Spotlight on Research

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HOKKAIDO UNIVERSITY

WHY ROBOTS ARE PIONEERS IN THE FUTURE OF AGRICULTURE?

Agriculture in Japan is gravely suffering because of aging population and a shortage of experienced leaders. On a global level, there are also concerns about food shortages as the population explodes on the planet. In response, scientists are seeking ways to solve these social problems by utilizing the technology of robotic farming.

Professor Noboru Noguchi of Hokkaido University, one of the world's leading experts of robotic agriculture, says, "Our vehicle robotics lab is developing robots that perform unmanned agricultural work. For example, they are running tractors, rice planters, harvesters, boats that sprinkle chemicals in paddy fields, and drones that observe farmlands from the sky." From 2018, three major companies started selling the unmanned tractors. They enabled automatic driving with an error of 5 cm or less by utilizing GPS and the Quasi-Zenith Satellite or "MICHIBIKI," which allows highly precise navigation.

"The underlying technology was developed in our laboratory. To implement our machinery for the awaiting farmers, we opened up the research results without acquiring patents. Thereby, many manufacturers became interested in commercializing products based on our technology," elaborated Noguchi. The Japanese government is also enthusiastic about supporting the "smart agriculture" utilizing robotics and information and communication technologies.

Noguchi's lab is now developing new technologies to allow unmanned tractors to work together, to select and harvest ripe pumpkins, or to evaluate the growth state of crops. In the future, Noguchi plans to make a small agricultural robot that can navigate narrow hills and mountainous areas. "In the times to come, my dream is to develop a robot that works on the rice terraces, an agricultural landscape unique to Japan. I would also like to make smarter agricultural robots that can make judgments based on gathered information as if they were skilled farmers," said Noguchi, "I am very particular about developing technology for the people who can make use of it."

In the implementation of smart agriculture, Noguchi believes that its incorporation into social systems is as important as achieving technological development. His team is conducting tests on Hokkaido University's experimental farms as well as fields in Hokkaido Prefecture. They listen to the opinions of farmers and request feedback on their needs and problems. Further, it is necessary to collaborate with both researchers and the private sector which has a good management strategy, to disseminate technology that leads to industrialization and regional revitalization. They also discuss the deregulation of related laws with the relevant authorities.

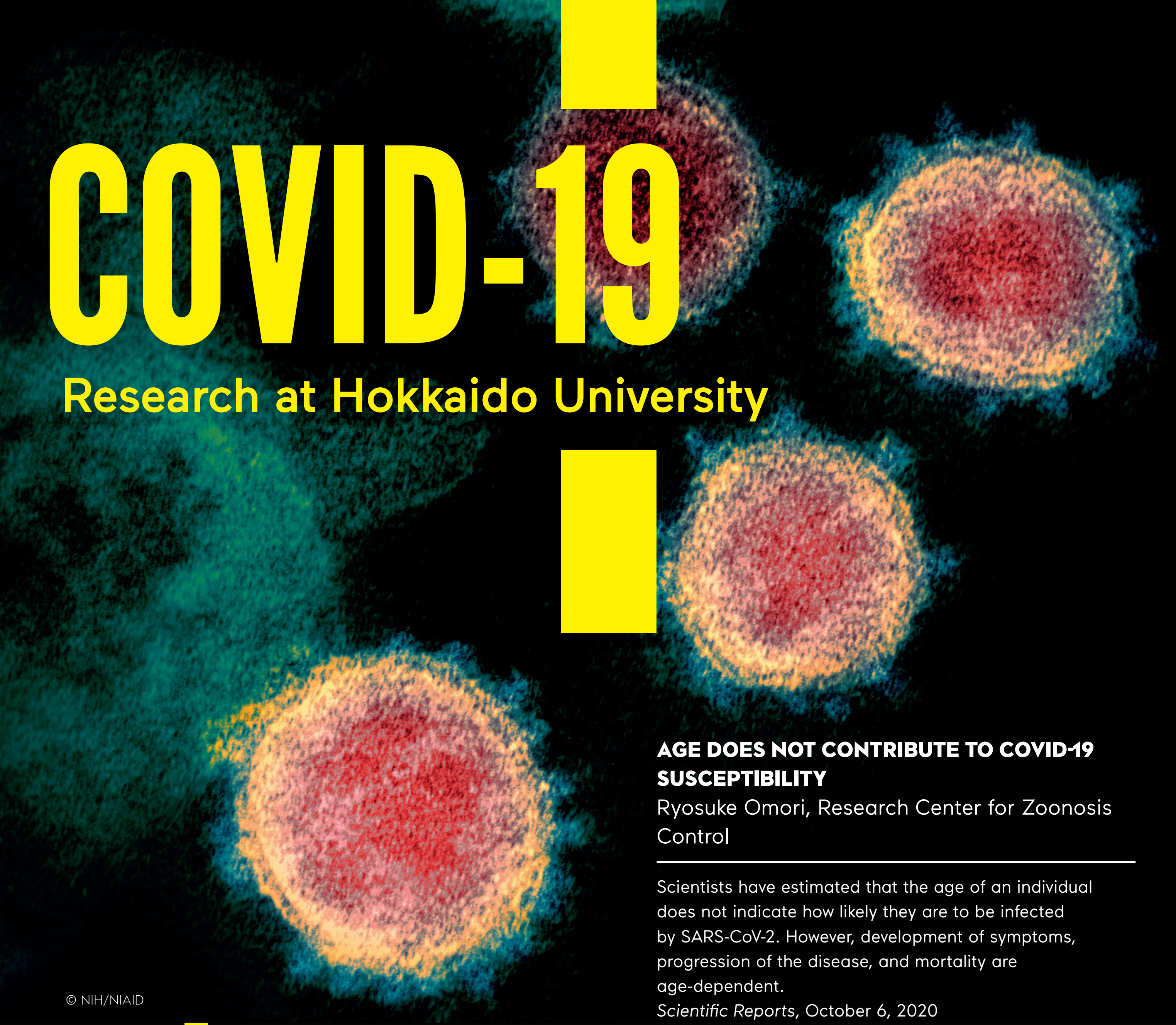
"Hokkaido is known for its accessibility to agricultural sites, and it is blessed with an environment that is more than suitable for pursuing agricultural research. There are challenges right before our eyes, many farmers are cooperative in our research, and local governments are also interested. So, I advise young people to have great ambitions! Make the best use of the large fields and go heart and soul into this dynamic research," commented Noguchi. ●

Photos and video provided by the Vehicle Robotics Laboratory

Watch the video of multiple unmanned tractors working in cooperation as a unit

Professor Noboru Noguchi in front of an unmanned tractor.

Equipment to harvest pumpkins attached to an unmanned tractor.



COVID-19

Research at Hokkaido University

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AGE DOES NOT CONTRIBUTE TO COVID-19 SUSCEPTIBILITY

Ryosuke Omori, Research Center for Zoonosis Control

Scientists have estimated that the age of an individual does not indicate how likely they are to be infected by SARS-CoV-2. However, development of symptoms, progression of the disease, and mortality are age-dependent.
Scientific Reports, October 6, 2020

CELLULAR-LEVEL INTERACTIONS THAT LEAD TO THE CYTOKINE STORM IN COVID-19

Ryo Otsuka and Ken-ichiro Seino, Institute for Genetic Medicine

Scientists address the role that macrophage activation syndrome (MAS) plays in severe cases of COVID-19, and highlight how existing therapies for MAS have shown initial success in ameliorating the disease.
Inflammation and Regeneration, August 6, 2020

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GENETIC VARIATION UNLIKELY TO INFLUENCE COVID-19 MORBIDITY AND MORTALITY

Ji-Won Lee, Graduate School of Dental Medicine

A comprehensive search of genetic variation databases has revealed no significant differences across populations and ethnic groups in seven genes associated with viral entry of SARS-CoV-2.
Infection, Genetics and Evolution, August 25, 2020

USING WASTEWATER TO MONITOR COVID-19

Masaaki Kitajima, Faculty of Engineering

Kitajima and colleagues suggested that wastewater could be used as a surveillance tool to monitor the spread of COVID-19 in communities. Later, they demonstrated that an adsorption-extraction technique can most efficiently detect SARS-CoV-2 in untreated wastewater.
Science of The Total Environment, June 5 and April 30, 2020.


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COVID-19 CYTOKINE STORM: POSSIBLE MECHANISM FOR THE DEADLY RESPIRATORY SYNDROME

Masaaki Murakami, Institute for Genetic Medicine

Leading immunologists proposed a possible molecular mechanism that causes massive release of proinflammatory cytokines, or a cytokine storm, leading to the acute respiratory distress syndrome (ARDS) in COVID-19 patients as well as its potential treatments.
Immunity, April 22, 2020

COVID-19: SALIVA TESTS COULD DETECT THE SILENT CARRIERS

Takanori Teshima, Faculty of Medicine

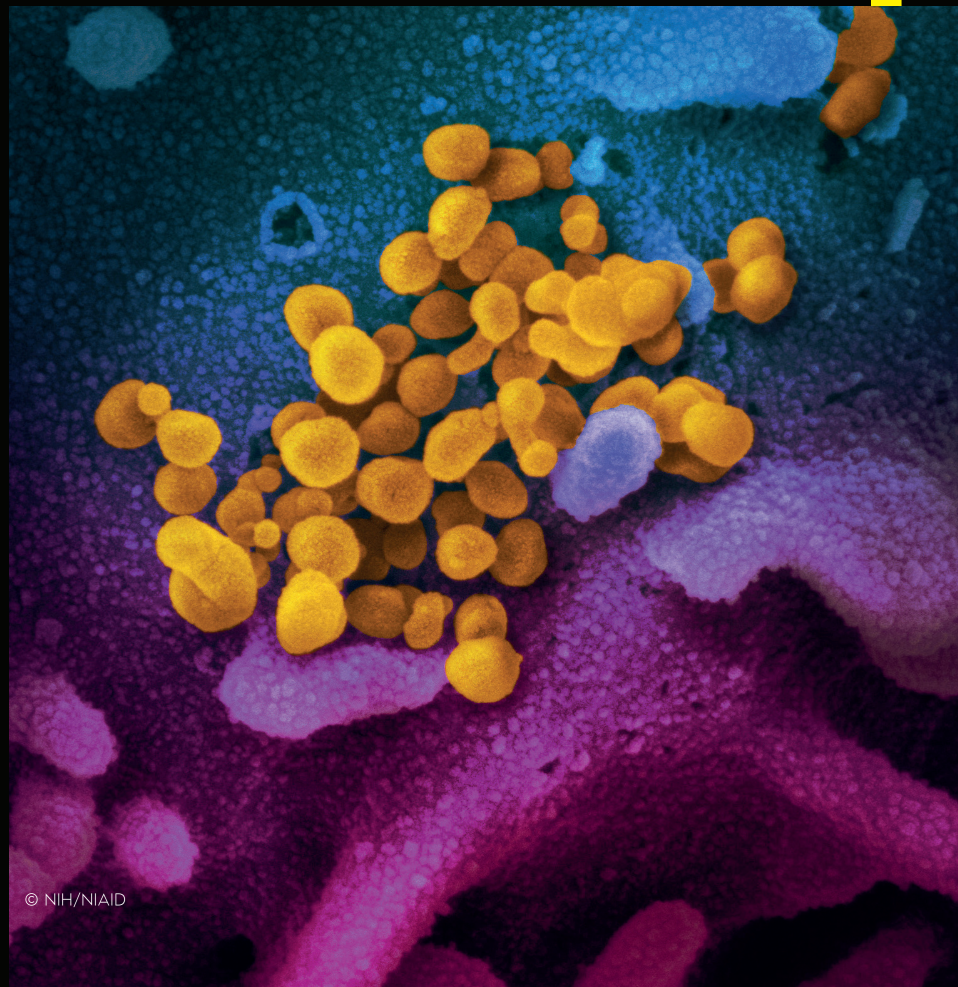
Scientists have demonstrated a quick and effective mass testing approach using saliva samples to detect individuals who have been infected with COVID-19 but are still not showing symptoms.
Clinical Infectious Diseases, September 25, 2020

GROWTH RATE OF THE COVID-19 PANDEMIC MAY BE OBSCURED DUE TO CHANGES IN TESTING RATES

Ryosuke Omori, Research Center for Zoonosis Control

Reviewing reported cases of COVID-19 in Italy, Japan, and California, USA, scientists argue that changes in the testing rate may be masking the true growth rate and extent of the pandemic.
International Journal of Infectious Diseases, April 19, 2020

Check out the most recent COVID-19 Research at Hokkaido University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A new duck-billed dinosaur, *Kamuysaurus japonicus,* identified

The dinosaur, whose nearly complete skeleton was unearthed from 72 million year old marine deposits in Mukawa Town in northern Japan, belongs to a new genus and species of a herbivorous hadrosaurid dinosaur, according to the study published in *Scientific Reports*.
The scientists named the dinosaur *Kamuysaurus japonicus*.

ORIGINAL ARTICLE
Kobayashi Y., et al, A new hadrosaurine (Dinosauria: Hadrosauridae) from the marine deposits of the late Cretaceous Habouchi Formation, Yezo Group, Japan, *Scientific Reports*, September 5, 2019.

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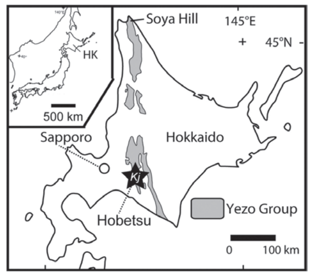
A partial tail of the dinosaur was first discovered in the outer shelf deposits of the Upper Cretaceous Hakobuchi Formation in the Hobetsu district of Mukawa Town, Hokkaido, in 2013. Ensuing excavations found a nearly complete skeleton that is the largest dinosaur skeleton ever found in Japan. It's been known as "Mukawaryu," nicknamed after the excavation site.

In the current study, a group of researchers led by Professor Yoshitsugu Kobayashi of the Hokkaido University Museum conducted comparative and phylogenetic analyses on 350 bones and 70 taxa of hadrosaurids, which led to the discovery that the dinosaur belongs to the Edmontosaurini clade, and is closely related to *Kerberosaurus* unearthed in Russia and *Laiyangosaurus* found in China.

The research team also found that *Kamuysaurus japonicus*, or the deity of Japanese dinosaurs, has three unique characteristics that are not shared by other dinosaurs in the Edmontosaurini clade: the low position of the cranial bone notch, the short ascending process of the jaw bone, and the anterior inclination of the neural spines of the sixth to twelfth dorsal vertebrae.

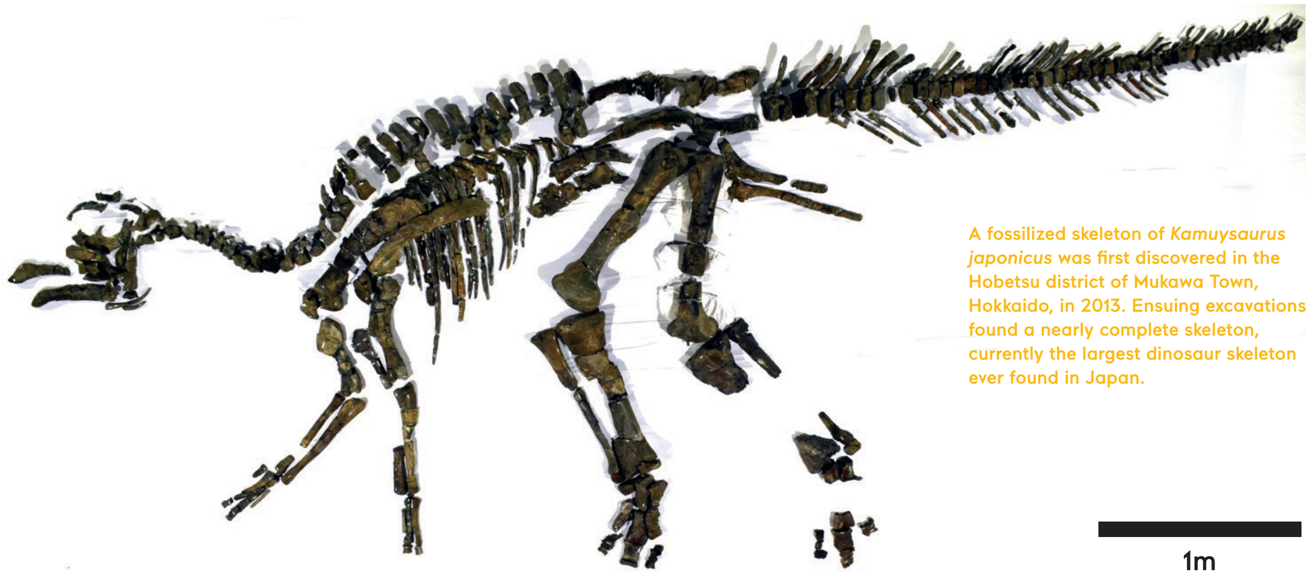
According to the team's histological study, the dinosaur was an adult aged 9 or older, measured 8 meters long and weighed 4 tons or 5.3 tons (depending on whether it was walking on two or four legs respectively) when it was alive. The frontal bone, a part of its skull, has a big articular facet connecting to the nasal bone, suggesting the dinosaur may have had a crest. The crest, if it existed, is believed to resemble the thin, flat crest of *Brachylophosaurus* subadults, whose fossils have been unearthed in North America.



Map of Hokkaido showing the location of Hobetsu district where *Kamuysaurus* (black star labeled "Kj") was excavated. (Kobayashi Y., et al, *Scientific Reports*, September 5, 2019)

The study also shed light on the origin of the Edmontosaurini clade and how it might have migrated. Its latest common ancestors spread widely across Asia and North America, which were connected by what is now Alaska, allowing them to travel between the two continents. Among them, the clade of *Kamuysaurus*, *Kerberosaurus* and *Laiyangosaurus* inhabited the Far East during the Campanian, the fifth of six ages of the Late Cretaceous epoch, before evolving independently.

The research team's analyses pointed to the possibility that ancestors of hadrosaurids and its subfamilies, Hadrosaurinae and Lambeosaurinae, preferred to inhabit areas near the ocean, suggesting the coastline environment was an important factor in the diversification of the hadrosaurids in its early evolution, especially in North America. ●



A fossilized skeleton of *Kamuysaurus japonicus* was first discovered in the Hobetsu district of Mukawa Town, Hokkaido, in 2013. Ensuing excavations found a nearly complete skeleton, currently the largest dinosaur skeleton ever found in Japan.

Selected skull elements of *Kamuysaurus japonicus*. Its unique characteristics include the low position of the cranial bone notch (quadratojugal notch, qjn) and the short ascending process of the jaw bone (surangular, acp). (Kobayashi Y., et al, *Scientific Reports*, September 5, 2019)

Gas insulation could be protecting an ocean inside Pluto

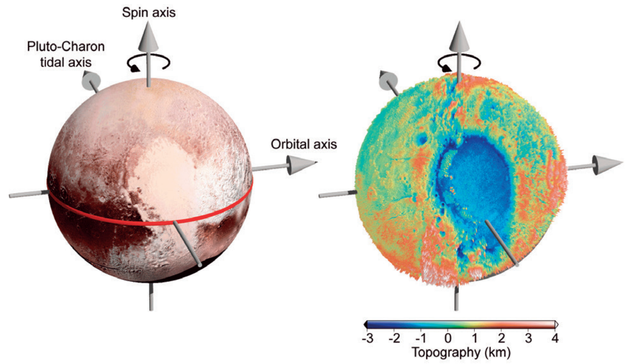
A gassy insulating layer beneath the icy surfaces of distant celestial objects could mean there are more oceans in the universe than previously thought.

Computer simulations provide compelling evidence that an insulating layer of gas hydrates could keep a subsurface ocean from freezing beneath Pluto's icy exterior, according to a study published in the journal *Nature Geoscience*.

In July 2015, NASA's New Horizons spacecraft flew through Pluto's system, providing the first-ever close-up images of this distant dwarf planet and its moons. The images showed Pluto's unexpected topography, including a white-colored ellipsoidal basin named Sputnik Planitia, located near the equator and roughly the size of Texas.

Because of its location and topography, scientists believe a subsurface ocean exists beneath the ice shell which is thinned at Sputnik Planitia. However, these observations are contradictory to the age of the dwarf planet because the ocean should have frozen a long time ago and the inner surface of the ice shell facing the ocean should have also been flattened.

Researchers at Japan's Hokkaido University, the Tokyo Institute of Technology, Tokushima University, Osaka University, Kobe University, and at the University of California, Santa Cruz, considered what could keep the subsurface ocean warm while keeping the ice shell's inner surface frozen and uneven on Pluto. The team hypothesized that an "insulating layer" of gas hydrates exists beneath the icy surface of Sputnik Planitia. Gas hydrates are crystalline ice-like solids formed of gas trapped within molecular water cages. They are highly viscous, have low thermal conductivity, and could therefore provide insulating properties.

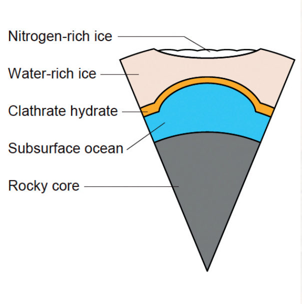


The bright "heart" on Pluto is located near the equator. Its left half is a big basin dubbed Sputnik Planitia. Figures created using images by NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.

The researchers conducted computer simulations covering a timescale of 4.6 billion years, when the solar system began to form. The simulations showed the thermal and structural evolution of Pluto's interior and the time required for a subsurface ocean to freeze and for the icy shell covering it to become uniformly thick. They simulated two scenarios: one where an insulating layer of gas hydrates existed between the ocean and the icy shell, and one where it did not.

The simulations showed that, without a gas hydrate insulating layer, the subsurface sea would have frozen completely hundreds of millions of years ago; but with one, it hardly freezes at all. Also, it takes about one million years for a uniformly thick ice crust to completely form over the ocean, but with a gas hydrate insulating layer, it takes more than one billion years.

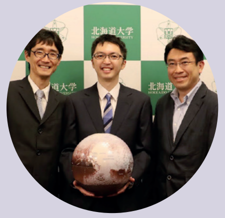
The simulation's results support the possibility of a long-lived liquid ocean existing beneath the icy crust of Sputnik Planitia.



The proposed interior structure of Pluto. A thin clathrate (gas) hydrate layer works as a thermal insulator between the subsurface ocean and the ice shell, keeping the ocean from freezing. (Kamata S. et al., *Nature Geosciences*, May 20, 2019)

The team believes that the most likely gas within the hypothesized insulating layer is methane originating from Pluto's rocky core. This theory, in which methane is trapped as a gas hydrate, is consistent with the unusual composition of Pluto's atmosphere — methane-poor and nitrogen-rich.

Similar gas hydrate insulating layers could be maintaining long-lived subsurface oceans in other relatively large but minimally heated icy moons and distant celestial objects, the researchers conclude. "This could mean there are more oceans in the universe than previously thought, making the existence of extraterrestrial life more plausible," says Shunichi Kamata of Hokkaido University who led the team. ●



(From the left) Atsushi Tani of Kobe University, and Shunichi Kamata and Kiyoshi Kuramoto of Hokkaido University from the research team. Photo taken by Yu Kikuchi.

ORIGINAL ARTICLE

Kamata S. et al., Pluto's ocean is capped and insulated by gas hydrates. *Nature Geosciences*, May 20, 2019.

FUNDING

The Japan Society for the Promotion of Science (JSPS)'s KAKENHI (JP16K17787, JP17H06456, JP17H06457) and the Astrobiology Center Program of the National Institutes of Natural Sciences (NINS).

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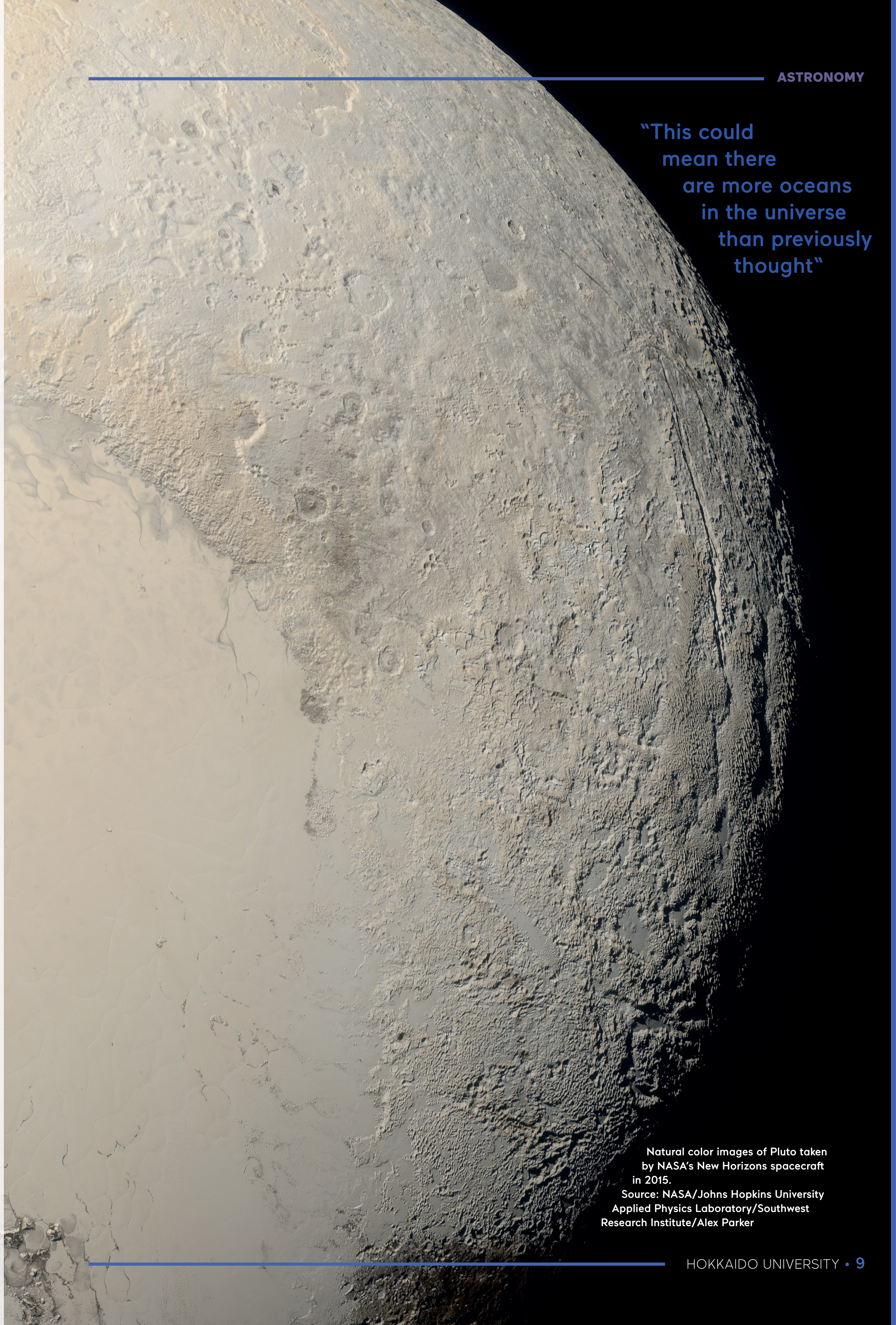
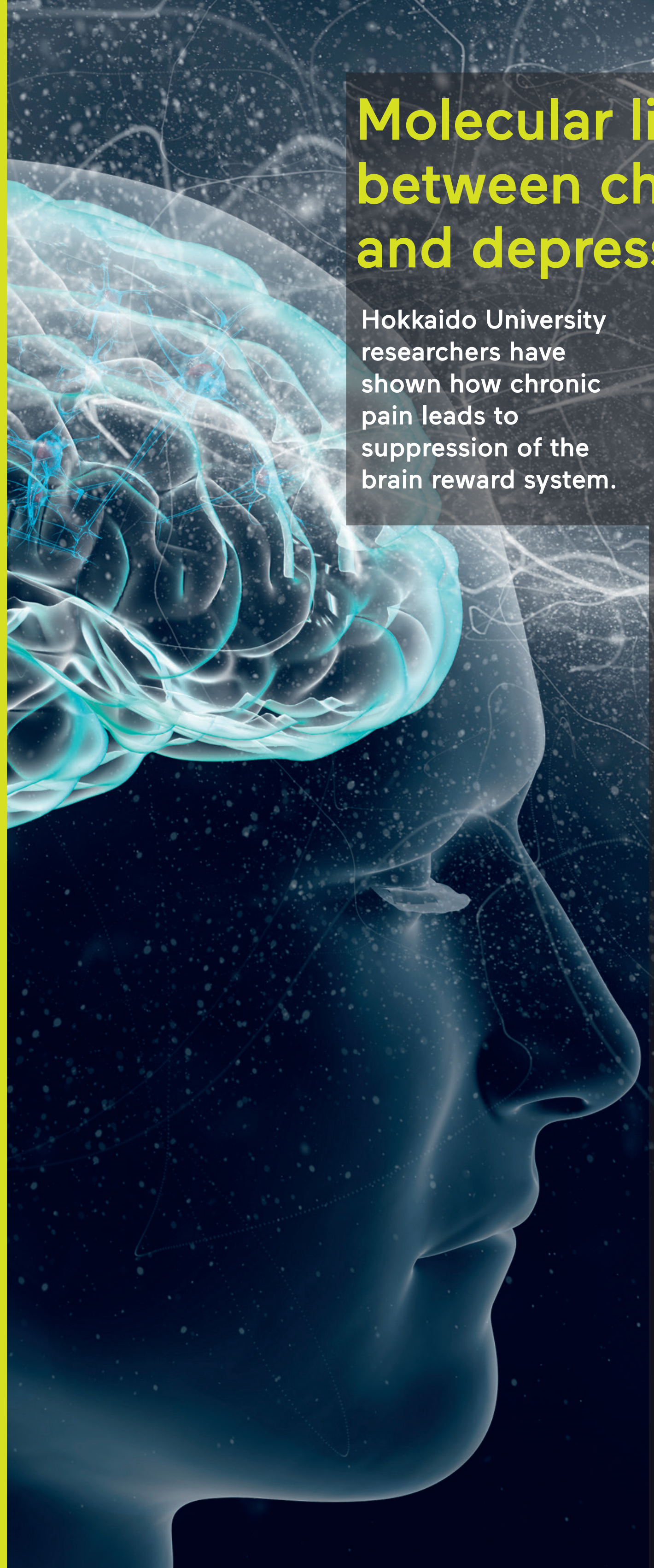
"This could mean there are more oceans in the universe than previously thought"



Natural color images of Pluto taken by NASA's New Horizons spacecraft in 2015. Source: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Alex Parker



Molecular link between chronic pain and depression revealed

Hokkaido University researchers have shown how chronic pain leads to suppression of the brain reward system.

Researchers at Hokkaido University have identified the brain mechanism linking chronic pain and depression in rats. Their research, published in *The Journal of Neuroscience*, could lead to the development of new treatments for chronic pain and depression.

"Clinicians have known for a long time that chronic pain often leads to depression, however the brain mechanism for this was unclear," said Professor Masabumi Minami at Hokkaido University, one of the authors of the paper.

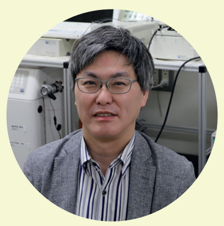
The researchers looked at how neuronal pathways were affected by chronic pain in rats. They used an electrophysiological technique to measure the activities of neurons after four weeks of chronic pain. They found that persistent pain caused changes in the neuronal pathway projecting from the brain region called bed nucleus of the stria terminalis (BNST) to the region called ventral tegmental area (VTA). Specifically, they found enhanced signaling mediated by corticotropin-releasing factor (CRF), which is a neuropeptide known to be involved in the negative emotions such as anxiety and fear, in the BNST of chronic pain animals.

Crucially, they showed that this enhanced CRF signaling leads to suppression of the brain reward system, the nervous system that is activated by rewards and related to production of pleasure and motivation. Suppression of the reward system is considered to be an underlying mechanism of depression, which leads to decreased pleasure and motivation.

"By clarifying the mechanism by which the brain reward system is continuously suppressed, we found the missing link between chronic pain and depression," says Masabumi Minami.

The researchers found that when they treated the rats with a drug that blocked the excessive CRF signals, the activity of dopamine neurons, which play an important role in the brain reward system, was increased. This suggests that drugs targeting neuropeptides such as CRF could be developed in order to treat chronic pain and depression in the future.

"These findings could not only lead to improved treatment of emotional aspect of chronic pain, but also to new therapeutics for depressive disorders," says Masabumi Minami. ●



ORIGINAL ARTICLE

Takahashi D., Asaoka Y., Kimura K. et al., Tonic suppression of the mesolimbic dopaminergic system by enhanced corticotropin-releasing factor signaling within the bed nucleus of the stria terminalis in chronic pain model rats. *The Journal of Neuroscience*, August 26, 2019.

FUNDING

A Grant-in-Aid for Scientific Research (23300130, 26290020, 17H03556) and Challenging Research (17K19469) from the Japan Society for the Promotion of Science (JSPS), a Grant-in-Aid for Scientific Research (25116501, 15H01273) from the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT), and the Japan Agency for Medical Research and Development (JP19gm0910012).

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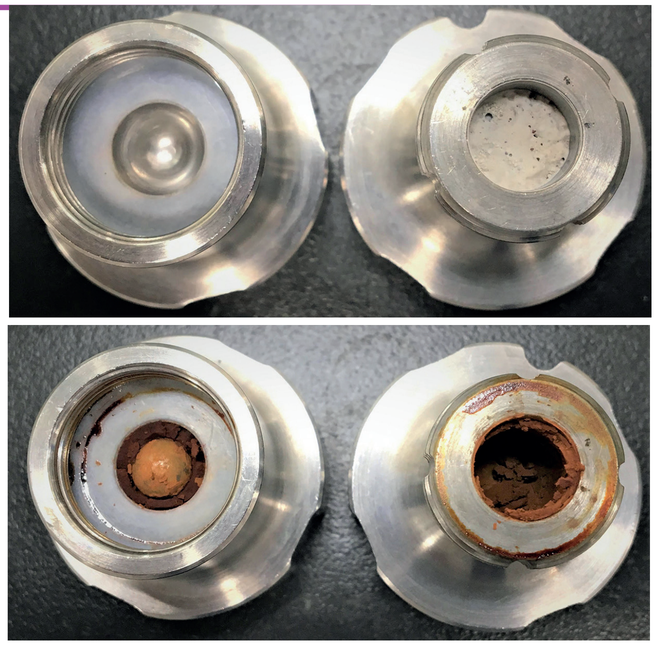
Mechanical force as a new way of starting chemical reactions

Researchers have shown mechanical force can start chemical reactions, making them cheaper, more broadly applicable, and more environmentally friendly than conventional methods.



Reaction mixtures before and after grinding in a ball mill. Mechanoredox arylation reactions occurred with aryl diazonium salts and furan in the presence of a piezoelectric material ($BaTiO_3$). (Kubota K. et al. *Science*, December 19, 2019)

Chemical reactions are most conventionally prompted by heating up the reaction mixtures. Within the last ten years, there has been extensive research on "photoredox catalysts" that can be activated by visible light and enable highly specific and efficient chemical reactions. However, these reactions often require a large amount of harmful organic solvents, making them applicable only to soluble reactants.

"Piezoelectric materials" such as barium titanate are known to generate electric potentials when a mechanical pressure is applied to them, which is why they are used in microphones and lighters. In the current study published in *Science*, the research team led by Hajime Ito and Koji Kubota of the Institute for Chemical Reaction Design and Discovery (WPI-ICReDD) at Hokkaido University proved this electric potential can also be used to activate chemical reactions. "In our system, we use the mechanical force provided by a ball mill to activate a piezoelectric material for redox reactions, while eliminating the use of organic solvent," says Koji Kubota. They call it a mechanoredox reaction as opposed to a photoredox reaction.

The team demonstrated that electric potentials derived from piezoelectric material ($BaTiO3$) activate a compound called aryl diazonium salts generating highly reactive radicals. The radicals undergo bond-forming reactions such as arylation and borylation reactions — both of which are important in synthetic chemistry — with high efficiency. The team also showed that the borylation reaction could occur by striking the mixture in a plastic bag with a hammer.

"This is the first example of arylation and borylation reactions using mechanically induced piezoelectricity," says Koji Kubota. "Our solvent-free system using a ball mill has enabled us to eliminate organic solvents, making the reactions easier to handle, more environmentally friendly, and applicable even to reactants that cannot be dissolved in the reaction solvent." They could also recycle the barium titanate and achieve better yields than photoredox reactions, even further increasing the attractiveness of this approach.

"We are now exploring the tunability of the mechanically generated electric potential. Together with computational predictions, we aim to extend the applicability of this technique," says Hajime Ito. "Our goal is to complement or at least partly replace existing photoredox approaches and provide an environmentally friendly and cost-efficient alternative to be used in industrial organic synthesis." ●

ORIGINAL ARTICLE

Kubota K., Pang Y., Miura A., Ito H. Redox Reactions of Small Organic Molecules Using Ball Milling and Piezoelectric Materials. *Science*, December 19, 2019.

FUNDING

The Japan Society for the Promotion of Science (JSPS)'s KAKENHI (JP18H03907, JP17H06370, JP19K15547), and the Japan Science and Technology Agency (JST)'s CREST grant (JPMJCR19R1).

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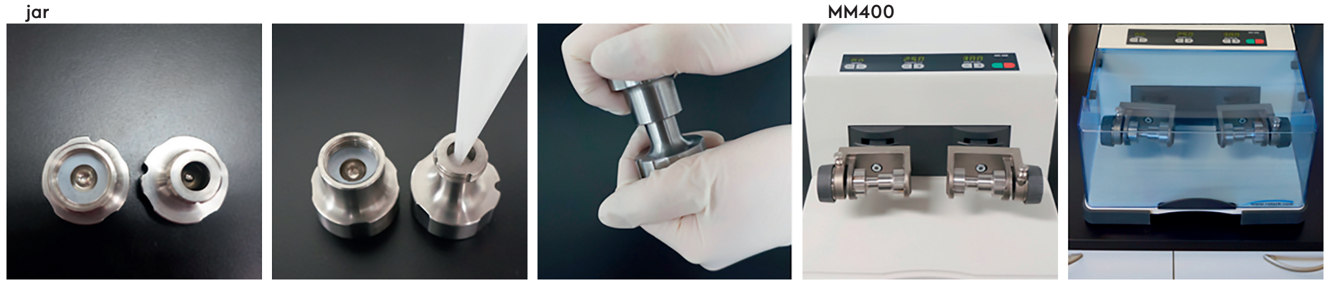
1) Ball was added to milling jar
2) Chemicals were added
3) Jar was closed
4) Jar was placed in Retch MM400
5) Grinding started



In ball milling, the chemicals and a steel ball are placed into steel jars which are then shaken vigorously.

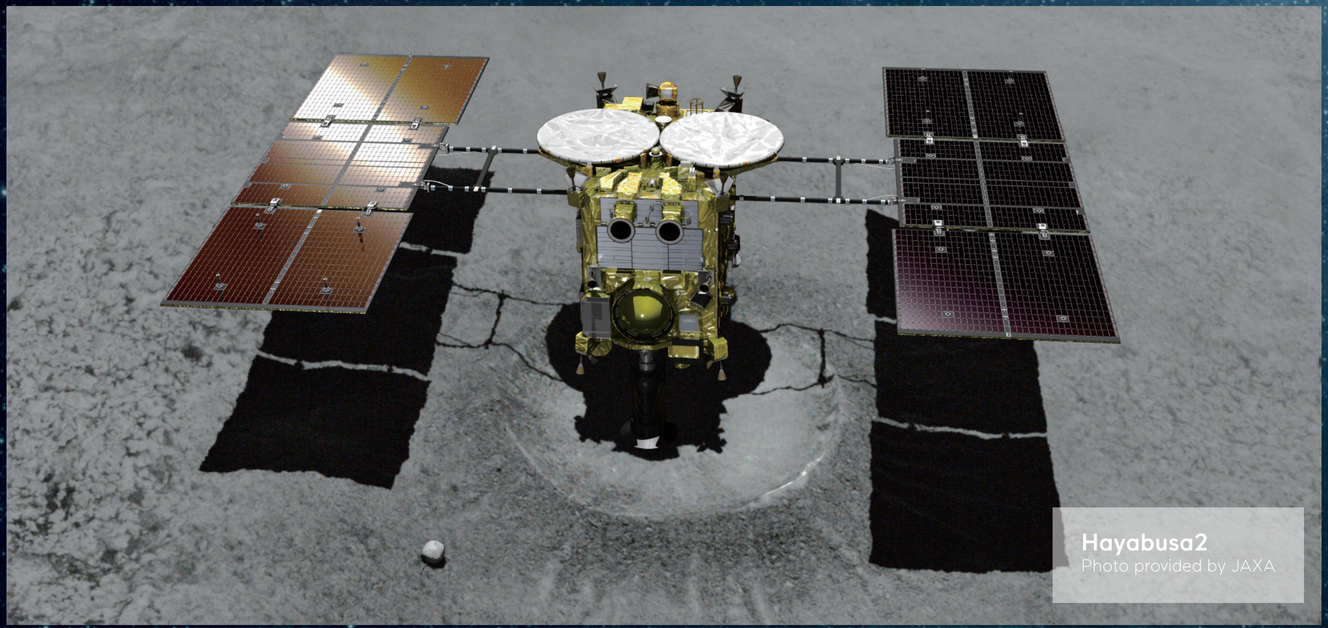
METEORITES

Message-bearers from 4.6 billion years ago

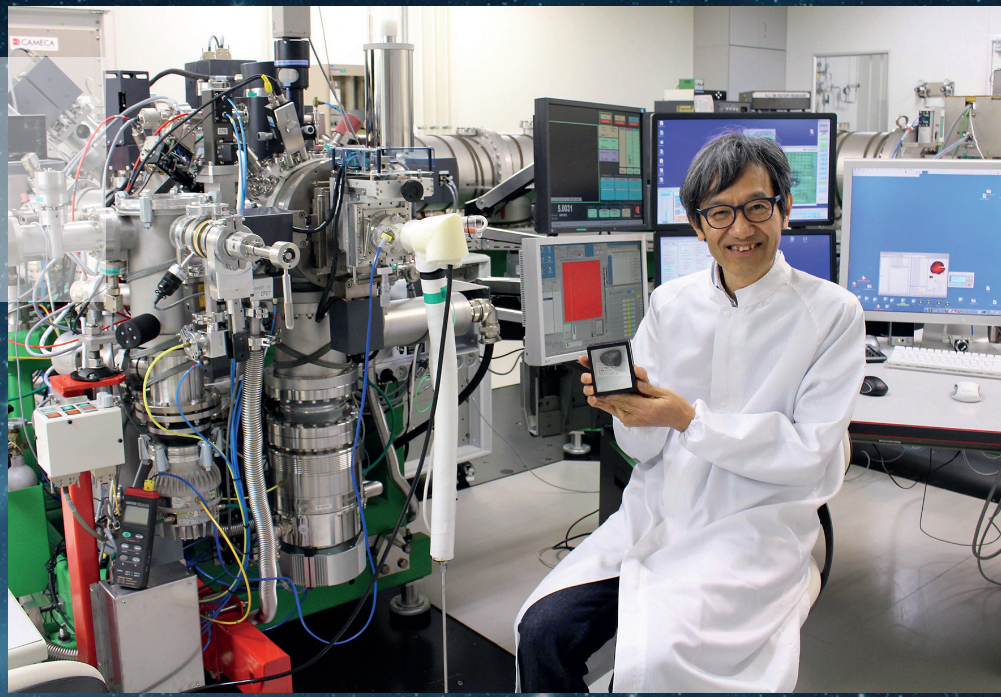
Hayabusa, a robotic spacecraft developed by the Japan Aerospace Exploration Agency (JAXA), returned to Earth in June 2010 after taking a sample from a small near-Earth asteroid named 25143 Itokawa. Professor Hisayoshi Yurimoto at the Faculty of Science, a member of the project is now analyzing the sample to find clues for elucidating how the solar system was born 4.6 billion years ago. He is also preparing to analyze a sample from another asteroid, Ryugu, which Hayabusa2 brought back to Earth in December 2020.

Yurimoto is a born scientist. He has had a keen interest in science, especially beautiful minerals, ever since he was young. "I was so elated when I found quartz in a nearby mikan tangerine field," Yurimoto said with a grin. Yurimoto researched minerals and obtained a doctor's degree in the study of peridots, a green transparent variety of olivine often used as semi-precious gems. Olivine is found in lava and meteorites.

A turning point came more than two decades ago when Yurimoto was around 30 years old. During a meeting with a meteorite specialist, Yurimoto learned that meteorites contain minerals that are not found on Earth. More specifically, some minerals have isotopic ratios different from that of substances on Earth. Isotopes — two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, thus differing in their mass — exist in a certain ratio in elements on our planet.



Hayabusa2
Photo provided by JAXA



Dr. Yurimoto holding a meteorite in front of the isotope microscope.

"I was astounded to discover a meteorite's isotopic ratio was different from the projected figure even though minerals in the meteorite were formed based on the same established laws of physics and chemistry," Yurimoto said, explaining why he started focusing his research on meteorites to unravel the origin and evolution of the solar system. In those days, however, meteorites were hard to come by in Japan. Yurimoto proceeded with his research by borrowing samples from the aforementioned specialist. He also started developing an isotope microscope, a one-of-a-kind device weighing 10 tons, to unlock the mysteries enveloping the isotopic ratio in meteorites.

A meteorite from one of Yurimoto's collections.

The huge microscope, which was completed after 20 years of research and development, enabled researchers to distinguish isotopes of the same element in meteorites.

Yurimoto's group used this isotope microscope to analyze the sample from Itokawa. His group examined the isotopic ratio of oxygen, the most abundant element in meteorites, which has three kinds of isotopes. The results showed the isotopic ratio in the sample was the same as that of ordinary chondrites, which account for 80 percent of meteorites that fall to Earth, demonstrating that meteorites are asteroid fragments and contain vital information from the time when the solar system was born. This finding was reported by the media and fueled discussions around the globe.

It is possible to deduce the pressure, temperature and time required to form meteorites by examining meteorites with the isotope microscope. "We are trying to figure out how the mysterious conditions in meteorites were created, based on isotopic microscopic analyses," Yurimoto said, referring to the different isotopic ratios. "There are various theories about this. Some researchers suggest it is a result of lightening in space, and others point to the effects of collisions between celestial bodies. Nobody knows for certain. It is difficult to think about a phenomenon nobody has seen, but I'd definitely like to unlock that mystery."

Use of the microscope is not limited to space science. As it is suitable for examining molecular movements, the microscope is used for research in fields including medicine, biology, agricultural science and engineering. "It is interesting to talk to many researchers in different fields who would like to use the microscope," Yurimoto said. "Doing so sometimes has led to joint research with my team."

Yurimoto's curiosity about the unknown has not dimmed since he was looking for pieces of quartz as a boy. He is determined to decipher information hidden in meteorites and the original materials that created them, which Hayabusa collected from Itokawa. Driven by his unlimited curiosity that culminated in the development of a groundbreaking device, Yurimoto's ultimate goal is to take a glimpse into a world nobody has seen before. ●

Center for Human-Nature, Artificial Intelligence, and Neuroscience (CHAIN) ESTABLISHED

(Left) The Center Director Shigeru Taguchi speaking at the inaugural symposium.

Hokkaido University launched the Center for Human-Nature, Artificial Intelligence, and Neuroscience, or CHAIN, in July 2019. It will conduct interdisciplinary research and education at the intersection of humanities, artificial intelligence, and neuroscience. The inaugural symposium was held at the university's Sapporo Campus on July 23rd to unravel its vision and ambitious plans for research and graduate-level education.

Professor Shigeru Taguchi, the Director of CHAIN, says, "Recent developments in neuroscience and artificial intelligence have made it possible for scientists to tackle problems that have been traditionally explored in humanities, such as consciousness, emotion, and self," explaining the ever-increasing demand for the integration of humanities and science. "We would like to open up new directions in understanding 'what human beings are'." The center aims, in particular, to integrate highly philosophical ideas with mathematical and empirical scientific methods and findings. Graduate-level education at CHAIN has also started in April 2020 for Master's and Ph.D. students in the university. ●

Hisayoshi Yurimoto bestowed the LEONARD MEDAL

Professor Hisayoshi Yurimoto of the Faculty of Science received the 2019 Leonard Medal from the Meteoritical Society for his outstanding contributions to meteoritics, or the science of meteors, meteorites and meteoroids.

Established in 1933, the Meteoritical Society is an international organization dedicated to the research and education of planetary science, meteorites, and other extraterrestrial objects. The society annually presents the Leonard Medal, named after Frederick C. Leonard, the first president of the society, to one scientist.

Professor Yurimoto studies the origin and evolution of the solar system via chemical and isotopical analyses. Recently, he has been analyzing a meteorite sample named 25143 Itokawa from a small near-Earth asteroid taken by the Hayabusa spacecraft by the Japan Aerospace Exploration Agency (JAXA). ●

A gold butterfly can make its own semiconductor skin

A nanoscale gold butterfly provides a more precise route for growing/synthesizing nanosized semiconductors that can be used in nano-lasers and other applications.

Hokkaido University researchers have devised a unique approach for making nanosized semiconductors on a metal surface. The details of the method were reported in the journal *Nano Letters* and could further research into the fabrication of nanosized light and energy emitters.

The approach, developed by Hokkaido University's Research Institute for Electronic Science and Hokkai-Gakuen University, involves generating localized heat on a gold nanoparticle within a butterfly-shaped nanostructure. The heat causes hydrothermal synthesis in which semiconducting zinc oxide crystallizes on the gold nanoparticle.

Scientists have been investigating ways to carefully place nano-sized semiconductors on metallic particles to utilize them in nano-lasing and nano-lithography, for example. But current methods lack precision or are too costly.

The approach developed by the Japanese team overcomes these issues.

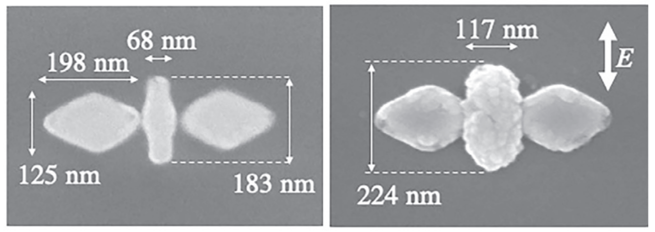
The team first conducted simulations to determine the optimal conditions for precisely controlling the generation of heat in nanostructures. They utilized a phenomenon called surface plasmon resonance, a process which partly converts light to heat in metallic materials.

According to the simulations, a butterfly-shaped nanostructure consisting of two rhombus gold particles placed on either side of a gold nanorod would lead to optimal conditions. In this system, the nanorod, or the body of the butterfly, works as a nanoheater using a specific polarized light. After rotating the light polarization 90 degrees, the rhombus particles, or the wings of the butterfly, should work as an antenna to gather light at subwavelength spots in the butterfly's semiconductor skin.

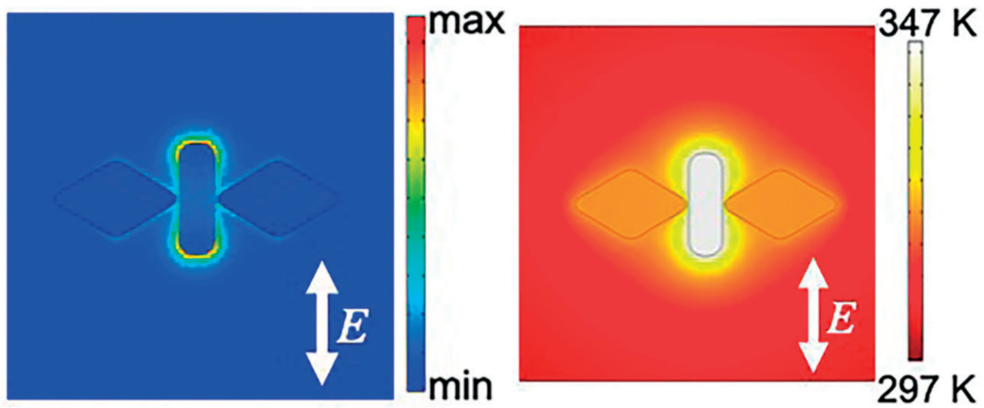
To test this theory, they fabricated the gold butterfly and placed it in water inside a glass chamber. A solution made from equal parts zinc nitrate hexahydrate and hexamethylene tetramine was added to the chamber, which was then sealed and placed on a microscopic stage. When the laser light was shone on the chamber, the system inside the chamber, the nanorod heated up and semiconducting zinc oxide particles crystallized along its surface as they expected.

This demonstrated that the butterfly-shaped gold nano-antenna can precisely control where plasmon-assisted hydrothermal synthesis occurs, therefore enabling the localized formation of nano-sized semiconductors.

"Further research is expected to lead to the development of powerful nano-sized light sources, highly efficient photoelectric conversion devices, and photocatalysts," says Hokkaido University's Keiji Sasaki of the research team. "It could also lead to applications in semiconductor electronics and optical quantum information processing." ●



Scanning electron microscope images of the nano-butterfly structure before (left) and after (right) laser irradiation. Semiconductor zinc oxide has crystallized on the surface of the gold nanorod. (Fujiwara H., et al, *Nano Letters*. December 23, 2019.)



Calculated localized field (left) and temperature distribution (right) of the nano-butterfly structure. (Fujiwara H., et al, *Nano Letters*. December 23, 2019.)

ORIGINAL ARTICLE

Fujiwara H., et al, Localized ZnO Growth on a Gold Nanoantenna by Plasmon-Assisted Hydrothermal Synthesis, *Nano Letters*. December 23, 2019.

FUNDING

The Japan Society for the Promotion of Science (JSPS)'s KAKENHI (JP16H06506, JP17K05016, JP18H03882, JP18H05205, JP19H04529), Dynamic Alliance for Open Innovation Bridging Human, Environment and Materials, and the Nippon Sheet Glass Foundation for Materials Science and Engineering.

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There is no escaping from climate change, even in the deep sea

Even though the deeper layers of the ocean are warming at a slower pace than the surface, animals living in the deep ocean are more exposed to climate warming and will face increasing challenges to maintain their preferred thermal habitats in the future.

Reporting in the journal *Nature Climate Change*, an international team of scientists, led by the University of Queensland in Australia and involving Hokkaido University, analyzed contemporary and future global patterns of the velocity of climate change across the depths of the ocean. Their metric describes the temporal rate and direction of temperature changes, as a proxy for potential shifts of marine biota in response to climate warming.

Despite rapid surface warming, the team found that global mean climate velocities in the deepest layers of the ocean (>1,000 m) have been 2 to nearly 4-fold faster than at surface over the second half of the 20th century. The authors point to the greater thermal homogeneity of the deep ocean environment as responsible for these larger velocities. Moreover, while climate velocities are projected to slow down under scenarios contemplating strong mitigation of greenhouse gas emissions (RCP2.6), they will continue to accelerate in the deep ocean.

"Our results suggest that deep sea biodiversity is likely to be at greater risk because they are adapted to much more stable thermal environments," says Jorge García Molinos, a climate ecologist at Hokkaido University's Arctic Research Center, who contributed to the study. "The acceleration of climate velocity for the deep ocean is consistent through all tested greenhouse gas concentration scenarios. This provides strong motivation to consider the future impacts of ocean warming to deep ocean biodiversity, which remains worryingly understudied."

Climate velocities in the mesopelagic layer of the ocean (200-1000 m) are projected to be between 4 to 11 times higher than current velocities at the surface by the end of this century. Marine life in the mesopelagic layer includes great abundance of small fish that are food for larger animals, including tuna and squid. This could present additional challenges for commercial fisheries if predators and their prey further down the water column do not follow similar range shifts.

The authors also compared resulting spatial patterns of contemporary climate velocity with those of marine biodiversity for over 20,000 marine species to show potential areas of risk, where high biodiversity and velocity overlap. They found that, while risk areas for surface and intermediate layers dominate in tropical and subtropical latitudes, those of the deepest layers are widespread across all latitudes except for polar regions.

The scientists caution that while uncertainty of the results increases with depth, life in the deep ocean is also limited by many factors other than temperature, such as pressure, light or oxygen concentrations. "Without knowing if and how well deep ocean species can adapt to these changes, we recommend to follow a precautionary approach that limits the negative effects from other human activities such as deep-sea mining and fishing, as well as planning for climate-smart networks of large Marine Protected Areas for the deeper ocean," says García Molinos. ●

ORIGINAL ARTICLE

Isaac Brito-Morales et al., Climate velocity reveals increasing exposure of deep-ocean biodiversity to future warming. *Nature Climate Change*. May 25, 2020.

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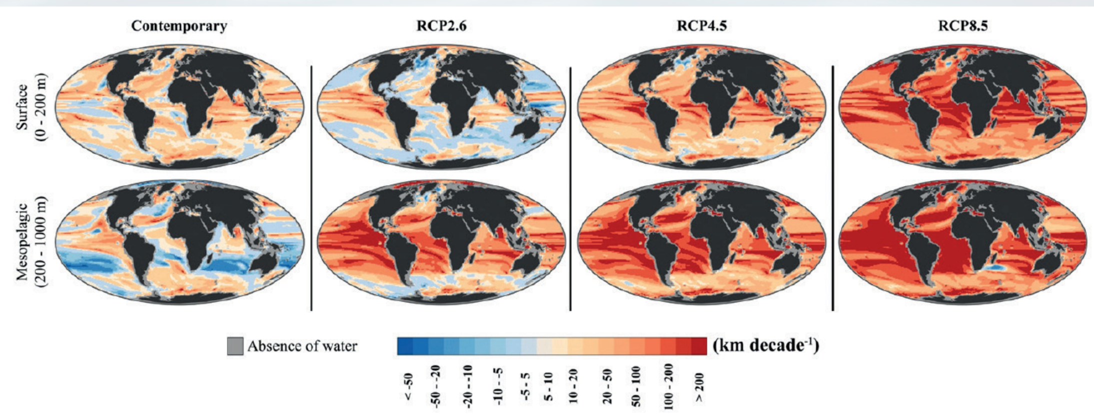


Climate velocity (km decade^{-1}) for contemporary (1955-2005) and projected future sea temperatures (2050-2100) at sea surface and the mesopelagic layer under three IPCC greenhouse gas emission scenarios (RCP2.6, RCP4.5 and RCP8.5). (Isaac Brito-Morales et al., *Nature Climate Change*. May 25, 2020)

Photo by YUCAR FotoGrafik on Unsplash

Deployment of the Philippines' first Micro-satellite "DIWATA-1" from the Kibo/ISS.
Photo: ©JAXA/NASA

MYANMAR-JAPAN COLLABORATION ON MICRO-SATELLITE DEVELOPMENT STARTED

Hokkaido University, Tohoku University, and Myanmar Aerospace Engineering University (MAEU) have started their first satellite development program from September 1st, 2019 funded by the government of the Republic of the Union of Myanmar. Over the course of five years, the program will develop and launch two 50kg-class Micro-satellites while carrying out capacity building for satellite development for students from Myanmar. It will contribute to agriculture, forestry, fisheries, and the mitigation of large-scale natural disasters.

Since 2015, Professor Yukihiro Takahashi of Hokkaido University and his collaborators at Tohoku University have accepted graduate students from the Republic of the Philippines and collaborated in the development, launch, and operation of Micro-satellites DIWATA-1 and -2 (PHL-Microsat program). This success urged the establishment of space agency PhilSA in the Philippines last year.

Similar to the Philippines program, this collaboration with Myanmar aims to develop and launch Micro-satellites for earth observation and to operate advanced observation instruments such as a multi-spectral camera installed on the satellite. Hokkaido University, Tohoku University, and MAEU will cooperate closely to promote research, development, and operation of the satellites. They aim to release the first satellite from the International Space Station in early 2021. ●

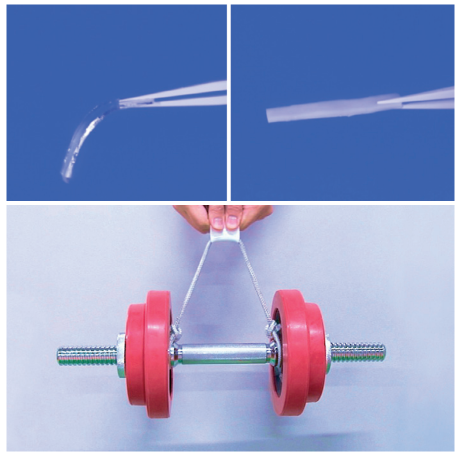
Bio-inspired hydrogel can rapidly switch to rigid plastic

A new material that stiffens 1,800-fold when exposed to heat could protect motorcyclists and racecar drivers during accidents.

Researchers have developed a hydrogel that does the opposite of what polymer-based materials, like plastic bottles, normally do: their material hardens when heated and softens when cooled. Their findings, published in the journal *Advanced Materials*, could lead to the fabrication of protective clothing items for traffic and sports-related accidents.

Takayuki Nonoyama and Jian Ping Gong of Hokkaido University and their colleagues were inspired by how proteins remain stable inside organisms that survive within extreme-heat environments, like hot springs and deep sea thermal vents. Normally, heat "denatures" proteins, altering their structure and breaking their bonds. But the proteins within thermophiles remain stable with heat thanks to enhanced electrostatic interactions such as ionic bonds.

The team developed an inexpensive, non-toxic polyacrylic gel based on this concept. A gel composed of polyelectrolyte poly (acrylic acid) (PAAc) was immersed in a calcium acetate aqueous solution. PAAc on its own acts like any other polymer-based material and softens when heated. But when calcium acetate is added, PAAc's side residues interact with the calcium acetate molecules, in a way similar to what happens inside thermophile proteins, causing PAAc to act very differently.



The gel is soft and transparent at 25°C (top left) and cannot support a 10 kg weight but it quickly becomes rigid and opaque when heated to 60°C (top right), becoming strong enough to support the weight (bottom). (Nonoyama T. et al., *Advanced Materials*, November 18, 2019)

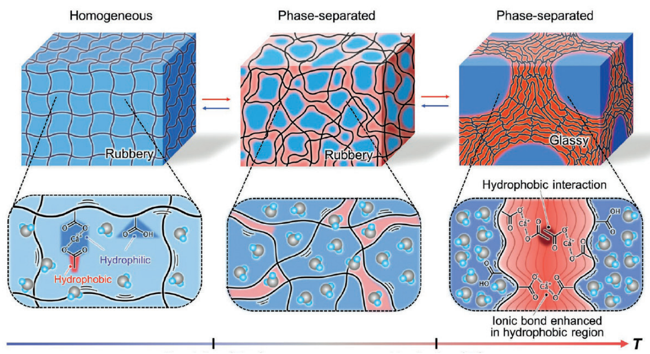
The team found that their originally uniform gel separates into a polymer dense "phase" and a polymer sparse one as the temperature rises. When it reaches to a critical temperature, in this case around 60°C, the dense phase undergoes significant dehydration which strengthens ionic bonds and hydrophobic interactions between polymer molecules. This causes the material to rapidly transform from a soft, transparent hydrogel to a rigid, opaque plastic.

The heated material was 1,800 times stiffer, 80 times stronger, and 20 times tougher than the original hydrogel. The soft-to-rigid switching was completely reversible by alternatively heating and cooling the material. Moreover, the scientists could fine-tune the switching temperature by adjusting the concentration of the ingredients.

They then demonstrated a possible application of the material by combining it with a woven glass fabric. This new fabric was soft at room temperature, but when it was pulled against an asphalt surface for five seconds at a speed of 80 km/hour, the heat generated by the friction hardened the material with only minor abrasions forming on the contact surface.

Takayuki Nonoyama says "Clothing made from similar fabric could be used to protect people during traffic or sports-related accidents, for example. Our material could also be used as a heat-absorbent window coating to keep indoor environments cooler."

"This polymer gel can be easily made from versatile, inexpensive and non-toxic raw materials that are commonly found in daily life. Specifically, the polyacrylic acids are used in disposable diapers and calcium acetates are used in food additives," Jian Ping Gong added. "Our study contributes to basic research on new temperature-responsive polymers, and to applied research on temperature-responsive smart materials." ●



Molecular structures and the mechanisms behind instant thermal hardening of the hydrogel. (Nonoyama T. et al., *Advanced Materials*, November 18, 2019)

ORIGINAL ARTICLE

Nonoyama T. et al., Instant Thermal Switching from Soft Hydrogel to Rigid Plastics Inspired by Thermophile Proteins. *Advanced Materials*, November 18, 2019.

FUNDING

The Japan Society for the Promotion of Science (JSPS)'s KAKENHI grant (JP17H06144, 17K19146, 17H06376).

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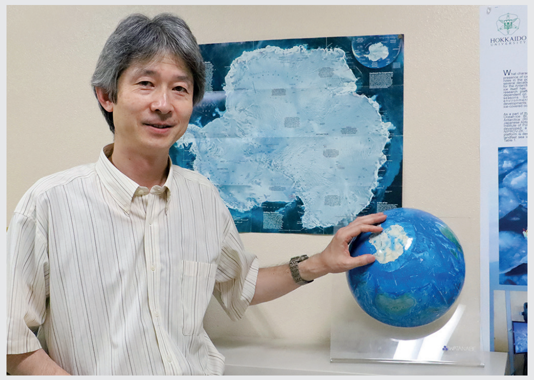
Antarctic Expedition ship *Shirase* during the 58th Japanese Antarctic Research Expedition in 2017.
Photo by Kazuya Ono, Institute of Low Temperature Science.

SHIGERU AOKI LEADS EXPEDITION TO ANTARCTICA



Associate Professor Shigeru Aoki at the Institute of Low Temperature Science.

For the first time, a Hokkaido University researcher led the Japanese Antarctic Research Expedition. Associate Professor Shigeru Aoki of the Institute of Low Temperature Science was selected by the government to lead the 61st Japanese Antarctic Research Expedition, which left Japan for the Antarctic in November 2019 and continued until March 2020.

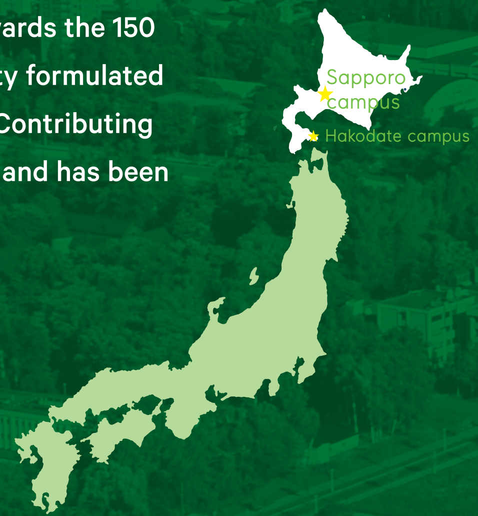
Aoki is an experienced scientist in the field of polar research, having participated in the 39th, 43rd, and 56th Japanese Antarctic Research Expeditions as well as a number of expeditions led by Australia. His role as the leader of the 61st expedition included managing the crew members and on-site research activities.

On board the observation ship Shirase, one of the main missions of the 61st expedition was to observe and uncover the relationship between ice and the ocean in the Antarctic regions, particularly in relation to climate change. ●

Hokkaido University *at a glance*

A Long History

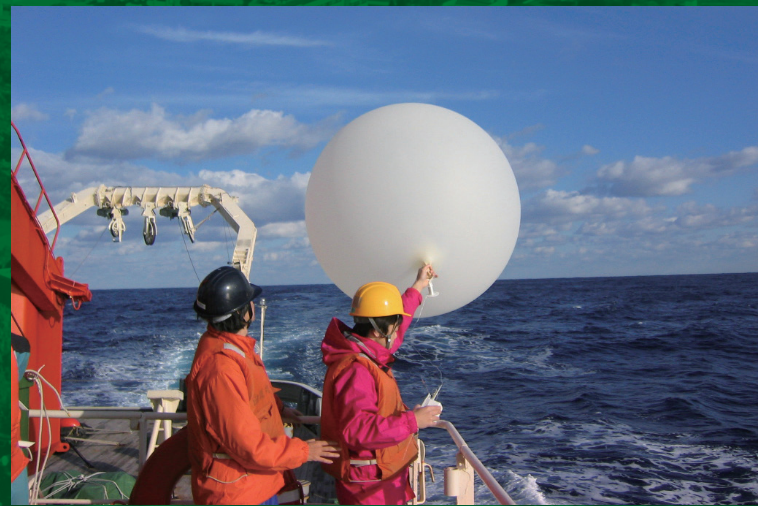
Founded in 1876 as Sapporo Agricultural College, Hokkaido University is one of the oldest, largest, and most prestigious universities in Japan. Boasting one of the largest campuses in Japan, the university houses cutting-edge research facilities, a university hospital, and a number of field research centers including one of the world's largest research forests. Towards the 150 anniversary of its founding, the university formulated an action strategy under the slogan of "Contributing towards the resolution of global issues," and has been implementing a number of reform plans.



Contributing towards the **resolution** of **global** issues

Hokkaido Universal Campus Initiative (HUCI)

Aiming to further internationalize the university and foster more world leaders who can contribute to the resolution of global issues, the university launched the Hokkaido Universal Campus Initiative (HUCI) in 2014 as part of Top Global University Projects by the Japanese government. Under the initiative, the university has implemented a number of programs to develop global leaders and promote international collaborations.



Research

Since its establishment as an agricultural college, Hokkaido University has expanded its research strength to encompass a variety of fields in the sciences and humanities. It has produced experts in the areas such as low temperature science, life science, veterinary science, and fisheries science.

In 2014, to further strengthen international collaboration and conduct top-level research in strategic areas including quantum medical science and engineering, the university established the Global Institution for Collaborative Research and Education (GI-CoRE). In 2018, the university launched the Institute for Chemical Reaction Design and Discovery (ICReDD) as part of the World Premier Institutional Research Initiative (WPI) by the Japanese government.

International programs

In addition to the regular 12 undergraduate and 21 graduate schools, Hokkaido University runs a number of degree programs taught in English for international students such as Modern Japanese Studies Program (MJSP) and Integrated Science Program (ISP) for undergraduate students. At the graduate level, courses in engineering, veterinary medicine, agricultural science, science, and environmental science among others, are offered in English.

During the summer, the Hokkaido Summer Institute (HSI) offers more than 100 short programs in English covering a wide range of disciplines from material science to archaeology which are run by top-level researchers from the university and around the world.

Today

Data as of April 2020

660 km²
total area
campuses & facilities

12
undergraduate schools

21
graduate schools

1
Nobel prize
Akira Suzuki, Nobel Prize in Chemistry (2010)

8
overseas offices

227,860
alumni

18,105
students

12%
international students

RANKING

1st
in Japan

76th
in the world

THE World University Impact Rankings 2020

29th
in Asia

132nd
in the world

QS World University Rankings 2020

111th
in the world

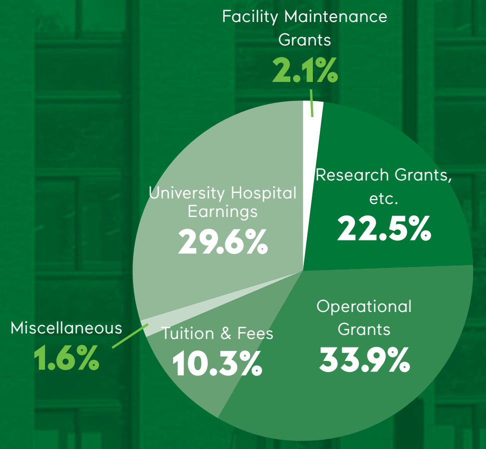
Nature Index Top Academic Institutions 2020

3,917
faculty & staff

25
research centers and institutions

REVENUE

¥103,728m
revenue in 2020



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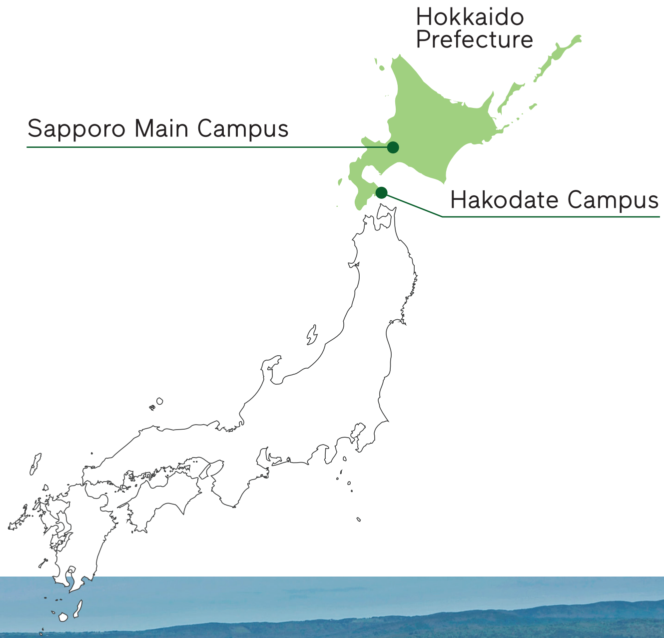

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