed Professor, School of Life Science and Technology, Tokyo Institute of Technology

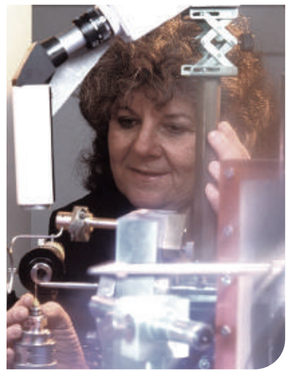
Hiroshi Iwasaki, Professor, Institute of Innovative Research, Tokyo Institute of Technology

16:30 **Closing Remarks**

Toshio Maruyama, Executive Vice President, Tokyo Institute of Technology

Dr. Ada E. Yonath

Abstract



Ada Yonath is an Israeli crystallographer best known for her pioneering work on the structure and function of the ribosome — the complex cellular particle made of proteins and long RNA chains that act as the cell's protein producing factories in all living cells. After successfully creating the first ribosome micro crystals in 1980, Yonath and her teams at the Weizmann Institute in Israel and the Max Planck Institute in Germany published the first complete three-dimensional structures of both subunits of the bacterial ribosome in 2000 and 2001.

The ribosome's structure gave scientists unprecedented insight into how the genetic code is translated into proteins and how antibiotics inhibit this process. In 2009, Yonath received the Nobel Prize in Chemistry together with Venkatraman Ramakrishnan and Thomas A. Steitz for "studies of the structure and function of the ribosome." Yonath's work has been important not only for stimulating research in ribosome structures, but also for providing a detailed understanding of the actions of some of the most widely prescribed antibiotics. Yonath is Director of the Kimmelman Center for Biomolecular Assemblies and Kimmel Professor in the Department of Structural Biology at the Weizmann Institute for Science in Rehovot, Israel.

Next generation environmental friendly antibiotics

Resistance to antibiotics is a severe problem in contemporary medicine. Structures of complexes of eubacterial ribosomes with antibiotics paralyzing them illuminated common pathways in the modes of antibiotics inhibitions, synergism, differentiation and resistance. More recent studies on structures of ribosome from a multi-resistant pathogenic bacteria identified features that can account for species-specific diversity in infectious-diseases susceptibility. Careful analysis and comparisons to ribosomes from benign bacteria indicated novel paths for the design of environmental-friendly degradable antibiotics, which are species-specific, thus also preserving the composition of the microbiome.

Dr. Tim Hunt

Abstract

Tim Hunt is a British biochemist whose research focuses on regulation of the cell cycle, or the chain of events that a cell undergoes from one division to another. Investigating protein synthesis in sea urchin eggs at the Marine Biological Laboratory in Woods Hole (USA) in the summer of 1982, Hunt discovered cyclins, proteins that are crucial for mitosis and other cell transitions. He showed that cyclins are degraded periodically at each cell division, a mechanism with great importance for cell cycle control. Hunt then found that cyclin regulates the function of cyclin-dependent kinase (CDK) molecules, discovered by Paul M. Nurse, which are key enzymes involved in many cell functions. In 2001, Hunt received the Nobel Prize for Physiology or Medicine together with Leland H. Hartwell and Nurse for "discoveries of key regulators of the cell cycle." His work been significant in aiding understanding of cancer cell development.

Until his retirement in 2010, Hunt was a principal scientist at Cancer Research UK. He is currently affiliated with Okinawa Institute of Science and Technology.

My Life As A Scientist

For as long as I can remember, I wanted to be a scientist. My first scientific hero was Madame Curie, whose biography I read as a teenager. I would have liked to be a physicist, but I was not clever enough (I had a close friend who did become a physicist, so fortunately I discovered this fact early on). Also very luckily, I discovered when I was maybe 11 or 12 years old that I had a natural gift for biology. A bit later I had a wonderful chemistry teacher, and given that the subject was exploding in the late 1950s and early 1960s, I thought that I should become a biochemist. I have never regretted this ambition, which was encouraged by a course of lectures I attended while still at school. They were given by a biochemist from Oxford University and were all about cell metabolism. I wondered how all the complicated pathways were controlled, a good thing to wonder at the time, because it was not known. We began to see how it worked in our last year at university. My friends and I all wanted to become researchers, but we didn't understand properly what that meant, or whether we would be any good at it. We had a sense that it required sacrifices and dedication, and we were right! On the other hand, we had no real idea of just how much fun it could be, when things are going well and you are hot on the trail of a problem. We were warned, on the other hand, what a miserable life it could be when things were not going well. One tends to remember the good times, fortunately.

I'll try to explain the meandering path that led me to make an extremely important discovery, first spotted completely by chance in fertilized sea urchin eggs and soon confirmed in clam eggs. The unanticipated observation was that one or two proteins disappeared from the eggs just before they divided in two. Then they came back, but disappeared again when the cells divided for the second time. And so on. At the time, people considered it quite impossible for proteins to vanish like this, so nobody had even suggested the possibility that this could be the key to the control of cell division. But I saw it with my own eyes! It was a thrilling eureka moment, and I knew almost at once that I had made the discovery of a lifetime. Proving it and working out the details took many years and many brilliant researchers. To go into all the details would take a course of many lectures.

The message I would like to convey is very simple. People often say that science is a "knowledge based" business, but in fact, it's an ignorance-based pursuit. We are often working in the dark, not knowing what we do not know! It often turns out that to understand something requires a much deeper knowledge than was available at the time you first wondered about how something worked. This means that direct approaches to problems often don't work, because you need to know things you don't even know exist! All you can do is to follow your nose wherever it leads. When people ask me, "How can I succeed in science?" I tell them to keep their eyes on the horizon, but their feet on the ground, and their noses to the grindstone – an English expression meaning, work hard and keep at it!

Dr. Bengt Nordén

Abstract

Bengt Nordén is a professor of physical chemistry at Chalmers University of Technology in Sweden. His main interest is optical spectroscopy of biomolecules including nucleic acids and proteins, where he has developed methods using polarized light for detecting interactions and for determining structure of the molecules and their complexes in aqueous solution. Based on his experience and world-spanning networks as Chairman of the Nobel Committee for Chemistry, he initiated the organization Molecular Frontiers Foundation (MFF), which has for 10 years arranged annual symposia at the Royal Swedish Academy of Sciences in Stockholm and also symposia hosted by other academies in other places, including in Japan, Korea, India, Singapore and Hungary. MFF has generally two goals: 1) to identify research breakthrough in science, especially in molecular sciences, and 2) to make young people interested in science.

Discovery of a stretched conformation of DNA

– could it have a biological role?

Biology is believed to take advantage of and exploit all kinds of physical and chemical properties of its cornerstones, the bio-macromolecules. We recently discovered, in single-molecule stretch experiments, that when applying a certain force to the ends of a DNA molecule, it is transformed into a new elongated state, a well-defined conformation. This seems to be a general phenomenon for guanine-cytosine-rich sequences and one may ask if Darwinian evolution has discovered it and exploited it for its purposes of optimizing the efficiency of life. The degree of extension is a factor 1.51 and we ask if it is a coincidence that the same degree of extension is also found for the DNA in complex with RecA or Rad51? RecA is a protein responsible for genetic recombination, introducing "intelligent" mutations in bacteria. It is possibly one of the oldest proteins. Rad51 is a protein with a similar structure in higher organisms (including humans) with a similar role of introducing mutations – but in this case by intelligently combining father's and mother's genes. In the RecA/Rad51 complexes with DNA, the DNA is kept as triplet packages such that three bases are stacked but have big gaps on either sides. One may speculate if it is a coincidence that the genetic code is based also on a stack of three bases of RNA coding for a specific amino acid? In text-books we read that we have three bases because two could not code for 20 amino acids since $4^2 = 16$, but $4^3 = 64$ is more than enough.

Dr. Joseph L. Kirschvink

Abstract

Prof. Kirschvink is an interdisciplinary scientist who focuses on the use of magnetism to make discoveries in the biological and geological sciences. He has used the fossil magnetism preserved in rocks to show that the earth was completely covered in ice ('Snowball Earth' events) several times in Earth history, demonstrated the presence of an ancient magnetic field on Mars from the study of a meteorite (as well as showing that this meteorite came to Earth on a low-temperature trip that microbes could survive), and discovered how animals sense the geomagnetic field using tiny crystals of the mineral magnetite (Fe_3O_4). He splits his time between the California Institute of Technology in Pasadena, California and the Tokyo Institute of Technology in Meguro, Japan.

Earth's Magnetic Biosphere

In this lecture, I will illustrate with several examples how the science of magnetism is leading to fundamentally new and fun discoveries about the origin and evolution of life on Earth. Some of these include: (1) Magnetic data first demonstrated that meteorites ejected from Mars can travel to Earth on low-temperature, low-shock trajectories that would not harm microbes traveling with them, thereby implying that our biosphere might have evolved first on Mars nearly 4 billion years ago, and traveled through space to Earth in them. (2) Recent genetic studies on the magnetotactic bacteria demonstrate that they evolved very early in Earth History (during Archean time), and show that the geomagnetic field also is very ancient, thereby protecting our atmosphere and oceans from the solar wind. (3) A record of Earth's magnetic field is trapped in many rocks as they form, allowing us to record the position of continents throughout most of Earth history, and can be used to test ideas like 'Snowball Earth' and True Polar Wander events, such as that which occurred during the Cambrian Explosion. Finally, (4) I will mention exciting new developments in the study of how animals detect and use the geomagnetic field with tiny magnets similar to those which evolved in the magnetotactic bacteria so many years ago.

Dr. Yoshinori Ohsumi

Abstract

The Laureate of the Nobel Prize in Physiology or Medicine in 2016 "for the discovery of the mechanisms of autophagy"

Yoshinori Ohsumi was born in Fukuoka, Japan. He studied at the University of Tokyo where he received his doctoral degree in 1974. After a few years at Rockefeller University, New York, he returned to the University of Tokyo. In 1996 he moved to the National Institute for Basic Biology in Okazaki. He has also been affiliated to the Graduate University for Advanced Studies (Sokendai) in Hayama and to the Tokyo Institute of Technology, where he is now working. Yoshinori Ohsumi is married to Mariko Ohsumi who is also one of his scientific collaborators. Discovery of autophagy in yeast.

In the lysosomes of our cells its components are processed for reuse. The mechanisms of this process were mostly unknown until the early 1990s, when Yoshinori Ohsumi conducted a series of groundbreaking experiments with yeast, where he detected autophagy and identified genes important for the process. Yoshinori Ohsumi's discoveries laid the foundation for a better understanding of the ability of cells to manage malnutrition and infections, the causes of certain hereditary and neurological diseases, and cancer.

What is autophagy? A dynamic cellular recycling process

I have been studying the tiny unicellular organism, yeast, for 40 years. Yeast is an ideal organism for science because it offers an easy means of performing experiments that give clear and logical results. Questions that can't be answered in yeast are very unlikely to be solved in animal cells. But there are still many unsolved mysteries in the tiny yeast cell.

I started out trying to understand the function of the vacuole, an organelle that at the time was thought of as just a garbage dump in the cell. But I found that the vacuole is able to actively pump amino acids and ions across its membrane, and also another type of pump that moves protons over the membrane. This indicated to me that the vacuole is not just a garbage dump, but plays an active, physiological role in the cell, returning material to the cytoplasm.

I was already 43 by the time I started my own lab, where I decided to find out whether the vacuole is like the lysosome in animal cells, which is an organelle that degrades cellular material. Soon, I observed widespread protein degradation in the vacuole, which is autophagy, using simple microscopy. We then quickly identified the genes that control autophagy, which was completely unknown at that time, and after this the molecular events that occur during autophagy. The research conducted in my lab by just a few people triggered the explosion of autophagy research today, which is my greatest pleasure as a scientist.

To conclude, I want to convey just a few lessons from my life as a scientist to you today:

- Don't limit yourself to common knowledge, and be prepared to question received wisdom
- Don't be afraid to be different to other people
- Observe and think about nature with your own eyes
- Don't simply follow the trends of the day, but rather nurture your interests and curiosity

Observing autophagy in yeast with Yoshinori Ohsumi

Autophagy is a process that allows cells to isolate and degrade their own components through the formation of a cargo-filled vesicle (a type of sac inside a cell) and its delivery to the vacuole (a large organelle that breaks down cellular components) (Figure 1). Autophagy was first observed in yeast by Yoshinori Ohsumi, three decades ago. At that time, the nature of degradation in cells was not well understood, and Ohsumi was researching how the vacuole functions in the cell. Ohsumi knew that the vacuole contains proteases, which are enzymes that can break down proteins, but it was unclear how cellular components are delivered into the vacuole for degradation. He used cells that lack proteases and looked at the vacuole under a normal light microscope. Importantly, Ohsumi assumed that degradation would be important when cells are starved and do not have access to nutrients, as the products of degradation could then be reused by the cell to survive starvation. Under these conditions, Ohsumi observed many spherical structures vigorously moving inside the vacuole. This was that first observation of autophagy in yeast, and was the starting point of a revolution in our understanding of degradation in cells.

This finding raised a range of new questions – what is degraded by autophagy, and when? How are cellular components delivered to the vacuole? And what molecular mechanism allows autophagy to occur? To answer these questions, researchers now use more sophisticated techniques than were available 30 years ago. One such important tool often used in autophagy research is the various fluorescent proteins, such as green fluorescent protein (GFP). Through genetic manipulation, the attachment of a fluorescent protein to a cellular component allows its location inside the cell to be observed by fluorescence microscopy. For example, attaching GFP to a mitochondrial protein allows us to see mitochondria in living cells under the microscope. This approach has allowed researchers to investigate not only what is degraded by autophagy, but also how the autophagy-related proteins (Atg proteins) behave in autophagy and recognize cellular material for degradation.

In this practical class, students will observe cellular organelles and their degradation by autophagy. Students will use the sophisticated fluorescence microscopes in the Ohsumi laboratory to identify and photograph a range of organelles within the cell and determine whether they are delivered to the vacuole by autophagy. With these images, students will then prepare an English-language summary of their findings, which will be presented to all participants of the 2017 Molecular Frontiers Symposium. This practical class will provide students with an experience of a world-leading research laboratory, and an insight into a Nobel Prize winning researcher's scientific values and innovative approach to research.

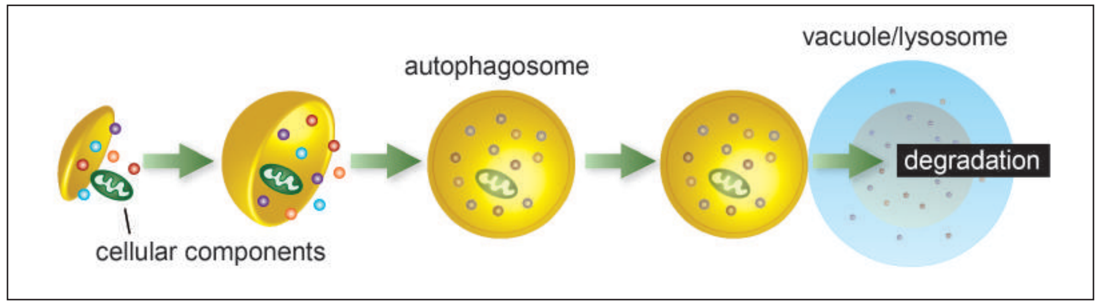


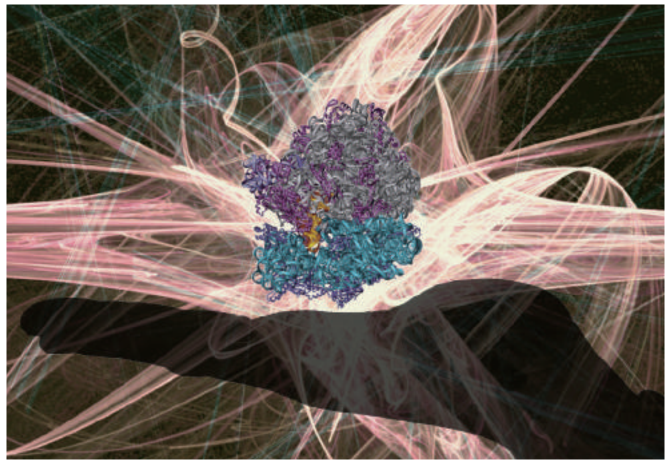
Figure 1. The process of autophagy

How can we imagine “Futuristic human” by revealing the wonder of ribosome?

Dr. Ada Yonath

Ribosome is known as a tiny protein-constructing factory in the cell. It has attracted many researchers, but it was considered to be impossible to reveal the structure of the ribosome due to its complexity. Dr. Yonath and her group contributed to the elucidation of the structural basis of the ribosome by achieving its crystallization. By this work, she received the Nobel Prize in Chemistry in 2009 along with Dr. Venkatraman Ramakrishnan and Dr. Thomas A. Steitz.

Ribosomal crystallography, which she has initiated, enabled us to access the making process of proteins. In other words, we may expect a new era in which proteins, as the chemical basis of mechanism of life, can be designed using biochemical technology. Participants were required to prepare their own ideas about how we can utilize the research of Dr. Yonath to our actual life. In the group work, we will discuss application based on the ideas that participants prepared. We will consider whether we can REALLY apply this technology to humankind. Let’s imagine what kind of HUMANS we could be in the future.

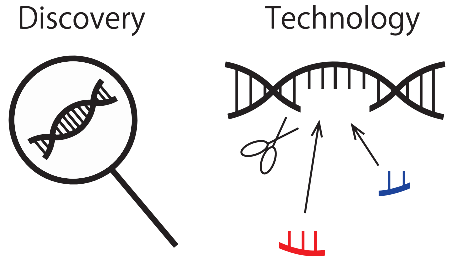


cited from the site for the NOVA program Secret of Photo 51.

Mentor	Miho Aizawa	Hiroto Kono	Yudai Takahashi	Hiroshige Yamaura
	D2, School of Materials and Chemical Technology	M1, School of Environment and Society	M1, School of Life Science and Technology	M1, School of Materials and Chemical Technology

Is “Science and Technology” always beneficial for human beings?

Dr. Bengt Nordén



(1) What will make a young scientist successful – how to get breakthrough?
(2) How formulate and address the crucial questions for the science for tomorrow?
(3) Are we allowed to question established biological paradigms such as the central dogma, genetic code, the chemiosmotic hypothesis of ATP synthesis etc – and what would we suggest as replacements?

In the beginning, each participant presents one key word which they chose as the answer to the first question in the homework regarding the first topic. Then, they brush up their opinions and try to figure out one most important thing for young scientists’ success.

Concerning to the second and the third topic, the participants will learn the differences between Science and Technology, then, they will learn that “technology beneficial for human” and “science beneficial for human” are totally different, at first. For the next step, they will find out the scientific origin of technologies, which they chose in their homework. The chosen technologies such as nuclear technology, artificial intelligent have brought (or will bring) human society benefits and harmful influences. This kind of topics, the positive and negative sides of technologies, have been widely discussed from different perspectives, as the participants should know through their homework. It is obvious that technologies have both positive and negative sides, but is it possible to ask that the scientific discovery, which is sometimes associated with the negative should have not been done? The participants will challenge this question, think the reasons to say “Yes” as well as “No” and how scientists should be. Then, the participants will go to a concrete example of this topic, biology.

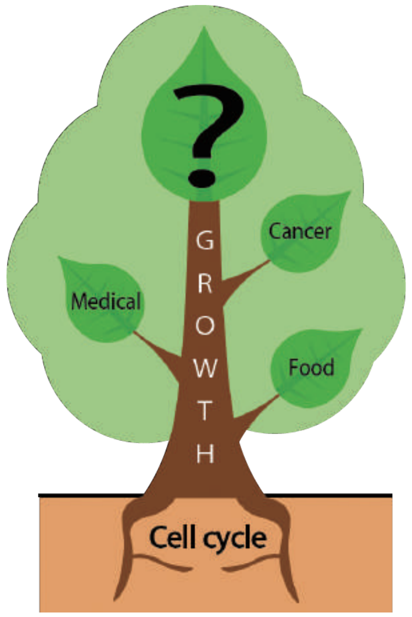
Mentor	Masaki Ishizu	Midori Kawaguchi	Yoichiro Koga	Hiroto Sakimura
	D2, School of Materials and Chemical Technology	D2, School of Engineering	D1, School of Engineering	D1, School of Materials and Chemical Technology

DAY 2 GROUP WORK

GROWTH; Grasp the Root of Organism

Dr. Tim Hunt

High school students will have a great opportunity to learn and discuss research and success of Prof. Tim Hunt, 2011 Nobel laureate in Physiology or Medicine who has discovered the cell cycle regulation. Before the group session, students will be asked to learn about biography and research content of Prof. Tim Hunt and asked to prepared questions to discuss with Prof. Tim Hunt. In group work, Students will have to consider about how Tim Hunt’s research can be applied to ‘Science for Tomorrow’. This could be considered not only in terms of advantages but also in terms of risks and problems. After consideration, students will be encouraged to discuss and debate passionately with Prof. Tim Hunt about the possibility of those idea. Basically, it does not matter that those idea can be realistic or not, however, those idea should be considered scientifically and creatively. Apart from research topic, students will be able to talk personally with Prof. Tim Hunt about the key of success as Nobel laureate. Finally, students will have to summarize and give a brief presentation based on what they can learn from Prof. Tim Hunt to create the better ‘Science for Tomorrow’ .



Mentor	Nattanai Kunanusont	Michihiro Tanaka	Naoto Ogura	Yasunobu Asawa
	D1, School of Materials and Chemical Technology	M1, School of Materials and Chemical Technology	M1, School of Life Science and Technology	M1, School of Life Science and Technology

The sixth sense - Magneto reception -

Dr. Joseph L. Kirschvink

On the day of symposium, we will conduct a simple experiment on magnetic bacteria which has sensory devices sensitive to geomagnetism and deepen understanding on magnetoreception. Figure of magnetic bacteria is shown in Fig. 1. Magneto reception is considered to exist also in human beings and plays an important role of our sensory organ. Professor Kirschvink played experiments to clarify the human magneto sense like shown in Fig. 2. This is the key part to learn about the theme on this time. Taking a lecture on the basis of experiments, you will be interested in the possibility of magneto reception, which human beings possess.

In the group work, to consider the bright future of science, we will start with sharing the future image what the world will be like after 100 years. On imagining the future of the world, we will be able to discuss how magneto reception, which is our basic research, can be useful in society.

Students will share their opinions on the agenda prepared in summer homework with each other and deepen their own idea. Through this project, we can not only touch on specialized fields, but also ask them to think about why we do research and what it means of research.

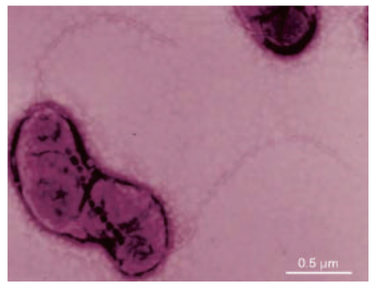


Fig. 1 TEM image of magnetotactic bacterium.

Dennis A.B and Richard B. F. *NATURE REVIEWS MICROBIOLOGY*, 2, 2004, 217

Fig. 2 Magnetic-sensing tests by professor Kirschvink.

http://www.sciencemag.org/news/2016/06/maverick-scientist-thinks-he-has-discovered-magnetic-sixth-sense-humans

Mentor	Amal Dilanka De Silva	Hiroki Sayama	Yuki Tokunaga	Zang Xiaofeng
	M1, School of Engineering	M2, School of Environment and Society	M2, School of Science	M1, School of Science

Dr. Hideki Shirakawa

Abstract

Hideki Shirakawa was born in Tokyo, Japan. He received his B.S., M.S., and Ph.D. from Tokyo Institute of Technology. After Completion of his Ph. D. in 1966, he joined Professor Ikeda's group at Research Laboratory of Resources Utilization, Tokyo Institute of Technology, where he investigated acetylene polymerization for the elucidation of the polymerization mechanism by Ziegler-Natta catalysts. In 1967, he noticed on formation of polyacetylene in a form of thin film with metallic luster following an unforeseeable experimental error by one of his coworkers. By chance, this silvery film caught the eyes of Professor Alan G. MacDiarmid, he was invited to work in University of Pennsylvania for one year during 1976 and 1977 where they found chemical doping of the polyacetylene film jointly with Professor Alan J. Heeger. In November 1979, he moved from Tokyo Institute of Technology to the Institute of Materials Science, University of Tsukuba, where he was appointed Associate Professor. In October 1982, he was promoted to full professor and worked on polyacetylene and other conjugated polymers. He retired from the University of Tsukuba at the end of March 2000. He received the Nobel Prize for Chemistry in 2000 with Professor Alan J. Heeger and Professor Alan G. MacDiarmid.

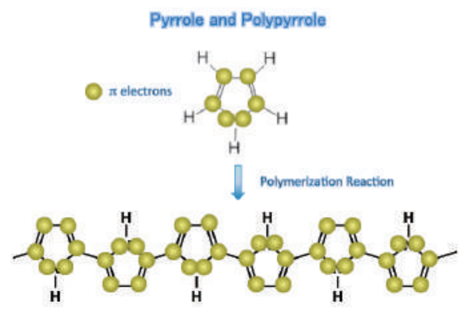
Fabricating conducting polymer secondary batteries

Since the discovery of conducting polymers, the field of organic electronics has been widely developed with their advantages such as lightness, flexibility and versatile design. In this experimental workshop, participants will understand synthesis and applications of conducting polymers. Polypyrrole and polyaniline, representative conducting polymers, are easily synthesized by electrochemical polymerization of pyrrole/aniline monomers with a simple setup. The obtained polymer films are then subjected to secondary battery tests as a cathode material. The charge/discharge characteristics are studied by operating the tests under various conditions.

Let's fabricate conducting polymer secondary batteries and check their charge/discharge characteristics

Contents:

1. A brief overview of conducting polymers and doping
2. Synthesis of conducting polymers (polypyrrole/polyaniline) by electrochemical polymerization of monomers
3. Fabrication of a simple checker "Tohru-kun" and check up on electrical conductivity of the polypyrrole/polyaniline
4. Investigation of the doping and undoping functions
5. Measurements of electromotive force and capacity of the batteries



One dimensional arrangement of π electrons

STAFF LIST

Molecular Frontiers Symposium 2017 Committee Member

- Hidetoshi Sekiguchi (chairman), Vice President for International Affairs
- Isao Sato, Vice President for Institute Strategy
- Hiroshi Iwasaki, Professor, Institute of Innovative Research
- Takehiko Mori, Professor, School of Materials and Chemical Technology
- Ken Nakajima, Professor, School of Materials and Chemical Technology
- Kyoko Yamamuro, Professor, School of Engineering
- Masayuki Takahashi, Specially Appointed Professor, School of Life Science and Technology
- Shinsuke Inagi, Associate Professor, School of Materials and Chemical Technology
- Hitoshi Nakatogawa, Associate Professor, School of Life Science and Technology
- Tadashi Kawamoto, Assistant Professor, School of Materials and Chemical Technology
- Hirofumi Saito, University Education Administrator, Center for International Education
- Shintaro Furuya, Research Fellow, Institute for Liberal Arts

Laboratory Workshop Assistant (Tokyo Tech Students)

Kodai Iijima (D3)	Yuki Koizumi (D3)	Mari Harada (M2)	Keita Saito (M2)
Yusuke Kataoka (M1)	Sota Kato (M1)	Kazuho Matsuhisa (M1)	Megumi Okazaki (M1)
Sayaka Osada (M1)	Yoshino Sudo (M1)	Yumiko Ito (B4)	Yu Kato (B4)

Group Work Mentor (Tokyo Tech Students)

Miho Aizawa (D2)	Masaki Ishizu (D2)	Midori Kawaguchi (D2)	Yoichiro Koga (D1)
Nattanai Kunanusont (D1)	Hiroto Sakimura (D1)	Hiroki Sayama (M2)	Yuki Tokunaga (M2)
Yasunobu Asawa (M1)	Hiroto Kono (M1)	Naoto Ogura (M1)	Amal Dilanka De Silva (M1)
Yudai Takahashi (M1)	Michihiro Tanaka (M1)	Zang Xiaofeng (M1)	Hiroshige Yamaura (M1)

memo