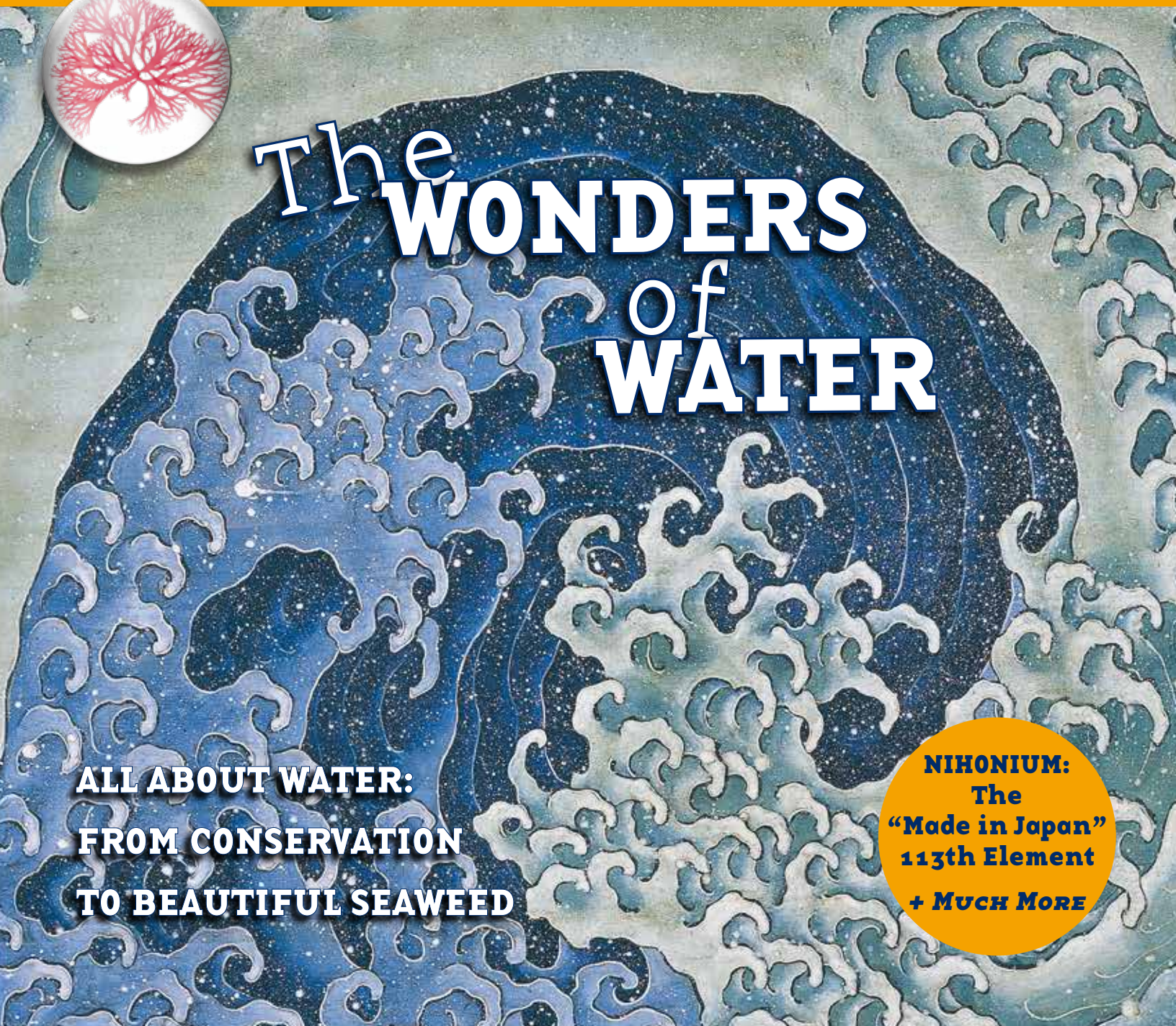
2018 SPECIAL ENGLISH EDITION

A Magazine from Japan

Science Window



The WONDERS of WATER

ALL ABOUT WATER:
FROM CONSERVATION
TO BEAUTIFUL SEAWEED

NIHONIUM:
The
"Made in Japan"
113th Element

+ 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 wonders of water 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.

Yuko Hiratsuka
Editor in Chief, Department for Promotion of Science in Society
Japan Science and Technology Agency

Japan Science and Technology Agency

Science Window
Spring 2018
Special Issue - English Edition vol. 7
President: Michinari Hamaguchi

Editors: Fumi Hayano, Shigemi Sasa
Production: Urban Connections
Cooperation: Bunkakobo, inc.

Shiho's Seahorse

Japanese Name:
Hanatatsu
Scientific Name:
Hippocampus Sindonis

The hanatatsu seahorses entangle their long, slender tails around coral branches to prevent themselves from being washed away in the current. Although they might not look it, hanatatsu are actually fish! They belong to the Syngnathidae family of fish that includes other seahorses and seadragons. Each hanatatsu has a unique appearance, with different patterns and colors variations of yellow, red, and brown. They also have different bumps on the head and varying protuberances on the body. What they all share is a camouflage ability that allows them to melt into their environs.

Hanatatsu are distributed throughout the waters of Japan's central Honshu area to the southern island of Kyushu. They meld into the beautiful fan corals and seaweed to the delight of divers. Seahorses are interesting to watch because they live their lives keeping their heads held high. They appear to stand as they move about by following the currents. Instead of scales like other fish, bony plates cover their bodies and give them a distinct angular appearance. They eat by sucking up plankton and other creatures through their long, tube-like mouths.

The hanatatsu in the lower left of the picture is sporting a big belly. Instead of a large meal, he is actually showing signs of the unique reproduction method of the seahorse. The males all have a pouch on their bellies into which females deposit eggs. The eggs are fertilized in the male's pouch, and after hatching the male watches over them until they are able to feed themselves as fry. When the young fry are finally released from the pouch, it remarkably looks like the male is giving birth.

The picture shows several hanatatsu exhibiting various characteristics. How many do you see? The answer might surprise you! Find out on page 13. **sw**

Cover Art:
Feminine Waves – One panel of a diptych ceiling painting for the Kammachi festival float
Katsushika Hokusai
Katsushika Hokusai (1760-1849) is known around the world for his woodblock print series *Thirty-six Views of Mount Fuji* and the *Hokusai Manga*. His work has had enormous global influence, including on Impressionists such as van Gogh and Monet.

Management: Hokusai-kan
Ownership: Kammachi Residence Association of Obuse Town

Illustration: Junichi Yamada

A collection of sea squirts, coral, and sea anemone that appears almost like a fruit tart (Komodo, Indonesia)

Gifts of the Ocean

*The ocean is a place where countless unimaginable miracles happen. **Yasuaki Kagii** is an underwater photographer who has long captured not only the vibrant colors of the ocean in photographs much like paintings, but also an almost spiritual beauty. We asked Kagii to tell us his impressions of the ocean, which he photographs by waiting patiently for the right opportunity rather than risking its capricious nature.*

Though I originally had no connection whatsoever with photography or the sea, I developed an interest in underwater photography while a student in university. This happened when I encountered an exhibit by underwater photographer Katsutoshi Itoh that just happened to be held in his neighborhood. Suddenly overwhelmed with a desire to take similar photographs, I practically forced Itoh to mentor me. Since then, I have photographed oceans throughout the world for over 25 years.

An entirely different world is found underneath the waves than the one on land. Anyone can encounter the wonders of the ocean, even without special equipment like diving gear. For example, numerous life forms can be observed in the small puddles formed in indentations on the rocky shore. While these creatures will typically disappear and hide the moment you approach, they and others will show themselves again if you wait patiently.

I grew up in Kawanishi City in Hyogo Prefecture, an area of abundant nature. I would often gaze on the cherry blossoms at shrines and watch the vivid sunsets, which taught me the beauty of nature. It is impossible to take beautiful photographs until you are able to truly understand the intrinsic beauty of things. This sense is what motivates me as I pursue the dynamic colors of nature's lifeforms.

But I was unable to do that when I saw the conditions under the waves after the Great East Japan Earthquake and tsunami in 2011. Though the sea should have been full of life, I could find almost nothing there except for a few sea urchins. This has led me to strive to photograph with even greater consideration for never harming nature.

Luckily, when I dove just eight months after the earthquake, I saw greenling fish return to the area and start breeding and laying eggs again. Thus the cycle of nature had restarted. I believe the ocean was greatly regenerated by two years after the earthquake. I realized the ocean is so powerful that it was almost presumptuous for us humans to be so concerned.

It is actually only possible to dive in a very small portion of the vast ocean. When I face the ocean, I am overcome with humility and realize the smallness of my existence. The ocean always exceeds our imagination. **sw**

Yasuaki Kagii

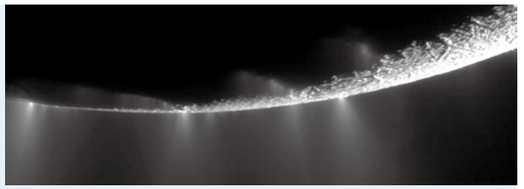
Yasuaki Kagii is an underwater photographer and head of Clé et Photos. He has won numerous awards, including a Nikkei National Geographic Photo Prize Award for Excellence (2013). His many published photo collections include *Kaichusanpo*, *Irodorinoumi*, and *Yukainaosakana* (all published by PIE International).

Threadfin anthias fish swim in front of a sea fan sharing similar colors (South Leyte, Philippines)

Photos: Yasuaki Kagii

Sea of Life

*The theory that the very first life on earth was born in the ocean is widely accepted. How was life first generated near the seabed in the hot deep sea? We asked **Dr. Ken Takai**, a researcher on microorganisms at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), for the answer.*



Oceans and life in the solar system

In the spring of 2017, NASA announced to great excitement that life may exist on Enceladus, a moon of Saturn. Because the tidal forces felt by the moon from massive Saturn change drastically according to the moon's orbit, warping and heat occurs within, and this is thought to have formed an ocean under the moon's ice.

It was found that organic matter exists in the gasses ejected from the sea inside Enceladus, and that there are currently active hydrothermal vents. If this ejecta can be analyzed in more detail, many things might be learned about the origin of life in the universe, including that of life on Earth. (Photo: NASA JPL-Caltech/Space Science Institute)

"Why did life first emerge in the oceans? To us this is not strange; we feel that it is natural."

Roughly 4.6 billion years ago, the newborn earth was still generally hot, and parts of it were still much like a molten mush. Then, by 4.4 billion years ago, conditions had cooled enough for there to be liquid water. By 4.2 billion years ago, that water began to evaporate and fall as rain, causing a great deal of precipitation to fall on Earth's hot crust. This is how the oceans were formed, mixed with many elements leached from the rocks. At the time, the rock had solidified from its melted state in such a way that the earth must have been generally flat. Thus without any large protruding land masses, the entire earth become covered in ocean.

"But when did life arise?" The oldest trace found yet is a fossil from Greenland dating from around 3.85 billion years ago. Specifically, mineral traces of life were found in graphite, a form of carbon, and this type of fossil is called a chemical fossil.

Accordingly, it is likely that the first life emerged on Earth about 4 billion years ago. At the time, there was nothing but ocean on the Earth.

A focus on metabolic activity

What was the very first life like? To answer this question, Takai is focusing on the metabolic activity of organisms. The metabolism is the network of chemical reactions occurring inside organisms using materials taken in from the outside as constituents.

"We believe that a system of reactions similar to a metabolism emerged naturally in the hot water. For example, oxygen is formed from carbon dioxide and hydrogen in the ocean, and then a metabolic system in the form of a citric acid cycle is formed from the oxygen. We believe that if this metabolic system is maintained in a hot water environment, then the necessary building blocks for life will be created."

If the metabolism is seen as the essence of life, then life at this stage could be called, for lack of a better term, "metabolic life". In the hot water environment of the deep sea, there was just the right amount of energy flowing in the form of heat, and there were ample minerals leached from rocks. This was then maintained over a geological span of time.

"As this metabolic activity was repeated over and over again, numerous substances were created, which created the foundations for life. We believe that DNA was later formed and began to fuse together."

Two ways to investigate the origins of life

When biologists research the origins of life, they take the approach of following the history of life backwards. When this research is done by chemists, they recreate the Earth's environment in their laboratory and look for the process by which life arises from basic chemicals. "However, if you really think about it, you cannot say that the life found through these two methods is the same."

The biology approach is to find a set of shared genes by examining the DNA of a vast number of organisms in order to find the last universal common ancestor (LUCA). It has been learned that that ancestor was a microorganism similar to the methanogens and acetobacter of today.

With the chemistry approach, it has been learned that such life functions as propagation and metabolic activity can be recreated by starting with some simple chemicals. However, there may be more than one correct path to achieve this. This is because scientists have not eliminated the possibility that something similar to life might still be generated even when the experimental conditions and steps are different.

Takai stresses that in order to discover the origin of life, the LUCA organism sought by biologists must match a single path from among the many found by chemists.

"But in fact, nobody had pointed this out yet. It only began to be discussed recently since the academic field of astrobiology was created."

There are planets and moons with numerous different environments in our solar system, and there is much we can learn by comparing those to Earth.

"If we find life or evidence of life on planets and satellites with oceans, and fail to find it on planets with no oceans, we would learn that an ocean is a requirement for the emergence of life after all. In other words, we need to look to space in order to know the origins of life, though that may seem like a roundabout way to do it." **sw**

Ken Takai

Dr. Ken Takai is the head of the Department of Subsurface Geobiological Analysis and Research at the Japan Agency for Marine-Earth Science and Technology. He is also a fellow of the Earth-Life Science Institute of the Tokyo Institute of Technology. His specialties include Earth microbiology and astrobiology.

The Beauty of Seaweed and the Power of the Sea

*Seaweed is a crucial ingredient in a wide variety of Japanese dishes, but we are not often able to see living seaweed in its natural ocean environment. **Michiyo Noda**, Chairperson of the Kaiso Oshiba Kyokai (Pressed Seaweed Association) explains, "Just like there are verdant green forests on land, there are beautiful forests woven from colorful seaweed within the ocean." We visited the pressed seaweed class taught by Noda to interview her.*

The role of seaweed

The cheerful greetings of the children echo through the classroom. There are 23 children, all 5th grade elementary school students, responding to Noda's greeting at the pressed seaweed class.

The class is split into two halves. The first involves watching videos of seabed forests to learn the importance of seaweed, while in the second, the children create postcards using pressed seaweed. First, Noda asks the children to name the seaweed they can identify using a quiz format. There are fewer answers than expected, though the children did come up with *wakame*, *konbu*, *mozuku*, and *nori*, which are all used in popular Japanese food such as miso soup and sushi.

She then asks them how many different types of seaweed there are in all of Japan. Though the answers ranged from 40 to 150, the correct answer is 1,500 types. Many of the children are surprised by this number. It is said there are about 10,000 types of seaweed throughout the world.

Next the children are shown full-size seaweed specimens and pressed seaweed artwork before watching a video showing ocean forests. The children learn how seaweed supports our daily lives by maintaining the environment, such as by carrying out underwater photosynthesis and maintaining the food chain, nurturing numerous life forms, and purifying the seawater.

The children instinctively sit up straight when the teacher points out, "So it would be a disaster if we destroyed the ocean forests by contaminating the water too much, wouldn't it?" The course contains numerous techniques, such as quizzes and video, to enable the children to study the environmental problem and its background in a scientific manner.

Seaweed's power for the global environment

The Pressed Seaweed Class emphasizes learning the role and importance of seaweed in addition to enjoying creating artwork.

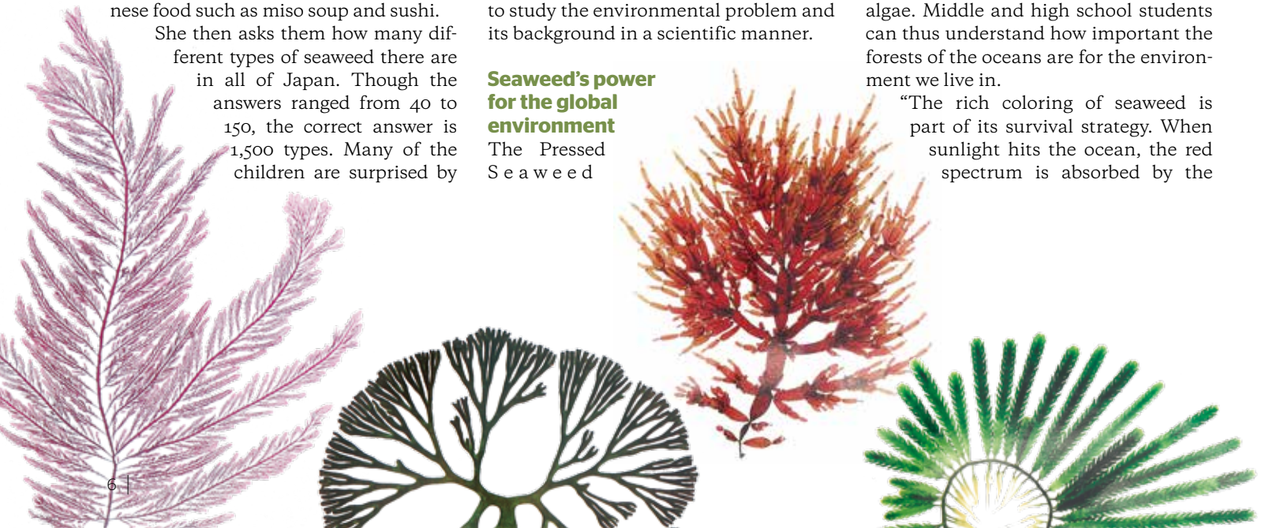
Depending on the age of the participants, there are times when the course discusses different topics than are taught to children, such as the importance of seaweed in the history of life on Earth.

Seaweed is generally algae large enough to be visible to the naked eye. Algae is a group of organisms that performs photosynthesis underwater to produce oxygen. When algae began producing oxygen through photosynthesis, oxygen was released into Earth's atmosphere causing the formation of the ozone layer. This enabled the blocking of the majority of the harmful ultraviolet rays.

In other words, the very foundation of Earth's environment was created by algae. Middle and high school students can thus understand how important the forests of the oceans are for the environment we live in.

"The rich coloring of seaweed is part of its survival strategy. When sunlight hits the ocean, the red spectrum is absorbed by the water while blue light is dispersed and disappears, allowing only light in the green spectrum to reach the furthest depths. Accordingly, the red coloration of seaweed, for example, assists in the photosynthesis process when absorbing light in the green spectrum. In this way, seaweed exhibits a range of coloration including reds, yellows, and blues, in order to absorb the light which reaches its particular environment."

The more we learn, the deeper we find the world of seaweed can be.



***Left:** Ms. Noda holds up a very large example of pressed wakame seaweed at 1 meter long. The children are surprised to see that wakame's natural color is brown, and not the green that it turns after being cooked in miso soup.*
***Below:** The children pretend they are seaweed swaying with the current. If the water is dirty, they cannot get away!*
***Bottom, left:** The seaweed art is strikingly beautiful once it has been delivered dried and laminated, taking on a clear sheen.*

Pressed seaweed postcards

In the latter half of the class, the children create postcards made with pressed seaweed. Noda has prepared ten types of seaweed in advance for use in the postcards. Once the postcard artwork is complete, the Pressed Seaweed Association carefully finishes them and mails them to the participants. The process is designed to allow children to completely focus on making the postcards themselves.

First, the children gather around Noda to learn the basics by watching a demonstration of pressing seaweed. The seaweed transforms into its full shape showing every detailed branching as it is immersed in a tray of water and gently stretched out. The children watch, completely enthralled.

Rather than using tweezers, the seaweed is laid out on the paper using toothpicks. This is because of an emphasis on detailed work and actually touching the seaweed with the fingers.

"Though we may eat seaweed often, we don't normally examine it carefully. Today I want you to pay close attention to how it feels."

Inspiration via beautiful colors and shapes

Once the children learn the basic techniques, they return to their seats to start creating their own pressed seaweed. The children begin creating ribbons and curves using *hiraaonori* or laying the semi-transparent *anaaosa* over other types of seaweed. Each creates uniquely imaginative art.

Some of the children stop to look at their friends' work if they run into trouble handling a certain type of seaweed, or become unsatisfied with the design. However, one of the appeals of pressed seaweed crafts is that the children can change the design if they don't like it because at this point, the seaweed is simply being placed on the paper.

The children work steadily with sparkling eyes as they are fascinated by the texture and transparency of the wet seaweed, or the shape when it is stretched out. The classroom becomes quiet as they focus. Once each child completes their pressed seaweed craft after about 20 minutes of work, Noda signals the end of the session.

"All of you have created wonderful crafts. I hope you remember from now on in your daily lives that there are forests of seaweed in the ocean."

Inspiration fuels further exploration

The children's artwork is taken by the Pressed Seaweed Association to be dried over several days and laminated, and returned to each participant in about one week. It must be difficult for the children to wait so long!

"I think it is first important for the children to take home the joyful realization and surprise that seaweed is so beautiful. Because once they become interested, they may create more art on their own or decide to study more about seaweed." The craft has certainly given the children food for thought the next time they see seaweed on the dinner table! **SW**

Michiyo Noda

Michiyo Noda is Chairperson of the Pressed Seaweed Association, and a member of the Japanese Society of Phycology. She graduated from the Joshibi College of Art and Design. Inspired by the beauty of seaweed when she worked as a research assistant at the Shimoda Marine Research Center, University of Tsukuba, she came up with the idea for the pressed seaweed craft. She carries out exhibits and hosts workshops on the craft.

Photos (p. 6): Michiyo Noda

This Egyptian water wheel, known as a sakia, lifts water in the Nile River.

Water is the Keyword to Knowing the World

*Not only is water necessary for life, it is also an essential resource for our daily lives and the economy. What are the current developments worldwide for water resources? We interviewed **Dr. Taikan Oki**, a researcher on the global circulation of water.*

Concerns over the water crisis

In developing nations, many people suffer from health issues because they do not have easy access to safe water. Children are the most easily affected, and every year 300,000 experience health issues. In order to obtain safe drinking water, people often must spend many hours every day collecting water, losing opportunities for study and employment.

Oki explains, "The climate is not the reason why water cannot be easily obtained in developing countries. The real causes are social issues such as income disparity, the allocation of resources, and conflict." In many regions, safe water is unobtainable despite there being an available supply because of a lack of necessary supply facilities or due to political problems.

Know your water impact

"People cannot enjoy a cultured life by drinking water alone. However, collecting too much water can damage the ecosystem. The question is how to balance people's lives with the environment. This is what we need to think about now."

About two or three liters of drinking water is needed per person per day to maintain human life. However, much more water is needed for using the bathroom, bathing, and washing. In developed countries, the amount of water used in daily life is more than 100 times that which is needed for survival. Vast amounts of water are also used for industrial and agricultural purposes. Roughly 70% of the water collected throughout the world, and 90% of the water consumed, is used for agricultural purposes.

Oki explains, "For example, when you import food produced using 2,000 liters of water, it is as if you were importing 2,000 liters of water because you did not have to use your own country's water supply. Accordingly, trade in food and industrial products is called the virtual water trade, and the water used for production is called virtual water. The production of one kilocalorie of food generally requires one liter of water."

Think of flow rather than stock

The majority of water on Earth is salt water, and the fresh water usable to us is only 0.01% of the total water on the planet. "However, water circulates. The problem is the amount used versus the available supply, so it is important to consider the amount circulated rather than the amount stored."

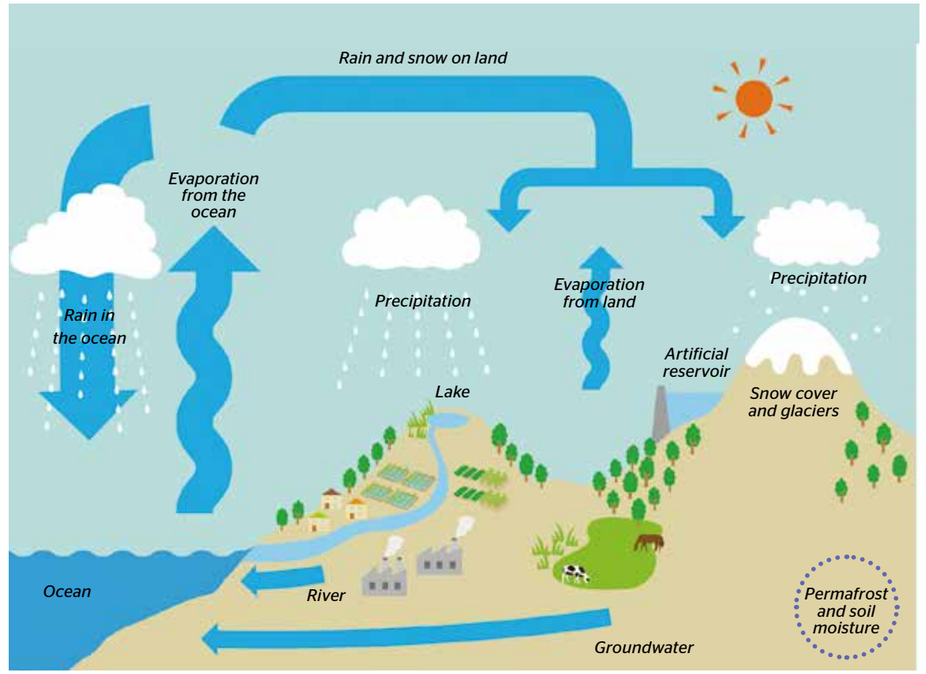
Of the fresh water that constantly flows from the surface of the land into the oceans, the amount used by humans is only approximately 10%. The reason that water shortages still occur is spatial bias. For regions with few water resources, it should be possible to conserve water by importing virtual water, but here the political and economic situation becomes complexly intertwined.

Oki explains, "The issues surrounding water are vastly different for each region. In order to solve them, we must look at the issues for each region separately rather than trying to grasp the world as a whole." What sort of water issues does your area face considering its regional characteristics?

Photo: Taikan Oki

Storage and circulation of water

Water vapor that evaporates from the surface of the ground or oceans becomes clouds and returns to the Earth's surface as rain or snow. The fallen precipitation joins rivers and groundwater and either returns to the sea, gets stored in lakes and dams, or becomes ice in glaciers, becoming water vapor again by evaporating from the ground or the leaves of plants.



■ COMMON WATER MISUNDERSTANDINGS

Does using water make it disappear?

Water circulates on the Earth's surface. Water thrown away will eventually come back. The total volume of water changes very little over spans of hundreds and thousands of years.

Will water conservation solve water shortages?

One reason for water shortage is the limited number of places water can be collected. No matter how much is conserved, that will not increase the amount available to other regions if the water is not transported there.

Is daily life mostly unaffected by water shortages?

A vast amount of water is required for food and industrial production, which falls during water shortages. Water shortages affect daily life in many ways, including food supply, the economy, and sanitation.

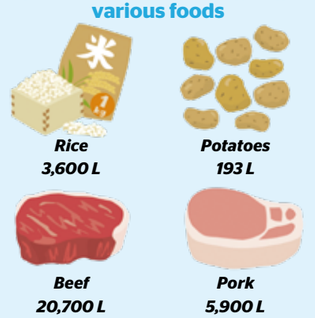
Will one person's overuse of water affect other people?

In many countries suffering from water shortages, the problem is not fighting over the water supply, but a lack of water supply facilities due to social or political reasons.

Can we solve water shortages through seawater desalination?

Seawater desalination has become practical and the number of facilities is rising. However, desalination currently requires a great deal of energy, making it very expensive. Further progress is needed. SW

The amount of virtual water equivalent for producing 1 kg of various foods



Taikan Oki

Dr. Taikan Oki is a hydrologist and Senior Vice-Rector of United Nations University while serving as Assistant Secretary-General to the United Nations. He currently teaches at the Institute of Industrial Science (IIS), University of Tokyo.

Learning from Disasters

*It has been seven years since the unprecedented disaster that was the Great East Japan Earthquake. Since then, many other disasters have occurred all over the world. What can we do to reduce the amount of damage that disasters cause, if even only a little? We spoke with **Professor Fumihiko Imamura** of the Tohoku University International Research Institute of Disaster Science (IRIDeS), which leads the field of action-oriented disaster science in cooperation with areas affected by disasters.*

A research institution born out of lessons from disasters

Miyagi Prefecture has always suffered a high rate of disasters. We created a disaster prevention team in the prefecture that brings together specialists from both the sciences and the humanities for collaborative work with local governments and people. According to our surveys, nearly 90% of people think that a disaster will occur again in the future. However, not many have taken actions to prepare for that, such as outfitting their homes with earthquake-resistant infrastructure or participating in evacuation drills.

This was the state of affairs as well when the Great East Japan Earthquake occurred on March 11, 2011. There are three types of information that are vital when predicting and preparing for an earthquake: its location, its timing, and its scale. Although there were predictions about the location and timing of the Great East Japan Earthquake, the predictions on its scale were greatly incorrect. We imagined an earthquake around magnitude 7.5 or 8, and preparations were made based on that, including the creation of hazard maps. The actual earthquake that occurred was magnitude 9, many times stronger than we imagined. The subsequent tsunami reached areas we had previously thought safe, doing a tremendous amount of damage.

We took what lessons we could learn from that disaster and reorganized our team. We created a new organization, IRIDeS, on April 11, 2012.

Whole timeline responses: From before the disaster to its aftermath

The seven divisions of IRIDeS are split among needed academic fields across the stages of the disaster management cycle (Mitigation, Preparedness, Response, Recovery and Reconstruction). It is a solid organizational structure that allows for not only collaborations between divisions, but between fields as well. Furthermore, we communicate the results of all of our research to local communities, allowing them to make use of what we develop. This is why we call what we do action-oriented disaster science.

The first activity we ever did under the banner of action-oriented disaster science was evacuation drills. It was right after the earthquake, when the priority for most was recovery and reconstruction, and many people felt that it was pointless to do the drills at that time. However, it is exactly during post-disaster periods, when ideas for reconstruction have not been cemented yet, that we can make use of evacuation drills to get people thinking again about the issues of their town during disasters, and that is useful for further reconstruction work.

Communicating experiences with disasters in a format that people can use

The Great East Japan Earthquake and the subsequent nuclear accident were a compound disaster unlike anything humanity has experienced before. Our experiences during this disaster must absolutely be passed down through the collective memory of humanity. That is why we began our work on the Michinoku-Shinrokuden archive project, which records all of the memories, records, case studies, and knowledge about the Great East Japan Earthquake for sharing with people in and outside Japan.

We don't know what records of disasters will be useful or where. We have put aside our preconceptions as specialists and tried to work with the intention of recording everything. As of March 2013, we had already collected approximately 100,000 data points. We have provided access to this archive to Harvard University, and are expanding it overseas.

Furthermore, we have created the Disaster Prevention Notebook of All, a resource enabling more people to utilize the results of our research on natural disasters. We have distributed approximately 150,000 copies of this handbook via governments inside and outside Miyagi Prefecture. It uses A6 sized paper, so it is easy to carry around. It contains the information that people need at every stage of a disaster, from disaster preparation information to content on disaster responses, repair, and reconstruction.

As for my own research, I have been using the K computer (super computer) to analyze the details of the tsunami that occurred after the earthquake in order to use the lessons of the Great East Japan Earthquake for the future. I am also putting together case studies on the tsunami by interviewing people about where they were, what they were thinking, and how they evacuated at that time.

Inspiring interest in disaster prevention

The first step toward disaster prevention is to study past examples and get everyone to become personally interested in it. That is why we are doing so many action-oriented disaster science projects. We held the World Bosai Forum 2017 in Sendai in November 2017 to communicate our experience with the Great East Japan Earthquake to the rest of the world. We will continue to hold this Forum, which takes up the results of the United Nations World Conference on Disaster Risk Reduction and links with the International Disaster and Risk Conference (IDRC) in Davos, Switzerland, as a place for the sharing of information among people involved with disaster prevention throughout the world.

The damage caused by disasters changes alongside changes in our lives. For example, during the Great East Japan Earthquake, the tsunami gave rise to many fires. These were caused by industrial equipment at ports and car batteries. If the number of electric cars on the road increases, the number of fires caused by tsunamis might increase as well, as they use large batteries. The type and state of damage caused by disasters changes with time.

When a disaster occurs, it is each person's judgement that will ultimately save their life. It is vital that everyone think about what they should do in each situation without becoming caught up in their past experiences or assumptions. We will continue to provide people with the information and tools they need for this. **sw**

What is IRIDeS?

A research organization that has pioneered action-oriented disaster science, which aims to reduce the damage caused by new large-scale disasters and make it possible for people and society to respond wisely to disasters.

- *Hazard and Risk Evaluation Research Division*
- *Human and Social Response Research Division*
- *Regional and Urban Reconstruction Research Division*
- *Disaster Science Division*
- *Disaster Medical Science Division*
- *Disaster Information Management and Public Collaboration Division*
- *Endowed Research Division*

1. A computer simulation showing tsunami movement. It is clear from this simulation that large volumes of sand along the shoreline get picked up by tsunami waves and then spread out by the force of the waves as they recede.

2. An evacuation drill held in August 2013 that imagined that a tsunami had hit Yamamoto Town, Watari District, Miyagi Prefecture, covering approximately 40% of the town. The drill boldly attempted to simulate car evacuations, which is an issue during times of disaster. By observing the state of traffic jams during the drill, researchers were able to gain knowledge useful for future evacuation plans. The drill will be held every year from now on.

World Bosai Forum / International Disaster and Risk Conference (IDRC) @ Sendai 2017 Following the establishment of the Sendai Framework as an international disaster reduction framework at the Third United Nations World Conference on Disaster Risk Reduction, it was decided that from 2017 a World Bosai Forum would be held biannually in Sendai. In addition to communicating knowledge from the Great East Japan Earthquake to the rest of the world and producing concrete solutions to problems, the forum aims to promote the spread of the concept of BOSAI, which can refer to everything from disaster mitigation to reconstruction and revitalization.

Fumihiko Imamura

Dr. Fumihiko Imamura is a professor at Tohoku University and Director of the Tohoku University International Research Institute of Disaster Science (IRIDeS). He conducts research on topics such as preventative measures for use in the Pacific Ocean to reduce the damage caused by tsunamis.

Humboldt Penguins

AMAZING ANIMAL SECRETS

How did birds become swimming champions?

A procession of Humboldt penguins begins walking attracted by the clapping of the breeding staff, followed by the visiting children and families. This "march of the penguins" has become a popular event at zoos and aquariums throughout Japan. However, the event takes a slightly different form at the Nagasaki Penguin Aquarium. The penguins are marching towards the actual ocean.

The total surface area of the enclosed cove is approximately 3,700 square meters. The penguins spend their time here swimming and chasing fish every day from 10:30 AM to 3:00 PM, and then walk back to their pen. This program allows aquarium visitors to view the penguins up close.

The different birds are distinguished by color bands attached to their flippers and by the pattern of spots on their faces and bodies.

The penguins are fed horse mackerel, with the size chosen by penguin type. The fish are sliced into three fillets or minced depending on each penguin's condition and growth level.

Japan's temperate penguins

While many imagine the South Pole when they think of penguins, the Humboldt penguin is actually a temperate animal residing in South America. The manager of the penguin pen at the aquarium, Satoshi Tasaki, explains, "They are adaptable to heat and adjust their body temperature by radiating heat from the pink skin around their eyes and beaks. There is no need for special temperature management to raise temperate penguins in Japan. Japan also provides the appropriate climate for breeding."

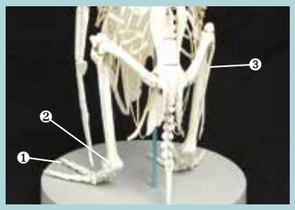
The majority of the 64 Humboldt penguins kept at the aquarium were born in Nagasaki. Generations of previous breeding staff established the ideal breeding methods by identifying the correct amount of feed to provide and how to exercise them to reduce stress, helping them acclimatize comfortably to Japan.

The search for food led penguins to the water

While penguins are birds, they have many differences compared to birds that fly. Tasaki explains, "Their wings are known as flippers and are shaped like single flat oars. They use them to paddle through the water in order to swim. They use their humorously chubby body and short legs to great advantage in the water. Their bones are also denser than other birds. Thus they are able to swim at speeds up to 20-30 km/h and dive as deep as 100 meters."

There are other secrets hidden in the bodies of penguins. Tasaki explains, "Their legs are actually long." According to Tasaki, their body structure is much like the pose we would take if we lifted our heels off the ground while kneeling and let our shirt tails cover our knees. The penguins' ability to fold their long legs into their body is believed to have reduced resistance in the water. Tasaki adds, "I love the intriguing combination of cuteness and wild toughness in penguins. I hope you will visit our aquarium to see these energetic, enigmatic creatures!" **sw**

THE STRUCTURE OF PENGUIN LEGS



Seen from behind

❶ The foot part touching the ground is like a human's toes.
❷ The ankle-like part is actually the heel.
❸ The shins and thighs of the legs are kept inside the body.

Penguins living in the cold seas of Antarctica, such as king and chinstrap penguins, swim as though flying in this pool with a depth of four meters. Their display pen is always kept at a temperature of 10 degrees Celsius.

HUMBOLDT PENGUIN FACTS

Humboldt penguins live in flocks on the shores of the Pacific Ocean in Chili and Peru in South America where the Humboldt Current flows, and survive by catching and eating fish such as anchovies. They have a single black band on their chests and black spots on their bellies. Adults reach a height of approximately 60 cm and a weight of approximately 4 kg, and have a lifespan of roughly 20 years. They dig holes for nesting in rocky crevasses on the coast or near the roots of cacti, and usually remain with the same partner for life. The male and female generally take turns warming two eggs which hatch in about 40 days. They also share in the raising of the young, and chicks become separated from their parents about three months after birth. The population in recent years has been reduced to between 30,000 and 40,000 due to the effects of the destruction of breeding grounds, overfishing of their food sources, and El Niño.

THE NAGASAKI PENGUIN AQUARIUM

This aquarium in Nagasaki Prefecture in southwest Japan specializes in penguins with 180 birds from 9 of the world's 18 species. Founded in 1959 to raise a chinstrap penguin from the Antarctic Ocean, the aquarium developed the world-recognized Nagasaki Method through breeding and raising penguins. The Fureai Penguin Beach has garnered attention for allowing visitors to see penguins swim in a real ocean.

Page 2 Quiz Answer
4

Photos: Akira Sato, Nagasaki Penguin Aquarium

Water

Miracle Compound of Life

Shunichi Takebe, Science Journalist

Let's condense the history of the universe into a single Earth year. Launching on New Year's Day with the Big Bang, the Universe evolved until September when the watery Earth was born in a solar system in the Milky Way Galaxy. Around mid-September life arose, with humanity arriving on the scene at just after 10 PM on December 31. It was not until the last second that humans learned water is a hydrogen-oxygen compound. Now let's travel through time in the story of water.

Water: Who discovered H_2O?

What is water? In the 6th century BCE, Greek natural philosopher Thales posited that water was the originating principle of all things, while in the 5th century BCE, Empedocles believed that all things were made of the four elements of fire, air, water, and earth. Water was also considered one of the five fundamental elements in ancient China. For centuries, this was the degree of understanding on water. It wasn't until the 18th century that a chemist finally discovered the truth.

In 1785, just four years before the French Revolution, Antoine-Laurent de Lavoisier drew a line in the history of water research, stating, "Water is not an element, but a byproduct of the combustion of flammable gas (hydrogen), and can be broken down and combined." Lavoisier, who also served as a tax collector and explosives administrator, conducted experiments at the laboratory/salon he founded in a weapons factory. He showed in 1783 that water could be created by placing hydrogen and oxygen in a glass sphere and heating it. In an experiment conducted the next year, he detected hydrogen and rust after passing water vapor through a red hot gun barrel. The rust was an iron oxide resulting from the bonding of oxygen with the iron of the gun barrel, and it was shown that water was broken down into hydrogen and oxygen.

Lavoisier was the first to discover that water was a chemical compound. Englishman Henry Cavendish synthesized water in 1781 by mixing hydrogen and air in a glass vessel and heating it, and while he found that the result was one fifth of the components of the air, he was unable to identify it as oxygen. While Lavoisier was simply repeating that experiment, he was the one to correctly interpret the water synthesis reaction, making an invaluable contribution to opening a new age for science. In the 19th century, Swedish chemist Jöns Jacob Berzelius clarified that the water molecule was comprised of two atoms of hydrogen and one of oxygen, which was represented by the alphabetical nomenclature he himself proposed. Thus, it was Berzelius who discovered H_2O.

Above: *A chunk of ice in a crater on Mars (image from the ESA Mars Express).*
Right, top to bottom: *Lavoisier (1743-1794); Berzelius (1779-1848)*

WORLDWIDE WATER STAMPS: *Many nations in the world produce stamps using the motif of water.*
Right, top: *Water is a natural treasure (Austria).*
Right, below: *United Nations Water Conference.*
Below: *Water conservation (Maldives).*

Searching for water in outer space

Water is a miracle compound that can transform between the gaseous, liquid, and solid states at near Earth temperatures, and has the special ability to dissolve and combine many things mixed in it. It is this special ability that made it the wellspring that fostered the birth of life itself.

But is the existence of life itself a miracle as well? We have long searched for water on extra-terrestrial bodies within our solar system in the search for more life, starting with our close neighbor Mars. In an image taken near the north pole of Mars by the European Space Agency's Mars Express orbiter in 2005, there is a blueish white accumulation of ice visible at the bottom of a crater. Furthermore, it appears that water flowed on the Martian surface in the not too distant past according to a series of images taken by NASA's Mars Global Surveyor. Though ancient Mars may once have also been a watery planet, no sign of life has yet been found by searching the planet's surface.

If one looks further afield, there are vast oceans of water hidden below thick layers of ice on both Europa, a moon of Jupiter, and Enceladus, a moon of Saturn. Compared to the Earth, which holds 1.4 billion cubic kilometers of water versus its diameter of 12,700 kilometers, Europa has a diameter of only 3,100 kilometers but holds 3 billion cubic kilometers of water. It truly is a planet of water.

Though Earth is also considered a watery planet, water in fact only comprises 0.03% of its mass. The majority is seawater, while fresh water, including that in rivers, is no more than 2.5% of the total. Thus water is a rare and irreplaceable resource. **sw**

Nh

Nihonium: The "Made in Japan" 113th Element

On November 30, 2016, the International Union of Pure and Applied Chemistry (IUPAC) announced that it had officially approved the name and symbol for the 113th element, the first element ever to be discovered in Japan and Asia. The element is now called "nihonium" and is represented by the chemical symbol "Nh."

Members of the RNC team as of 2014

"We are guaranteed to succeed, if we're patient."

Not every element can be observed in nature. Some can only be seen in a lab as a result of artificial syntheses. The discovery of a new element through these artificial means has long been the dream of the RIKEN Nishina Center for Accelerator-Based Science (RNC).

The development of nihonium began as a follow-up to announcements on the successful creation of the 108th, 110th, and 111th elements. Experiments showed that the RNC had sufficient capabilities to develop a 113th element, and so researchers began the long journey toward the synthesis of nihonium.

"Success is guaranteed if we're patient." These were the words of Dr. Kosuke Morita, Team Leader (then Associate Chief Scientist) of the group that confirmed the successful synthesis of the third set of nuclei of element 113. Experiments were run for 24 hours a day for months at a time. The experience that the RNC team accumulated over the course of three years gave them total confidence in their methods. Each member of the team knew that if they continued their experiments, they would without a doubt be able to successfully confirm the synthesis of element 113.

On July 23, 2004, the team did just that, when they produced their first set of nuclei. A second set of nuclei was created on April 2, 2005, and a third was at last synthesized on August 12, 2012. With that third set of nuclei, the team could confirm that it was able to successful synthesize element 113.

The passion of researchers

The RNC research team synthesized element 113 by bombarding the 83rd element, bismuth (which has 83 protons) with a beam made from the 30th element, zinc (which has 30 protons). This combination of protons, 30 + 83, allowed them to produce nuclei with 113 protons, the new element. However, this was tricky business – if the group set the beam even a little too high or too low, no nuclei of the new element would be produced.

Furthermore, the process the team used to synthesize element 113 also had the side effect of synthesizing other elements as well. The RNC team developed a proprietary device, GARIS, to help it pick out element 113 from all of the other elements around it. Through improvements to this device, the team was eventually able to detect element 113 with double the efficiency of the devices used by other research institutions.

Over their nine years of experimentation, the RNC team bombarded bismuth with zinc beams over 400 trillion times. In order to detect the synthesis of element 113 just three times out of those over 400 trillion collisions, the team developed a strong zinc beam, a high-performance detection device, and the strength of mind to discover what no one else could find.

Having officially discovered nihonium, the team's next goal is to expand the periodic table even further. The team aims to confirm the existence of hypothetical elements beyond period 7 with atomic numbers past 119. **sw**

GARIS

In addition to facing the challenge of just synthesizing the new element, the RNC team also required equipment that would allow it to detect element 113 before it decayed. The RNC team developed GARIS to do just that. By utilizing helium gas, GARIS is able to detect elements with a much higher precision than other devices. This new technology contributed greatly to the discovery of element 113.

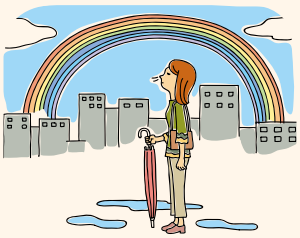
Photos: RIKEN

Sunset heralds clear weather
If there are no thick clouds to conceal the sun setting in the west, the following day will have clear weather. However, a particularly vivid sunset could also be a sign of a coming storm. There is a corresponding historic English phrase: "Red sky at night, sailors' delight."

Sunrise heralds rain
If sunrise burns a vivid red in the sky, it is because there are many clouds and moisture in the air. There is a corresponding phrase in English: "Red sky at morning, sailors take warning."

Unusually blue skies herald cold weather
For a few moments after sunset, the clear sky becomes enveloped in a bewitching blue light during the so-called "blue hour." If it is very clear, this could be a sign of impending intense cold the next morning due to radiative cooling.

Summer sea rumbling heralds a typhoon
When typhoons approach, rather than influencing the weather, you can hear a sort of "rumbling of the sea" in which fast, high waves surge forward on the shores with a low noise.



Predict the Weather

Using Natural Signs

Deep morning fog heralds a warmer day
Radiation fog, the term used to describe a cooling fog the morning after rain, means it will become clear. This is because the atmospheric temperature will rise with strong solar radiation.

Mother nature provides many hints to predict weather changes, including wind direction and cloud shapes. Warm winds coming from the south are signs of a coming storm. Rain can be predicted by looking for clouds of over two different heights moving in different directions. Japanese people have a saying for this phenomenon: "If the clouds are fighting, the rain will fall." If an icy wind suddenly starts blowing and large dark clouds move in, this is a sign of a guerrilla rainstorm (cloudburst). Plants and insects also hold important signs. It is said that rain will fall if cicadas stop their characteristic cry at midday. It is also said that if the cicadas start singing, even if it is rainy, clear skies are on the way.

Hideaki Iwatsuki

Nicknamed Wapi-chan, he is a weather forecaster, a writer, and actively involved in natural science research and public awareness.

The term "weather lore" refers to using natural phenomenon and other signs to predict the weather. I have discovered little subtle changes in daily life that help me predict the weather. For example, I've noticed that if I hear a sound like a rumbling train in the distance, rain is coming. Wherever your location in the world, urban or rural, if you pay attention to changes in the nature around you, you will be able to create your own weather lore useful for your daily life.

Although weather information is now just a click or swipe away, it's more fun to develop your own system to get a better feel for the weather. Use all five senses and be your own weatherman or weatherwoman! SW

Photos: Hideaki Iwatsuki

Japan Science and Technology Agency
ISSN1881-7807

Publisher: Japan Science and Technology Agency
Address: 5 - 3 Yonbancho Chiyoda-ku Tokyo, JAPAN, 102-8666
Phone: +81-3-5214-7377 Email: s-window@jst.go.jp
Please visit our website (Japanese only): http://sciencewindow.jst.go.jp/