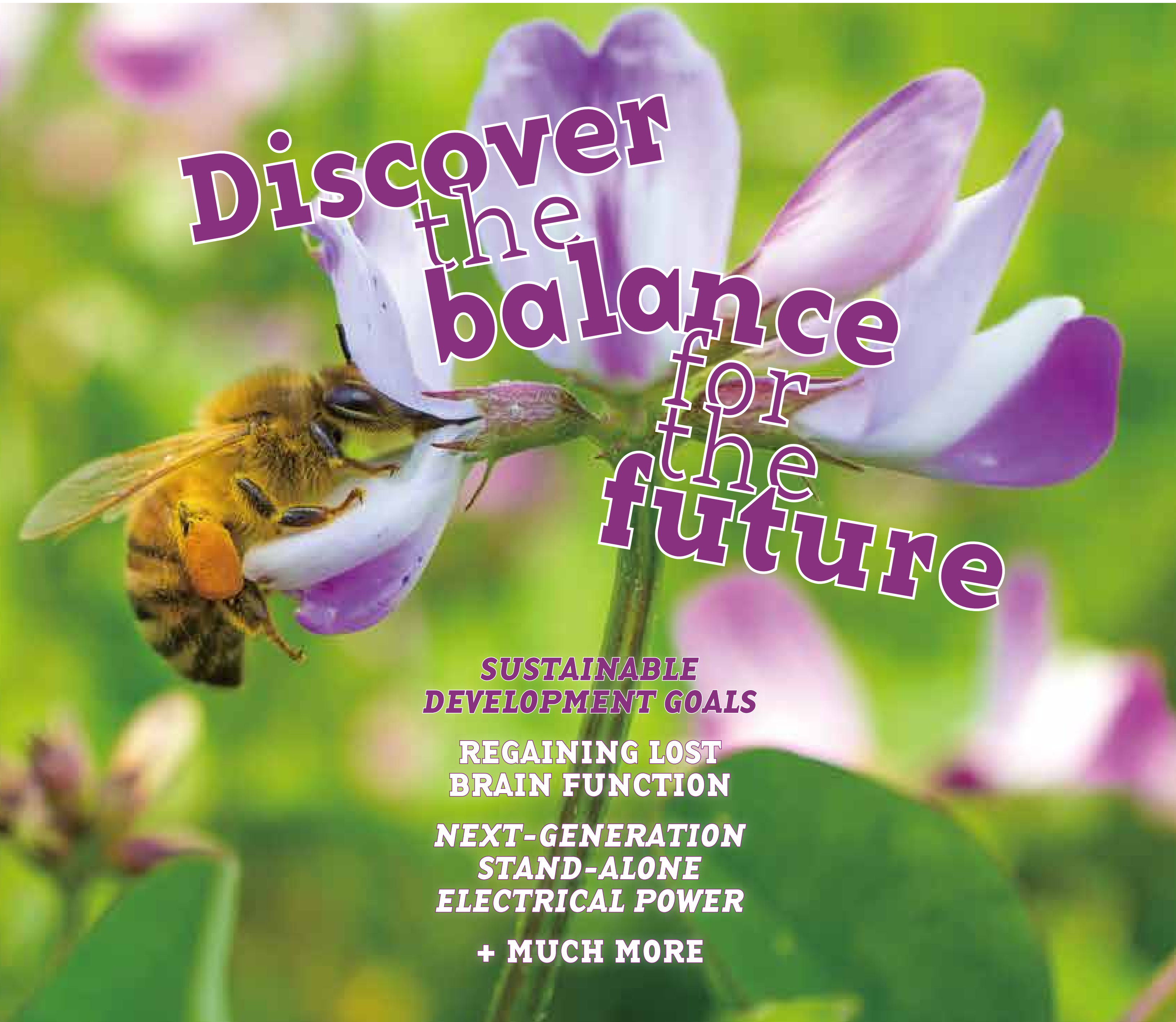
2019 SPECIAL ENGLISH EDITION

A Magazine from Japan

Science Window



Discover the balance for the future

SUSTAINABLE DEVELOPMENT GOALS

REGAINING LOST BRAIN FUNCTION

NEXT-GENERATION STAND-ALONE ELECTRICAL POWER

+ MUCH MORE

Science Window

SCIENCE WINDOW

A science education magazine that children and adults can read together

The sense of excitement that comes from learning something that leaves us amazed or wondering "Why?" plants the seeds that help our minds grow into ones with a spirit of inquiry toward the world of nature. The Japan Science and Technology Agency (JST) publishes the science education magazine *Science Window* with the aim of encouraging children and adults alike to ask questions about their world and indulge their curiosity. This publication is distributed to elementary, junior high, and high schools across Japan, and is also available free of charge on the JST website.

This is a special English edition featuring articles from recent Japanese language issues that introduce the Sustainable Development Goals and other fascinating topics. Japan's contributions in the areas of science and technology are important for the creation of a sustainable global society. We hope that people around the world with an interest in this area, as well as in education, will enjoy reading this magazine.

Department for Promotion of Science in Society
Japan Science and Technology Agency

Japan Science and Technology Agency

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DEAD LEAF BUTTERFLY

Japanese Name:
Konohacho
Scientific Name:
Kallima inachus

Deep within the dim tropical forest, a single dead leaf seems caught in a tree trunk. However, when a Euchirinae scarab beetle approaches, the leaf spreads its wings and flies away. Its wings have a dazzling brilliance, the pattern a bluish-purple and orange reminiscent of a Japanese kimono belt. The Euchirinae must be dumbfounded. What seemed like a leaf was actually a dead leaf butterfly, feasting on its favorite tree sap.

The wings of the dead leaf butterfly have an eye-catching front but the reverse is completely different, resembling a plain withered leaf. This side even has a pattern that mimics the veins of a leaf. The forewing tapers like a leaf's pointed edge, and the hindwing has bumps resembling a leaf's base. The dead leaf butterfly was thus named for its ability to look just like a single withered leaf when it suddenly closes its wings.

The dead leaf butterfly belongs to the nymphalid family of butterflies. It measures up to 10 centimeters when it closes its wings to resemble a withered leaf. It inhabits subtropical areas such as Taiwan and can be seen nearly year-round in Japan's Okinawa Prefecture. As it is a designated protected species of Okinawa, catching it is prohibited.

Each butterfly has a different withered leaf pattern on its wings. The patterns include colors like brown, red and grey, and elements closely resembling leaf veins and holes. It can easily blend into scenery with many kinds of dead leaves, evading detection by birds and other natural enemies.

The eye-catching side of their wings, on the other hand, is the same beautiful colors and pattern for all the species. Both the males and females spread their wings and fly boldly around their own territory. It's thought that the butterflies can recognize one another since they all have the same showy pattern.

The butterflies close their wings to hide but spread them to show off in their territory. The dead leaf butterfly thus has different purposes for the two sides of its wings. sw

Article cooperation:
Kazuo Unno, Insect Photographer and Chairman of the Society of Scientific Photography

Sustainable Development Goals (SDGs)

17 Goals to Transform Our World

The First annual Multistakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum) was held on 6-7 June 2016, at the UN Headquarters in New York, aiming to address how the Science, Technology and Innovation (STI) could contribute to the implementation of the SDGs ("STI for SDGs"). It is highly expected that, to achieve the SDGs, the STI play an indispensable role by resolving various emerging issues we face and by providing scientific data and analysis for better political decisions.

"JST is an advanced network-based research institute promoting state-of-the-art R&D projects to co-create innovation for tomorrow's world together with society. Based on the Science and Technology Basic Plan adopted by the government, JST implements various R&D programs and formulates strategies for co-creating the future with society. Such missions of the JST as "maximizing R&D achievements" and "co-creating the future with society by resolving issues" are highly compatible with the SDGs which aim to "transform the society and realize a sustainable society." Therefore, JST set its action plans for playing a leading role in harnessing Science, Technology and Innovation (STI) for the SDGs in Japan and for promoting the establishment of a robust innovation ecosystem to co-create the future society in Japan and across the world." sw

Cover Photo: Toshimitsu Matsuhashi

Illustration: Junichi Yamada

Regaining lost brain function for sensing movement

A new rehabilitation technique and its future

Jun Morimoto
Jun became head of the Department of Brain Robot Interface at the ATR Computational Neuroscience Laboratories in 2008. The photograph shows a lower exoskeleton robot currently under development. It supports patients having difficulty walking due to strokes or other issues and spurs the recovery of brain functions.

*There is a technology that enables the moving of machines just by thinking. Research on this technology known as Brain Machine Interface (BMI) has expanded our understanding of the brain. **Jun Morimoto** of the Advanced Telecommunications Research Institute International (ATR) is aiming to achieve the recovery of brain functions lost through accidents or illnesses through rehabilitation using robots as intermediaries. Both brain activity and bodily sensations play an important role.*

Operating robots with brain activity

BMI technology has been attracting attention recently as it enables the direct exchange of information between the brain and telecommunications devices. Research into how brain activity can be used to operate a wheelchair was in the news last year. The BMI technology for controlling humanoid robots is known as Brain Robot Interface (BRI).

Morimoto's research uses BRI to support rehabilitation of patients who have conditions such as paralysis of half of the body due to a stroke, and aims to help them recover and improve. Even if these patients have functioning muscles and nerves, they cannot move their bodies well because their brain cannot send normal commands. An instrument for measuring brain activity affixed to the head enables the user to determine the areas of the body to move. If the measured brain activity approaches a particular state, it becomes a command to move the robot, which in turn moves the paralyzed arms or legs. Morimoto explains, "Because patients just need to wear a light-weight EEG cap that measures brain activities, physical burden is not significant."

Though robots that can be moved by thought alone have clear convenience benefits, this is not the true extent of BRI research. Operating the robot through BRI is not simply about replacing movement ability, but also about aiding the recovery of brain functions.

Selecting commands from the brain

Morimoto explains, "When we move our bodies, our bodies are always sending out some sort of information that we can pick up on. However, measurable brainwaves are so complicated they just look like noise at first glance. We first have to detect the meaningful information using the important process of decoding."

The brainwave measuring device we use in our research only reads the information on the very surface of the brain. It decodes information such as when to get up or sit down through advanced analysis. However, it cannot go as far as deducing information for controlling the angle to bend the back or knees.

Despite this Morimoto's research has enabled their robot to automatically achieve balanced movement to a certain extent. If the robot is supporting the lower body, it has automatic control to prevent falling even if force is exerted from the side, ensuring a high degree of safety.

However, because everyone has unique brain activity, practice is necessary for handling BRI. Even if progress is made in operation, there are still issues such as the lag when wearing the measuring instrument that could change the measurable brain activity patterns. Morimoto notes, "If many people use this and the measurement data increases, we'll be able to grasp patterns and tendencies using big data analysis. I think it will be possible for anyone to easily use this in the future."

The "sensory loop" restores the brain

Why does controlling a robot with the brain help restore brain functions? Morimoto explains, "First, sensory information that movement occurred is sent to the brain from the body. Second, the impetus for creating that sensory information is one's brain activity. This loop changes the brain."

Using outside force to move a paralyzed body was done before. Forming a "brain activity loop," entailing the brain issuing a command based on one's will and then the brain receiving a sensation back that movement occurred, was impossible with older technology.

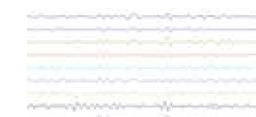
Morimoto says, "Within BRI research, it can happen that brain activity is responded to with sensory input that is different to that sent when the person moves normally. How does the brain respond when this happens? I think we will learn a lot of new things going forward."

Brain functions change through repeated experiences

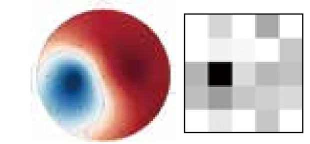
By using BRI to move a body that lost the ability to move, the experience that movement occurred returns to the brain as a skin and deep sensory response. It is believed that repetition of this will cause recovery and improvement of brain functions. sw

Operating the robot through commands

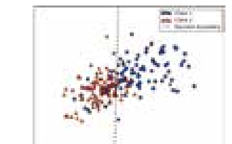
1 The brain activity when the test subject imagines "raising their right arm" is measured with an EEG.



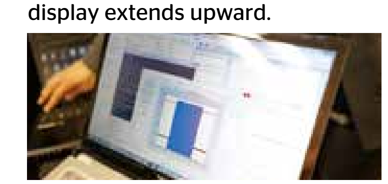
2 As these measured values are recorded the distribution and strength is processed as data.



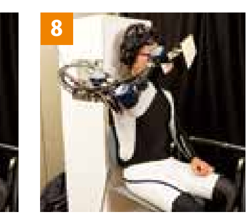
3 The features are extracted from this data, and the machine learns the classifier.



4 As it becomes closer to the target brain activity pattern of "raise the right arm," the bar on the display extends upward.

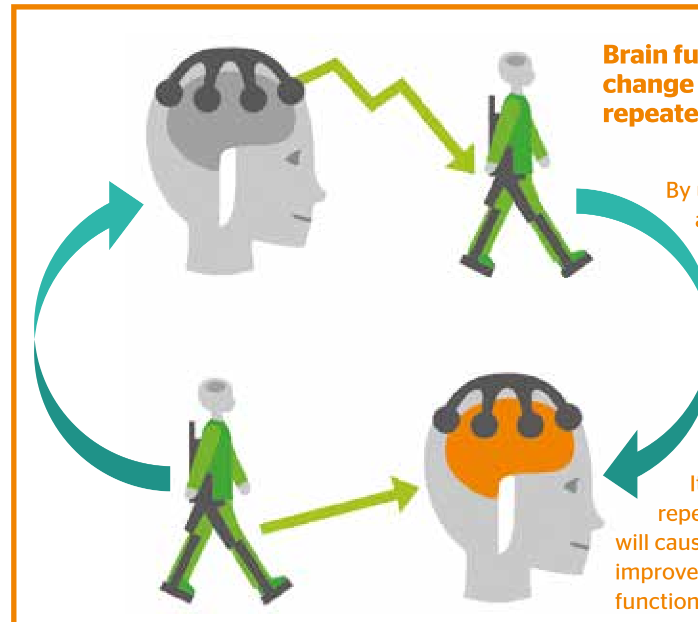


5 When the bar exceeds a certain threshold value, it produces a command to move the robot, and the robot moves its arm.



The point of the training is to have a constant visual of the subject's brain activity on the monitor. By training and confirming how well a person is imagining movement, even people who initially performed poorly are able to pick up the technique and operate the robot.

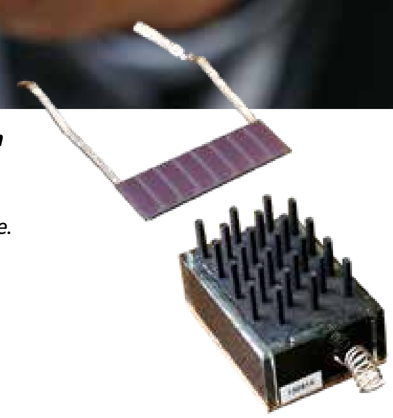
Brain functions change through repeated experiences



By using BRI to move a body that lost the ability to move, the experience that movement occurred returns to the brain as a skin and deep sensory response. It is believed that repetition of this will cause recovery and improvement of brain functions.

Next-generation stand-alone electrical power generated by transforming various forms of energy into electricity

Energy harvesting technology that produces electricity from familiar unutilized energy is garnering attention. An introduction to energy harvesting that is being increasingly used in various fields.



Vibration power generation
This is power generated using the vibrations from walking or riding on a bicycle. A flashing LED can increase visibility at night and result in the prevention of traffic accidents.

Generation devices and units
Top: *Photovoltaic cell modules, made by TDK Corporation, can even use indoor lighting to generate electricity, and are made and used in a variety of forms.*
Below: *Thermoelectric generation transmission units, made by Yamaha Corporation, contain a thermal electric generating device that generates electricity using the temperature difference between the base of the device and the surrounding temperature.*

Energy harvesting, an old yet new power generation technology

Energy harvesting technology generates power by using unutilized energy, such as light, vibrations, and waste heat. Its biggest difference with renewable energy like solar and wind power is the amount of power generated. For example, although power generation of thousands of kilowatts is possible with one turbine, energy harvesting can yield only microwatts to a few watts. Another difference is that energy harvesting can be used for stand-alone power, unconnected to an existing power grid.

Energy harvesting actually began in the early 1900s. The representative example is the crystal radio, operated solely through energy received from received radio waves.

Though the 20th century was the "age of electricity", energy harvesting technology did not spread much since the power necessary to operate one device was quite large. However, electricity requirements fell significantly with the "age of electronics" in the second half of the 20th century. Devices that energy harvesting previously lacked the capacity to power could now operate with just a small amount of power in the micro-watt to single-digit watt range.

Energy utilized in energy harvesting includes electromagnetic waves like visible light and radio waves, mechanical energy such as vibrations and thermal energy, and even the energy of living things. The combination of used energy and generation techniques can be utilized for stand-alone power generation in a variety of scenarios.

Achieving a society with convenience and safety in the near future through stand-alone power

Stand-alone power from energy harvesting has various merits, including eliminating or lowering the incidence of changing out batteries and making charging and wiring unnecessary. There are numerous examples of energy harvesting technology in use. The first is the safety device of fire shutters. Energy harvesting is performed through a device that, if something comes between the shutters, has a switch pressed and uses the generated power to temporarily reverse the shutter movement. This also avoids a situation in which the shutters can not move due to a dead battery.

Another example is the water-conserving automated faucets often seen on top of innovative Japanese toilets, which allow you to wash your hands in clean water that is then transported to the toilet tank to be used for the next flush. The power used for the toilet sensors and flush lever is generated from the water current that occurs when you flush. In addition, energy harvesting is used for light switches in Europe. The reason is that rewiring cannot be easily conducted in the continent's many stone buildings.

In the future, which areas can energy harvesting use be extended to? It's expected that it will be used in diverse fields including weather sensors in locations where it is difficult to supply electricity as well as electricity for measuring vitals like blood pressure and heart rate during daily life. For example, there is ongoing research into a method to power pacemakers using power generated from the movement of the human heart itself.

Energy harvesting enabling stand-alone electricity will also play a major role in advancing a trillion-sensor IoT (internet of things) society. We might not be far off from a world where a long-term energy supply is possible through harvesting energy from the nearby environment and converting it to power. SW

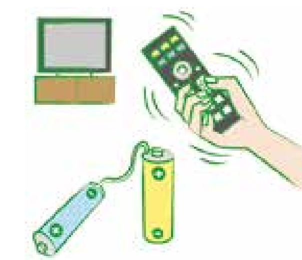
Energy harvesting examples

Automatic faucets
Charged using the electricity generated by the water currents during use; the motion detector and sensors turn the water lever.

Wristwatches
By improving performance, solar cell modules that previously took up a large amount of space can now be incorporated into the small area of a wristwatch dial and power the wristwatch.

Manholes
Power is generated from the manhole's day/night temperature difference and used to measure the sewer's water level.

Shutters
If a person gets caught within the shutters, the sensors perceive this and reverse the motor that powers the shutters.



Battery-powered generators
These incorporate vibration-powered equipment and a rechargeable battery in the battery case. Energy harvesting is thus possible even with equipment that is not directly compatible with energy harvesting.

Types of power generation by energy harvesting

Energy source	Generation method
Electromagnetic waves (Visible light, radio waves, etc.)	Solar power is a typical example of electricity generated using light. A rectenna (an antenna with a rectifier) is a device that captures electrical waves such as TV or radio waves and changes them into electricity.
Mechanical energy (Vibrations, etc.)	In addition to methods that use electromagnetic induction through magnets and coils in a similar way to a thermal power station, there are also techniques that use a piezoelectric element, which creates electricity through the application of pressure.
Thermal energy (Temperature difference)	This method uses a thermoelectric element that generates electricity when there is a different temperature on either side. A thermoelectric element uses a semiconductor and junctions of several different metals. It is also commonly known as a Peltier element.
Other (Bio-energy, etc.)	There are also methods of generating electricity by using the glucose within blood or the electrolytes in gastric acid and urine, or by using the osmotic pressure difference between salt water and fresh water.

Keiji Takeuchi

After graduating from Kyoto University's Graduate School of Engineering, Keiji worked at a think tank and then at the NTT Data Institute of Management Consulting from 2010. Centered on the communications field, he also has experience with projects in diverse fields including energy, public services, and e-business. He established the Energy Harvesting Consortium in 2010 and aims for swift utilization and implementation of energy harvesting.

Iki City, Nagasaki Prefecture

A remote, bountiful island attracting businesses and young people through the ideas of islanders

Iki City, located on one of the remote islands of Nagasaki Prefecture, Japan, is tackling its issues of population decline, low birthrate, aging islanders, and lack of successors for its industries by starting diverse initiatives founded on citizen dialogue and exchanges with people from off the island.

A far-flung island facing a lack of successors

Iki City is a remote island located in the Sea of Japan, in the north part of Nagasaki Prefecture. It is facing a low birthrate, aging population and population decline. Its population of 26,857 as of March 31, 2018 is expected to fall to 18,000 by 2040. Kazunobu Ogawa, who works on policy planning at Iki City Hall, explains, “Although there are two high schools on the island, about 90% of the graduates leave the island to pursue higher education and employment.”

In order to improve this situation, the Population Vision and General Strategy for Overcoming Population Decline and Vitalizing Local Economy in Iki City was established in 2015. With it the city aimed to revitalize industries, improve PR, and increase its exchanges with people off the island. Its major goal is to maintain a population of 18,000 through 2060 by offering support for people from off the island to move there and receive child support, as well as industry promotion for agriculture, fisheries, and more. Ogawa adds, “So what could we do to accelerate what the city has already undertaken? We focused on the Sustainable Development Goals, for which the national government is supporting municipalities.”

**Sustainable Development Goals (SDGs): 17 goals and 169 targets advocated by the United Nations to realize a sustainable world.*

Considering Iki in 2030

Iki aims to realize its Iki Lively Interactive Society “Chic Society 5.0 in Iki” by 2030. The city has been conducting international trade since before 2000. It is now promoting exchanges with people off the island through dialogue. It aims to create an “interactive society” through increasing opportunities for exchange.

Ogawa explains, “First we are eliminating primary industry problems through advanced technologies like the Internet of Things (IoT) and AI. We are also thinking of creating a system for electric vehicles to automatically transport crops and enable senior citizens to freely move about the island. We are further advancing the introduction of clean, sustainable, natural energy, incorporating diverse wisdom from off the island, and creating a strong island unafraid of progress and change. This will be Iki in 2030.”

**Society 5.0: the new society that resolves social issues through AI, IoT and robots, following on from the hunting society (1.0), agricultural society (2.0), industrial society (3.0), and information society (4.0).*

Increasing the appeal of primary industries through advanced technology

Comprehensive economic, social, and environmental initiatives are necessary for realizing Iki’s aims for the SDGs. “First, regarding economic initiatives, by introducing advanced technologies to primary industries like agriculture and fisheries, we are increasing the transparency of all industrial processes and aiming for efficiency and zero waste. We can foster successors by passing on specialized techniques to the next generation. We are also increasing the appeals of primary industries by raising their productivity and earning power.”

Social issues on the agenda include the low birthrate and aging population. Islanders are conducting lively interactive exchanges, and based on citizen-focused communities are nurturing IoT-savvy human resources who can leverage smart agriculture and manufacturing transparency. Through this, there are more exchanges between people on and off the island and more people moving to the island itself.

Iki has unique environmental issues as a remote island. Because the city’s electricity is not connected to the mainland, it generates power from two internal combustion power plants. Michihiro Shinozaki explains, “Because energy becomes increasingly necessary as digitalization advances, environmental awareness among the islanders is increasing regarding next-generation energy and energy conservation.”

Cultivating asparagus using advanced technology

Iki will carry out a demonstration test on cultivation, transport, process transparency, sales, and increasing demand for its asparagus that has great value as an agricultural commodity. It was found that rather than expanding cultivated land area, people who engage in agriculture want to be able to take breaks and ensure they have time for their hobbies, childrearing, and regional exchange outside work. As a solution to reduce working hours, the city decided to collaborate with OPTiM Corp., a company that leverages IoT and AI for agriculture.

At the demonstration test they plan to employ the “remote work support service” streaming real-time images of farmlands enabling the transmission of specialized techniques to the next generation, and the “house information management service” to accurately assess water and fertilizer amounts as well as scattering schedule in houses where asparagus is cultivated.

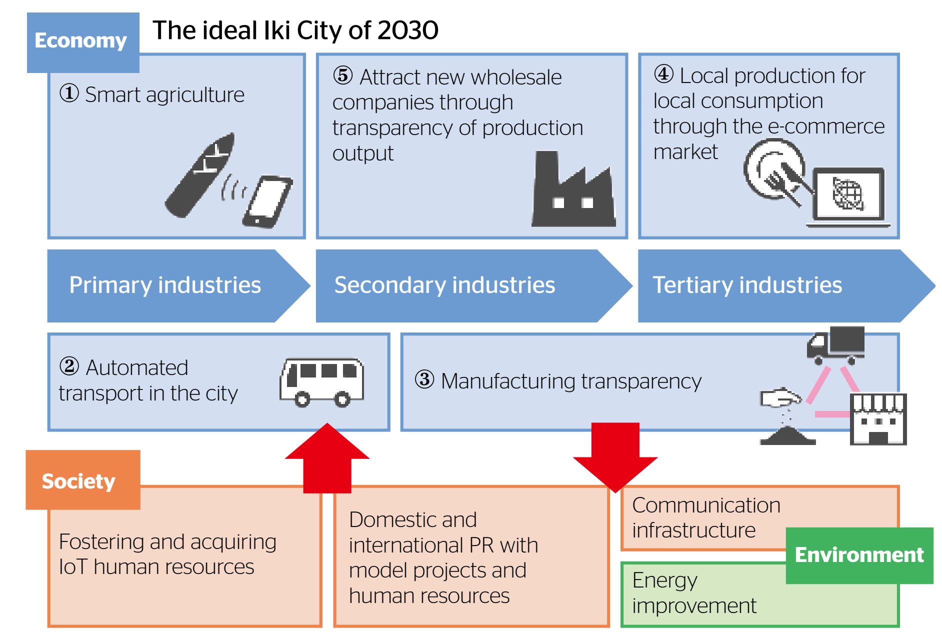
PR communicating Iki’s projects as a model for revitalization of remote islands

Iki aims to communicate to the world the results of its initiatives to tackle the issues that arise on a remote island. It is collaborating with Global Compact Network Japan (GCNJ), the Japanese organization of the United Nation’s Global Compact, which works on building frameworks to realize sustainable growth by companies and organizations. While communicating its initiatives, Iki will undertake exchanges and mutual study with municipalities and regions around the world that face the same issues and work on similar projects. sw

Opposite, *Tatsunoshima Island (Photo: Iki City)*

Providing agricultural skill advice in remote lands ***(right)*** *while monitoring the harvesting situation through a surveillance camera* ***(below)*** *(remote work support services). (Photos OPTiM)*

The ideal Iki City of 2030



Kazunori Ogawa, Iki City Hall

Michihiro Shinozaki, Iki City Hall

Issei Shinohara, Iki Miraizukuri Site

Discovering new value in Japan's *satoyama* habitats, where people and nature coexist

As Professor Izumi Washitani of Chuo University explains, "Today's nature incorporates the complexities of both the natural and human worlds." Following her experience researching ecosystems all over the world, ***Professor Washitani*** *has rediscovered afresh the richness of Japan's natural environment. Amidst the loss of many valuable ecosystems in recent years, the connection between humankind and nature is being re-examined from a new perspective.*

Increasing diversity through human intervention

How interested are you in the nearby natural environment? Like many countries, the islands of Japan are rich in diversity of life with plenty of environments in which to enjoy natural wonders.

History shows that humans have always lived using nature. The Japanese concept of satoyama as a cultural landscape refers to grasslands and forests used to gather resources close to areas inhabited by humans. Satoyama habitats make up one quarter of Japan's landmass. Satoyama extend over a mosaic of diverse environments including paddy fields, water areas like reservoirs, and copses. The varying environments serve as habitats of diverse living things. Humans use satoyama to gather resources like firewood and edible wild plants, and have intervened to shape satoyama environments to make them easier to use. Moderate human intervention actually helps ensure the diversity of living creatures.

For example, there is a satoyama called Sennen no Sougen at the base of Mount Aso in Kumamoto Prefecture containing a grasslands area, forest and paddy field. Two pastures with nationally owned livestock at the foot of Mount Aso were managed as national projects.

The grasslands necessary for raising horses are not naturally formed, but rather created through human intervention and protected with periodic maintenance. Satoyama once had a direct connection to each individual's economic activities, be it planting crops, raising livestock or gathering firewood. However conditions changed once Japan entered the period of rapid economic growth following World War II, and the economic value of satoyama began to dwindle.

Many paddy fields, which are a vital component of satoyama, had their irrigation ditches covered with concrete and lost their function as places for living things to inhabit and grow. Non-native invasive species began to spread diseases due to environmental changes such as imported grass introduced for mechanical work occupying footpaths between rice fields, and eutrophication caused by excessive use of chemical fertilizers. The rich diversity alive in satoyama began to disappear.

As satoyama diversity continued to dwindle, areas which for so long had cultivated coexistence with human life, a movement emerged to rediscover the new value of natural diversity. Although there was practically no change in the prioritization of economic considerations, the movement calls on people to recognize the importance of observing and paying attention to nature.

Wisdom gained from studying living things

Since life began on Earth, living things have evolved to adapt to their environment. They are the products of time and diversification in order to survive. Ecosystems today are the result of about 3.5 billion years of trial and error since the beginning of life itself. There is much wisdom to be had here, and much that we should study. For instance biomimicry, the study of creating new technologies by mimicking the functions of living things, has garnered much attention in recent years.

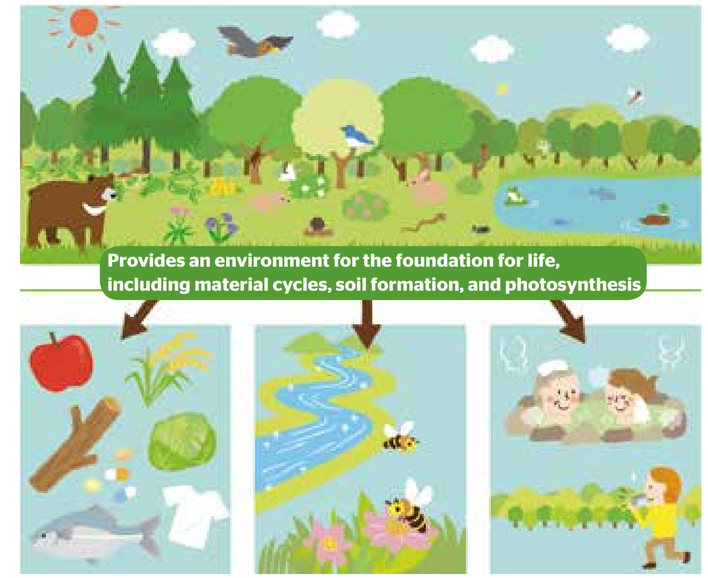
With the last 200 years of modernization, the risk of extinction for various species has grown dramatically. Now is the time to clearly understand the importance of biodiversity, a treasure trove of wisdom, and we must pass these values onto the next generation. Conservation and restoration of nature are necessary for this, and we must increase our knowledge, understanding, and awareness of satoyama and other related matters.

Natural history is a focus of education in the United States and Europe, particularly the United Kingdom. All society supports conservation of biodiversity and initiatives there are making progress. Recently "citizen science," in which the public participates in scientific monitoring, has become popular with many active volunteers.

My laboratory also places high importance on citizen science and undertakes research in collaboration with informatics researchers for a monitoring program on butterflies in Tokyo and storks . Scientific understanding gained through monitoring data leads to policies and proposals. I have high hopes for the spread and development of citizen science. SW

Photo: Izumi Washitani

The diverse benefits of biodiversity



Provides directly usable materials like food and ingredients.

Provides natural adjustment functions such as water purification and pollen intermediaries.

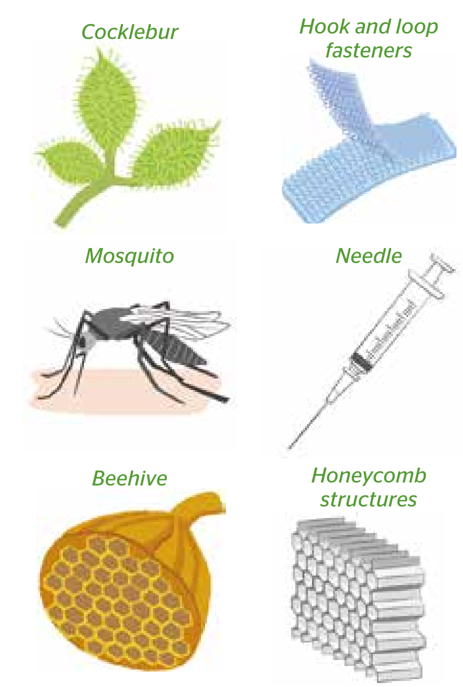
Provides cultural and psychological benefits such as entertainment and leisure.

Satoyama near Tsukizaki, Ichihara-shi, Chiba
Satoyama are regions of mountains or forests that are used partly by humans.
A patchwork of various environments such as rice paddies, reservoirs, and woodland.

As satoyama lose their direct connection to economic profit, she believes it is important to ascertain and leverage more diverse values through culture and education.

Izumi Washitani

Professor at the Chuo University Faculty of Science and Engineering, and Professor Emeritus of the University of Tokyo. Together with extensive research regarding conservation and restoration of biodiversity in satoyama and water areas, she also works on diffusion activities and contributes to the preservation of regional biodiversity and ecosystems.



Biomimicry

The structure of cockleburs that makes them stick to clothing inspired Velcro and other fasteners, while painless needles were inspired by the mouthparts of mosquitos that discreetly pierce flesh. The structure of a beehive has also inspired stronger building construction. In this way, technology in various fields has been created through hints from living things.

Food connects the world

What can science do for the future? What can we do?

Those inhabiting developed nations tend to worry more about menu choices than the threat of starvation. But why are there countries with an abundance of food and other countries without?

The mechanisms behind starvation

Present-day starvation occurs in areas where the land itself makes daily food production difficult, but there are also cases where civil wars, climate change, abnormal weather and other factors can limit food production. For these food shortages due to sudden causes, the problem should be solvable by transporting food from other regions.

Although it is now a developed nation, Japan has in fact experienced famine in the past. During the Edo period (1603–1868), 1 million people died of starvation. In present-day Japan, starvation is no threat even if rice crops fail. For example, there was a shortage of rice in 1993, but government measures brought in emergency rice imports. Thanks to these imports and substitutes including bread, not a single Japanese person starved. However there are still many countries and regions that do not have the luxury of such a social system. Thus, when hit by drought, disease or pests, their people can do nothing but starve.

Food inequality creates conflict

Carefully studying the volume of food produced in the world today shows that we produce just enough across the globe to support all of humanity. It has been calculated that if the food produced around the world was equally spread among its people, there would be no more starvation on Earth. However, this is not yet happening.

In developed countries, we tend to think that if we lack food we can simply buy it, but if we do so, then countries that do not have that ability may express resentment. In fact, because Japan imported large quantities of rice from Thailand during the rice shortage of 1993, the price of rice in Thailand increased and there were deaths from starvation among its poorer people.

Due to its different taste and being considered overly fragrant, Thai rice was not popular in Japan and there were cases where rice was thrown away as industrial waste after the shortage had been resolved. There was a backlash from Thailand and relations temporarily deteriorated. Food is, after all, a life and death matter. Feelings of resentment were strong, and afterwards drove cracks into relationships with a variety of other countries.

Starvation changes people's ways of thinking and their behavior. If it means their families will live longer, people no longer balk at the crime of stealing food from a stranger. In regions that commonly suffer from starvation, public security deteriorates, and that instability is linked to civil wars and conflict.

The importance of nutritional balance

Agronomists such as Dr. Norman Borlaug, who led the "Green Revolution," carried out research and developed high-yield grains to try and eliminate starvation around the world. As a result, they succeeded in reducing the number of starving people.

However, even if there is enough food volume in terms of calories, by looking closely at the content of their food we can see clearly that there are a lot of people whose nutritional intake is becoming severely imbalanced. Lacking essential nutrients like vitamins, the number of people suffering from health problems has reached 2 billion.

Increased production of principal grains such as wheat, rice, and corn has been achieved through the cooperation of many agronomists, and they can now be supplied cheaply. Yet the supply of other crops has not substantially improved. The principal grains have become able to fill people's stomachs at very cheap prices, but as a result there are many people whose nutritional balance is deteriorating.

Different activities carried out by the Japan International Research Center for Agricultural Sciences (JIRCAS). *JIRCAS is the only institution in Japan that researches agriculture, forestry, and fisheries in the tropics and developing regions. Being able to stabilize food production overseas will also lead to political and economic benefits for Japan.* (Photos: JIRCAS)

Left, top: *People in Africa are aiming to increase rice production. Production technology and crops that can be grown reliably even in the dry, minimally fertile environment of the tropics are being developed.* ***Right, top:*** *Aquaculture techniques that have been used in combination with multiple living organisms are being trialed in the Philippines. They are to prevent environmental degradation such as eutrophication caused by the coexistence of milkfish, edible sea cucumber, and seaweed.* ***Left, bottom:*** *Cowpea in Nigeria. These have been bred to be strong for plentiful harvests, but in recent years a further increase in product value has led to a demand for higher-grade varieties.* ***Right, bottom:*** *Planted forests with native tree varieties in Southeast Asia. Techniques for cultivation, resource management, and lineage selection are being developed, and excess deforestation is being prevented, thereby improving productivity in farming and mountain villages.*

What Japan can do today

The world's population is continuing to increase. By 2050, we will need a food production increase of 60% or more over today's levels. Though we have a history of continuously cultivating more and more land, the total area has not increased since the 1960s. There is no more land into which we can expand.

Therefore, in order to increase food production, we need to combine a variety of techniques, including: developing cultivars that are resistant to climate change, dryness and salt damage; developing measures against disease and pests that do not rely on agrochemicals; maintaining and increasing soil fertility; developing cultivars with high nutritional value; improving the efficiency of water use; developing food storage and processing techniques; and developing techniques to reduce food waste. The effects of each of these may be small, but it is vital that we realize a food supply with both enough calories and nutritional value by combining these many techniques together.

Fortunately, Japan possesses advanced agricultural technologies. It can therefore play an important role in ensuring food supply stability and subsequently peace in our highly interconnected world. sw

Masa Iwanaga

Masa Iwanaga was born in Nagasaki Prefecture, Japan in 1951. After working in various international organizations, including the International Potato Center (CIP) and the International Center for Tropical Agriculture (CIAT), he became the first Asian to be appointed Director General of the International Maize and Wheat Improvement Center (CIMMYT) in 2002. Since 2011, he has served as President of the Japan International Research Center for Agricultural Sciences (JIRCAS).

On the front lines of disaster prediction

Being able to forecast when and where a natural disaster will occur can considerably curb the damage it will cause. Here we take a look at some of the front-line research that is attempting to anticipate various natural disasters.

Discover the BALANCE for the Future

Announcing the definite, not possible, arrival of a tsunami

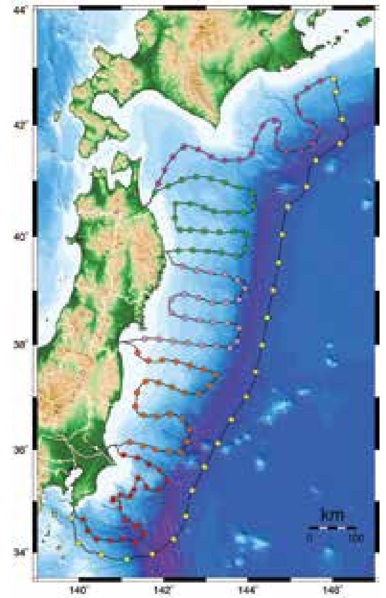
(National Research Institute for Earth Science and Disaster Resilience (NIED))

During the 2011 earthquake that occurred off the Pacific coast of the Tohoku region, the actual tsunami that hit the area was larger than the height predicted and announced by the Japan Meteorological Agency (JMA) directly after the earthquake struck. In addition, since only the height of tidal waves near the coast were being observed, it took some time for the JMA to realize that a huge tsunami was in fact approaching. These and other factors delayed the evacuation of the area and resulted in an immense loss of lives.

This led the National Research Institute for Earth Science and Disaster Resilience (NIED) to develop a Seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net), which can directly observe tsunamis that occur off the Pacific coast of east Japan. It uses sensors placed in ocean areas prone to tsunamis, and can accurately and quickly notify authorities when a tsunami is forming.

S-net can also ascertain how the tsunami is expanding minute-by-minute. By using this tsunami information taken directly from the ocean, and combining it with accumulated data on various tsunami patterns from the Tsunami Scenario Bank, it will be possible to more accurately forecast earthquake information such as the regions where the water will retract as a tsunami approaches.

The 5,500km-long S-net can rapidly detect earthquakes in around 30 seconds, and tsunamis in about 20 minutes.



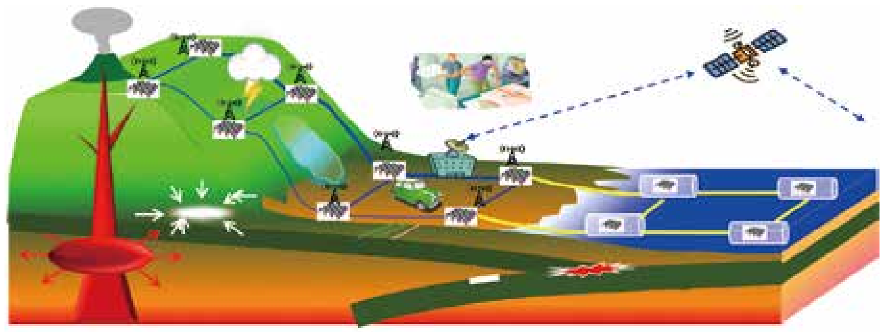
Ascertaining space-time distortion using an ultrahigh-precision clock

(School of Engineering at The University of Tokyo, and the Katori Quantum Metrology Laboratory at RIKEN)

The Theory of Relativity states that a clock ticks slower by gravity. For example, if you place two clocks above ground at a height difference of 1 cm, the two clocks tick differently. However, this difference is “1 quintillionth of a second” per second and scientists haven’t been able to measure this time lag on any existing clock.

University of Tokyo professor and RIKEN chief scientist Hidetoshi Katori and his research group have developed two strontium optical lattice clocks that can match their frequencies to an accuracy of 1 quintillionth. These ultrahigh-precision clocks can detect height differences of 1 cm through frequency differences. By building a network consisting of these ultrahigh-precision clocks scientists will be able to not only achieve extremely accurate time synchronization, but also potentially use them to observe movements in the earth’s crust such as volcanic activity and plate movements and in various other applications.

Building a network of lattice clocks for extremely accurate time synchronization. *(Image: Katori Laboratory)*



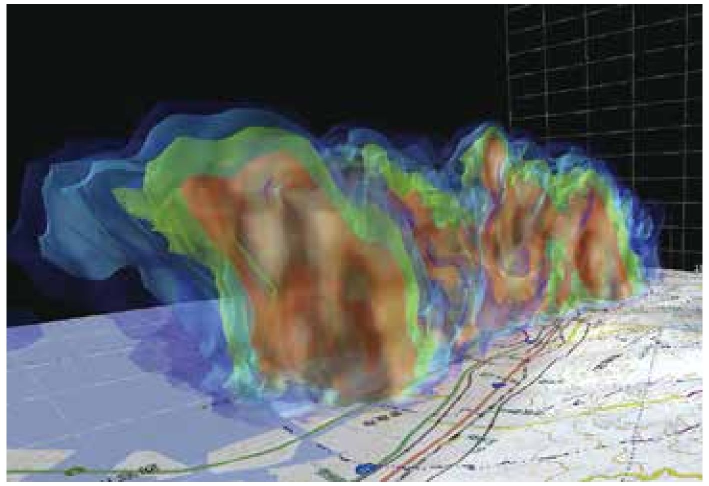
Predicting sudden heavy rainfall using the K computer

(Data Assimilation Research Team at the RIKEN Center for Computational Science (R-CCS))

It is difficult to predict when sudden heavy downpours will happen because there is only a short time from when the cumulonimbus clouds that cause such rain are formed until rainfall. The current weather forecast system uses airspace, which is divided into 2 km meshes in all directions, to calculate and forecast climate changes based on hourly data. However, even more precise analysis is required to predict when unexpected torrential rain will occur.

Leader of the Data Assimilation Research Team (DA team) at the RIKEN Center for Computational Science (R-CCS) Takemasa Miyoshi and his colleagues have developed a new calculation method using highly precise simulations done on the K computer, based on vast amounts of information from high-speed, high-density radars developed by the National Institute of Information and Communications Technology (NICT) and Osaka University.

Using 100m meshes and data taken every 30 seconds, the DA team was able to successfully recreate in detail the movements of an actual sudden downpour. There are high hopes this method will be used to conduct unprecedentedly precise analysis.



Example of a simulation of unexpected torrential rain; the stronger the rainfall, the deeper the red on the screen.
(Image: RIKEN)

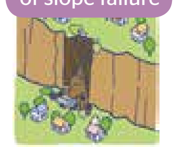
Using tweets to mark signs of landslide disasters

(Sabo Department in the National Institute for Land and Infrastructure Management (NILIM), at the Ministry of Land, Infrastructure, Transport and Tourism (MLIT))

Landslide disasters are difficult to predict, occurring not only with high rainfall but also because of the soil condition and topography, vegetation and a combination of several other factors. Though there are some advance warnings that indicate when a landslide will occur, such as the sound of the ground rumbling and an earthy smell, nearby residents often don’t report them so this information has not been used effectively in disaster prevention. However, the spread of social media has made it easier for residents to send out and share information via tweets and other SNS regarding advance warnings and other strange occurrences around them. The National Institute for Land and Infrastructure Management (NILIM) at the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has analyzed this information and confirmed its potential usefulness in disaster prevention.

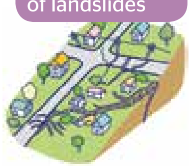
Analyzing this information involves collecting and analyzing tweets that include the keyword of “disaster,” and combining this data with weather information and real time monitoring and observation data from sensors placed near landslide areas and elsewhere. It is expected this type of analysis will make it possible to forecast the occurrence of landslides with a higher level of accuracy.

Warning signs of slope failure



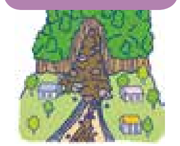
- Small rocks fall in a scattered way
- Cracks become visible in the cliffs
- Water gushes from the cliffs
- The gushing water stops or becomes muddy
- Sound of the ground rumbling

Warning signs of landslides



- Cracks appear in the ground and it starts to sink
- Cracks and unevenness appear in buildings and other structures
- Trees start to slant to the side
- Water gushes from the sloping ground
- Water in wells and swamps become muddy
- Sounds of the ground and mountains rumbling

Warning signs of earth and debris slide



- River water level sinks
- River water becomes muddy and contains pieces of driftwood
- Sound of the mountains rumbling
- Sounds of trees cracking and rocks crashing into each other
- Smell of rotten earth

*Prepared by the editing department using diagrams and charts from the Government Public Relations Office of the Cabinet Office.

Deepening the connection between **science** and **society** and shaping the **future**

ALIVE WITH EXCITING PROJECTS.
SCIENCE AGORA 2018
https://www.jst.go.jp/sis/scienceagora/en/
November 9–11, 2018
Telecom Center Building and Miraikan (Odaiba, Tokyo)

Science Agora is an open forum that aims to deepen the connection between science and society through discussions held by diverse participants including the general public, researchers, specialists, media personnel, industry representatives and government officials. JST holds the Science Agora under the vision of "a future woven through dialogue between science and daily life." It was held for the 13th time in 2018.

Various exhibits and sessions sparked thought on how to adopt science and technology to enrich each of our lives and what we can accomplish with science and technology, while overcoming barriers between academic fields and people with different social, national, cultural, or generational backgrounds. Here we will introduce two of the projects implemented at the Telecom Center Building on November 10 and 11 from among the total of 120 programs.

**Agora means "public square" in ancient Greek.*

Programming Pepper with performers from Yoshimoto (Provided by Yoshimoto Robotics Laboratory)

Try programing **Pepper** the robot with a quiz about the **SDGs**

Exhibit title: ***Yoshimoto Robot Programming Workshop for SDGs***
Exhibitors: ***Yoshimoto Robotics Laboratory and the Secretariat of Science Agora***

Yoshimoto Robotics Laboratory holds its Pepper Programing Workshop at many different events. The workshop fosters problem-solving abilities, logical thinking and creativity through programming a robot, Pepper, to conduct various actions and conversations.

At Science Agora, the workshop involved programming a robot with a quiz about the Sustainable Development Goals (SDGs). Participants thought of correct and incorrect answers for the SDGs quiz and programmed them into Pepper. It became an excellent opportunity for children to take an interest in the SDGs, important targets to ensure humankind's continued existence on Earth.

Thinking about the **future** of regional communities leveraging **drones**

Exhibit title: ***Drones Linking Us to the Future***
Exhibitor: ***KEIO Research Institute at SFC, Consortium for Co-Creation of Drone Collaborative Society***

Researchers from many different fields participate in Keio University's Consortium of Co-creation Drone Society. Predicting that in the near future drones will be used as tools in our everyday life, the consortium conducts technology development as well as activities toward drone education and implementation in society.

It is now expected that drones will be utilized for aerial photography, spraying agricultural chemicals and luggage transportation. Going forward they will also be used during disasters and will probably transform industrial concepts. At the workshop it was discussed how we should solve regional issues through the use of drones. Following the discussion, participants could experience automated drone flight programmable by tablet.


From the 2017 exhibit "The First Drone"

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