SDGs Special Issue 2020

Science Window

Think about the future we want to live in,
and create it.

JST | SUSTAINABLE DEVELOPMENT GOALS

Think about the future we want to live in, and create it.

In 2020, the world was hit by the novel coronavirus disease (COVID-19), plunging us into an unprecedented crisis, with a state of emergency issued in Japan to stem the contagion. It has exposed vulnerabilities and raised a plethora of questions among us all about happiness, well-being and the future. The year 2020 also marked five years since the adoption of the Sustainable Development Goals (SDGs) by the United Nations General Assembly, leaving just 10 years before the goals are to be achieved. The decade in which we steadily progress towards a sustainable world by 2030 has begun. Taking the lessons learnt from disasters, applying deep insights into the values we want to retain and the new values we hope to foster, what kind of sustainable society lies ahead? Science is a key means by which to achieve the SDGs. Ahead of a decade of action, let this be an opportunity to consider the future vision and actions needed from scientists if we are to make the promise a reality.

Contents

What is Science Window?

We are surrounded by science and technology. Many innovations help us by making our lives easier or our days more fulfilling. A lot of hope is placed on the development of science and technology. We are aiming for a better future through science and technology. As a first step, we have established Science Window, an online magazine full of fun information designed to be as accessible as possible.

See Science Window for free here
(https://scienceportal.jst.go.jp/)
- Integrated with Science Portal

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—Science for Global Well-Being—

Interview with Michinari Hamaguchi

In recent years, science and technology has evolved at a speed beyond our imagination, especially in the areas of information-communication technology and biotechnology. However we also face a mountain of global common challenges including epidemics of emerging and re-emerging diseases like coronaviruses, large-scale natural disasters, climate change, famine, water shortages, and inequalities of education and wealth. The question is how science and technology can contribute to solving them. In October 2019, scientists from across the globe attended the World Science Forum in Budapest, Hungary. The declaration adopted at the end of the event stated that the approach should be "science for global well-being." What message did the world's scientists imbue in this phrase? We asked Japan Science and Technology Agency (JST) President Michinari Hamaguchi, who attended the event.

The light and dark side of science

——Chapter one of the World Science Forum 2019 Declaration was entitled "Science for Global Well-Being." What message does this phrase carry?

Hamaguchi: I believe the phrase arose from reflections on the experiences of humanity over the course of modern history. Since the industrial revolution of the 18th century, science has evolved rapidly and our lives and communities have been transformed. As a result, the world population has exploded. Medical progress, improved agricultural productivity, and the development of an array of industries and energy sources have brought us comfortable lives. Increased longevity has triggered a population explosion. However, the progress of science and technology has also brought about a host of issues. While science has helped humanity to flourish and contributed to higher standards of living, environmental degradation has advanced with staggering momentum, making the 21st century an era in which humanity is questioning its own survival.

——These are the 'light' and 'dark' sides of science and technology.

Hamaguchi: Typical examples of these are the issues of microplastics and global warming. The 21st century is an age where the dark side of science and technology is in full view. Many people are starting to see it. Though science and technology is still flourishing, researchers are realizing they must address the question of what human well-being means. This is the message behind the words "science for global well-being."

Science for well-being

——Environmental issues are even mentioned in the Sustainable Development Goals (SDGs)*1 put forth by the United Nations in 2015. Does "science for global well-being" come into them?

Hamaguchi: The SDGs represent a range of goals to be achieved for the sustainability of humanity and the planet, such as food, education and gender. Another key phrase of the SDGs agenda is "no one will be left behind." This mission equally supports the right of all people to lead comfortable and happy lives.

The late Dr. Tetsu Nakamura*2, who dedicated much of his life to Afghanistan, said that the most important thing for most people is "three meals a day, at home with family." This may be something those of us living in Japan take for granted, but I think Dr. Nakamura found the template for well-being in those words. However, that template is under threat in many regions of the world today. I strongly feel that we must face this reality and orient science to the well-being of the world.

——Looking at Japan, there have been a lot of large-scale disasters in recent years.

Hamaguchi: The words of Dr. Nakamura do not just apply to Afghanistan. Even in Japanese society with its advanced and convenient systems, sudden natural disasters can strike in an instant and change our lives. That is exactly what happened with the Great East Japan Earthquake disaster in 2011.

After the earthquake, a medical team from Nagoya University (where I was president at the time) also went to the disaster zone in Tohoku. Amid the destruction, they camped in sleeping bags and gave their all to help the community. JST also engaged in a number of initiatives to support local reconstruction. I believe we made a significant contribution, restoring and further developing the traditional jobs of the local people through the power of science.

What impressed me a great deal was when dosimeters were distributed to high school students living in Fukushima to measure their daily radiation exposure. This provided evidence that they were not exposed to levels of radiation that were exceptional compared to other regions of Japan or worldwide. It was very important to be able to help people in the affected communities to return to work using science, and provide the support they needed to continue their livelihoods with peace of mind. Science does not end with analyzing earthquake mechanisms or weather forecasts. I strongly believe that science should address and contribute to people's well-being, and it has plenty of potential to do so.

——The novel coronavirus (COVID-19) that we face today is also a threat to people's happiness and well-being.

Hamaguchi: The more developed and civilized a society becomes, the more vulnerable it can be. Among researchers there are regrettably those who forget their mission as scientists and conduct fraudulent research, or create dangerous environments for humanity. That is why I am convinced that science needs to contribute to the well-being of people in our daily scientific activities. "Science for global well-being" is an important message to stop us forgetting this. In fact, as Japanese representatives, we strongly argued for this to be reflected in the Declaration at the 2019 Budapest conference.

Diversity and inclusivity

——You were president of Nagoya University before your appointment at JST. Were you involved in any initiatives related to well-being back then?

Hamaguchi: One such initiative was our partnership with industry. The university got together with industry to think about the kind of research and development needed to create a good society.

Another was our outreach to Asia. We invested a lot in the Well-being in Asia program, which aimed to increase well-being in Asia based on the keywords of "food, health, environment, social systems and education." What we saw then was that most of the issues of the SDG agenda were linked to gender.

One thing I recall now is the time I visited a sanitorium for tuberculosis (TB) in Cambodia when I was dean of the medical school. It was staggering. The majority of patients were women in their late 30s and 40s without access to proper medication or diagnostic instruments, and I saw them as they waited to die from multi-drug resistant TB. Many also had AIDS. The reason this was happening was because girls from poor Asian villages were being sold into prostitution, and it is still happening today. This is a complex problem. Even though the warm climate allows for triple cropping, the profitability of agriculture is very poor, and in addition, there is the gender issue. At the time, I heard that around half of the girls entering elementary school would not be able to graduate. I felt that if societies do not protect the rights of girls and women, their activities and their education, this unhappy situation will inevitably continue.

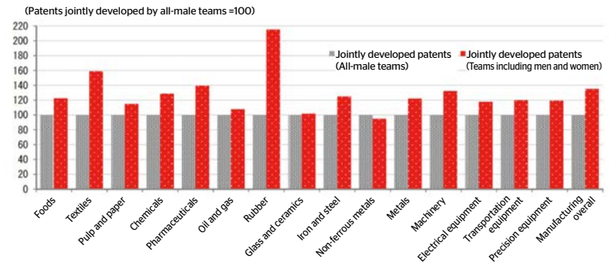
*1: Global targets agreed unanimously by the 193 Member States of the United Nations in 2015. They set forth 17 goals to be achieved by 2030 and 169 more specific targets.

*2: The local representative for the NGO Peshawar-kai, which conducts humanitarian assistance in Afghanistan. From 1984, Dr. Nakamura provided medical support for refugees in Pakistan and Afghanistan. He also set about digging wells and building irrigation channels to support the local communities under the motto, "One irrigation canal is better than 100 medical centers." Dr. Nakamura was killed by an armed group in Afghanistan on December 4, 2019.

Global Gender Gap Rankings 2019			
1 (1)	Iceland	9 (6)	Rwanda
2 (2)	Norway	10 (14)	Germany
3 (4)	Finland	53 (51)	USA
4 (3)	Sweden	75 (73)	Thailand
5 (5)	Nicaragua	106 (103)	China
6 (7)	New Zealand	108 (115)	South Korea
7 (9)	Ireland	112 (108)	India
8 (29)	Spain	121 (110)	Japan

*Figures in brackets are the previous year's ranking

Economic value comparison of patents jointly developed by all-male teams and teams including men and women



Left: World Economic Forum (WEF), 2019 Gender Gap Index (GGI)
Right: Economic value comparison of patents jointly developed by all-male teams and teams including men and women
*From the Development Bank of Japan

——In Japan gender equality is barely progressing, and we seem to be lagging behind global standards.

Hamaguchi: At its heart, I think the problem is that Japanese men do not have enough experience as a minority. To achieve real diversity, it is not enough simply to understand gender, language and cultural differences. The key is the extent to which you really feel it, and to which you have a multifaceted perspective. When I lived in New York, there were a lot of times that I understood what it meant to be a minority. That woke me up to the unconscious bias within myself. It was quite a discovery to gain a multifaceted perspective from that experience, and it was fulfilling in a way too.

Diversity is also very important in bringing about innovation, which is clear from the data. A comparison of the competitive strength of patents pending from male-only teams and from teams of both men and women reveals that the latter is far stronger. This applies to virtually every industry. It is a clear message of how diversity can lead to innovation.

——So JST is also promoting the work of female scientists with initiatives such as establishing the Jun Ashida Award*3.

Hamaguchi: The Jun Ashida Award has been a real eye-opener. If you looked at the scientists supported by JST and thought there were not many female researchers in Japan, think again. There are thousands of brilliant female scientists.

——From the perspective of "no one will be left behind", what are the prospects for those with disabilities?

Hamaguchi: Just as important as diversity is "inclusivity" in its true sense. A differently abled individual may think of unique solutions to an issue precisely because they have more challenges in their own life. Someone I personally admire is Chieko Asakawa*4, an IBM Fellow. As a blind person, she came up with an invention that no seeing person would normally think of. Her innovative spirit makes her a great choice for the next director of The National Museum of Emerging Science and Innovation (Miraikan).

We also have a growing issue regarding children suffering from attention deficit hyperactivity disorder (ADHD) and social withdrawal. Though if we think about it differently, we can also view their 'weaknesses' as valuable traits. The important thing is to recognize and appreciate these traits and work together. If we can create a society in which those with such traits and potential are able to flourish, then Japan will become a more vibrant place.

——What does inclusivity have to do with science?

Hamaguchi: We're not there yet, but science and technology are beginning to emerge that can overcome severe disabilities. A study by Professor Nguyen Thanh Liem - known as "the father of pediatric medicine" in Vietnam - transplanted stem cells into infants with cerebral palsy, and reported cases where these children could stand unaided. Even in Japan, patients at Sapporo Medical University with spinal injuries have become able to walk again. Science has the power to create well-being.

*3: A prize established by JST to promote women in science. It is awarded in cooperation with the Ashida Fund, for female scientists carrying out excellent research contributing to a sustainable future as well as institutions supporting that research. The Ashida Fund is operated by the Japan International Science and Technology Exchange Center (JISTEC) and was established by late designer Jun Ashida with the purpose of nurturing the younger generation.

*4: An information technologist at IBM Japan and a Doctor of Engineering. Dr. Asakawa lost her sight after an accident in a swimming pool at junior high school. At IBM she has done groundbreaking work in digital Braille and voice browsers for the Internet. She is seen as a leader in accessibility research. She became an IBM Fellow in 2009, the top honor for its technical professionals.

People are the only Japanese resource

——Some people think that Japan is losing its competitive edge. What future do you see in Japan?

Hamaguchi: Japan hardly has any natural resources. Our prosperous lives currently depend on importing 98% of our energy and 62% of our food. This is due to the benefits of our past trade surpluses. Now that industry is stagnant in Japan, it is difficult for new innovations to emerge. Some predict that in 40 years' time GDP will be 25% lower, so if nothing is done, Japan may shrink while our debt remains the same. Our convenient and comfortable society may become nothing more than a distant memory.

Furthermore, Japan's population is ageing and shrinking more rapidly. We need to redesign society to be life-sized, and we must come up with the innovations required for an ageing population. It is challenging but achievable.

The key to success will be our human resources. Japan's major resource is its people. We must create a liberal environment, where young people can forge Japan's future.

——It is vital to build up experience while you are young. What is your message for the young readers of this magazine?

Hamaguchi: Newton discovered gravity, and Archimedes observed the law of buoyancy while he was taking a bath. There are so many things around us that we can see yet we do not notice. When you notice something like this, it is called a "Eureka moment." Research is the same. You carry out experiments day and night and find nothing, but one day a discovery is made and it is very exciting. I think this moment of fulfilment is the origin of science.

In recent years, many Nobel Prizes have been won by Japanese scientists, but most are findings from 20-30 years ago. There was more room to move in Japan back then, because every research laboratory would receive funding based on the number of teachers and students. The classic example is the research on blue light-emitting diodes (LEDs). Everyone said it would be impossible to do in the 20th century and so it did not attract major funding, yet the research could continue thanks to the 8 million yen annual grants to the laboratory. Even if the government were to allocate 8 million yen to every laboratory in Japan for 10 years, this wouldn't compare to the monetary gain from blue LEDs. Just one event like this can transform Japan and the world, and change our lives. Energy consumption decreases, so all that investment is repaid in full. That is the power of science.

——How will JST help Japanese research and development going forward?

Hamaguchi: Most R&D today must bear fruit within the short period of five years. If you take out preparation and wrap-up time, that becomes three years of actual research. This makes it difficult to conduct challenging or unconventional research. That is why we are launching "Fusion Oriented Research for Disruptive Science and Technology," which will provide funding for seven to ten years. By funding researchers sustainably yet with discretion, this will provide opportunities for communication with people from different industries as well as for friendly rivalry within the same industry and for exchanges with other regions. I hope that stimulating researchers will lead to the creation of technologies that provide clues to a new Japan.

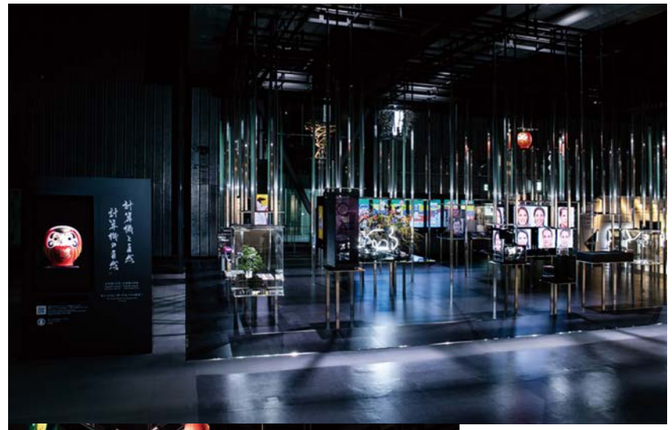
On the other hand, we also need research and development to ensure a bright future for the world. That is why we have launched the Moonshot Research & Development Program, with specific targets to be met by 2050. The aim is to bring together top researchers to trigger dramatic innovations in Japan. This R&D reflects the hopes of various stakeholders but also encourages researcher freedom. At JST we understand the responsibility we have as the implementing organization for these two programs and will do everything in our power to make them into successes.

Profile

HAMAGUCHI Michinari

President, Japan Science and Technology Agency (JST)
Chairperson of the Council for Science and Technology, Ministry of Education, Culture, Sports, Science and Technology
Chair of the Japanese National Commission for UNESCO

Born in Mie Prefecture in 1951. Earned his Ph.D. in medicine from Nagoya University in 1980. He was appointed research associate at the Nagoya University School of Medicine in the same year. Pursued research in molecular oncology as a research associate at Rockefeller University in the U.S. from 1985 to August 1988. Took up the post of professor, Department of Molecular Pathogenesis, Nagoya University School of Medicine in 1993. In 2003, he became a professor with the Center for Neurological Diseases and Cancer, Nagoya University Graduate School of Medicine. In 2005, he was appointed dean of the Nagoya University School of Medicine/Graduate School of Medicine. He has been in his current post at JST since completing his tenure as president of Nagoya University from 2009 to 2015.



Above: The "Digitally Natural - Naturally Digital" Permanent Exhibition, Miraikan (photograph: Miraikan)
Left: Naturally Digital. The senses are questioned with mirrors and displays of differing resolutions.

Vision for our future

How Will We Live in a Future Society Where the Natural and the Artificial Meld Together?

Interview with Yoichi Ochiai

On November 14, 2019, Miraikan opened a new permanent exhibition. It was supervised by media artist and University of Tsukuba associate professor Dr. Yoichi Ochiai. His "Digitally Natural - Naturally Digital" exhibition, depicts a future in which computers are ubiquitous and it is no longer easy to distinguish the natural from the artificial. What will nature be like in this future? What challenges does the world face today? And what is required of scientists? We put the questions to this modern sorcerer of many trades – researcher, artist and businessman – with research interests that span the likes of computer science, applied physics and media art.

A future where the natural and the artificial merge

Envisioning the future in shifting resolutions

——Since November 2019, the National Museum of Emerging Science and Innovation (hereafter "Miraikan"), has had the new exhibition "Digitally Natural - Naturally Digital," of which you were the general supervisor. What was your vision as a supervisor and what is the intent of the exhibition?

Ochiai: The first thing I did was to think about the role of Miraikan. It does not have the archival function of a museum, nor does it provide the context for old and new artworks like an art gallery. I came to the conclusion that its role is to stimulate in-depth thinking about science as a culture. The idea I came up with was to harness the role to create an exhibition to make people think about the future of science and technology. I also wanted to make this a place where you feel a strong sense of "questioning" to draw visitors into the mystery. In doing this, we made sure to keep the written explanations to a minimum. The printed explanation becomes outdated from the moment it is printed. I wanted people to experience the sense of being convinced after doing research on your questions. But now is an age when you can instantly access the information you want online. People always need information to guide their search, so striking the balance of how much information to provide was very difficult. The explanation on the exhibit can be also viewed with QR codes.

——What is the aim of the "Digitally Natural - Naturally Digital" display?

Ochiai: The concept of one of the main exhibits, "Naturally Digital," is "resolution." I feel that we are approaching an age when humans are unable to distinguish between what is nature and what is digital. What's lies behind is the advance of technology. The classic example would be resolution of the display, on which fineness of the image is shown. In this exhibit, we have used displays with a resolution that will trick your eyes and your awareness. Some displays have low resolution while others have extremely high-resolution.

Moreover, we placed mirror exhibit to show people how primitive current display technology is. In terms of design, the theme of resolution is seen throughout the entire silver pillar exhibit. A mirror has higher resolution than any electronic display, yet when we look in a mirror every day, we do not notice it. That is why we included mirrors in the exhibition: to wake people up to the fact that the mirror gives you an even clearer image of yourself than a display.

I think tricks like this will be thought-provoking for visitors, making them wonder how this technology was created. Display resolutions are improving every day, so in five years' time, this exhibit will be a historical relic. There will be a discussion focusing on resolution like "that old 'high vision' couldn't fool a child." I believe having people feel and discuss in this place will create history and lead to creating the future.

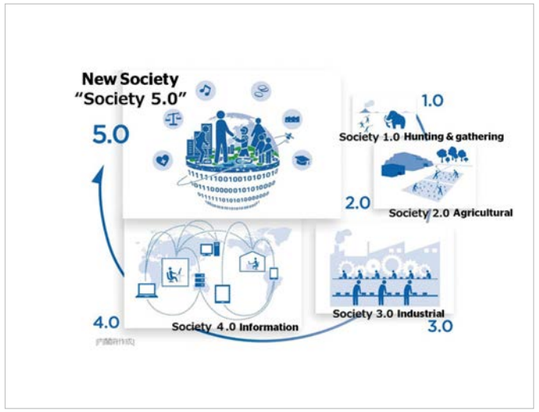
The other main exhibit, "Digitally Natural," I created it thinking it would

Above: A robot that keeps moving, replacing humans.
Right: The model of a morpho butterfly (by Yoichi Ochiai). How does look compared with the butterfly specimen? ©Yoichi Ochiai

be fun if people would imagine the way robots blend in with "nature." I want people to feel some doubts when they see robots doing human work and operating endlessly, and feel different sense of time from their own, or the difference in lifespan and physical strength, for example. We also ask visitors how they see the specimen of morpho butterflies, and the model I made respectively. Perhaps in 100 years, there will be less and less sense of distance from artificial things, and even models might be perceived as "natural." I think that may be a "new nature," a sense you get over time. Computers would be integrated into nature in the future, and people might take it for granted; I imagined such world without a boundary between nature and computers.

——You are showing how our view of nature will be updated by the advent of computers, through various differences in resolution. What else was behind this exhibit, and what other tricks can you reveal?

Ochiai: When Miraikan came and asked me to do something on the theme of computers and AI, Society 5.0 came across my mind. Society 5.0 is a world where all people, products and information are connected within a network. A world where everyone can live true to themselves, like anybody can access information from anywhere, and all people can live without disparity and inconvenience. I think that is a little more natural. I also accounted for the imperatives of society and government, but to do so at full throttle is not right for an exhibition. I am attempting to express something more conceptual, while keeping all that in my mind.



Society 5.0 is a society in which physical (real) and cyber (virtual) spaces are fused at a high level, a human-centered society achieving a balance between economic development and resolution of societal challenges. (Source: Cabinet Office website)

Solutions vs desire for knowledge and expression

Are art and science unnecessary to solve society's problems?

——What are the obstacles to achieving a "better future?"

Ochiai: The issues that Japan must address are clear. The maintenance of infrastructure, income inequality, the desire to achieve zero carbon emissions while being unable to eliminate thermal electricity…solving these problems requires consensus, people and time. The biggest issue is that those things are completely lacking, so I think we need to solve this first. A lot of students would like to work for society to solve these problems, but they tend not to because there are few models to pursue such activities and earn a living at the same time. In a society whose goal is to solve problems, an emerging issue is a bias at universities and academia toward engineering and design. I think there is a need for people wanting to drop out of the established social system and work for a better world to be able to make a living. Some kind of mechanism for this should be sustainably established with the participation of business too.

——If you focus too much on the highest-priority issues, academia loses its balance, doesn't it?

Ochiai: Artists contribute to culture, but next to societal issues and disasters, art tends to be deprioritized. Art is absolutely essential to society but with the sheer number of high-priority challenges we face today, it takes special effort to persuade people. It is very difficult. This might surprise you, but I think it is the same with pure science. When you are sitting next to somebody in trouble, it might not be the right time to ask them to detect a gravitational wave! Whether it is detecting gravitational waves, discovering the inner workings of cells or the movement of fungi, science is vital because it all leads to unlocking the mysteries of life. Most importantly, don't you want to find out new things? So that desire to find out and express things is also vital, because it leads to solutions to society's problems. I wanted to come up with a good way of alerting people to the importance of such desire.

——When people flock to the professional areas that "solve society's problems," the ranks of scientists and artists required by society over the long term are exhausted. At this rate, would you say that this bias is going to get extreme?

Ochiai: Yes, I would. However, this issue stands out because it is happening in Japan. The importance of this issue is well-recognized in Europe and the United States, and mechanisms have been established to invest in science and art, and things are working pretty tidily. However, no such structures exist in Japan, which tends to spend a lot of money in engineering and design to overcome big challenges. If money was also invested in things not directly connected to overcoming those challenges, by establishing investment criteria and mechanisms to do so, then the balance would return and society would function well. Therefore, for this Miraikan exhibition, we brought in a humanities expert to supervise, and many artistic elements were incorporated. The beauty of science as a culture is also a theme of Miraikan exhibitions.

It is essential for researchers to "get involved in society"

What is the strategy to maximise your vision?

——I think it would be very interesting if the students and young people of today were able to see the potential of being a researcher in terms of being able to take various stands and as a launching pad, like you have. What would you like to say to students and young people who do not know what they want to do in the future?

Ochiai: Since the first goal of a Ph.D. is to graduate, once you have gone through post-doctoral studies, an assistant professor job and earning a livelihood by your mid-30s or 40s, you forget something. I think that is sad. At the extreme, any engagement with society is good, so if you can make a living through study, research or culture, that is great. In this context, I think it is important to know how to relate to society. For example, you could go freelance without a university affiliation, carry out research at home, write a bestselling book or write a thesis.

It is also good to live that way. I think that doing business in accordance with your own interest is very natural and wonderful. Yet, few are

Right: Digitally Natural. Flower arrangement using natural flowers and machines together. Which butterfly is real? Take a look.

living that way. I am not sure why, but it seems that people stop researching once they find something profitable. If people like profitable researchers and commentators could have their own labs, that could also lead to more open science and citizen science – ideas that have caught on recently – which would allow them to participate in all research activities.

Also, in working with young researchers, I have come to see things from a human resources development perspective as well. I have realized that the role of creating jobs for researchers is very important. I am hoping to dedicate myself to this for the next year or two. Bring more people in the team and to keep an eye on them over the long term is also essential. You have to build an ecosystem. The grass may look greener next door, but the work is hard wherever you go, so you should not throw away passion. You might call it the richness of loving knowledge.

——What specifically are you aware of?

Ochiai: It's simple, "never turn down a job." To truly become a scientist or someone who loves thinking, you had better be open-minded about things and broaden the horizons of what you find interesting. If you do so, you will learn to move that way little by little. I personally think everything in life is a field trip. There is no subject that is off-limits to research tools like Human Computer Interaction (HCI) or fields that consider human engagement, so it is always fascinating. In other words, if you want to get to the bottom of a given problem, whether it is engineering or social science research, it is important to look at phenomena through various frameworks. Specifically, we could make 3D displays by shining a grain of plasma which is a molecule of light. As a researcher, artist and business owner, when I do all three properly at the same time, it takes three times longer. I think I will start to get better in my late 30s, then about six or seven years later I will be a mostly finished product.

Now I am thinking about my favourite gravitational waves, as well as applied research in the engineering of physical phenomena and HCI research. I am also looking at more scientific fields based on digital nature. I have heard that scientists do their most important work around the age of 35 and for me as well, this is a time when my horizons opened up. As a researcher I may have a five-year cycle and I predict that I may want to follow a new interest again in my early 40s.

What I want to tell everyone is, be interested in as many different areas as possible. That is key. You should broaden your perspectives early and if take steps early, you will be able to achieve more. This is something I have been through, and it is a strategy. You should be interested in all sorts of things in your life.

*Digital Nature: the concept proposed by Ochiai. Like Digitally Natural - Naturally Digital, it is a worldview that features "new nature."

Profile

Photo credit: Mika Ninagawa

OCHIAI Yoichi

Media Artist. Born in 1987. Gained Ph.D. in Interdisciplinary Information Studies (Applied Computer Science), Tokyo University in 2015 (in under two years, a record for the Graduate School of Interdisciplinary Information Studies). Associate Professor at University of Tsukuba, where he is the Director of Strategic Platform for Digital Nature. He is also Research Director on the JST CREST xDiversity Project.

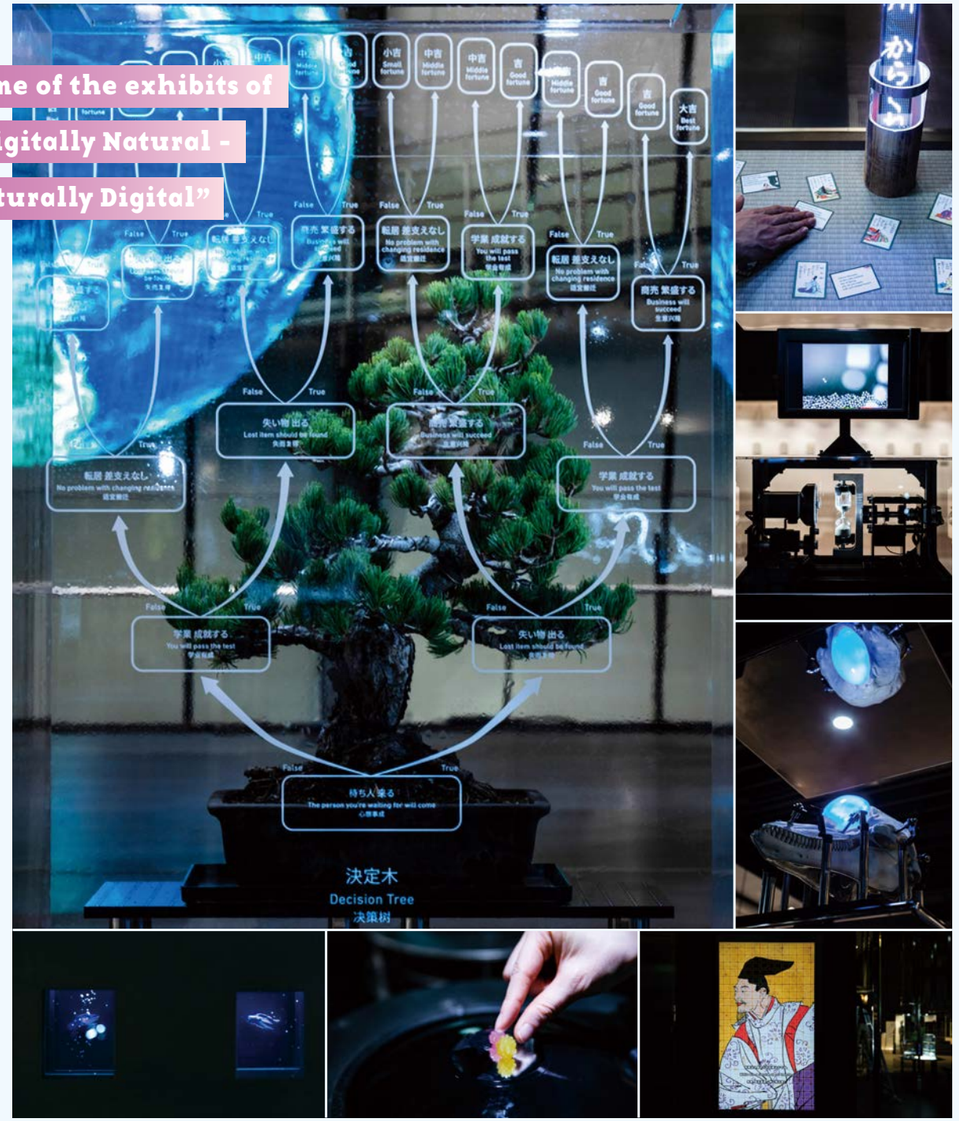
His awards include the World Technology Award 2015, Prix Ars Electronica in 2016, and STARTS Prize from the EU. Won the Laval Virtual Award from Europe's largest VR festival, Laval Virtual, five times in the four years to 2017, the SXSW Creative Experience ARROW Award in 2019 and in 2017 was selected as one of the Leaders of Tomorrow by the St. Gallen Symposium in Switzerland. He has held a number of solo exhibitions including "Image and Matter (Kuala Lumpur, Malaysia, 2016)," "Sehnsucht nach masse (Tokyo, 2019)" and "Jonen to no Hansuu - Rumination with Pathos (Leica Ginza, 2019)."

Recent publications include Digital Nature (Planets), Atlas of the World in 2030 (SB Creative) and a photographic collection, Sehnsucht nach masse (amana).

With his statement that he is "Confronting the development of digital nature, ruminating on the longing and pathos that lie between image and mass," Yoichi freely crosses the boundaries of research and artistic activity, and continues to explore and express his philosophy.

● Yoichi Ochiai Digital Nature Laboratory https://digitalnature.slis.tsukuba.ac.jp/vision/

Some of the exhibits of "Digitally Natural - Naturally Digital"



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1: "Some days you're lucky, some days you're not (decision tree)"
The "decision tree" computer mechanism looks like a lottery ticket?! As you answer each question, where do you end up? A decision tree is a method of machine learning carrying out classification or regression. Its name comes from the resemblance to the branches and leaves of a tree.

2: "You missed!"
You reached out for the card, but you couldn't pick it up. You could see it, so why did that happen? Try it for yourself.

3: "There is a computer lying in the grains"
Just an ordinary hourglass? The grains fall smoothly through the hole. It looks like sand, but further inspection reveals...

4: "Click, click, whistle...This is dolphin. Over?"
Dolphins are mammals that use echolocation. They use ultrasound to monitor their surroundings and work out where they are. What will communication look like in the near future, and what does communication with non-humans look like?

5: "Which is the inside and which is the outside of the computer?"
Tropical fish swim gracefully around two tanks. On one side are the real fish and on the other, a high-resolution display of the fish. Can you work out which side the real fish are on? Once you have worked it out, a new question will await you. (Image: Miraikan)

6: What is virtual?
It seems within reach, but it is untouchable. Is the world I see real or fake? Here you have a model of Konpeito sugar candy, there you have a model of the candy reflected in a mirror. You may be able to work out the trick if you look at the parabolic mirrors facing each other.

7: Ukiyo-e: Heian poet Ki no Tsurayuki
Ki no Tsurayuki's Tosa Diaries may be Japan's oldest diaries. The way a diary is kept may have been transformed by YouTube and other social media, but the essence of daily life and culture has not.

Source: Miraikan

Vision for our future

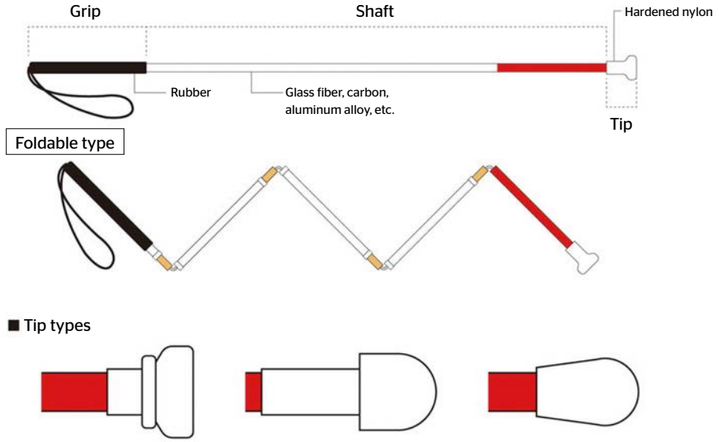
A New Worldview Born from Unseen Senses

—The Body as Seen Through the Eyes of Disabled People—

Interview with Asa Ito

Things look a certain way and behave a certain way. But does everyone perceive them the same way? Is our own "common sense" and what is natural for us the same for others?
Asa Ito is a researcher and Associate Professor at the Institute for Liberal Arts, Tokyo Institute of Technology. As a student of biology, she felt a keen interest in aesthetics, a subject that deals with concepts that defy verbal description like sensation and perception, and switched to humanities. She is pursuing a joint research project with NTT on the influence of perception of the body, developing unique ways of "watching" sport and introducing new ways to enjoy the Olympics and Paralympics. Ito says that when we cast off our existing worldview and open our eyes to the diversity of the world, we gain a glimpse of the new values that will be required in future.

Types of white cane



The white cane has three functions to protect the user from obstacles and danger: (1) alerting others to their disability, (2) gathering information about one's surroundings, the walking surface and so on, and (3) physical support. In addition to these, an extendable cane lets the user adjust the length for height, gait and preference.

Source: Kawasaki City Information Culture Center for the Visually Impaired website and others

What will future society require?

Being appointed Director of the Future of Humanity Research Center

——The Tokyo Institute of Technology established the Future of Humanity Research Center in February 2020, and you were appointed Director. What are the aims of the Center, and what kind of research will it undertake?

Ito: As a topic that is absolutely vital right now, altruism ("rita" in Japanese) will be the focus for the next five years. I feel that we are reaching the limits of "faster, stronger, higher" that is our existing criteria for sporting prowess. This Center aims to consider humanity and society from a different perspective, breaking free from the ingrained competitive values of society that maximize profit and neglect the disadvantaged. When thinking about the problems confronting the world like poverty and the environment, different answers will emerge when we start acting not just for ourselves but by acting altruistically and considering the needs of others in decisions.

The Tokyo Institute of Technology also aimed to beat its academic rivals through scientific research, but in real life, the most cutting-edge technology is not necessarily the best solution. For example, white canes used by the visually impaired may look low-tech, but based on the experience of users, their design has been updated over 300 times. Nobody is asking for an electrified or more hi-tech cane. In a time when we are taking another look at things we have long ignored, it is clear that an aesthetic approach can be useful.

What are "aesthetics?"

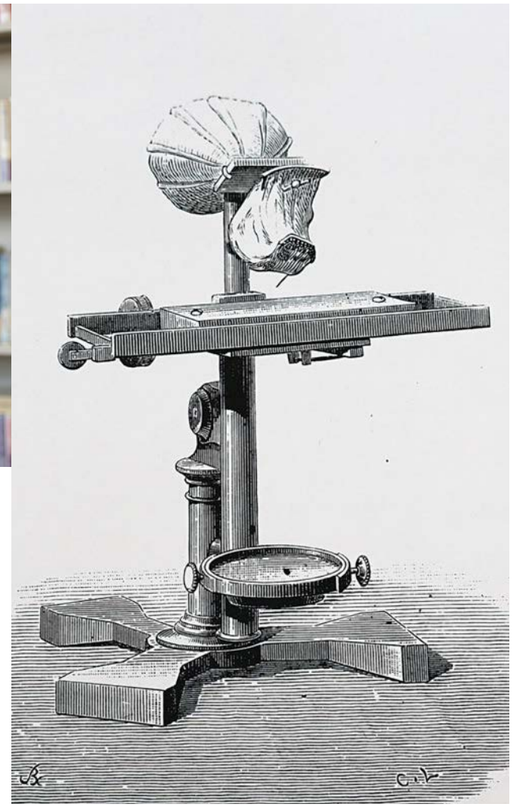
Researching sensations and sensitivity

——Now, please tell me about aesthetics, which you mentioned. You are an expert in the field. What kind of field is it, and how did you become interested in it?

Ito: Aesthetics is a discipline closely related to philosophy. Like philosophy, it is word-based, but the main subjects of philosophical research are concepts like time and existence. Aesthetics on the other hand deals with research topics such as physical experiences, sensitivity, the feelings evoked by looking at art – feelings that humans have but are very hard to put into words.

For example, we say "the five senses," but I am dubious as to whether we really do have five senses. I get the feeling that the saying exists because it is a convenient explanation. I have my doubts that something can be understood through digitalization. Aesthetics deals with aspects that cannot be digitalized. One of the subject areas of aesthetics is art. For example, when an artist creates a work of art, something happens that is beyond logic, whether it is a sudden thought or feeling. It is a sensation of encountering something beyond your comprehension as you struggle to distinguish the whole picture.

This is something related to the disability research I am currently



Left: Graham Bell's phonautograph. It featured a vibrating membrane modelled on the human ear that captured voice. The vibrations were then transformed into visible etchings.
Right: Mienai Sports Guide.
Photo: Kaori Nishida
[Mienai Sports Guide]
https://mienaisports.com/

doing. If definitions show the standard way to understand the world, it will skew those definitions a little. I am fascinated by this kind of thing.

Translating what is felt within the body

Study of disabilities

——You are researching disabilities, but your approach from the aesthetic and philosophical perspective seems very fresh. How do you carry out your research on people with disabilities?

Ito: A lot of studies of disability focuses on the outside and quantifying, such as measuring eyesight, but I want to find out what is going on inside. It is their subjective world. It is the perspective of how blind people see the world, how they use their bodies. Even if you ask them directly, you will not fully understand what it is like to be blind. This research seeks to imagine what the blind world looks like, if it were visible.

It is funny how definitions change. An able-bodied person's "seeing" is visual, but "seeing" is a blind person's word for "touching (seeing by touch)." Depending on their own characteristics or experience, others "see" by hearing, while others rely on the senses of others around them and "see" by listening.

Changing definitions can generate new technologies. Take Bell, inventor of the telephone. He started out as a teacher of Visible Speech, a lip-reading system of symbols representing the position of speech organs in articulating sounds that his father invented for the deaf to communicate. Deaf people are unable to hear the sound they are making; therefore it is difficult to improve their articulation of words. It was in his search for a method of "seeing sound" instead that helped him find a way of making the changes in soundwave vibrations visible. From there came the telephone. In other words, this alteration of the definition of "seeing sound" was born from the perspective of disabled people. It is exciting to study disability because it brings a different perspective.

——With events like the Paralympic Games, surely more and more people who normally do not encounter disabled people will have a chance to meet them. Is there a way to provide new realizations and interests for people?

Ito: The Mienai Sports Guide that we developed together with NTT is now available publicly online. It began as a project to help blind people enjoy being spectators of sports. The key thing was not to approach this as a way to "assist" people but rather as a collaboration with them.

Usually, visually-impaired spectators enjoy sports by listening to live broadcasts. But those I spoke with felt it was a passive, descriptive experience, saying that they could not get a "sense of the sport" or spirit of unity with other spectators. So the starting point for the research was the question, how can sports be enjoyed without using words?

We then realized that typical spectators enjoy sport in a limited way: visually. Did this really allow the viewer to catch what the players were doing? Even athletes don't always depend on their vision. For example, in table tennis, spinning is key, and players recognize spin by the sound or the feeling of the bat hitting the ball. So the players are using their sense of hearing and touch.

For those watching, we felt there must be way for them to spectate in a way that would allow them to experience the sensations of the athlete. We are "translating" the sensations they feel when playing 10 different sports using similar equipment. I doubt that you can taste the rarefied air of an athlete who has put in an incredible effort to learn the skills required for their discipline, but I believe a close approximation of what the athlete feels is good enough. That is because once you have felt those sensations, you will be able to enjoy a much richer spectating experience.

For example, to translate a judo bout, two sighted people hold each end of a towel and pull. When they close their eyes and grab the center of the towel, it resembles the feeling of grappling. Another is fencing. People think it is thrusting with a sword, but in fact the weapon is very flexible, so wrist movement to parry and thrust is vital, so you can experience the sensation through two people trying to solve the same disentanglement puzzle.

——Visually watching sports and actually playing sport are two very different things, as is the drastic difference between sports and parasports, which is not just the contrast between playing using your feet and playing in a wheelchair.

Ito: Yes, my research is all about wanting to translate internal sensations. Whether it is a sport or parasport, it

is completely different when you are actually playing it. I believe that by translating this for people, and by adjusting definitions, we can make new discoveries.

> "They must live in a world completely different from mine. I want to see the world that they see"
>
> Why she switched courses, and her motivation to learn

——From a different point of view, I hope you can give us a message about how to live life in order to find new perspectives. But first, what were your hobbies as a student attending junior high and high school?

Ito: It was as a junior high school student that I realized there was life after study. I felt that the exams we were forced were pointless. However, I loved science, so science never felt like study. At lunchtime I would be in the biology room patiently tracing specimens. I also started researching clams when I noticed during lunch that they all had a black part.

You were so immersed in science as a high school student, you went on to study science at university. However, halfway through you switched to arts.

In the lectures on cells, they talk about cell membranes, they talk about proteins, they talk about channels within cells…it gets more and more finely segmented. I did not want to know about that, I wanted to know about "life." Different creatures living differently, yet coexisting in the world. Look at the relationship between fish and parasites. As a food for humans, parasites in fish can be harmful, yet from the point of view of the parasite, the fish is their ecosystem, so there is an aspect of their relationship that is symbiotic. That is the kind of creature's perspective I was looking for. So my switch to aesthetics was due to my wish to avoid anthropocentrism and gain a non-human perspective.

> Unstoppable curiosity and an experience of body over mind
>
> Childhood, and being with child

——Going further back, what did you like as a young child?

Ito: I loved insects. I also liked tree bark. That is fascinating; moss and other things grow on the bark. That may be where my interest in looking at paintings comes from. I would try making tea from bark I peeled off

Source: Mienai Sports Guide. Photo: Kaori Nishida [Mienai Sports Guide] https://mienaisports.com/

trees in the garden, or try frying an egg on the bonnet of the car. I loved experimenting.

——You were very curious about everyday life and the things around you. Didn't your family ever stop you?

Ito: No. They always tried to make sure that they raised me without "being a girl" getting in the way, for which I am very grateful.

——On the other hand, you also went through a change as a researcher when you got married and had a baby.

Ito: I got pregnant as a third year doctoral student. When I found out, I freaked out that I had better hurry up. That is the day I started writing my doctoral dissertation, and I finished it by the time I gave birth. Whether you are the mother or the father, childbirth changes your outlook on life. My research focus also changed. I felt that it was pointless to fiddle around, I really had to focus on the big picture. The experience of delivering a baby exceeded my imagination. I had no sense until then that I had the ability to give birth, but when my body went ahead and did it, I thought "Wow, this is amazing."

Very few books have been published in the field of aesthetics or philosophy about childbirth, but it is clear that this is due to lack of information as most researchers are men. But men also change with the birth of a child. As philosophers and aesthetes, we tend to think about ourselves in abstract terms, but this made me feel that I had to do more. I came to the conclusion that I needed to study the "actual human body." Then, I thought that by looking at disabilities, which are completely different physical traits, I would be able to bring down the level of abstraction in the discussion.

——Right, so that is what led to your disability research. So finally, what research are you planning going forward?

Ito: Personally, I would like to do research on dementia. It has to do with moving away from the current values of faster, stronger, higher. Even though there are a lot of people suffering from dementia, we do not have a good idea of the world they live in. One patient, who had a mountain view from his window, saw a different view every day, so perhaps it was not a mountain he was seeing. By seeing the world of people with dementia from within, we can discover a sensibility that is different from our "normal" in terms of time and space. Such a discovery could lead to new ideas and enable us to design more humane institutions.

Profile

ITO Asa

Director, Future of Humanity Research Center, Institute of Innovative Research, Tokyo Institute of Technology
Associate Professor at the Institute for Liberal Arts, Tokyo Institute of Technology
Visiting Scholar, Massachusetts Institute of Technology (2019)

Born in 1979. Specialized in aesthetics and modern art. Originally, Ito aimed to become a biologist, but she switched to an arts degree in her third year of university. Obtained her Ph.D. in Literature at Graduate School of Humanities and Faculty of Letters, University of Tokyo. Her publications include How a Blind Person Sees the World (Kodansha), The Body Theory of Unsighted Athletes (Ushio Publishing), A Human Body That Stutters (Igaku-Shoin) and The Human Body Remembers (Shunbunsha) (Japanese only).

The relationship between science and society according to Professor Kobayashi

	1950s, 1960s	1970s	1980s	1990s	2000s	2010s–present
Key events concerning science and society	• The four big pollution diseases	• Focus on global warming • Destruction of the ozone layer by chlorofluorocarbons (CFCs) • Japan Expo 1970 • Three Mile Island nuclear plant accident (1979)	• Declaration of the eradication of smallpox (1980) • First case of Mad Cow Disease confirmed in the United Kingdom (1986)	• Global conference on environmental issues: First United Nations Earth Summit (1992) • Dolly the cloned sheep born (1996) • Adoption of the Kyoto Protocol by countries signing up to the United Nations Framework Convention on Climate Change (1997) • Declaration on Science and the Use of Scientific Knowledge – the Budapest Declaration (1999)	• Focus on renewable energy • Mapping of the human genome (2003) • Proposals for deep learning (2006) • Former Vice President Al Gore and IPCC awarded the Nobel Peace Prize • H1N1 influenza pandemic (2009)	• Great East Japan Earthquake disaster and the Fukushima Daiichi nuclear plant disaster (2011) • World's first hamburger made from lab-grown meat (2013) • United Nations summit: Adoption of SDGs (2015) • Gene-edited babies born (2018) • COVID-19 pandemic (2020–)
Communication tools	Popularization of the telephone	First personal computers	Launch and boom of family computers	Launch of Windows95 and Internet boom Development of ICT	Launch and popularization of smartphones	Popularization of online tools such as social media, avatar-based virtual event tools
Status of science	An instrument of national power Strong expectations for convenience and economic benefit	Hi-tech reaches the mainstream Technology becoming increasingly opaque to consumers Environmental issues debated globally	Children's disinterest in science (change in the content of compulsory education, reduced class hours) Many of technologies and products that lead to today were introduced	Shared environmental awareness lead to progress with dialogue on good resource use Easier dissemination and exchange of information	"Science in society" and "science for society" Science communication flourishes	Growing need for environmental and scientific or technical assessment of innovation, as well as for consideration of ethical, legal and social issues

Kobayashi says "up to the 20th century, there was a strong sense that general public trusted and accepted useful products or services that were provided using knowledge produced by experts, even if they did not fully understand how they worked." He points out that it was a "leave-it-to-experts" era in a way. However, gradually a question arose that "science and technology had a negative aspect, not only a positive one." In that context, the Budapest Declaration (1999-2000) was one of the major influences on the scientific experts. In order to solve various issues associated with the progress of science and technology, dialogue with society and cooperation with people who are not scientific experts will be very important.
Source: Kobayashi (2007) and interviews with Kobayashi

with/post Living in the with/post-COVID-19 society

Creating a Desirable Future Through Dialogue Between Science and Society

Interview with Tadashi Kobayashi

With the expansion of the novel coronavirus disease (COVID-19), thoughts are turning to a future that is different from what we imagined. Daily routines, public services and industries are taking a blow, causing a major stagnation in society. It has also been a trigger for us to largely change the values that we used to take for granted. And a question has arisen as to how science and technology can contribute to solving these issues. We spoke to Tadashi Kobayashi, Principal Fellow of the Research Institute of Science and Technology for Society (RISTEX) of the Japan Science and Technology Agency (JST), Professor Emeritus at the University of Osaka, and Specially Appointed Associate Professor at the university's Center for the Study of CO Design.

"An era in which we live while reflecting on the 20th century"

The 20th century was the era when science and its applied technology became closely connected, and the term "science and technology" came to be used. Science and technology flourished rapidly in fields of science, medicine, engineering etc. and transformed our lives into ones of convenience and affluence. However, when it came to aspects concerning human life, there has been a lot of discussion about, for example, donor-recipient relevance for heart transplants, and determination of brain death.

As the study of scientific and technology progressed in the 21st century, more effects and situations emerged that the scientists had not anticipated. A prominent example is genome editing, an efficient technique for altering genes. In November 2018, a Chinese scientist announced that he had used the technology to produce twins. Both in China and elsewhere in the world, the safety and ethics of his research were questioned.

Kobayashi says, "Science and technology do not function with the goodwill of researchers alone. If society is not convinced, you can not use what you can use, which is something very unfortunate both for researchers and for society. There are many such problem groups, not limited to COVID-19. What is more, science and technology, which were supposed to make our lives better, may generate new problems that are difficult to solve. A typical example is pollution. How will society harness science in order to solve those problems faced by society? That is what must be fully debated."

Scientific and technological progress has caused environmental destruction and more. The current situation is that society has not caught up with the growth of science and technology. There have also been various accidents and incidents in which credibility of science was questioned.

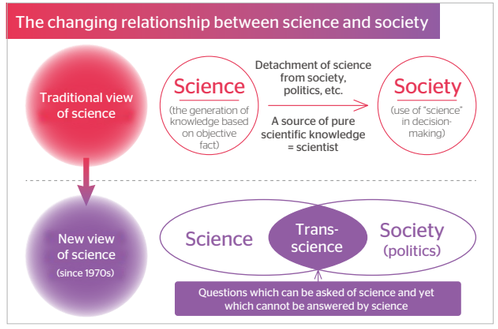
"The 21st century is an era in which we live while reflecting on the 20th century," Kobayashi concedes. "We were to create a system that allows not only scientists but people in the humanities and social sciences to think together about how to utilize science in society, remaining alert to ethical and legal issues. The global COVID-19 pandemic hit just as these efforts were being made."

The role of science on a planetary scale

In 1999, the Budapest Declaration was promulgated at the World Science Forum held in Budapest, Hungary. It declared the role of science in the 21st century to be "science for knowledge," "science for peace," "science for development" and "Science in society and science for society."

Kobayashi says "in the sense that the perspective 'Science in society and science for society' has become more important, we can say that the relationship between science and society in the 21st century has definitely changed. From around 2010, this perspective has become associated with innovation, with a focus on its economic efficiency. However, at the same time, the importance of global issues such as the SDGs and environmental problems has raised the question of the role science should play. It is extremely difficult to solve such problems in an economically viable manner. Nevertheless, science must tackle both issues."

Trans-science refers to questions that cannot be answered by science alone. The concept expresses the changing relationship between science and society that occurred around 1970, a time when dialogue and collaboration with citizens were increasingly required to overcome challenges, rather than simply the introduction



Trans-science refers to "questions which can be asked of science and yet which cannot be answered by science." Today we face many challenges for which we must consider a range of factors that are outside the scientific realm. One such example is the safety of nuclear plants.
Source: Kobayashi (2007) and interviews with Kobayashi

of new technologies or knowledge. Kobayashi believes that the response to COVID-19 is one such challenge.

Changing communications

What kind of changes has the COVID-19 pandemic brought? "People's sensibilities may have changed," Kobayashi believes.

Fundamentally, science explains all phenomena in terms of "how matter behaves." In other words, the phenomena humans experience through their five senses are expressed in the language of materiality, such as atoms and particles.

Kobayashi acknowledges that "thinking about everyday life from a scientific perspective is sometimes quite hard."

Consider, for example, smell. How do people sense odors? Something giving off strong odor has fallen on the side of the road. Particles from the object rise into the air and directly attach to the mucosal membrane in your nose. From there the signal reaches your brain, and you recognize the smell from past experience. You realize that it is an unpleasant odor, you see the object lying there and see that something malodorous has fallen on the roadside. In brief, it is a direct contact with the substance from which the smell comes, so in that sense smell is actually the same as "touch."

Not many people normally think about all phenomena as being "the behavior of matter." However, Kobayashi says, COVID-19 has probably woken people up to the behavior of matter.

"COVID-19 has made us aware of the 'behavior of matter' in normal interactions with others. Along with an exchange of information, voices and feelings, we have now become aware that 'speaking with others is also an exchange of certain materials.' We probably did not consider in our everyday lives that speaking with people was an exchange of airborne droplets. Now, when you see people having a conversation close to one another on TV, it makes you a little nervous."

The pandemic has not just brought a new normal, it has also changed our sensibilities.

Our pandemic-altered sensibilities

COVID-19 has dramatically accelerated the shift to online communications using information technology. With this method for contacting anyone at any time from the location of your choice, what kind of society is being created?

"We may end up meeting people only when strictly necessary. However, I think it means a lot to have a body. Humans try to grasp communication physically. We are not just exchanging information, we might be looking at what kind of person they are, we might be wondering if it might be fun to date them. There are still so many aspects that cannot be satisfied by current technologies alone," notes Kobayashi.

Let's compare an online chat with someone you have met before and with someone you have not. In the former case, you know their appearance and have a sense of their demeanor, therefore you are likely to communicate well by voice or video data alone. On the other hand, if you have not met the person, you may feel defensive.

Speaking of online chat, we have seen in recent years the development of remote-controlled robots as avatars and Digital Transformation (DX)*.

"The speed with which new science and technology filter into society depends on the timing of the encounter of that science or technology with people and society. This is key. Developing vaccines and effective medicines is harder than you can imagine, so if the next wave of the virus comes with a high fatality rate, it may be argued that we should immediately switch to remote-controlled robots, and that technology might therefore find much wider uptake," predicts Kobayashi.

New science and technology has the potential to make our lives richer. They are easier for young people to accept. On the other hand, scientifically excellent advances may not quickly find broad acceptance. Kobayashi says, "What is important is whether people find an innovation to be truly necessary. If not, it may take a little more time to penetrate society." Pandemics like COVID-19 or other wide-scale events have the potential to trigger the adoption of new science or technology.

*Changes to every aspect of life through the penetration of IT.

Chat with a wide range of players

No decision can be made simply by asking whether something is scientifically correct. To address issues that involve all people alive today or the future of the planet, we must all consider the right path forward for all of us. In order for this to happen, we must decide what to keep, what to change and what mechanisms to create.

"Every scientist values their own research and they hope it will be useful to society. However, the problems of society cannot be the subjects for discussion by scientists alone. Scientists are very important players, but they are not the only players. This must be assumed in our thinking," says Kobayashi.

There is no question that science is a powerful intellectual mechanism for generating reliable knowledge. However, the research and the time it takes for science to come up with answers is much longer than the time it takes for society to decide things.

Kobayashi notes, "When it comes to what we keep and what we change, the debate cannot be left to scientists and experts in their fields alone. We need to build mechanisms for everyone to consider these questions together. Some argue if we should separate scientists and other experts from civilians in the first place. For roles between scientists and civilians can easily be switched depending on the topic. Outside of their own specialization, scientists and other experts are amateurs like anyone else. In other words, experts are only experts within their field, otherwise they are 'special amateurs'. The key will be how to utilize the respective expertise while rotating roles."

COVID-19 is an issue that should involve all people, regardless of if they are experts or non-experts, including scientists. Kobayashi predicts that infectious diseases will continue to hit us on a regular basis, and that there will be new problems.

"Since the 1970s, the borders between humans and wild animals' habitats have shifted. As human society has expanded rapidly, the microbes and viruses found in wild animals have crossed over into human communities. Therefore, infectious diseases and environmental issues are two sides of the same coin. This situation continues to develop, so such outbreaks may be a regular occurrence from now on. The change we need now is for society to be thinking about these issues and how we can coexist with them, even when things appear to be going well. I believe that looking ahead, if we are to generate excellent scientific findings, we need to create mechanisms that allow researchers to explain their aims and their findings to people and to listen to the demands from society by talking with a wide variety of players."

Virtual reality (VR) technology is increasingly seen and used.
Top row: ANA's AVATAR technology. Touch is felt in real time, giving the user a sense of "being there." (Photos: Digital Design Lab, ANA Holdings.)
Bottom row: The Japan XR Science Forum 2020 in US Midwest was held in a virtual space. It was hosted by United Japanese Researchers Around the World (UJA), an academic conference services provider. For further details, see the August 17, 2020 report, "Science forum held in VR space – an ambitious attempt to undo the physical and psychological constraints during the pandemic" (Japanese only) at Science Portal (http://scienceportal.jst.go.jp).

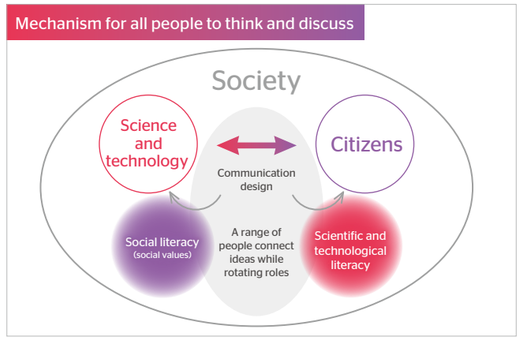


Illustration of collective thinking and debate by everyone, including scientists. Outside of their specialization, scientists have no expertise, which makes them amatures. Debates also require literacy in a range of aspects including society, science and technology, etc..
Source: Kobayashi (2006) and interviews with Kobayashi

Profile

KOBAYASHI Tadashi

Born 1954. Accomplished credits for doctoral program of the Division of Science, University of Tokyo Graduate School in 1983. After teaching at the University of Teacher Education Fukuoka, Nanzan University and other campuses, from 2005 he was appointed to the board of Osaka University, then Executive Vice President. He has been a Principal Fellow of the Research Institute of Science and Technology for Society (RISTEX), Japan Science and Technology Agency (JST) since 2019, Professor emeritus at Osaka University since 2020 and is currently a professor of the Center for the Study of CO Design at the university. His research interests include philosophy of science, and science, technology and society (STS) studies. His publications include Who Should Think About Science and Technology? An experiment called a consensus meeting (University of Nagoya Press, 2004) and The Age of Trans-Science (NTT Publications, 2007).

with/post Living in a with/post coronavirus society

The Relationship Between Humans and Viruses That the History of Infectious Diseases Shows Us

Interview with Hiroyuki Ishi

The first cases of the novel coronavirus disease (COVID-19) were confirmed in China at the end of 2019. The virus spread rapidly across the globe, triggering a global pandemic. In fact, the association between humans and infectious diseases is extremely long. In the past too, changes in the global environment or human activity have been accompanied by the spread of infectious diseases that, in some ways, have defined their particular eras. Meanwhile, at each of those times, humans have responded by making major changes to their social structure. How should we better confront viruses in the eras that lie ahead? We spoke to environmental journalist Hiroyuki Ishi, who in some respects warned of the latest pandemic in his book *Kansensho no Sekai-shi* (World History of Infectious Diseases), about the relationship between viruses and humans from the perspective of the history of infectious diseases.

What are viruses?

They have always coexisted with humans

What are viruses in the first place? They are around 1/10,000th of a millimeter in size, and can be found anywhere, including in the air, in the middle of deserts, and even on the deep ocean floor. The natural world is filled with viruses. Mr. Ishi explains viruses by saying: "Think of them as something that becomes active as a result of genes popping out from the inside of cells.

Viruses cause illnesses and as such they tend to be treated as "villains." However, they also have a positive side, Mr. Ishi points out. For example, research over the past 20 years or so has shown us that viruses protect the fetuses of mammals.

Half the genes of a fetus come from its father. From the mother's perspective, half the proteins are different from hers. By rights, the fetus should not be able to survive the attack caused by the mother's immune system. The answer to why the fetus is able to survive has been a mystery for a long time.

"When a baby is inside its mother, viruses that are always present within the mother's womb gather to form a membrane that encloses the baby. We now know that thanks to this, the attack of the mother's immune system can be intercepted. This suggests that if it were not for the presence of viruses, we as humans would not exist in this world, so they are very important." Mr. Ishi explains.

Why do viruses like this invade our bodies and cause harm? Viruses have no inherent intention whatsoever of trying to make humans suffer, Mr. Ishi declares.

"The one and only goal of a viruses is to perpetuate their offspring, and they are constantly searching for places where this can happen. Just as a computer virus repeats an almost infinite trial-and-error process until it finds a password and infiltrates a computer, real viruses also undergo repeated mutations. When by chance they find a "keyhole" to unlock a "door," they infiltrate the human body. They then reproduce and cause damage to people's cells, internal organs and so on" (Mr. Ishi).

What is COVID-19?

Did it originate from bats?

So, what sort of viruses are coronaviruses, exactly?

"By tracing back the pattern of a virus' mutations it is possible to estimate where it originated. Coronaviruses are estimated to have appeared about 10,000 years ago. Initially they were considered livestock diseased that infect chickens and pigs. In the 1960s coronaviruses were confirmed as the viruses that cause colds in humans. However, no-one guessed they were viruses that would trigger the major event we are facing now" (Mr. Ishi).

Bats are said to be the initial hosts of COVID-19. According to a study by the Wuhan Institute of Virology, China's greater horseshoe bats carry several dozen viruses that resemble COVID-19, and it would not be unusual for them to newly infect humans via an intermediary animal. So, coronaviruses constantly have the potential to undergo a genetic variation and attach themselves to humans.

"There is a possibility COVID-19 will weaken in the years to come and become a virus like the common cold. On the other hand, from here on, the virus may also become more "cunning" and discover ingenious way to infect and spread. Coronaviruses have triggered a succession of outbreaks, from SARS (severe acute respiratory syndrome) in 2002, to MERS (Middle East respiratory syndrome) in 2012, and now COVID-19. I have a feeling that the 21st Century is going to be the era of coronaviruses" (Mr. Ishi).

Environmental changes and infectious diseases

Malaria on the rise amid global warming

Humankind has been battling infectious diseases since ancient times. Let's look back at that history, which should provide clues for the future.

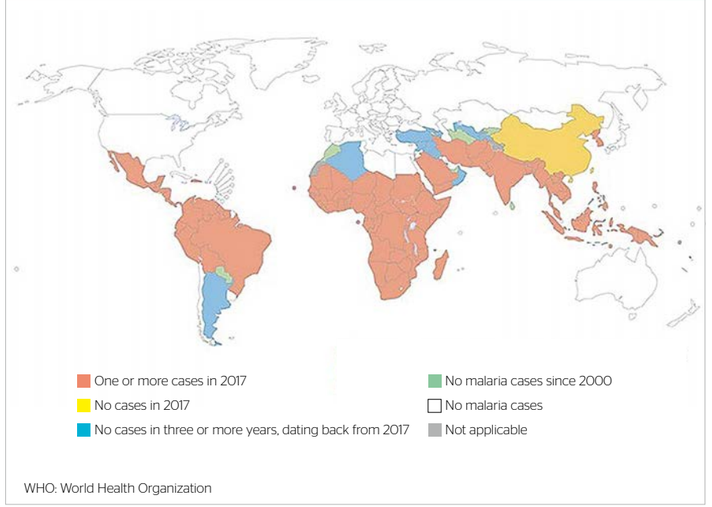
According to Mr. Ishi, who has researched the history of infectious diseases, studies of the mummies of ancient Egypt have revealed that people in ancient times were also plagued by parasites and infectious diseases such as measles, Hansen's disease and malaria.

In addition, infectious diseases tend to be influenced by environmental changes. Malaria is a tropical disease, but its range is widened due to global warming, Mr. Ishi explains. Areas affected by malaria are expanding even in Africa and Central and South America.

"Even high altitude locations where the temperatures were previously cool and where malaria did not spread have recently started to see malaria cases. Conceivably, this is because the habitat in which malaria can be transmitted has widened because of global warming" (Mr. Ishi).

Infectious diseases that were in all likelihood malaria cases also appear in Japan's old literature. In the 11th Century Heian period, temperatures were hotter than they are now, and Taira no Kiyomori (a military leader at the time) died of a delirious fever brought on by malaria. There is even a famous humorous poem that

Countries where malaria was reported in 2000, and the situations in those countries up to 2017



WHO: World Health Organization
Source: Created by the Quarantine Information Office, Ministry of Health, Labor, and Welfare Japan, based on the World malaria report 2018 (https://www.who.int/malaria/publications/world-malaria-report-2018/en/)

states: “The doctor disrobed before he went in to take Kiyomori’s pulse.” Even in more recent times, from the early Meiji era to the Showa era, there were malaria outbreaks throughout Japan, including along the coast of the Japan Sea, Okinawa, Hokkaido and elsewhere.

Infectious diseases are mirrors that reflect their times

The shift from the digestive system to the respiratory system

When human beings began living in permanent settlements, the relationship between humans and infectious diseases changed dramatically. According to Mr. Ishi, when humans shared river water as a result of initial settlement near water, water-borne diseases of the digestive system were prevalent, but subsequently, as human populations began amassing in cities, this began to trigger outbreaks of infectious diseases of the respiratory system that are passed from person to person.

There are also traces of water-borne infectious diseases in the mummies of ancient Egypt. The eggs of schistosomiasis haematobia (urinary blood flukes), which are parasites that multiply in the bodies of snails and infect through the skin, have been found in these mummies. Subsequently, water-borne diseases such as dysentery and cholera spread to regions where sewage systems were not widely established.

As cities grew, since there were initially no sanitation systems, infectious diseases proliferated through litter. In the 14th Century, cities in Europe became infested with rats, and the plague bacillus that they carried spread. However, the cause of the plague was not known at that time. Rumors spread that “Jews have poisoned the water wells.” Persecution of Jews intensified, and witch hunts flourished. It seems that when something unexplainable happens, fear drives humans to look for scapegoats. Almost without exception, natural disasters or epidemics of infectious disease appear to go hand-in-hand with phenomena such as misinformation and discrimination. Even in this current COVID-19 pandemic, there has been an endless stream of discrimination, prejudice and persecution against various races.

As cities grew massive and overcrowded in the 20th Century, infections began to be spread from person to person through the air and airborne droplets. These viruses spread to congested societies by entering the human respiratory system. Mr. Ishi points out that the current COVID-19 fits this pattern perfectly.

Infectious diseases change the social structure

Toward an era of overcoming distance to connect with one another

In previous outbreaks of infectious diseases, the social structure has changed significantly. We asked Mr. Ishi to go over some examples that may serve as references when considering society in the 21st Century.

“I think the plague of the 14th Century could be called one example. One quarter to one third of Europe’s population died of the plague. It would probably be appropriate to describe the plague as the greatest and most formidable threat to humankind in history. The plague played an important role in the demise of the Middle Ages. The population plunged due to the disease and farming villages became deserted, and as a result the feudal system that had existed up to then collapsed. Furthermore, the church, which sought God’s help, was powerless against the disease, and the mistrust that this produced was a factor behind the Lutheran Reformation. This led on to the human liberation witnessed in the Renaissance, as people freed from the restrictions of the feudal system gathered in the cities.”

During the Industrial Revolution, factories were built and people from farming villages who lacked immunity gathered in cities, which sparked tuberculosis outbreaks. Even in Japan, the same scenario happened in the cotton mills of the Meiji era, Mr. Ishi says.

“Factory work was heavy labor, and the workers’ nutrition was also poor. Due to overcrowded conditions, outbreaks of tuberculosis occurred quickly. A famous example is Japan’s Meiji era cotton mills. In some factories, infection with tuberculosis was the reason for the dismissal of approximately 70% of the female mill workers. The government was finally spurred into action in 1911, when it at last formulated mill legislation that limited mill workers’ working hours and established a system of aid for work-related injuries, sickness and death” (Mr. Ishi).

So what will happen in the age of coronavirus that we are facing? Ensuring distance between people to prevent infections is something we have not experienced before. How will this change human relationships and the social structure?

“Humans are creatures of a highly social nature. It is not that humans are particularly exceptional physically. However, a due to the evolution of their intellect and social nature, they have weathered the battle to survive. As a result of the virus, these same humans have been transformed into “lethal weapons” that kill and harm one another. Physically severing relationships are likely to lead to the abandonment of our social nature, which is a terrible prospect” (Mr. Ishi).

“Dance of Death,” Michael Wolgemut, copperplate engraving, 1493

Major infectious diseases that spread in each era

Era	Major Infectious Disease	Cause	Contents
14th to 16th Centuries	Plague	Bacteria (plague bacillus)	A pandemic that struck in Europe in the middle of the 14th Century that is thought to have been the result of humans being infected by pathogen-carrying rats. Approximately one-third of the population at the time died. In the 16th and 17th Centuries also, there were major outbreaks of the plague that centered on Europe. The pathogen was not identified until the 19th Century, and various superstitions and discrimination spread regarding the cause of outbreaks.
16th Century	Syphilis	Bacteria (spirochaete)	A large number of infections occurred as a result of sexual intercourse, but in some cases fetuses were also infected from their mothers during pregnancy. (Furthermore, nowadays the symptoms can be prevented from advancing by administering antibiotics, but for a long time syphilis was feared as an incurable disease).
16th to 17th Centuries	Smallpox	Virus	In the 15th Century Columbus and other Europeans took smallpox to the Americas. It brought huge harm to the indigenous peoples there, who had no immunity to it. With the development of the smallpox inoculation (vaccination) at the end of the 18th Century the number of smallpox sufferers declined, and in the latter half of the 20th Century there were no new patients and the number of cases fell to zero (the eradication of smallpox).
19th Century	Cholera	Bacteria (cholera bacterium)	Cholera originated in the Ganges River delta in the 19th Century and spread worldwide via the British and others who had colonized India at that time. (Ensuring safe water and hygienic environments is key to preventing the disease. In modern times it is a rare disease in developed nations, but in some countries in Africa, Southeast Asia and elsewhere it remains serious even today).
19th to 21st Centuries	Tuberculosis	Bacteria (tuberculosis bacterium)	Accompanying the overcrowding of working populations that was ushered in by the industrial revolution, tuberculosis cases increased rapidly from the 18th Century. Even today it is one of the top 10 infectious diseases in terms of the number of people it kills worldwide (according to WHO; 2015). It is by no means a disease of the past, with resistant bacteria strains that are difficult to fight with antibiotics appearing, for example.
20th to 21st Centuries	Influenza	Virus	In 1918, at the height of World War I, an outbreak of influenza among soldiers in the U.S. military spread worldwide. Due to widespread reports of infections among the Spanish royal family the pandemic is also known as the “Spanish flu.” Vaccines and treatments are now available, but the virus mutates rapidly, and even today outbreaks frequently occur.
20th to 21st Century	AIDS	Virus	AIDS cases were first reported in the U.S. in 1981, but it is known to have originated in monkeys (chimpanzees etc.) in Africa and infected people on several occasions prior to that. Advances have been made with researching the nature of the virus and the process up to the onset of symptoms, and thanks to progress with antiviral agents it has become possible to substantially delay the appearance of symptoms.
21st Century	SARS/MERS/ COVID-19	Viruses	Viruses belonging to the coronaviruses family of viruses are causing successive epidemics of SARS (severe acute respiratory syndrome), MERS (Middle East respiratory syndrome) and COVID-19.

*Note: Created based on discussions with Mr. Ishi

Viruses even change fundamental human behavior. COVID-19 will also compel us to re-examine our approaches to human relationships and our social nature. However, if we look back at history, even in instances where major changes to the social structure have been pressed upon us by infectious diseases, we have responded flexibly to come up with new lifestyles and patterns.

“Recently it has become possible to take lessons, cover the news and do various other things remotely. As an example, here is something that I experienced myself the other day: People from inside and outside Japan who were my students long ago were kind enough to celebrate my 80th birthday online. It has become possible to overcome distance and connect people globally. It could well be that in the future, technological innovations will mean that when we look back at today, even celebrating a birthday online like this will appear to be quite an old-fashioned way of doing things” (Mr. Ishi).

Viruses are also part of nature

“Love your enemies”

When humans change the environment, viruses mutate in response to that. It is not possible to sever the relationship between humans and viruses.

“As a part of nature, viruses participate in various areas. There are many things we do not know. Potentially, a succession of findings about the sorts of things that viruses do will surface from here on. Any living thing will go backwards the moment its natural enemies disappear, so I guess it is a case of love your enemies,” Mr. Ishi adds.

Lastly, Mr. Ishi left the following message for the young people who will forge ahead through the “coronavirus era.”

“If you scoop up dirt from the garden with a spoon, one spoonful of dirt will contain more than 100 million living things. Many of them are viruses. Viruses play various roles within nature. Going forward, I believe we will continue to make major breakthroughs with regard to viruses. The natural world is still full of things that humans don’t know. Looking back on my 80 years of life, my greatest pleasures came from curiosity and a sense of accomplishment. I want young people to feel the pleasure of pursuing things and thinking about things, and to relish the sense of accomplishment that comes from clarifying the mechanisms of nature.”

Profile

ISHI Hiroyuki

Born in Tokyo in 1940. After graduating from the University of Tokyo, Mr. Ishi joined The Asahi Shimbun Company. He served as the newspaper’s special correspondent in New York, as an editorial committee member and in other roles, before leaving the company and going on to work as a senior consultant to the United Nations Environment Program (UNEP), as a professor at the University of Tokyo and Hokkaido University’s graduate schools, as Japan’s ambassador to Zambia and in other positions. During this period he also concurrently held positions such as Advisor to the Japan International Cooperation Agency (JICA) and Director at the Regional Environmental Center for Central and Eastern Europe (REC). He has won the UN A. H. Boerma Award, the UN Global 500 Award, and the Mainichi Publishing Culture Award. Mr. Ishi is a prolific author. His key works include Kansensho no Sekai-shi (The World History of Infectious Diseases) and Tetsujomo no Sekai-shi (The World History of Barbed Wire Fencing) (both Kadokawa Sophia Bunko); Kanko Saiko-shi (The History of Environmental Restoration) (Kadokawa Shinsho); Chikyu Kanko Hokoku (Global Environmental Report) and Meisaku no Naka no Chikyu Kanko-shi (The History of the Global Environment within Masterpieces) (both Iwanami Shoten); and Watashi no Chikyu Henreki (My World Travels) (Yosensha).

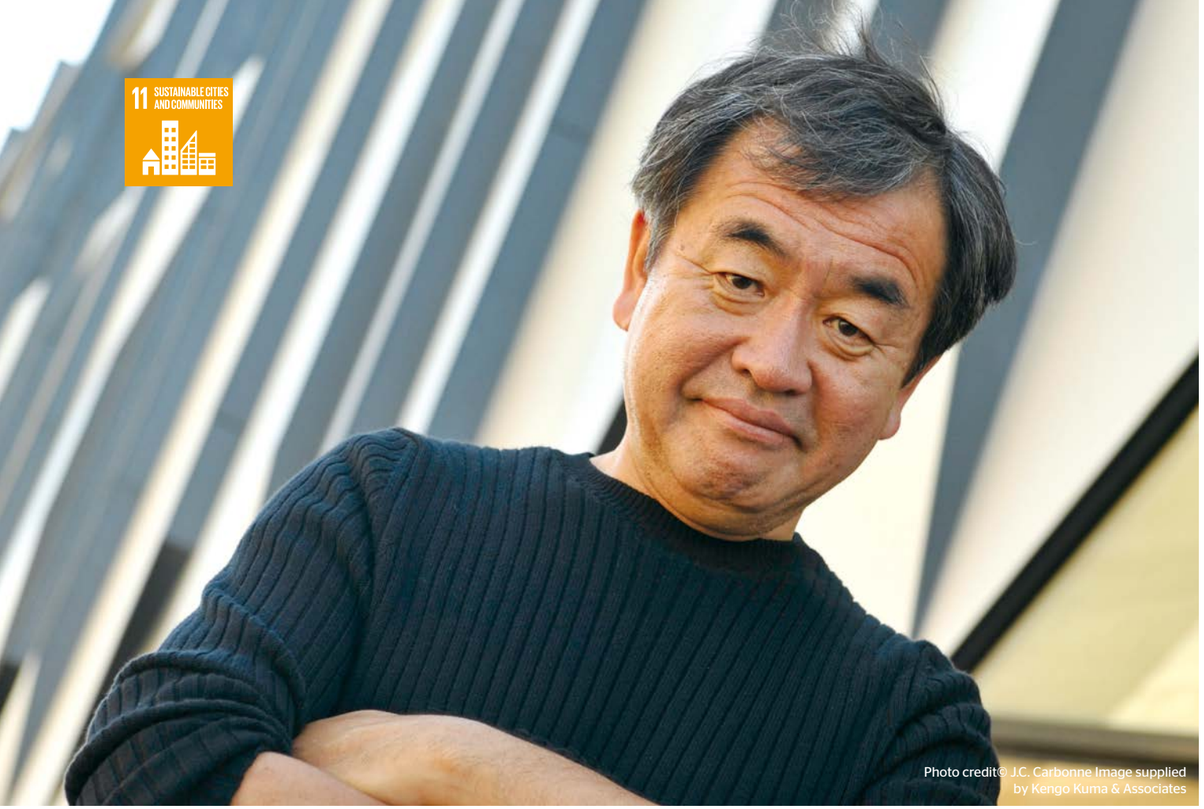


Photo credit© J.C. Carbonne Image supplied by Kengo Kuma & Associates

with/post Living in a with/post coronavirus society

Does Architecture Make People Happy? —Liberating People from Closed "Boxes"—

Interview with Kengo Kuma

Create large, closed "boxes" by stacking concrete up high, and bring large numbers of people together within those highly airtight boxes. This 20th Century model of architecture (high-rise buildings constructed of glass and concrete) had been generally believed to be the most efficient. However, the spread of the novel coronavirus disease (COVID-19) has revealed the fragilities and weaknesses of the 20th Century model, and has provided an opportunity for us to take note of the shortcomings of contemporary architecture and cities that, until now, we have been accepting as reasonable. As the shape of society that has existed up to now is called into question, how should architecture change going forward? Architect Kengo Kuma continues to propose flexible designs that are people-friendly, while aiming for architecture that is integrated with the environment and culture of its site. We spoke to him about the future of architecture, and about liberating people from closed boxes.

What architecture has brought to people

Humankind is believed to have evolved in Africa around 200,000 years ago and spread around the world. For those of us living in modern times agriculture is something that is taken for granted, but in fact humans only began farming around 10,000 years ago. In historical terms we followed a hunting-and-gathering lifestyle for a long period. Humans' lifestyles changed suddenly with the advent of farming, because it offered us the option of "settling down" by setting up residence in one location.

Mr. Kuma says the thing that architecture initially delivered to humans was a sense of security. "Human beings are by no means strong creatures physically. That being the case, they were able to obtain a sense of security by building the "boxes" that we know as houses and feeling protected by them. Seeking protection in boxes to achieve peace of mind is a primitive desire." Following on from this point, Mr. Kuma then has this to say about the relationship between architecture and humans:

"These boxes vary depending on the region, culture and climate, but the foundation of contemporary architecture has its roots in the geometric, closed boxes that became established in the Renaissance. In the Middle Ages there were people who believed that confined, cluttered residences were unhygienic and could cause the spread of the plague. As a result of pursuing architecture that was well-organized in terms of geometric order, the Renaissance style of architecture was born."

Subsequently, as a result of the steady evolution of Renaissance architecture, the so-called "20th Century model" of architecture was born. That model is represented by stacking boxes up high, and then cramming as many people as possible into those large, closed boxes.

"Former UK Prime Minister Winston Churchill said that "We shape our buildings, and afterwards, our buildings shape us," and as that remark suggests, when architecture is built people become bound by it in some respects. The 20th Century model transformed not only architecture but the lifestyles of the people living in it. A new lifestyle was born in which people worked in boxes in cities and lived in the suburbs, and this became the model for human life as a whole" (Mr. Kuma).

Do not take the environment you are currently in for granted

Up to now we had been convinced that the 20th Century model was indeed the most efficient and outstanding approach to architecture. However, because of the COVID-19 pandemic, this value system is now deeply shaken.

"Until now we had been under the illusion that unnaturally closed spaces with air conditioning were the epitome of efficiency, and we did not attempt to escape this mindset. However, COVID-19 has made us realize the various fragilities and weaknesses of closed boxes. My belief is that when considering architecture, "you should not take your own current environment for granted." Humans must constantly recreate the environments in which they are living, in response to new circumstances. We need to use COVID-19 as an opportunity to free ourselves from the closed box architecture" (Mr. Kuma).

Architecture in the with/post coronavirus society

The COVID-19 crisis has highlighted the fragilities and weaknesses of the 20 Century model, in which people congregate within closed boxes. This style of architecture will be reviewed in the future, Mr. Kuma says.

"From here on I think it will become important to create "ventilated-style" boxes by blurring the boundaries between inside and outside the boxes, which will improve the comfort of the spaces outside the boxes as well. Up to now urban planning has proceeded based on a top-down approach, but going forward it will be necessary to make bottom-up proposals for linking boxes and cities, by incorporating proposals from communities and regions regarding how they want public spaces such as streets and squares to be used for them."

Enhance the quality of public spaces

In pursuing urban planning, the utilization of streets, squares and other public spaces is important, but until now there has not been a great deal of interest in those spaces. Mr. Kuma points out that public spaces need to be perceived as places for people, and consideration needs to be given to mechanisms for ensuring that proper returns can be obtained from enhancing the quality of those spaces.

We must not forget about traffic issues when considering the quality of public spaces. City streets are often very busy, and the air is not very clean either, which is a lot of times not the kind of environment you would want to walk willingly.

"How public spaces can be made walkable is an important challenge. And public transport system such as trains must also change at the same time. Like architecture, up to now trains have been "inhumane" in the sense that they carry a huge number of people who have been crammed into closed boxes. There is a need to reconsider approaches to public transport systems, including "commuting to work," which could also be described as a time management

What a new home and life may look like after COVID-19, as pictured by the editorial department, based on Mr. Kuma's comments.
According to Mr. Kuma, the ideal situation is one that liberates people from highly airtight high-rise buildings composed solely of glass and concrete. He says there will be a need for, for example, living environments that are integrated with public spaces, mobility that unifies movement between work and day-to-day life, and the construction of houses that offer good ventilation, such as Kyo-Machiya (traditional Japanese townhouses).

system. Utilizing self-driving will also be of some help, no doubt. A future challenge will be how to combine public transport and walkability in order to design new public spaces" (Mr. Kuma).

Japanese traditions offer clues for breaking away from closed boxes

What sorts of cities should we aim for in the future in order to break away from closed boxes and enhance public spaces? Mr. Kuma points out that Japan's traditional frameworks, spaces and arrangements provide clues to address this issue.

"I believe it is possible to discover "systems" within traditional Japanese architecture, as opposed to just shapes as objects. For example, in Kyoto's traditional townhouses the space between the street and the building is fluidly connected, creating a comfortable environment in which each component complements the other."

Other clues can also be found in the arrangements that existed in the Edo period, Mr. Kuma goes on to explain.

"In Edo period cities also, there were mechanisms in place to encourage people to venture out of the city. For example, the sankin-kotai policy (which required feudal lords to alternate their place of residence between their domain and the capital of Edo) is in fact a system for living while using two bases. Even feudal lords' residences comprised not only of their main residences but of secondary and suburban residences as well, and this was a structure that encouraged the dispersal of people by avoiding overconcentration. It seems these practices evolved because experience had taught people that overconcentration could cause significant damage when a fire broke out. Such Edo period systems can provide us with various clues when we consider the urban societies of the future."

In recent years, there has been a sense of crisis over closed boxes. With that as a backdrop, Japanese models are attracting the world's attention. Mr. Kuma expresses hope that architecture and science technologies will be merged in the future. He points out that "If Japan's traditional systems and designs can be blended with technology to revive them in more modern formats, they could well serve as models for the world."

Making wood fire-resistant and reviving it as a building material will be key

Mr. Kuma points out that up until now, "it was based on an optimistic mindset that the problem of overconcentration could be resolved by steadily stacking up boxes." The style of architecture based on stacking concrete and glass boxes high to secure the maximum space out of a limited area is certainly a result of focusing on efficiency. However, due to the impact of COVID-19, we have been made aware that the approaches to architecture and space that we have been following up to now are not necessarily correct. How should science and technology be applied to architecture in the future?

"Up until the Edo period Japanese cities had been avoiding the problem of closed boxes because of the refined, wooden architecture that offered good ventilation. Wood is not only light, but has the ability to reduce people's stress. I call it "a human material." However, since the 20th Century, architecture that utilizes this human material has gradually been disappearing because it is vulnerable to fire. Nevertheless, recent technological advances in making fire-resistant wood has been attracting attention. Resurrecting wood as a material and looking back on the past will undoubtedly be key to discovering new approaches to cities and architecture" (Mr. Kuma).

This is not limited to fire-resistant wood – many technologies are already in place to construct new cities, Mr. Kuma continues.

"Utilizing carbon fiber, for example, which is lighter and easier to handle than steel, makes it possible to ensure that timber-built architecture possesses the strength to stand up to earthquakes while retaining a light and gentle appearance. A lot of technologies to avoide the problem of closed boxes already exist and are right under our noses. The same applies to mobility-related technologies. By combining new technologies such as self-driving and simulations to avoid congestion with urban planning, it should be possible to produce better environments, I believe."

"What can humans do?" is an important perspective

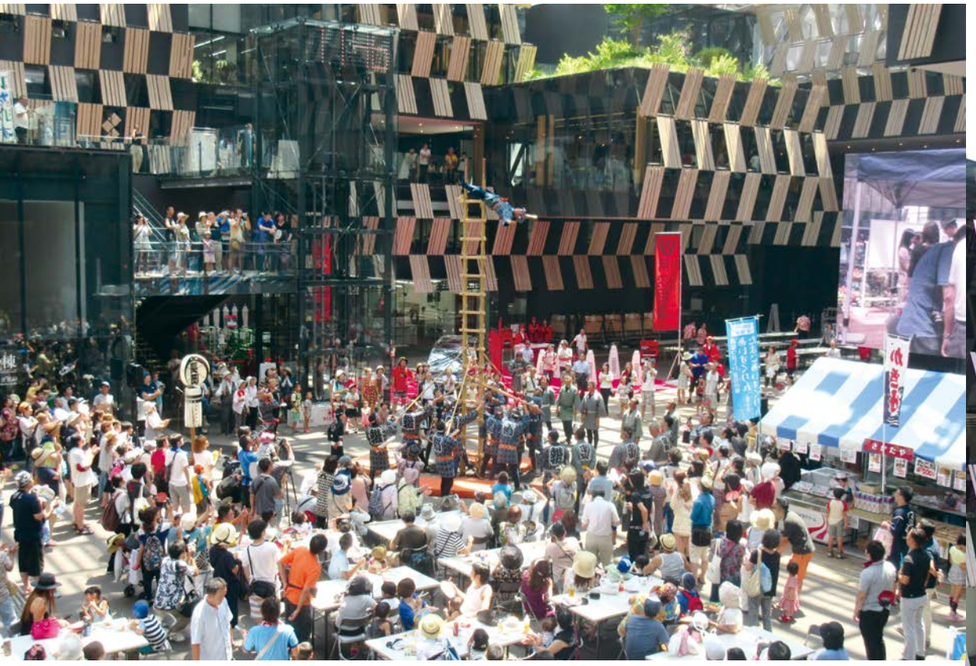
When it comes to finding harmony between architecture and nature, up to now the only expectations were for "scenic" outcomes. However, Mr. Kuma says that a more scientific perspective will be needed in the future. Vegetation plays an important role in environmental conservation, including by absorbing carbon dioxide through photosynthesis and working to regulate air temperature. Additionally, planting greenery leads to a cycle in which the soil is made more permeable and so rain is properly absorbed by the soil. This also has the effect of preventing flooding by preventing soil surface erosion. Nevertheless, scientific knowledge like this is yet to be fully exploited in architecture, Mr. Kuma says.

Given these current circumstances, Mr. Kuma expresses a sense of crisis: "New technologies and knowledge generated by science need to be rapidly integrated into urban planning and architecture."

"In recent years when floods and other disasters are reported, in many cases they are thrown out with the single phrase "abnormal weather." It seems to me, there's an important perspective missing; "What can humans do?" It is a very sad thing. I would expect that if urban design is carried out based on scientific simulations and research, it will also make it possible to mitigate such disasters" (Mr. Kuma).

With regard to environmental problems also, many research reports suggest that using wood can reduce greenhouse gas emissions, but currently those research outcomes are not reflected in actual policies or legislation, Mr. Kuma points out.

"Collaborations between scientists, policy-makers and designers will undoubtedly become increasingly important in the future" (Mr. Kuma).

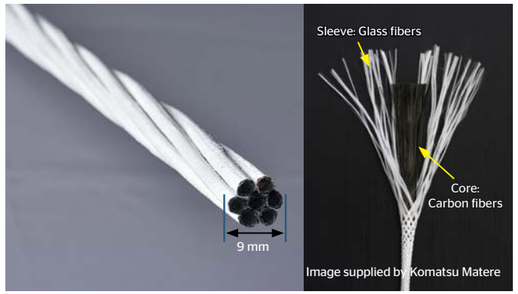


Nagaoka City Hall Aore, which Mr. Kuma designed based on the concept of a nakadoma - a meeting point for the community. Nagaoka City has a population of less than 300,000 people, but more than one million people a year, from children through to senior citizens, visit the roof-covered square known as Nakadoma. Source: supplied by Nagaoka City Hall

Examples of the technologies, spaces, architecture and other components that are needed for constructing new cities

"fa-bo," a fabric laboratory (the former head office building of Komatsu Matere Co., Ltd.) that arose out of a collaboration involving Komatsu Matere and others, and which was planned and designed by Mr. Kuma.

These images show the Tomioka Warehouse No.3 warehouse following seismic reinforcing carried out based on Mr. Kuma's renovation design. The existing roof trusses and existing walls were utilized as much as possible, in order to preserve the building's aesthetics. Images supplied by Komatsu Matere.



The project to renovate the former head office of Komatsu Matere was the first project in the world to utilize CABKOMA Strand Rod (a flexible rod-shaped carbon fiber composite) as the seismic reinforcing material. With CABKOMA Strand Rod a bundle of carbon fibers forms the core, and the outer layer of this core is then covered with braids of synthetic fiber. Adding loose strands to the carbon fiber core gives rise to a material that is flexible and easy to handle. It is being applied to the seismic reinforcing of timber-built architecture in particular, and is even being used in seismic upgrades of historical buildings such as temples.

Snow Peak Land Station Hakuba, Snow Peak Inc.'s interactive-type complex in Hakuba Village, Nagano Prefecture, was designed by Mr. Kuma. Mr. Kuma has created a large number of architectural works that focus on fire-resistant timber. In the outdoor excursion area (below left) it is also possible to learn about disaster prevention and disaster reduction. Will there be more environments where it is possible to naturally absorb knowledge like this in the future?

The "Jyubako" (lit. "living box"), which was jointly developed by Mr. Kuma and Snow Peak. The Jyubako allows people to travel and live freely. This mobile house (trailer house) is movable, made of wood and can be towed by a car. It can serve as a dwelling, as a workspace or even as an accommodation facility. The resurrection of well-ventilated wooden architecture, combined with mobility that makes it possible to move anywhere, may well emerge as a new approach to architecture and space.

What is architecture that generates a feeling of well-being?

The use of remote working and online studies has become widespread, accelerated by the COVID-19 pandemic. The pandemic has brought a variety of problem areas that are inherent to contemporary housing to the fore, and as such, it is serving as an opportunity to reconsider approaches to housing, architecture and even cities. In closing, we asked Mr. Kuma what types of architecture can imbue us with a sense of well-being.

"Until COVID-19 surfaced, I think in a large number of cases people working in boxes in cities lived in places where they could commute to work, and so their homes were little more than places where they slept – not workplaces. As a result, when they now find themselves trying to work remotely problems are surfacing, including being unable to concentrate on work because they are unable to simply switch off from their families' conversations. In Japan, in the past, regional communities existed and a "shift system" was also in place, which meant children could be entrusted to someone to look after. The representative example is the extended family system that was adopted by farming families. It worries me that the dwellings and ways of living that have become commonplace in modern times, such as the denuclearization of families in the suburbs, may not be adaptable to the changes currently taking place."

Mr. Kuma goes on to discuss the outlook for realizing inclusive societies:

"If considered in terms of our inherent physiology as living things, human beings have been living highly unnatural lifestyles up to now. One outcome of compulsively stacking up boxes has been the appearance of various convenient machines such as elevators. On the other hand, my feeling is that this has resulted in living environments that are not at all conducive to people with disabilities or senior citizens, for example."

This is also the starting point for the difficult-to-live environments that we all face. If you consider the notable characteristics of "human beings" as living things, their bodies are in no way robust. So it is necessary to create natural, horizontal environments, Mr. Kuma says.

"Unless we begin seriously considering designs and technologies with that in mind, we will likely be unable to respond when another powerful virus emerges. If you look at the history of humankind, it is our history as hunters and gatherers that is much longer. Humans' current style of habitation, which involves settling down in closed boxes, is not in our intrinsic nature as living things. Using the COVID-19 pandemic as an opportunity to take another look at our approaches to cities and architecture should surely lead us to think about what constitutes truly happy lifestyles and existences" (Mr. Kuma).

Profile

KUMA Kengo

Born in 1954. Completed his Master's Degree in Architecture at the University of Tokyo. Established Kengo Kuma & Associates in 1990. After working as a Professor at the University of Tokyo, he is currently Special Professor and Professor Emeritus at the University.

Mr. Kuma decided to become an architect at a young age, having been inspired by Kenzo Tange's Yoyogi National Gymnasium, which he saw during the 1964 Tokyo Olympics. While at university he studied under Hiroshi Hara and Yoshikazu Uchida. While at graduate school he traversed the Sahara Desert in Africa and carried out research on the settlements there, which awakened him to their beauty and power. After serving as a visiting researcher at Columbia University, in 1990 he established Kengo Kuma & Associates. Kengo Kuma & Associates has thus far designed architectural works in over 20 countries, and has received a range of awards both domestically and overseas, including the Architectural Institute of Japan Prize, the Spirit of Nature Wood Architecture Award (Finland), and the International Stone Architecture Award (Italy). Kengo Kuma & Associates proposes gentle, soft designs on a human scale, with the aim of realizing architecture that integrates seamlessly with the environment and culture of its site. It is also pursuing approaches to architecture for post-industrial society by seeking out new materials to take the place of concrete and steel.

At the observation deck of the Miraikan (Edo City, Tokyo)

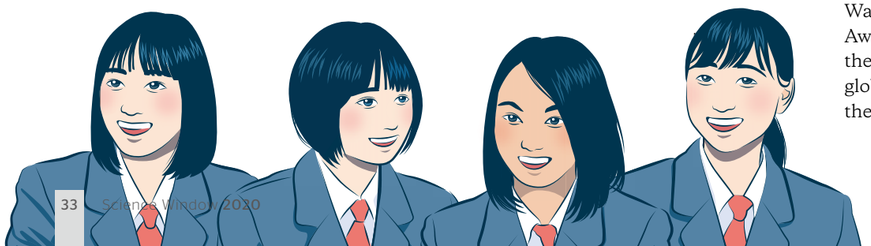
Recipients of the Next Generation Award of the STI for SDGs Awards 2019

Out of a Desire to Protect Their Beloved Hometown of Amakusa

—High School Students Predict Rising Sea Levels Due to Global Warming—

Interview with Shino Yamashita, Saika Ito, Seira Matsumura, and Anmi Wakata

It's been a while since "global warming" became a word that everyone knows, but how many people consider it as a threat to their own lives? The Science Club at Amakusa High School in Kumamoto Prefecture has been working on a way to predict sea level rise due to global warming, and the impact it will have on their community, since 2017. Through their research, they have found that global warming is an issue that will affect them directly, and they are now working to expand the scope of their research.



Predicting sea level rise using pollen and microalgae

"We must take action to solve global warming. There are things that we can do now to help the future."

Speaking on the stage at Science Agora in November 2019, Shino Yamashita, a second year student at Amakusa High School and member of the Science Club ended her presentation by calling on everyone "to do research together." This scene took place as part of the winner presentations segment of the STI for SDGs Awards ceremony*1, in which praiseworthy initiatives leading to solutions to the problems of local society using science and technology are given awards. The four students, Yamashita, Saika Ito, Seira Matsumoto, and Anmi Wakata, received the Next Generation Award for their research on predicting the extent of rising sea levels due to global warming. They asked Miyazaki, their advisor, about the research.

There is growing concern that as global warming progresses, it will raise sea levels, and ultimately sink island countries in the Pacific Ocean. And the same effect may also impact the coastal areas of Japan. The majority of populated areas in the Amakusa region of Kumamoto Prefecture are located at a low elevation facing the sea, and flooding could occur if the sea level rises.

The four students have been working on a research to predict how high the sea level would rise in the future due to global warming. This research was started by former members of the Science Club in 2017, when the school was selected for the government's Super Science High School (SSH) support program*2, and taken over by the current members. What is this "impressive research" that made them want to continue in their generation?

Plants can be found naturally in a region that features temperatures that are appropriate for each of them, and the pollen of those plants can be found in fossils within geological strata. When the type of pollen found in strata from a known period can be identified, the plant can be associated with that time period, enabling the temperature of the period to be estimated. In addition to estimating past temperature by analyzing pollen, the Science Club at Amakusa High School attempted to use diatom, a type of phytoplankton, as an indicator of past sea levels.

They collected pollen and diatom from two or more locations of "boring cores," or cylindrical soil samples, obtained by boring into the ground. They first analyzed the pollen to estimate the temperatures. They then went on to use one type of diatom,

The students present their research at Science Agora

Anmi Wakata

Shino Yamashita

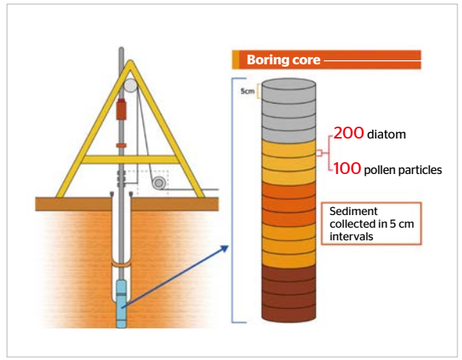
Science Agora: An open forum in which individuals from numerous walks of life come together for dialog to deepen their understanding of the relationship between science and society. **https://www.jst.go.jp/sis/scienceagora/**

*1: The STI for SDGs Awards is an award program established by the Japan Science and Technology Agency (JST) to recognize excellent examples of local initiatives to use innovations in science and technology to solve social issues. https://www.jst.go.jp/sis/co-creation/sdgs-award/

*2: The Super Science High School (SSH) support program is a program from the Ministry of Education, Culture, Sports, Science and Technology for research and development on the educational curriculum with a focus on sciences education. The program aims to raise personnel in science and technology to contribute internationally in the future. A total of 212 schools have been designated throughout Japan as of FY2019.

Left: The Amakusa region is surrounded by ocean.
Above: Tryblionella granulata used as an indication of sea water
Source: Amakusa High School

Analyzing diatoms and pollen from the boring core



The left shows an example of a boring core collected for a geological survey. A boring core is a long cylindrical soil sample collected by boring into the ground. The students of Amakusa High School collected sediment samples from the boring cores they received at 5 cm intervals, and identified 200 diatom and 100 pollen particles in the samples for analysis.

Boring core collection sites

Amura, where former members collected their sample, is 30 km away from Hondo.
Source: based on map tiles provided by the Geospatial Information Authority of Japan

known as Tryblionella granulate, as an indicator of whether sea water was present (in the form of tidal flats). This enabled them to capture the sea level. And they divided the changes in sea levels (cm) by the change in temperature (°C) to calculate how many centimeters the sea level would rise with a 1°C rise in temperature.

They then calculated the increase in temperature over the next 50 years based on the report by the Intergovernmental Panel on Climate Change (IPCC)*3 released in 2018 that stated that if global warming continues at the current pace, temperatures will rise an additional 0.5°C between 2030 and 2052. They estimated that the temperature could increase up to 22.1°C, and reached the prediction that the sea level could rise up to 52.1 cm 50 years from now. Accordingly, the students were awarded the Exploration-Oriented Award at Tsukuba Science Edge 2019 for their successful estimation of sea level rise by combining an analysis of pollen and diatoms.

The four students are now working to expand the research they took over from former club members.

Ito explains, “Previous members of the club used a boring core collected in Amura, which is about 30 km from the community of Hondo where Amakusa High School is. We wanted to find out if the seal level would rise in the same way in a location closer to home, so we decided to collect a boring core in Hondo by ourselves.”

What happened when the students tried to collect a boring sample themselves?

The four wasted no time in researching about boring online, and then proceeded to make a list of construction companies to call in Amakusa city that might be able to lend a hand borer. They soon found a company that was willing to lend them the tool, but they realized an important mistake when they received it. Quite simply, while some borers are made to collect cores, others are used to measure the hardness of the ground. Unfortunately, the one they were able to borrow was of the latter type.

Yet the students believed that if they tried collecting a sample at low tide on a dried out tidal flat during the spring tide, when the difference between low and high tide is highest, it still might work, and so they gave it a shot. But unfortunately, they went out to the flat at the wrong time of the day.

Wakata explains, “It was nearly high tide when we reached the tidal flats. We rushed to start boring, but as the tide continued to rise, the sand got quite muddy, and we were unable to collect cores.”

The students add that in the end, the tidal flats were completely flooded by the tide and they had to swim back to the shore, which shows the extent of their efforts to collect boring cores. They planned several more attempts on later dates, at low tide during high tide period, but school events prevented them getting the opportunity.

They eventually gave up doing it by themselves, and decided to request a geological survey company in Amakusa city to provide them with some samples. But the girls still learned a great deal from the experience. Each local company they contacted was very receptive despite the sudden phone call, going so far as to offer words of encouragement, and this strengthened the girls’ sense that they wanted to, and even had to, do something to contribute to the community. Also, despite their initial failure, there repeated trial-and-error and discussions surely enhanced teamwork, which would prove invaluable in their later activities.

*3: The Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to comprehensively evaluate human caused climate change, influence, application, and countermeasures from scientific, technological, and socio-economic standpoints.

Yamashita (foreground) attempting hand borring in the tidal flats near high tide as her club mates look on.
Source: Amakusa High School

They learned to see global warming as an issue that affects them directly

The students collected sediment samples at 5 cm intervals along the roughly 21 m boring core they were given, and analyzed the pollen and diatoms. After removing any impurity that might impede the observation of the pollen and diatoms, they prepared over 200 specimens for observation using a microscope. They then used the microscope to examine each specimen in turn to identify the types of diatoms and pollen present.

They were able to identify that a sample represented a time when the collection point was covered in seawater if the aforementioned type of diatom was found. Meanwhile, they analyzed the pollen using the so-called modern-analogue method*4. They observed the type and quantity of pollen found in the core, and fed that data into a piece of software programmed according to the modern-analogue method to estimate temperature and rainfall from the period.

The students continued this work, receiving advice from Miyazaki and former club members, and arrived at an estimate that the sea level would rise 11.5 cm for every degree of rise in temperature. Then, just like the former club members, they used the IPCC temperature predictions to calculate that the sea level would rise by up to 24 cm in 50 years.

Having concerned about the effect that a 24 cm rise would have on their community, the students conducted a simulation using a real sea wall. The simulation showed that if a major typhoon were to strike after the sea level had risen 24 cm, the high tide during the storm would exceed the sea wall. This would mean that surrounding homes would be flooded. After learning these results, the students became aware that global warming was exactly the crisis they were facing, not someone else’s problem.

The team is continuing their research to improve data precision and possibly offer specific guidance on how tall the sea wall needs to be to ensure safety, while also working to spread their work to predict rising sea levels to a wider group. They are driven by a desire for more people to realize the direct impact that global warming has on their lives by researching its effects on their own communities for themselves. In addition to already working with a local community group called the Amakusa

*4: The modern-analogue method is used to show past temperature by analyzing the types and ratios of pollen contained in geological strata.

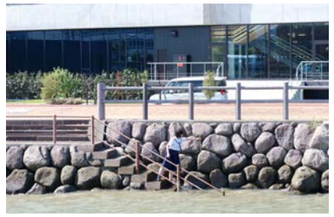
The students research activities

Source: Amakusa High School

The students learning how to identify diatoms and pollen under the direction of their club advisor

The students visiting the local company providing the boring core to collect samples for analysis

The students discussing paleoenvironmental changes based on their analysis



Field research at a sea wall near the city hall

The majority of the research involved painstaking observation using a microscope

Each of the four students has a different role in the research.

Left: Hajime Miyazaki, teacher and Science Club advisor at Amakusa High School in Kumamoto Prefecture.
Right: This image, taken of the sea wall near the city hall, shows the current level of high tide (blue), the predicted future rise in sea level of 24 cm (orange), and the predicted sea level during high tide if a major typhoon with pressures of 930 hectopascals struck after the sea level had risen (yellow). Once the sea level has reached 24 cm, another high tide in storm conditions would bring the sea water over the wall (the white line at the top).
Source: Amakusa High School

Sea Club that aims to spread information about the appeals of the Amakusa seaside, the team is engaged in other activities such as giving presentations at science events and calling on high schools in other regions to engage in joint research. And the scope of the research will be sure to spread more in the future.

The team has also held workshops on preparing specimens for observation via microscope for their own school and at culture day events at elementary schools in the area to spread the enjoyment of science to other students. Wakata explained the purpose of their initiatives by saying, "Global warming is an issue that affects all of us."

"I believe that high school students doing research on rising sea levels makes it easier to explain why this is an important issue. Our generation must find a solution to the problems of future society, and future generations will inherit that."

Readers may be surprised to hear the words "future generations" come naturally from a high school student, but it may show how they've come to think in terms of decades on a daily basis as they think about global warming.

Student initiative comes first

The adviser's job is just to give advice on research method, etc.

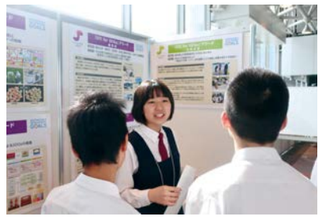
Miyazaki explains that every work the students have been doing is their own idea, such as working with local organizations and high schools students from other prefectures, and encouraging the next generation, etc. He has just been watching over them. But what about the research itself?

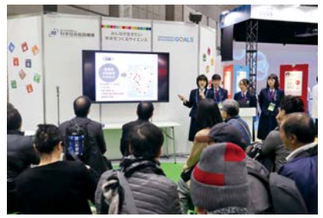
Yamashita explains, "Our teacher taught us research methods such as carbon dating, how to identify pollen, and how to use the PC." Miyazaki adds, laughing, "I enjoy being pushed around by the girls." The students did receive technical guidance from their advisor, but it was them who thought for themselves and took real action, such as choosing Hondo as their local field of analysis, or trying to do the boring on their own. The school has a unique initiative that may have played a role in the promotion of independence and proactivity.

The curriculum at Amakusa High School includes a themed research project that is mandatory for all first year students, and that theme must be related to solving a problem for the local community. Miyazaki explained what the school focuses on in carrying out the program.

"Most of the students struggle with choosing a research theme, but we make sure they think of it on their own. Teachers don't give themes. The most important ability to be a part of society is the ability to find issues on your own."

Activities to expand the circle of research in various locations


Ito explaining to visitors at Science Agora 2019


The four students giving a presentation at EcoPro 2019


Matsumura introducing their research at a local festival (foreground)

From the left.
Seira Matsumura
Shino Yamashita
Anmi Wakata
Saika Ito

Another element that helps the students find issues within their community is the Amakusa Ongoing Lecture Series, part of the SSH framework, in which members of local companies, organizations, and universities from mainly science and technology related fields give lectures on different aspects of Amakusa. This is said to greatly broaden students' prospectives.

Miyazaki explains, "We expect that their stance of explore things scientifically that can be gained through their themed research projects will apply to any field they might enter in the future."

For the future of their beloved hometown

Finally, we asked the students what their feelings were towards their hometown of Amakusa and what they planned to do in the future.

Matsumura answers, "If Amakusa, where I have lived my whole life, is faced with a threat, then I want to do something about it so that I can continue to live here." After graduating, she hopes to enter the architecture and civil engineering field to work on developing homes and communities that are resilient against disasters caused by global warming.

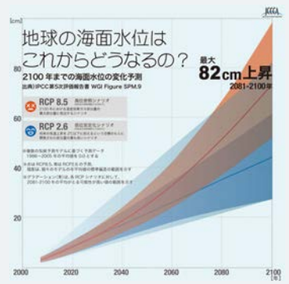
Yamashita and Wakata, who both hope to enter science fields after having been inspired by the excitement of research, each reflected on their activities so far.

"The positives about the seas around Amakusa have always been at the forefront, such as the delicious fish that can be caught and the dolphins that swim offshore. But when I realized how scary rising sea levels could be, I felt that I wanted to protect that beautiful sea with a balanced awareness of the positives and negatives," says Yamashita.

"I love the seas off Amakusa, and I want to do ocean related research at university as well. I think I was able to develop that sort of awareness of the future by studying at SSH school," says Wakata.

Ito hopes to study radiology, a field unrelated to the issue of global warming, but she hopes to leverage the knowledge and data the team acquired in the future at any opportunity she gets to discuss the global warming issues facing society that will likely increase in number. Expressing her strong feelings for her community, she adds that, "There are many other issues that Amakusa is facing in addition to rising sea levels and depopulation. I feel there are many things that need to be done, such as offering specific proposals to city hall."

These four high school students who were inspired by former club members to take on their research and continue it are working hard to develop that research further with an eye towards the local community in order to find specific and scientific solutions. They also see a bright future as a result of their collaborations with many different people and communities. Youths like these four students, who have a strong awareness of the communities and society they live in, will be the ones to build the future of Japan and the world.



A basic understanding of global warming
—What will become of the Earth's sea level going forward?—

Global warming is the phenomenon in which the average temperature of the planet overall is rising due to the massive release of greenhouse gases, such as CO_2, into the atmosphere as a result of human activity. As introduced in this article, if no effective measures are taken as global warming worsens, then the concern is that it will cause numerous issues including rising sea levels. The main reason for that is that rising temperatures will cause the volume of sea water to increase. Other causes include melting glaciers on land and the Greenland ice sheet, resulting in a large volume of water to flowing into the sea, raising the sea level. According to the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), it is predicted that sea levels will rise by as much as 82 cm by the end of this century.

Source: IPCC 5th Assessment Report, Website of the Japan Center for Climate Change Actions (http://www.jccca.org/)

2019 STI for SDGs Excellent Practice Award

Tackling Global Warming Through Agriculture

—Controlling Rice Paddy Methane and Developing Heat Resistant Rice—

Interview with Shigeto Sudo and Masayuki Yamaguchi

There is a profound relationship between agriculture and the worsening problem of global warming. Focusing on the fact that wet field rice farming generates methane gas, a powerful greenhouse gas, the National Agriculture and Food Research Organization (NARO) has developed a more advanced approach to midsummer drainage to control it. The organization also promotes the development of a rice variety that is more resilient to global warming conditions. These two initiatives received praise throughout Japan, including their potential global applications, which lead to the 2019 STI for SDGs Excellent Practice Award.

Rice cultivation produces 45% of human generated methane

Since the industrial revolution, humanity has been releasing a variety of greenhouse gases into the atmosphere, such as CO_2, through the use of fossil fuels such as coal and oil, bringing about global warming. According to the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*1, the global average temperature may rise as high as 4.8 degrees from 1986-2005 levels by 2100.

If global temperatures rise to this extent, then the impact on agriculture will likely be unavoidable. It will be even more necessary to take measures against global warming in order to maintain agricultural production, but there may also be ways to contribute to the control thereof directly through agriculture. Shigeto Sudo, Senior Researcher at the Institute for Agro-Environmental Sciences, NARO, has been carrying out research focusing on the fact that Japanese wet field rice farming produces massive amounts of methane, a greenhouse gas that is 25 times more powerful than CO_2.

According to Sudo, “Bacteria that produce methane live in the soil under rice paddies, and they generate that methane when they feed on organic matter such as rice straw. The volume of methane produced in rice paddies is surprisingly high, and 45% of all methane emitted by human activities in Japan is produced by rice farming. Therefore, if we could reduce the amount of methane produced in rice paddies, it would have the effect of limiting global warming.”

Oxygenating the soil through midsummer drainage

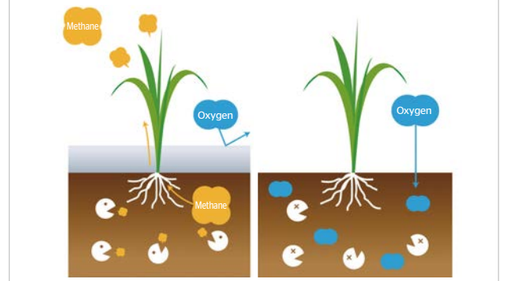
The question is how methane is generated in rice paddies.

Even in rice paddies filled with water, there is still a lot of oxygen in the soil immediately after planting, and the presence of oxygen prevents bacteria from producing methane. However, once rice plants absorb oxygen to breath, oxygen in the soil is gradually decreasing. The rice paddies become largely depleted of oxygen about one month after planting, and the bacteria begin to produce methane. Sudo explains, “In April and May, when there is oxygen in the soil, the ground temperature is low and the bacteria are not very active.

However, the environment becomes perfect for the methane to produce bacteria by June, when oxygen in the soil is lost. Then, about one month later, the number of rice stalks increases, which behave like smokestacks and release methane into the atmosphere.”

Accordingly, a method should be found to control the activity of methane producing bacteria. The approach recommended by Sudo is to extend the period of midsummer drainage, or Nakaboshi in Japanese. Midsummer drainage is a method long practiced by Japanese rice farmers in which water is drained out of the rice paddy to control the development of the rice plants and maintain root health. By draining the rice paddies, the mud dries and develops cracks that allow oxygen to enter. This enriches the soil with oxygen, controlling the activity of the methane producing bacteria.

Effects of Midsummer Drainage



In the left illustration, water prevents oxygen from entering the soil, allowing the bacteria to produce methane. By draining the water, oxygen is added to the soil, controlling the generation of methane.

Method tested in eight prefectures for standardization and national deployment

The Fukushima Agriculture Technology Center was already taking control of methane generation through midsummer drainage. The organization reported that by moving the start of the process forward by one week and extending it, they were able to control the production of methane without affecting yield. This means that farmers can potentially be expected to cooperate by extending their midsummer drainage periods to reduce methane. However, Sudo explains that in order to recommend the approach throughout Japan, there was still something that needed to be tested.

“Climate and soil quality vary depending on the regions, so we were not sure that the Fukushima results could be applied across the country. Then, we conducted an experiment involving nine locations in eight prefectures, from Yamagata in the north to Kagoshima in the south, to test the effects of extending midsummer drainage. We standardized the method, to ensure that there is no variation in the methane measurement method, and held workshops in each cooperating prefecture so that the measurements would be done correctly,” says Sudo.

The method used to measure methane production in rice paddies is called the Chamber Method, involving the placement of a chamber, or small greenhouse, on the surface of

*1: The Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to comprehensively evaluate human caused climate change, influence, application, and countermeasures from scientific, technological, and socio-economic standpoints.

Technology used to measure greenhouse gas emissions from rice paddies efficiently and accurately

A sealed box is placed over the rice plants on the paddy surface, and air is collected from within at regular intervals (left). A sensor measures the density of three greenhouse gases simultaneously (right) to calculate emissions versus area.
Source: NARO

the paddy to measure the density of methane generated from the soil over time. The method is, however, quite sensitive, and measurements can become skewed if the chamber is placed haphazardly because it can cause methane to be released from the soil all at once. During the two years over which the measurements took place, Sudo found himself constantly traveling back and forth throughout Japan to stay informed of the latest numbers as quickly as possible and provide guidance when questionable measurements were reported.

Methane emissions reduced by a third by extending midsummer drainage by a week

By extending the midsummer drainage period by about one week, it was possible to reduce the amount of methane produced by about a third on average compared to the standard length of midsummer drainage. This did not have a major effect on yield, but caused a slight decline in protein content, which actually results in better tasting rice. Consequently, the team learned that they could control methane production while maintaining yield and quality. Sudo's team prepared a manual for the control of methane production through extension of the midsummer drainage period, and the manual is available from the NARO website in PDF format.

Sudo adds, "Shiga prefecture had already promoted agriculture that protects the environment, and is able to implement the extension of midsummer drainage over a very wide area. I myself want to make every effort to spread this initiative throughout Japan. And since the production of rice isn't limited to Japan, I would like to share this technique overseas abroad as well."

Temperatures are high in South East Asia, another region where rice production is common, and it is thought that methane producing bacteria are particularly active in the region. If midsummer drainage were extended there, methane production would likely be affected. However, some overseas area have the essential irrigation infrastructure for midsummer drainage, while others do not, so it is necessary to take into consideration the local conditions in each country. But if the impact of extended midsummer drainage was more widely known, it could be helpful in combatting global warming.

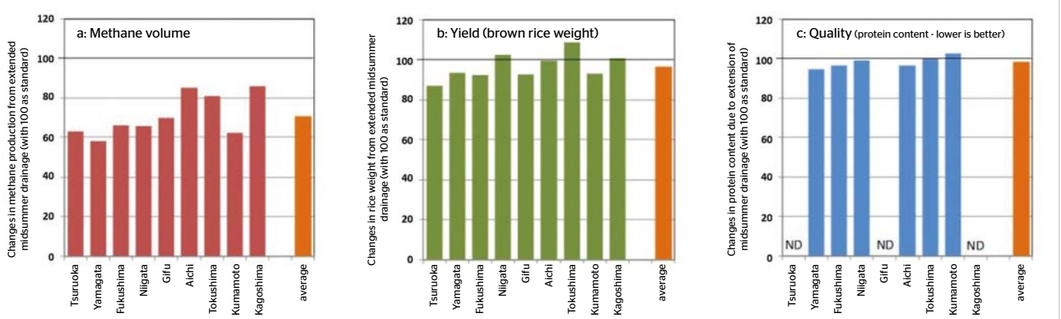
Rice becomes cloudy and less tasty at an average of 26°C or higher

Even if the extension of midsummer drainage is implemented to reduce methane production everywhere, it remains difficult to stop the progress of global warming right away. Furthermore, the impact of global warming is already a reality in agriculture. One impact on rice is high temperature damage. Masayuki Yamaguchi, Director of the Division of Rice Research at the Institute of Crop Science, NARO, explained the issue with the following example.

"Healthy rice is semi-transparent, but if the average temperature over the 20 days period during which the rice grains grow is 26°C or higher, the rice becomes cloudy in color. This is because the heat causes cracks to form in the grains, and the light reflecting in these cracks causes it to take on a cloudy white color. When these immature cloudy white rice grains are steamed, they absorb more water than usual and become softer, resulting in a negative impact on taste. Therefore, we need to find a variety that is less likely to become cloudy when it is under high heat."

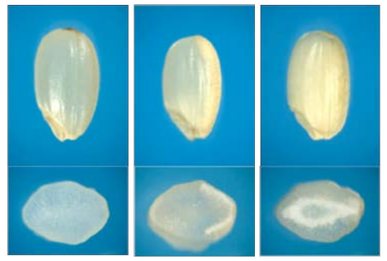
Yamaguchi explains that the rate of immature grains has risen in recent years everywhere from Southern Tohoku and below due to the impact of global warming. This means that the need for rice varieties with resistance to high temperature damage is becoming more urgent.

Changes in methane volume, yield (brown rice weight), and quality (protein content) after extending midsummer drainage.



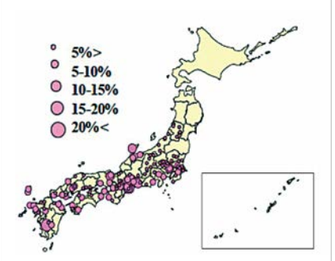
Extending the period of midsummer drainage by about one week reduces methane by about 1/3 without affecting yield or quality. Source: NARO

External visual changes to rice under high heat



With standard rice varieties that are not adapted to high heat damage, immature cloudy white grains develop when the average temperature is 26°C or greater for the 20 day period when grains grow large (middle and right photos), reducing quality. Source: NARO

Rate of white immature grains



The rate of white immature grains is high from Yamagata Prefecture and below. Source: NARO

Crossbreeding and selection using DNA markers

How are rice varieties resistant to global warming produced?

Yamaguchi explains, "Selective breeding is a tedious process from cross breeding to selection. To develop a variety resistant to high temperature damage, we first grow a range of rice varieties in a greenhouse, or outdoors, at temperatures exceeding 30°C and select those varieties in which fewer immature grains occur. We then cross breed those varieties and select from their offspring, those which not only exhibit fewer immature grains, but also exhibit desirable characteristics in terms of flavor, yield, and disease resistance, among many other characteristics. Finally, we check over generations,whether those desired characteristics are maintained, and if so, a new variety is born."

To date, such diligent efforts have already led to the creation of several new varieties such as Aki-haruka, Nikomaru, Koi-no-yokan, Emi-no-kizuna, and Niji-no-kirameki, and these are being introduced in areas of Kyushu and Kanto where immature grains are becoming an issue.

Genetic technologies have also improved in recent years, and are being applied to selective breeding in agriculture. If a specific gene is identified as having an influence, DNA markers that show that gene is present in a plant can be used in the process of selective breeding. This means that varieties can be selected by analyzing the DNA of seedlings and cultivating only those in which the desired DNA marker is present, without waiting for harvest, making the process more efficient. Genes that are resistant to specific diseases have already been identified, and their DNA markers are being used to grow new varieties. Accordingly, NARO is using both the standard cross-breeding approach to selective breeding as well as selection technology based on DNA markers to practice selective breeding using the most efficient approach in each case.

High temperature sterility and the threat to the food supply

According to Yamaguchi, adapting to the increasingly severe global warming extends beyond the development of rice variety that is less likely to produce immature grains. There is also a need for varieties resistant to typhoons because climate change makes storms bigger. Also, as temperatures rise even higher, it can even cause a condition called high temperature sterility, in which yield is greatly reduced because the rice plants cannot pollinate.

Concerned over the future of the global environment, Yamaguchi explains, "The cloudy white phenomenon of rice is just a quality issue, but if temperature sterility occurs frequently, it will impact yield as well. This is an important issue that directly affects global food security." Extreme high temperatures during the flowering can interfere with rice pollination. Accordingly, NARO has already begun taking measures on high temperature sterility, such as research on rice varieties that flower early before temperatures rise. Much hope rests on these efforts at NARO as they fight global warming.

Profile

SUDO Shigeto

National Agriculture and Food Research Organization
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Senior Researcher

YAMAGUCHI Masayuki

National Agriculture and Food Research Organization
Institute of Crop Science
Director, Division of Rice Research

*As of the time of this interview. Currently Director, Division of Lowland Farming Research, Kyushu Okinawa Agricultural Research Center.

'STI for SDGs' AWARD

'STI for SDGs' Awards 2020
List of Awarded Initiatives

The 'STI for SDGs' Awards is an awards program that recognizes excellent initiatives to solve problems in local communities using Science, Technology and Innovation (STI). The program aims at the further development of the initiatives and their application to other communities facing similar problems in order to achieve the Sustainable Development Goals (SDGs).

https://www.jst.go.jp/sis/co-creation/sdgs-award/

MEXT Minister Award

WheeLog!, Shimane University Interdisciplinary Faculty of Science and Engineering, OryLab Inc., nanoconnect Inc.

WheelLog!: a barrier free access map made through user participation.

The problem: Today, despite the progress in barrier free access, many mobility impaired people, like wheelchair users, cannot move freely. These individuals face obstacles when they travel, which limits their daily lives and can lead to loss of life..

Initiative overview: Development of WheeLog!, an app for sharing information on barrier free access geared towards the mobility impaired people. The app combines spot information and route logs using camera and GPS functions to provide the type of comprehensive information needed by the mobily challenged. The project involves those who do not face such challenges as well in order to help build a society that is easy for all to carry out their day-to-day lives.

JST President Award

Kagawa University, Melody International Ltd., NPO e-HCIK (Electronic Health Care Innovation in Kagawa)

Realizing an ultra-compact mobile fetal monitor for safe and secure pregnancy and delivery.

The problem: There are many areas in the world where safe and secure childbirth is not possible due to a lack of obstetricians and midwives, leading to a disparity in medical care. There are also many high risk pregnancies in such regions.

Initiative overview: Development of an ultra-compact mobile fetal monitor. The monitor enables pregnant women to measure the heartbeats of the fetus by themselves and share the data with obstetricians. This has enabled an online diagnostic system that helps solve the disparity in medical care in regions with a shortage of obstetricians and midwives, and helps ensure safe and secure pregnancies and deliveries for high risk cases. The device is expected to be used in emergency transport, disasters, and developing countries.

Excellent Practice Awards

Shimaame Lab

Akashima Revitalization Project —The search for a sustainable society by leveraging rain water—

The problem: Island areas continue to suffer from water shortages, while concerns are growing due to the increasing frequency and severity of heavy rains and droughts even in urban areas. The development of rainwater system and the training of personnel to promote them are becoming a major challenge for society.

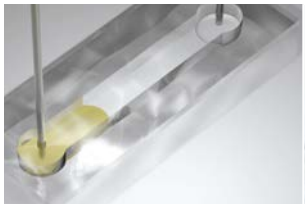
Initiative overview: Akashima is an island in Goto, Nagasaki Prefecture that relies entirely on rainwater for its water supply. This initiative has put in place an autonomous distributed system for the smart use of rainwater to secure and manage the island's scarce water resources. The initiative also provides an environmental educational program on the use of rainwater to train personnel and promote the understanding thereof. Besides helping with water resources for island areas, the initiative is expected to help with floods in urban areas, and see its application overseas as well.

CRAIF Inc.

Early detection of cancer with a high level of precision through the comprehensive analysis of miRNA in urine using an original device.

The problem: The number of people who die from cancer worldwide reached 9.6 million as of 2018, and this number is expected to continue to rise. (Source: WHO) However, cancer screening has not yet spread adequately.

Initiative overview: Development of an exome-based liquid biopsy platform that combines an original device and AI technology to enable detection of various types of cancer, including lung cancer and brain tumors, in only 1 ml of urine. The project intends to provide urine tests that can detect multiple forms of cancer, but will first distribute a risk check kit using the same technology.



JST is supporting the achievement of the Sustainable Development Goals (SDGs).

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