HOKKAIDO UNIVERSITY

Hokkaido University is one of the oldest, largest, and most prestigious universities in Japan. The University was originally founded as Sapporo Agricultural College in 1876 to educate students to become national leaders, and to help develop Hokkaido.

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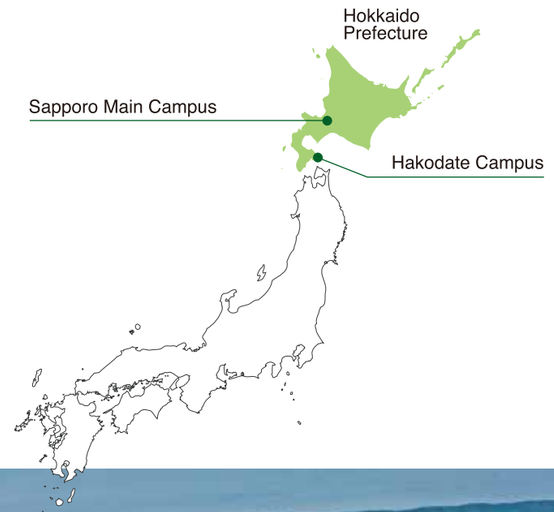

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Spotlight on Research

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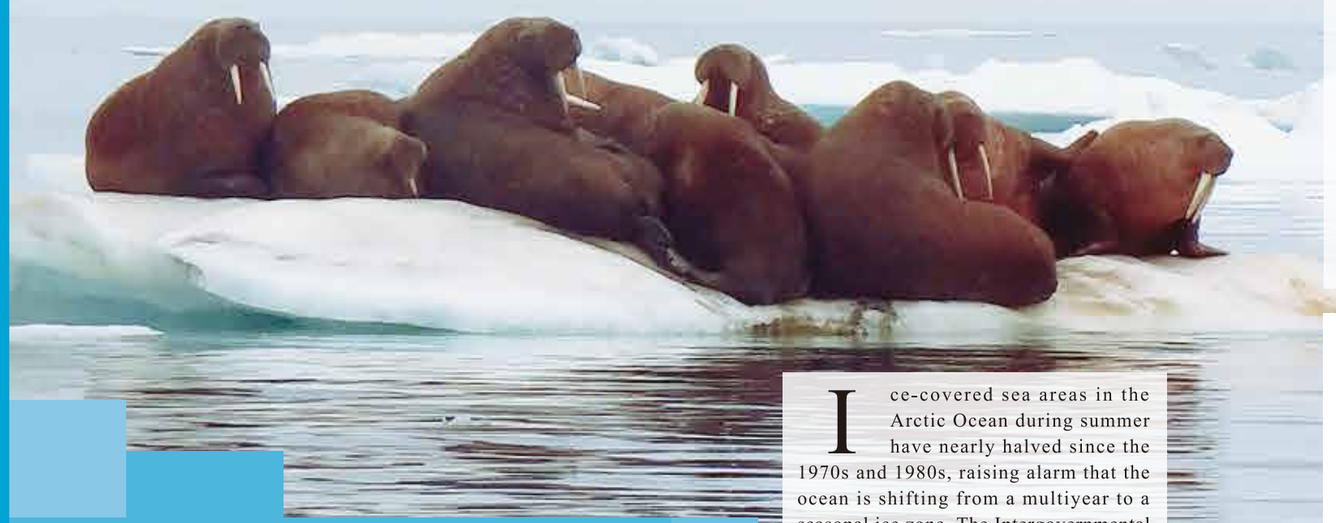
Melting ice in the Arctic Ocean: Unraveling its acceleration mechanism

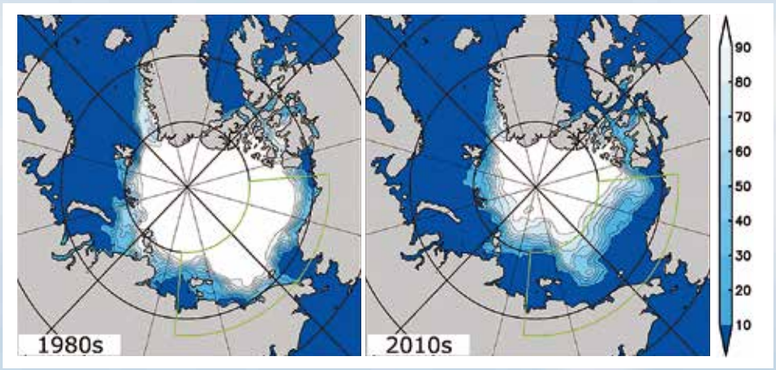


Walruses huddling together on a block of ice in the Arctic Ocean in August 2012 right before the summer ice cover hit a record low in the following month. Photo by Toru Takatsuka

Quantitative analysis has evidenced that dark water surfaces absorb more heat than white ice surfaces, thus melting ice and making more water surfaces in the Arctic Ocean.

Ice-covered sea areas in the Arctic Ocean during summer have nearly halved since the 1970s and 1980s, raising alarm that the ocean is shifting from a multiyear to a seasonal ice zone. The Intergovernmental Panel on Climate Change (IPCC) has forecasted summer ice cover in the polar ocean might disappear almost completely as early as 2050. Various factors have been cited as causes, including rising temperatures and changes in atmospheric circulation patterns.

Recently, however, ice-ocean "albedo feedback" has emerged as a key cause for sea ice melt. The feedback is generated by a large difference in albedo — a measure of light reflectivity — between open water and ice surfaces. As dark ocean surfaces absorb more light than white ice surfaces, solar heat input through the open water melts sea ice, increasing both open water areas and heat input and thus accelerating sea ice melt.



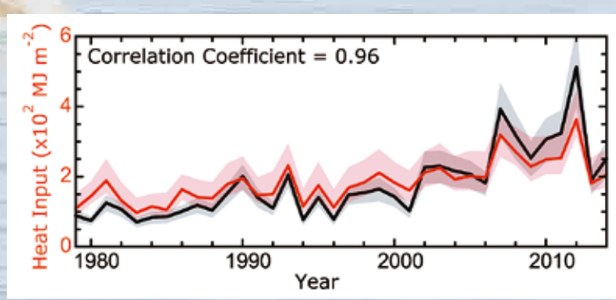
Sea ice concentrations in September. The left and right maps show the average ice concentration in the Arctic Ocean in the 1980s and 2010s respectively. The fan-shaped outline marks the study area. The maps are based on information provided by the National Snow and Ice Data Center.

To examine this theory, a team of researchers including Hokkaido University Professor Kay I. Ohshima and Haruhiko Kashiwase of the National Institute of Polar Research, conducted a quantitative analysis of key factors such as solar energy input, ice melt volume and ice divergence of a sea area that has shown major ice melt.

Analyzing the data from 1979 to 2014, the researchers found the solar heat input through open water surfaces correlated well with ice melt volume, suggesting heat input is a major causative factor of melting ice. This was particularly obvious after 2000, when there were considerable reductions in sea ice.

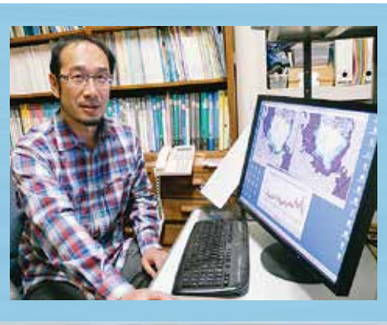
Their data also revealed that sea ice divergence in the early melt season (May–June), which reflects the amount of sea ice spreading outward making more water surfaces, triggers large-scale feedback which subsequently amplifies ice melting in the summer. The volume of ice divergence has doubled since 2000 due to a decline in multiyear ice and a more mobile ice cover. This can explain the drastic ice reduction in the Arctic Ocean in recent years.

"This study was the first to quantitatively elucidate that ice-ocean albedo feedback is a primary driver of seasonal and yearly variations in Arctic sea ice retreat," says Kay I. Ohshima. "The study pointed to the possibility of forecasting the largest sea ice retreat in a given year based on the magnitude of ice divergence in May and June. Furthermore, unraveling the causes of sea ice retreat should help us understand the mechanisms behind climate change on a global level, which is interrelated to the ice reduction in the Arctic ocean."



Accumulated heat input through open water surfaces in the surveyed area from May to August (red line) correlated well with interannual variations in ice melt volume (black line) between 1979 and 2014. Sea ice melt volume is converted to the heat input required for ice melt.

Researcher Details



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Original paper:
Kashiwase H., Ohshima K. I., et al., Evidence for ice-ocean albedo feedback in the Arctic Ocean shifting to a seasonal ice zone, *Scientific Reports*, August 15, 2017.
DOI: 10.1038/s41598-017-08467-z

Funded by:
The Green Network of Excellence (GRENE) Arctic Climate Change Research Project of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan

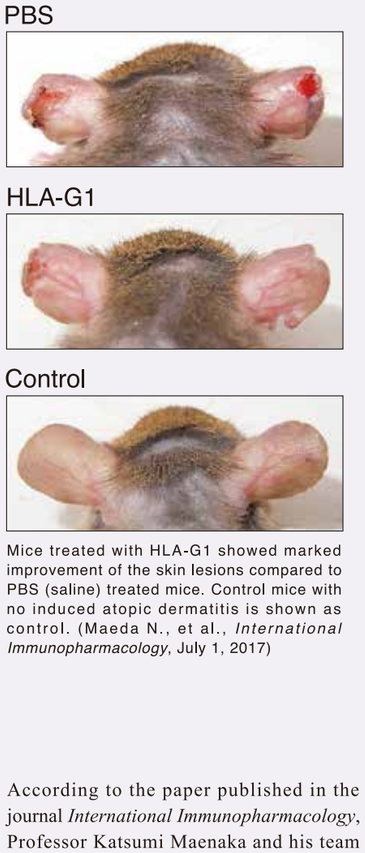
Countering atopic dermatitis immune reactions

Emily frost/shutterstock

A protein which protects the fetus during pregnancy, HLA-G1, shows high potential for treating atopic dermatitis and other related diseases.

Human leukocyte antigen (HLA)-G is a protein that interacts with specific cell receptors to inhibit immune responses. The protein is best known for its role in protecting the fetus from attack by its mother's immune system. A team of researchers from Hokkaido University successfully used it to treat mice with an induced form of atopic dermatitis.

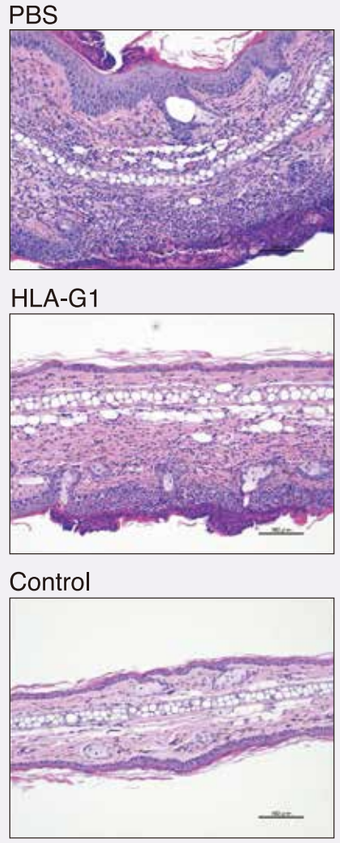
Atopic dermatitis is a chronic form of eczema commonly seen in developed countries, particularly in children. It occurs as a result of a hypersensitive immune reaction but the exact mechanism is still unknown although extensive research has been carried out around the world. It causes redness of the skin, itchiness, scaling and vesicles.



Mice treated with HLA-G1 showed marked improvement of the skin lesions compared to PBS (saline) treated mice. Control mice with no induced atopic dermatitis is shown as control. (Maeda N., et al., *International Immunopharmacology*, July 1, 2017)

According to the paper published in the journal *International Immunopharmacology*, Professor Katsumi Maenaka and his team used an extract made from a common dust mite to induce atopic dermatitis in mice. Dust mites are known as a causative allergen in atopic dermatitis. Bleeding, scarring and dry skin were evident after applying the extract on and around the mice's ears for 15 days. Blood samples also showed evidence of an immune reaction. The affected areas around the ears were then treated with topical HLA-G1, a major form of HLA-G, every other day for 20 days. These HLA-G1 proteins had been produced in bacteria and purified for the experiments.

Mice treated with HLA-G1 showed marked improvement of the skin lesions. Blood samples also showed a reduced immune response compared to mice that weren't treated with HLA-G1. The results suggest that HLA-G1 could improve conditions by suppressing an excessive allergic reaction in the atopic dermatitis model. Importantly, the treated mice didn't show weight loss, a common side effect in anti-atopic dermatitis treatments. Other experiments showed that HLA-G1's suppressive function involves the inhibition of lymphocytes that work in allergic reactions.



Histological analysis showed a marked decrease in epidermal hyperplasia and infiltration of inflammatory cells in the dermis of HLA-G1 treated mice. (Maeda N., et al., *International Immunopharmacology*, July 1, 2017)

The team previously reported that HLA-G proteins can suppress joint swelling in an animal model for rheumatoid arthritis. "Our study provides novel insights on the function of HLA-G proteins, which can provide clues on efficient therapeutic strategies for patients with atopic dermatitis, rheumatoid arthritis and other related diseases. Further investigation is needed to better understand HLA-G's suppressive mechanism against excessive immune reactions," says Katsumi Maenaka.

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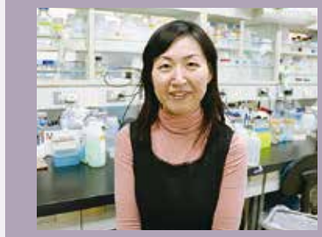

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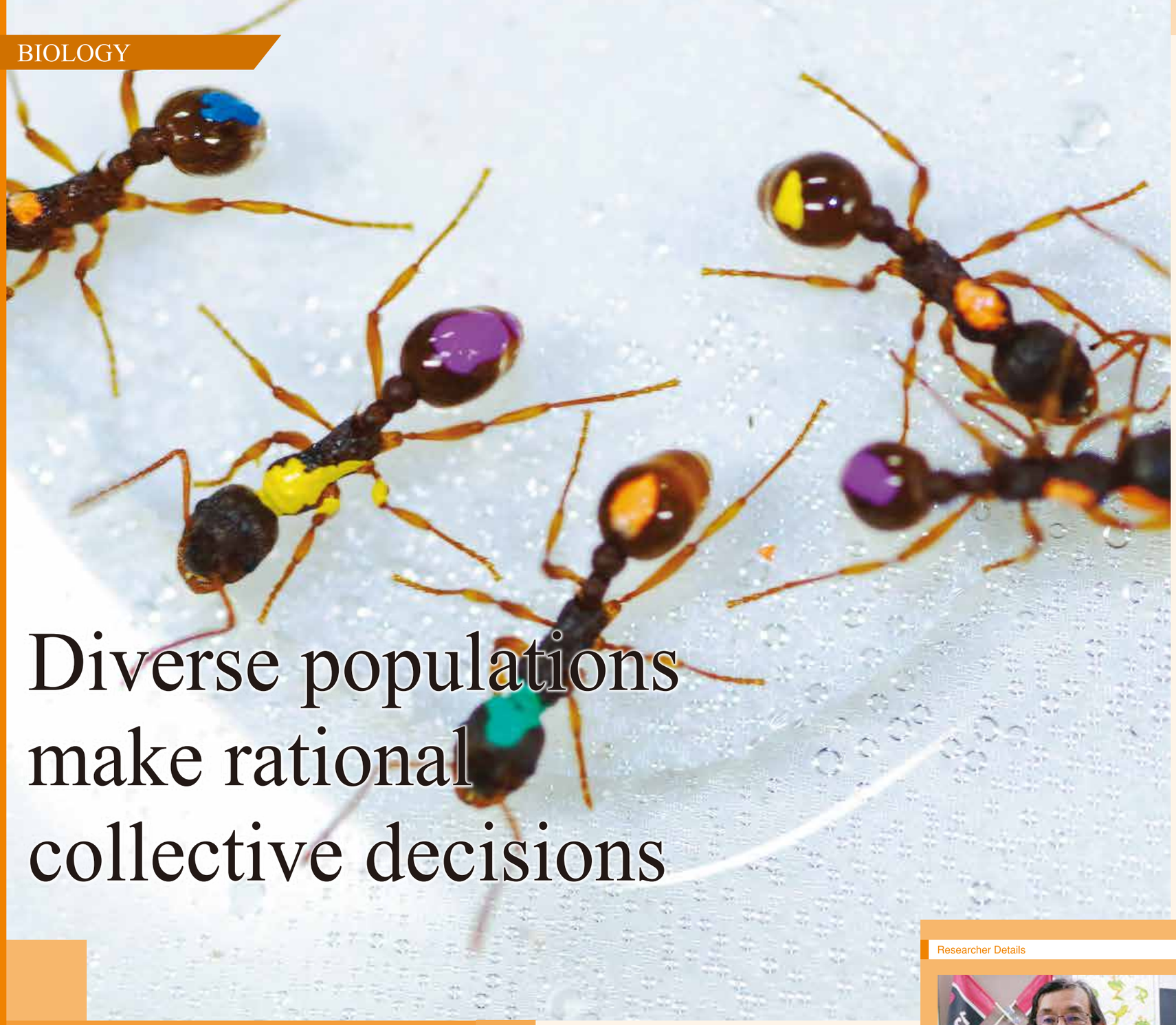
Original paper:
Maeda N., et al., Therapeutic application of human leukocyte antigen-G1 improves atopic dermatitis-like skin lesions in mice. *International Immunopharmacology*, July 1, 2017.
DOI: 10.1016/j.intimp.2017.06.026

Funded by:
The Platform Project for Supporting in Drug Discovery and Life Science Research from the Ministry of Education, Culture, Sports, Science and Technology (MEXT)(12723020) of Japan, the Japan Agency for Medical Research and Development (AMED) (17933644), and a Grant-in-Aid Scientific Research by the Japan Society for the Promotion of Science (JSPS) (15H02384)



Diverse populations make rational collective decisions

Understanding how ant colonies make collective decisions could provide insight into the functioning of the human brain.

Ant species *Myrmica kotokui* marked with colors.
Photo by Tatsuhiro Yamamoto

Yes/no binary decisions by individual ants can lead to a rational decision as a collective when the individuals have differing preferences to the subject, according to research published in the journal *Royal Society Open Science*. This binary mechanism of decision-making could provide a basis for understanding how neurons in the human brain, which also make binary choices, work together.

Honey bees are known to "dance" with varying levels of enthusiasm depending on the quality of nectar they find. The more attractive the nectar is, the stronger they dance, appealing to other members. As a result, the majority of the members, and later the entire colony, gather to the better option. However, this mechanism doesn't explain how a collective rationality within the brain is made because neurons can only make binary decisions.

Tatsuhiro Yamamoto and Associate Professor Eisuke Hasegawa of Hokkaido University set up six experimental colonies of 56 *Myrmica kotokui* ants. Each individual ant was marked to distinguish them from one another.

They starved the ants for three days, then fed them sucrose solution with two different concentrations: 3.5% or 4.0%, and observed their behaviour. This process was repeated three times with an interval of three days between them.

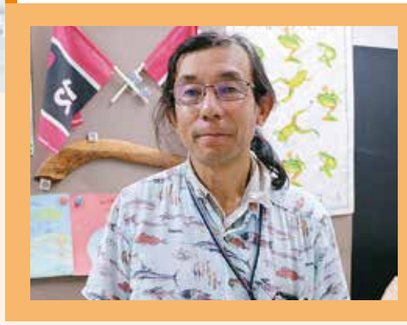
The team found that individual ants had different yet consistent preferences. Some of the ants were happy to feed on either of the two solutions. Picky ants refused to feed from either. A third "middle" group consistently chose the solution with a higher concentration. These varied choices demonstrated that individual ants had individual thresholds to the sucrose concentration and made yes/no binary decisions accordingly.

The researchers then fed each colony again with the differing sucrose solutions and found that the majority of the ants in all six experimental colonies chose the 4.0% sucrose solution, without being influenced by other ants in the colony. The "collective" decision of the colony was thus for the more nourishing solution.

"Importantly, neither ants with a low threshold and high threshold contributed to the collective decision making, since the former didn't care about the concentration and the latter refused both concentrations. Thus, the decision maker was the middle group which preferred the higher concentration," says Hasegawa.

"The study demonstrates simple yes/no judgements by individuals can lead to a collective rational decision, without using quality-graded responses, when they have diverse thresholds in the population," he continued. This mechanism can be applied to various fields including brain science, behavioural science, swarm robotics and consensus decision-making in human societies, conclude the researchers.

Researcher Details



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Original paper:
Yamamoto T., Hasegawa E., Response threshold variance as a basis of collective rationality. *Royal Society Open Science*, April 12, 2017.
DOI: 10.1098/rsos.170097

Funded by:
Grants-in-aid from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) (26440228, 15H04420) of Japan.

Equatorial jet in Venusian atmosphere discovered by Akatsuki

Observations by Japan's Venus climate orbiter Akatsuki have revealed an equatorial jet in the lower to middle cloud layer of the planet's atmosphere, a finding that could be pivotal to unraveling "superrotation."

An illustration of Akatsuki successfully tracking lower-altitude clouds during the night with its near-infrared camera IR2. ©PLANET-C Project Team

Venus rotates westward with a very low angular speed; it takes 243 Earth days to rotate once. The planet's atmosphere rotates in the same direction but at much higher angular speeds, which is called "superrotation." The planet is covered by thick clouds that extend from an altitude of about 45 kilometers to 70 kilometers. The superrotation reaches its maximum near the top of this cloud, where the rotational speed is about 60 times that of the planet itself. The cause of this phenomenon, however, is shrouded in mystery.

Images showing the time course of 2.26-μm radiance obtianed by the IR2 camera onboard Akatsuki on July 11-12, 2016. The brightness is shown reversely, so the brighter in the images represents the fewer radiance indicating thicker clouds. (Remark: The original images between 18 and 22 h include the dayside of Venus in the observational field of view, so the radiance change near the day-night boundary in the middle of the images is spurious owing to the dayside brightness) ©PLANET-C Project Team

Watch the movie

Akatsuki was launched in 2010 by the Japan Aerospace Exploration Agency to unravel the atmospheric mysteries of Venus. Although lower-altitude clouds cannot be seen through with visible light, Akatsuki's near-infrared camera IR2 successfully tracked the clouds — in particular, thicker clouds between 45 kilometers to 60 kilometers in altitude. This was made possible by observing the silhouettes of clouds that appear when infrared light from thermal radiation originating in the lower atmosphere filter through clouds.

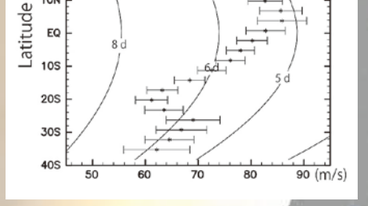
Similar observations were previously made by the Venus Express orbiter of the European Space Agency and Galileo spacecraft of the U.S. National Aeronautics and Space Administration, but they provided only limited data of the planet's low-latitude zones. From these observations, scientists speculated that wind speeds at lower-to-middle cloud altitudes are horizontally uniform and have few temporal variations.

In the study published in *Nature Geoscience*, the team of researchers including Hokkaido University Associate Professor Takeshi Horinouchi analyzed the data collected by Akatsuki between March and August 2016. The team employed a cloud-tracking method they recently developed to deduce horizontal distributions of winds based on data from Akatsuki.

They discovered an equatorial jet in the wind velocities based on image data from July 2016 and that the jet existed at least two months after that. In March that year, the wind velocities in the same latitude zones were rather slow — thus there was no jet.

The findings showed for the first time that wind velocities can be markedly high forming a jet near the equator, which have never been found not only in the scantily observed lower to middle cloud layers but also in the more-extensively studied high layers.

"Our study uncovered that wind velocities in the lower-to-middle cloud layer have temporal and spatial variabilities much greater than previously thought," says Takeshi Horinouchi. "Although it remains unclear why such an equatorial jet appears, the mechanisms that could cause it are limited and related to various theories about superrotation. So, further study of the Akatsuki data should help glean useful knowledge not only about local jets but also address superrotation theories."



Westward wind speed obtained from the IR2 observations on July 11–12, 2016; longitudinally averaged winds are shown with respect to latitude. The wind speed peak at low latitude indicates the jet. ©PLANET-C Project Team

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Original paper:
Horinouchi T., et al., Equatorial jet in the lower to middle cloud layer of Venus revealed by Akatsuki, *Nature Geoscience*, August 28, 2017.
DOI: 10.1038/NGEO3016

Funded by:
The Japan Society for the Promotion of Science (JSPS) (KAKENHI 15K17767, 16H02225, 16H02231, 16K17816), the NASA Grant (NNX16AC79G), and the JAXA's International Top Young Fellowship (ITYF)

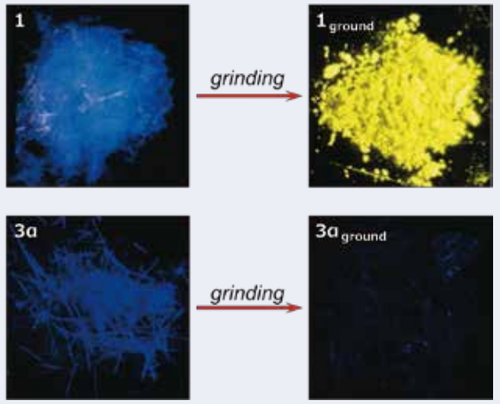
When gold turns invisible

A gold compound shifts from a visible fluorescence to emitting infrared when ground — a big shift with potential applications in bioimaging and security inks.

Some materials luminesce, changing their color and intensity when under mechanical forces such as grinding or rubbing. These luminescent "mechanochromic" materials can produce various emission colors in the visible light spectrum, from blue to red. Their color-shifts under force are well documented, and are caused by changes to the molecules' crystal structures.

Recently, a big shift from the visible spectrum to the infrared has been identified and described in the *Journal of the American Chemical Society*. Such a large change is unprecedented and is exciting because of its potential applications for bioimaging and invisible inks.

In an attempt to develop new mechanochromic compounds, a research group at Hokkaido University found that a gold compound called 9-anthryl gold(I) isocyanide complex has a unique feature. In its original form, the substance produced a visible blue fluorescence with a wavelength of 448 nanometres (nm). After being ground up into a fine powder, the substance produced infrared emissions (phosphorescence) invisible to the naked eye with a wavelength of 900 nm.



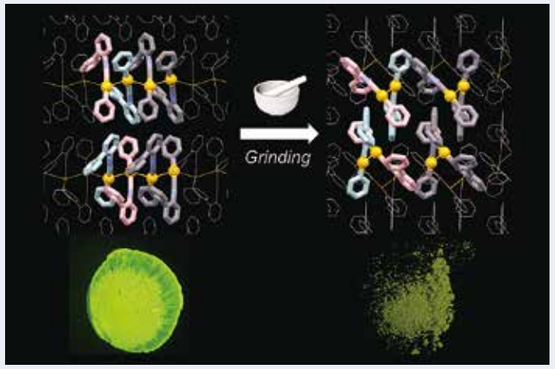
9-anthryl gold(I) isocyanide (3α) turns invisible and emits infrared after it's ground whereas phenyl gold(I) isocyanide (1) turns yellow. (Seki T. et al., *Journal of the American Chemical Society*, May 2, 2017)

"This is the first time a material has been reported to make such a dramatic shift — a change of 452 nm — that also reaches into the infrared part of the light spectrum," says Assistant Professor Tomohiro Seki, the lead and corresponding author of the paper.

The research group's X-ray crystallographic analyses revealed that the large shift is based on a crystalline-to-amorphous phase transition which should create strong intermolecular interactions between the gold ions.

"The development of infrared emissive materials is generally difficult, and appropriate design strategies remain limited. However, in this case, simple grinding can afford an infrared emissive material," says Professor Hajime Ito, the other corresponding author. "Infrared is invisible to the naked eye but detectable using a spectrometer. So, our material has a great potential for bioimaging and security inks."

Weeks after publishing the paper, Ito's group also discovered crystals made from gold complexes which change colors as they change structure from "chiral" to "achiral" when ground. Regarding this research, Ito said "This is the first proof that the chiral-to-achiral phase transition caused by a mechanical stimulus could alter emission properties." These results suggest that the dynamic change between the two crystal phases may be a promising strategy to design universal mechano-responsive functional materials.



Grinding chiral crystals of gold and isocyanide complexes caused them to transition into achiral crystals while simultaneously changing their emission properties.

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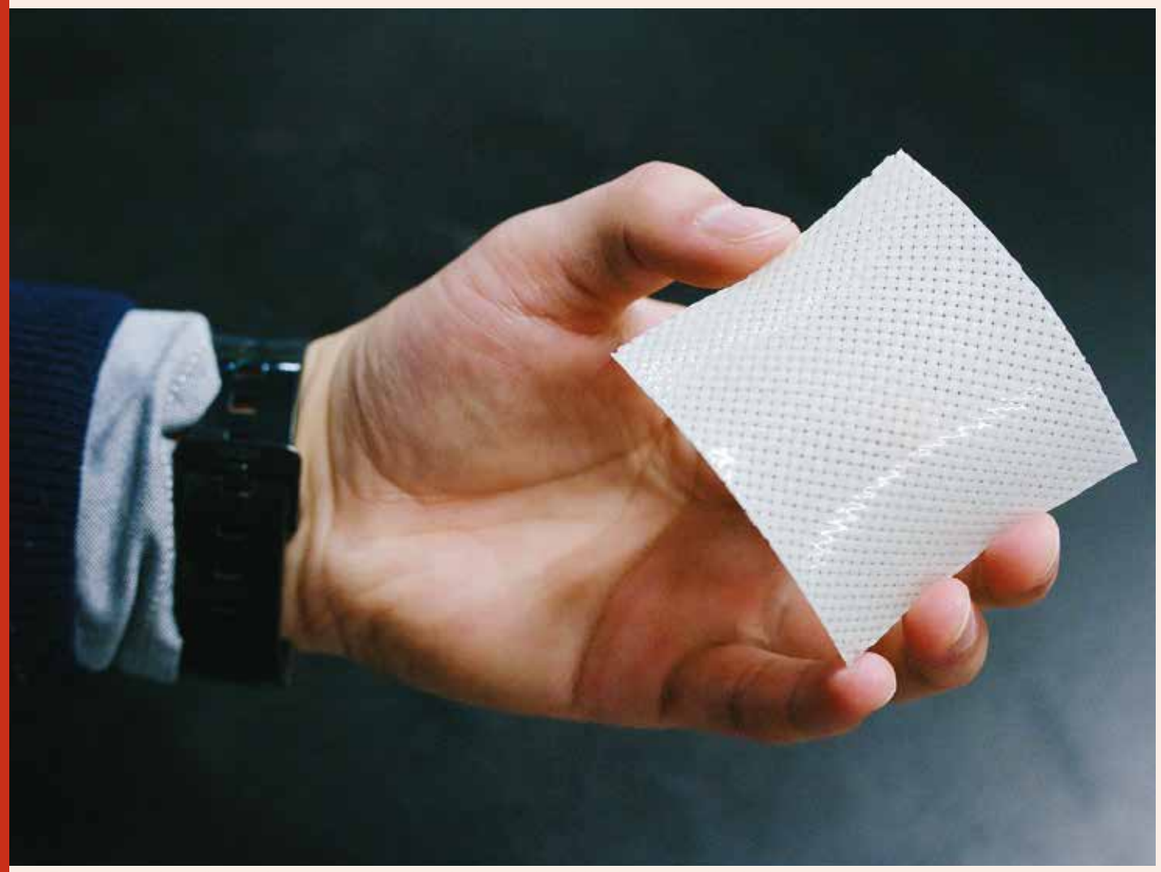
Original paper:
Seki T. et al., Luminescent Mechanochromic 9-Anthryl Gold(I) Isocyanide Complex with an Emission Maximum at 900 nm after Mechanical Stimulation. *Journal of the American Chemical Society*, May 2, 2017.
DOI: 10.1021/jacs.7b00587

Mingoo Jin, Tomohiro Seki and Hajime Ito. Mechano-Responsive Luminescence via Crystal-to-Crystal Phase Transitions between Chiral and Non-Chiral Space Groups. *Journal of the American Chemical Society*, May 23, 2017.
DOI: 10.1021/jacs.7b04073

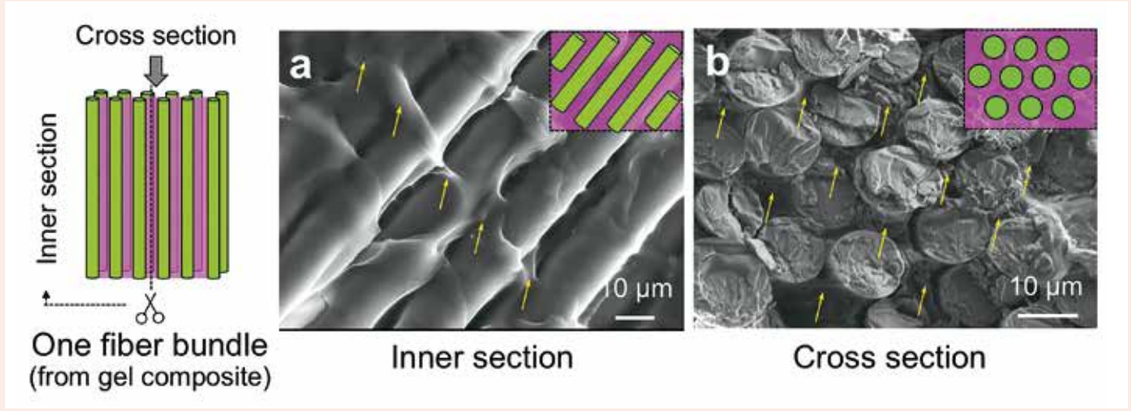
Funded by:
The Program for Fostering Researchers for the Next Generation, the Japan Society for the Promotion of Science (JSPS) (KAKENHI JP15H03804, JP16H06034, JP17H05134, JP17H05344, JP17H06370), and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan via the "Program for Leading Graduate Schools" at Hokkaido University's "Ambitious Leaders Program"

New "tougher-than-metal" fiber-reinforced hydrogels



The newly developed fiber-reinforced hydrogel consists of polyampholyte (PA) gels and glass fiber fabric.

Fiber-reinforced soft composites, or tough hydrogels combined with woven fiber fabric have been created by Hokkaido University scientists. These fabrics are highly flexible, tougher than metals, and have a wide range of potential applications.



Scanning Electron Microscopy (SEM) images of the fiber-reinforced hydrogels. The polymer matrix (arrows) filled the interstitial space in the fiber bundles and connected the neighboring fibers. The team theorizes that toughness is increased by dynamic ionic bonds between the fiber and hydrogels, and within the hydrogels. (Huang Y. et al., *Advanced Functional Materials*, January 16, 2017)

Efforts are currently underway around the world to create materials that are friendly to both society and the environment. Among them are those that comprise different materials, which exhibit the merits of each component.

Hokkaido University researchers, led by Professor Jian Ping Gong, have focused on creating a reinforced material using hydrogels. Though such a substance has potential as a structural biomaterial, up until now no material reliable and strong enough for long-term use has been produced.

To address the problem, the team combined hydrogels containing high levels of water with glass fiber fabric to create bendable, yet tough materials, employing the same method used to produce reinforced plastics. The team found that a combination of polyampholyte (PA) gels, a type of hydrogel they developed earlier, and glass fiber fabric with a single fiber measuring around 10μm in diameter produced a strong, tensile material. The procedure to make the material is simply to immerse the fabric in PA precursor solutions for polymerization.

When used alone, the fiber-reinforced hydrogels developed by the team are 25 times tougher than glass fiber fabric, and 100 times tougher than hydrogels — in terms of the energy required to destroy them. Combining these materials enables a synergistic toughening. The team theorizes that toughness is increased by dynamic ionic bonds between the fiber and hydrogels, and within the hydrogels, as the fiber's toughness increases in relation to that of the hydrogels. Consequently, the newly developed hydrogels are 5 times tougher compared to carbon steel.

"The fiber-reinforced hydrogels, with a 40 percent water level, are environmentally friendly," says Jian Ping Gong, "The material has multiple potential applications because of its reliability, durability and flexibility. For example, in addition to fashion and manufacturing uses, it could be used as artificial ligaments and tendons, which are subject to strong load-bearing tensions." The principles to create the toughness of the present study can also be applied to other soft components, such as rubber.

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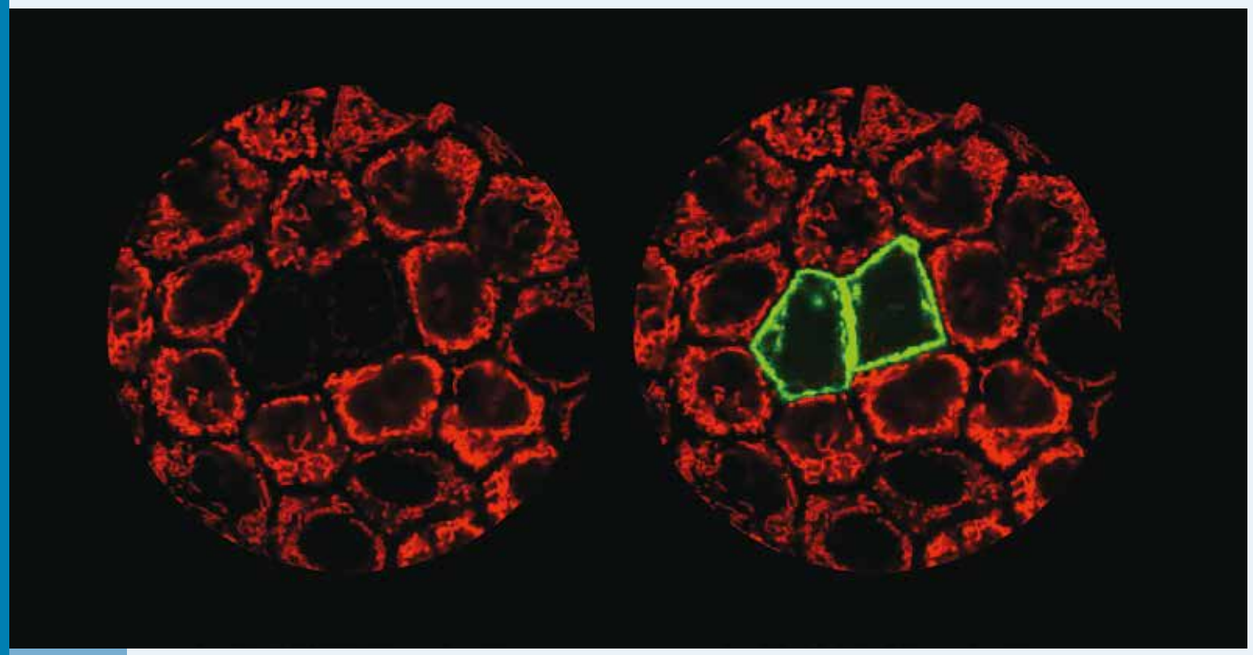
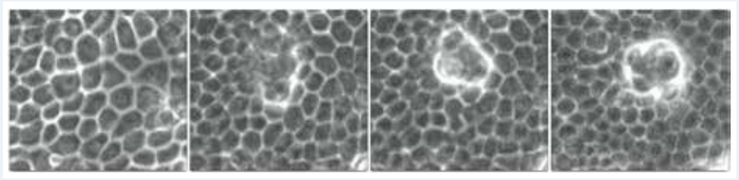
Original paper:
Huang Y. et al, Energy-Dissipative Matrices Enable Synergistic Toughening in Fabric Reinforced Soft Composites, *Advanced Functional Materials*, January 16, 2017. DOI: 10.1002/adfm.201605350

Funded by:
The Japan Society for the Promotion of Science (JSPS)(JP24225006), the ImPACT Program of Council for Science, Technology and Innovation, and the Hokkaido University Tenure Track System Promotion Program

Natural defense mechanism preventing cancer at the earliest stage



Cells in the initial stage of cancer change their metabolism before getting eliminated by the surrounding normal cells, suggesting a novel target for developing cancer prevention drugs.



The time lapse images (from left to right) show transformed cells become extruded after losing a competition against surrounding normal cells. The study suggests the surrounding cells influence the metabolism of transformed cells during the elimination process.

Watch the movie

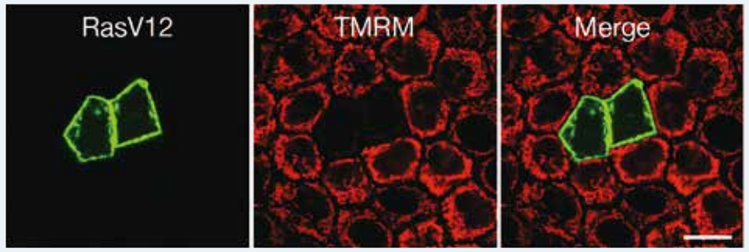
Most cancers begin when one or more genes in a cell mutate. These newly "transformed" cells get extruded and eliminated after losing a competition against the surrounding normal cells in the epithelium, or the outer layer of the body. However, the mechanism by which normal cells recognize and attack the transformed cells remains elusive.

A research team led by Professor Yasuyuki Fujita of Hokkaido University's Institute for Genetic Medicine explored this natural defense mechanism using cultured mammalian cells and a mouse model. The study uncovered two metabolic changes occurring in the newly transformed cells: mitochondrial dysfunction and an elevated glucose uptake. The changes were significant only when the transformed cells were surrounded by normal epithelial cells, indicating that the changes are induced by the normal cells. Furthermore, according to the study, the metabolic changes play an important role in eliminating the transformed cells.

Interestingly, these metabolic changes are similar to the Warburg effect, which is observed in cancerous cells in the middle and latter stages of cancer. The Warburg effect is generally thought to play tumor promoting roles whereas the newly discovered metabolic changes could suppress cancer in its initial stage. "Although these two processes have similar metabolic alterations, mitochondrial downregulation and increased glycolysis, they are governed by distinct regulators and have opposing effects on the development of cancer," says Fujita.

Their findings shed new light on the inherent ability of normal cells to eliminate cancerous cells and opens up potential avenues for cancer prevention. "Considering that the metabolic changes could either suppress or promote cancer cells depending on the stage, further elucidation of the mechanism is essential to help develop cancer prevention drugs while avoiding adverse effects," Fujita commented.

This research was conducted in collaboration with Kyoto University, Kanazawa University, Keio University, Osaka University and University College London, and published in the May issue of *Nature Cell Biology*.



Transformed cells (RasV12, green) showed reduced mitochondrial membrane potential (TMRM, red) when surrounded by normal epithelial cells. (Kon S., et al., *Nature Cell Biology*, April 17, 2017)

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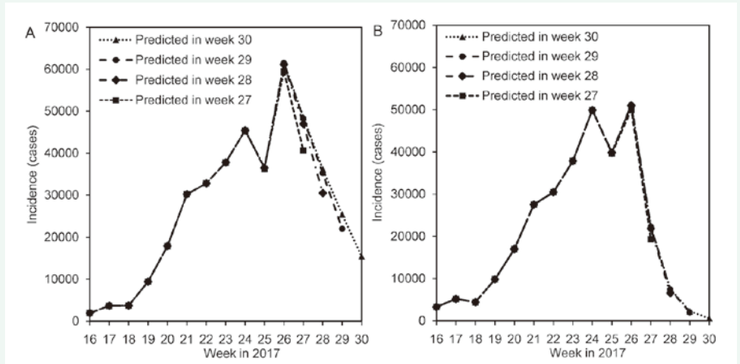
Original paper:
Kon S., et al., Cell competition with normal epithelial cells promotes apical extrusion of transformed cells through metabolic changes, *Nature Cell Biology*, April 17, 2017.
DOI: 10.1038/ncb3509

Funded by:
The Japan Society for the Promotion of Science (JSPS) Grant-in-Aid for Scientific Research on Innovative Areas (26114001, 26112701) and Grant-in-Aid for Scientific Research (A)(26250026), the AMED Strategic Japanese–Swiss Cooperative Program, the Takeda Science Foundation, the Kato Memorial Bioscience Foundation, and The YASUDA Medical Foundation.

Researchers predicted when cholera epidemic in Yemen would peak

A new mathematical model accurately forecasted the devastating cholera epidemic in Yemen would peak by early July of 2017 and the cumulative incidences would be around 700–800 thousand cases.

Ricardo Mayer/shutterstock



Predicted weekly reported incidence to be reported in week 27, 28, 29 and 30, 2017. (A) Logistic model and (B) Richards (generalized logistic) model. Parameter estimates of both models were obtained from the datasets from week 16 to 26. (Nishiura H., et al., *Theoretical Biology and Medical Modeling*, July 26, 2017)

Cholera, which is caused by the bacterium *Vibrio cholerae*, infects the small intestine through water and food. Symptoms include diarrhea, abdominal cramps and dehydration. Yemen has been hit by one of the world's worst cholera epidemics, in particular since April 2017. A total of 356,591 suspected cases were reported between April 27 and July 17, of which 1,802 people died.

Epidemiologic research has been conducted globally, using mathematical modeling to study transmission dynamics of major cholera epidemics, mostly with regard to the 2010 epidemic in Haiti. Many studies were conducted to study and evaluate measures to contain cholera epidemics, with most centering on how best to distribute limited resources. But virtually no real-time analyses of data from devastating outbreaks, like the one in Yemen, were conducted to frequently provide updated forecasts.

After the cholera outbreak in Yemen, scientists at Hokkaido University compiled a real-time forecast based on weekly data collected by the World Health Organization (WHO) about suspected cases and fatalities between April 16 (16th week of 2017) and July 1 (26th week). The team incorporated reporting delays — time lags between the onset of the disease and the reporting of cases — in the mathematical model by analyzing the epidemic curve that was updated every week. It also discovered a method, through the study of weekly death rates, to adjust the ascertainment bias — the tendency that more cholera cases likely will be reported after many cases have already been reported rather than in the initial phase of the outbreak. Incorporated in the epidemic curve is a logistic curve or generalized logistic (Richards) curve.

The team estimated the cumulative cholera cases at the end of the epidemic would be 790,778 on the logistic model and 767,029 on the Richards model. The researchers estimated the epidemic curve would peak by the 26th week of 2017 and then drop monotonically in the subsequent weeks. The forecasted monotonic decline has been actually seen in WHO data by mid-August 2017.

"Our model succeeded in excluding two biases for the first time and the resulting forecast has been proven reliable so far. Real-time forecasting could assist enhancing situation awareness about the ongoing epidemic communication between experts and citizens while avoiding excessive pessimism, in addition to crafting future measures against cholera," says Professor Hiroshi Nishiura of the research team.

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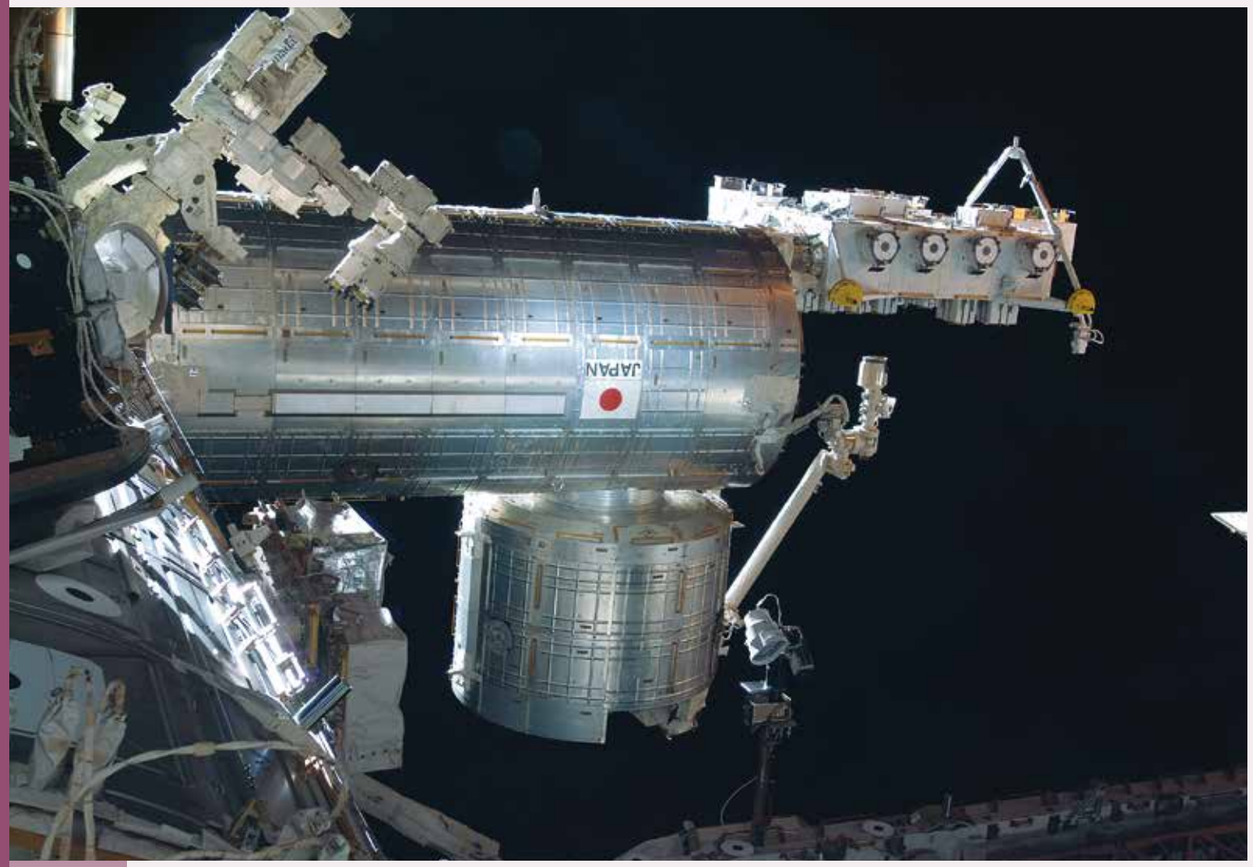
Original paper:
Nishiura H., et al., Transmission dynamics of cholera in Yemen, 2017: A real time forecasting, *Theoretical Biology and Medical Modeling*, July 26, 2017.
DOI: 10.1186/s12976-017-0061-x

Funded by:
The Japan Agency for Medical Research and Development (AMED), the Japan Society for the Promotion of Science (JSPS) (KAKENHI 16KT0130, 16K15356, 17H04701), the Japan Science and Technology Agency CREST program (JPMJCR1413), and the RISTEX program for Science of Science, Technology and Innovation Policy, and the China Scholarship Council

Why don't fish freeze to death in icy water?



Japanese experiment module KIBO at the International Space Station. The experiments were conducted in its pressurized cabin from November 2013 to June 2014. Photo provided by NASA

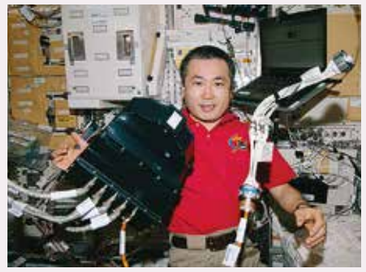
Microgravity experiments at the International Space Station (ISS) revealed supercooled water containing antifreeze glycoproteins accelerates and oscillates its ice crystal growth rate, shedding new light on the mysterious antifreeze effect in living organisms.

Fish can survive even in subzero environments, such as under ice floes. Researchers have hypothesized that when glycoproteins contained in fish blood are absorbed on the surface of ice crystals, it curbs the growth of ice crystals. Verifying the functions of these glycoproteins requires precise measurements of the normal growth rates of crystals over time. Yet this is difficult to do so on the Earth because of the natural convective flow around the growing crystal induced by gravity.

The researchers, led by Hokkaido University Professor Emeritus Yoshinori Furukawa, hoped to use the microgravity conditions of space to accurately measure the normal growth rates of crystal faces, as convective flow does not occur in this environment.

To carry out the experiments on the ISS, Hokkaido University's Institute of Low Temperature Science and JAXA jointly developed Ice Crystal Cell 2, a device for measuring the speed of ice crystal growth in space. Once installed in the Japanese experiment module KIBO, experiments were carried out by controlling the device using signals from the ground.

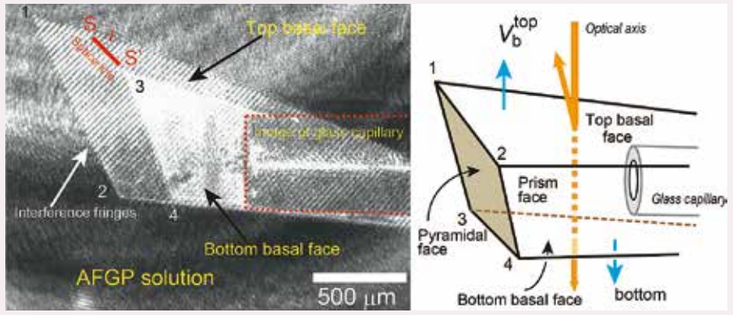
The researchers conducted 124 experiments of which 22 were deemed to have accurately measured ice crystal growth rates in supercooled water containing a glycoprotein impurity. The results showed that the bottom basal faces of the ice crystals grew three to five times faster than in pure water. Ice crystals also exhibited periodic oscillations as they grew. "The results were contrary to what was expected, as the glycoprotein actually facilitated the growth of ice crystals, rather than curbing it," says Assistant Professor Ken Nagashima of the research team.



Japanese astronaut Koichi Wakata with Ice Crystal Cell 2 during its installation. Photo provided by NASA/JAXA

What, then, explains glycoprotein's antifreeze effect? The researchers discovered the tricky process in which flat crystal faces with high growth rates were truncated by faces with slower growth rates, causing the polyhedral crystal to be surrounded by only flat faces with the lowest growth rates. This resulted in greatly slowing down the growth of the ice crystals.

"Our results suggest that the prevention of freezing in living organisms cannot be solely explained by the growth depression effect of glycoproteins. In other words, the novel mechanism we observed is essential for preventing living organisms from freezing," says Nagashima. "The function of glycoproteins in ice crystal growth is closely connected to how biopolymers regulate the growth of various inorganic crystals. A better understanding of this may lead to the creation of novel materials," he added.



(Left) A snapshot of a video of ice crystal growth. The striped patterns in the center show the bottom basal faces. These patterns are interference fringes produced by light reflecting off the basal face. The speed at which these move was used to calculate how fast the bottom basal face was growing. (Right) An illustration showing the three-dimensional geometry of the ice crystal.(Furukawa Y. et al., *Scientific Reports*, March 6, 2017)

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Original paper:
Furukawa Y. et al., Oscillations and accelerations of ice crystal growth rates in microgravity in presence of antifreeze glycoprotein impurity in supercooled water, *Scientific Reports*, March 6, 2017. DOI:10.1038/srep43157

Funded by:
The Japan Society for the Promotion of Science (JSPS) (KAKENHI 26287095, 25600081)

Japan's largest complete dinosaur skeleton discovered

The bones of the dinosaur Mukawaryu which have been prepared so far. These likely represent more than half of the bones the dinosaur had.

The complete skeleton of an 8-meter-long dinosaur has been unearthed from marine deposits dating back 72 million years at Japan's northern island of Hokkaido, making it the largest dinosaur skeleton ever found in the country.

Excavations to uncover a fossilized duck-billed dinosaur (hadrosaurids) in the Hobetsu district of Mukawa Town have been underway since 2013. It is the third time a complete skeleton of a hadrosaurid from a marine stratum has ever been reported, according to the research team from Hokkaido University and Hobetsu Museum in Mukawa.

Hadrosaurids, or duck-billed dinosaurs, were common herbivores during the Late Cretaceous Period (about 100 million to 66 million years ago) and thrived on the Eurasian, North and South American continents as well as at Antarctica. Complete hadrosaur skeletons have been unearthed on these continents, but it is extremely rare for a complete skeleton of a land dinosaur to be discovered in a marine stratum.

The fossilized caudal vertebra of Mukawaryu found July 2013 in Mukawa town, Hokkaido, Japan.

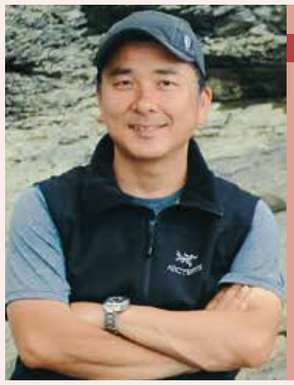
In 1936, a complete hadrosaur skeleton was unearthed from a marine stratum in Sakhalin and named *Nipponosaurus* by Professor Takumi Nagao of Hokkaido Imperial University (predecessor of Hokkaido University). It had been the only such fossilized dinosaur from a marine stratum that was assigned a name. The latest discovery of the fossilized skeleton, nicknamed "Mukawaryu" (Mukawa dragon), represents the third such discovery in the world, including a complete skeleton of an undescribed specimen.

When a complete skeleton is defined as a skeleton containing more than 50 percent of the bones, Mukawaryu represents the second complete dinosaur skeleton unearthed in Japan after *Fukuivenator*, a 2.5-meter carnivore from the Early Cretaceous Period (about 145 million to 100 million years ago) discovered in Katsuyama City, Fukui Prefecture. Mukawaryu is also the first complete skeleton of a herbivore from the Late Cretaceous Period and from a marine stratum in Japan.

An excavation uncovering a fossilized duck-billed dinosaur (hadrosaurid) in the Hobetsu district of Mukawa Town, Hokkadio.

Associate Professor Yoshitsugu Kobayashi of the research team said "We first discovered a part of the fossilized Mukawaryu skeleton in 2013, and after a series of excavations, we believe to have prepared more than half of the bones the dinosaur had, making it clear that it is a complete skeleton."

There are more than 50 kinds of dinosaurs in the hadrosaurid dinosaurs, which is grouped into two groups: uncrested (Hadrosaurinae) and crested members (Lambeosaurinae). "Although Mukawaryu has some characteristics of both groups, our preliminary analysis indicated it might belong to the Hadrosaurinae. Further preparation of the fossils and detailed research should make it clearer which group the Mukawaryu skeleton belongs to," says Kobayashi.



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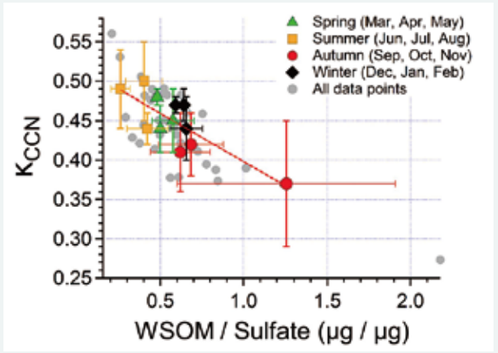
Cloud formation suppressed by biogenic organic emissions

Researchers have found evidence that near-ground biogenic emissions of organics suppress cloud formation in cool-temperate forests in autumn, providing clues to how global warming will affect cloud formation and the overall climate.

Hokkaido University's Tomakomai Experimental Forest in Autumn with Mt. Tarumae (left) and Mt. Fuppushi (right) in the background.

Submicron atmospheric aerosols, although they are not so visible, play a pivotal role in the climate system. They cause temperature variations by scattering or absorbing sunlight, while they also act as cloud condensation nuclei (CCN). Consequently, they can impact cloud cover and the precipitation process. Organic matter, which constitutes up to 90 percent of aerosols, is often attributable to biogenic sources.

Many questions, however, remain as to how differences in variation and quantity of biogenic organics affect aerosols and cloud formation in a cool temperate forest which has vegetation highly susceptible to climate change.



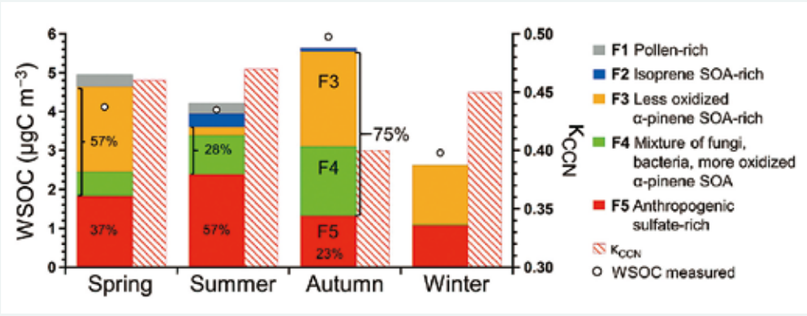
A scatter plot showing CCN activity of atmospheric submicron aerosols (y-axis) and the mass ratio of organics and sulfate (x-axis). The higher the ratio of organics to sulfate, the lower the CCN activity. This trend becomes noticeable in autumn. (Müller A. et al., *Scientific Reports*, August 16, 2017)

At the Tomakomai Experimental Forest, a cool temperate forest in northern Japan, the researchers of Hokkaido University collected submicron atmospheric aerosols one week at a time for each sample for around two years, resulting in 52 samples. They then analyzed the chemical compositions and CCN activities of the aerosol samples.

Their research revealed a clear seasonal variation of CCN activity, which showed a maximum in summer and a minimum in autumn. Importantly, CCN activity is controlled by the mass ratio of sulfate and water-soluble organics. The ratio of sulfate, which facilitates cloud formation, is higher in summer and that of water-soluble organics is relatively higher in autumn. The study indicates an increased amount of water-soluble organics can coat sulfate particles, suppressing its CCN activity.

Furthermore, the researchers found for the first time that aerosols originating from natural organics emitted from soil and litters (fallen leaves) on the forest floor can suppress cloud formation. This provides a new insight into the conventional belief that tree leaves are the primary source of organic gases and aerosols that can affect the cloud formation.

Assistant Professor Yuzo Miyazaki of Hokkaido University, who led the research, said “In recent years, some studies have pointed out that the amount of organics emitted from the forest floor is similar to, or even larger than, that emitted from tree leaves in cool-temperate or other higher-latitude forested areas. Our research should provide clues to evaluate how differences in the variety and amount of organics in high-latitude zones, which are vulnerable to global warming, will affect cloud formation and the overall climate in the future.”



Seasonal differences in the concentrations of organics in aerosols (white circles indicate measured values) and the estimated distribution of organic sources (F1-5). The ratio of organics originating from on or near the forest floor (F3-4) peaks in autumn, when CCN activity is lowest. (Müller A. et al., *Scientific Reports*, August 16, 2017)

Researcher Details

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Original paper:
Müller A. et al., Evidence of a reduction in cloud condensation nuclei activity of water-soluble aerosols caused by biogenic emissions in a cool-temperate forest. *Scientific Reports*, August 16, 2017.
DOI: 10.1038/s41598-017-08112-9

Funded by:
Grants-in-Aid for Scientific Research (B) (25281002, 25292079, 16H0293106) and Scientific Research (S) (24221001) from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, and the Sumitomo Foundation

HOKKAIDO UNIVERSITY

65,000 hectares of campus resources...

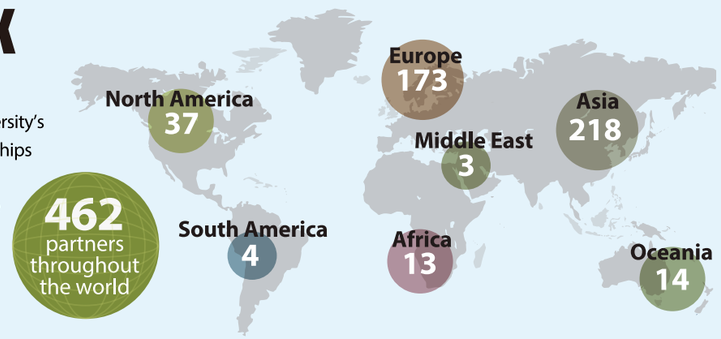
UNIVERSITY A GLANCE

- Established 1876
- Sapporo Campus Size 180ha
- Total Research Staff 2,093
- Total Research Budget 2016 20.2 Billion Yen
- Total Student Numbers 18,074

FACILITIES

WORLD WIDE NETWORK

Hokkaido University has forged 462 International Partnerships throughout the world, and these linkages reflect Hokkaido University's global outlook and a history of productive international relationships for research, teaching and learning and engagement.
The number of bilateral international agreements contains those signed at both a university-wide level (172 agreements) and departmental-wide level (290 agreements).



Museum

Hokkaido University has spent more than 130 years collecting, preserving, studying and storing around 4 million specimens and materials. Among these items are more than 10,000 precious specimens that serve as benchmarks for their respective species. The museum also plays an important role in the training and education of both students and local citizens.

Botanic Gardens

Hokkaido University Botanic Gardens are the oldest of their kind in Japan, opening in 1886. Today, the site is 400 m², and consists mainly of old growth trees including alpine varieties. The resource rich gardens hold around 4,000 kinds of plants and a museum, known as the Natural History Museum, which exhibits Ainu artifacts, and local archaeological and biological specimens.

Experimental Forests

Hokkaido University's network of University Forests consist of six experimental forests, a tree breeding station, a tree nursery, and two experimental stands and cover around 700 km². The University Forests range from cool-temperate forests to warm temperate forests including one that has the largest field training station amongst any Japanese university. All research is focused around forest dynamics, forest environment and function, conservation biology, as well as regional resource management.

Marine Stations

Covering both fresh and salt-water, Hokkaido University owns six marine stations which conduct research on farming techniques, genetic engineering, oceanography, and marine ecology, conservation and diversity. These outposts offer regular field work to students of both science and fisheries science.

Livestock Farm

Research and education on livestock production and sustainable landuse is carried out at Shizunai Livestock Farm. Particular research carried out on the farm include but is not limited to: studies on keeping native Hokkaido horses; high roughage feeding systems for growing and fattening cattle; management systems for grazing cattle in uneven pastures; behavioral studies for grazing animals in sloped mountainous lands; physico-chemical properties of meadow soils and runoff of sloped grasslands.

Marine Research Vessels

The Oshoro Maru (left) as well as the smaller Ushio Maru are training ships which belong to Hokkaido University's School of Fisheries Sciences. They are used as facilities for students to conduct experiments and receive hands-on training as well as for research. The vessels play an important role in investigating marine-related physics, chemistry, biology, and biological production sciences as well as data collection.

Contributing Towards the R e solution of Global Issues

Age and Prestige

Hokkaido University is one of the oldest, largest, and most prestigious universities in Japan. The university has the largest number of faculties out of Japan's national universities, covering almost all areas of the humanities and sciences. Furthermore, we are one of the leading institutions for research activities in Japan and around the world.

The breadth and depth of pioneering research conducted at Hokkaido University has seen the cultivation of many great thinkers. Our alumni include a Nobel laureate, business leaders, research pioneers, artists and prolific writers. Hokkaido University is determined in its aim to develop curious minds that can embrace challenges and reveal new global perspectives to find solutions which change society for the better.

Internationally renowned research

With one Nobel Prize, two recipients of the prestigious 'Order of Culture' and twenty-one recipients of the Japan Academy Prize, Hokkaido University has produced a wealth of talent - and with this, ground breaking research. Emeritus Professor Akira Suzuki, who worked tirelessly for decades at Hokkaido University, won a Nobel Prize in Chemistry in 2010. The prize was awarded for his research on "palladium-catalyzed cross couplings in organic synthesis." His breakthrough was that he produced a more stable, nontoxic reaction compared to other reactions in inorganic synthetic chemistry, and in doing so changed the face of manufacturing, including the production of pharmaceuticals. Other notable alumni include two Stockholm Water Prize Laureates - Dr. Takeshi Kubo who is renowned for his long and distinguished career in organizing Tokyo's massive sewage system (awarded in 1994), and Dr. Takashi Asano for his outstanding contributions on the efficient use of water in the domain of wastewater reclamation, recycling and reuse.

Global Research Center for Food and Medical Innovation (FMI)

Established in 2015, the Center promotes research and development toward the creation of an ageless society in which people of all ages lead healthy, active lives. In such a society, the focus of health promotion is shifted from hospitals to homes, that of health maintenance from medical treatment to prevention, and that of health-related information management from a distributed approach led by medical institutions to a unified concept led by individuals. The Center also provides opportunities for casual interaction among researchers and locals through the publicly open spaces on its first and second floors. The facility is expected to serve as a place for locals and people from industry and academia to share a variety of novel ideas toward true innovation.

https://www.fmi.hokudai.ac.jp/en/about_fmi/index/

Arctic Research Center (ARC-HU)

The ARC-HU conducts cutting-edge interdisciplinary research through projects such as the Belmont Forum on the sustainable use of marine resources in the Arctic and carbon management in Eastern Siberia. The ARC-HU is the center of excellence of Arctic research in Japan, and is a part of the Japan Arctic Research Network Center (J-ARC Net) in collaboration with the Arctic Environment Research Center, the National Institute of Polar Research, and the Institute of Arctic Climate and Environment Research run by the Japan Agency for Marine-Earth Science and Technology. J-ARC Net promotes collaborative research actions by industrial, governmental and academic institutions on Arctic issues especially those conducted using interdisciplinary approaches. J-ARC Net also introduces newcomers to Arctic research by providing introductory seminars and courses on Arctic issues so as to nurture personnel who can contribute to solving problems in the Arctic region.

http://www.arc.hokudai.ac.jp/en/

Global Institution for Collaborative Research and Education (GI-CoRE)

GI-CoRE is a faculty organization under the direct control of the university's president to bring together world-class researchers from around the world to conduct collaborative research with those at the university. The purpose of GI-CoRE is to promote and support international collaborative research and education that leverages the university's strengths and distinctive features. At the present, GI-CoRE consists of six global stations: the Global Station for Quantum Medical Science and Engineer-ing (GSQ), Zoonosis Control (GSZ), Food, Land and Water Resources (GSF), Soft Matter (GSS), Big Data and Cybersecurity (GSB) and Arctic Research (GSA).

https://gi-core.oia.hokudai.ac.jp/main

Global Facility Center (GFC)

The mission of the GFC is to support on campus researchers and students as well as off-campus and international research and educational activities through the creation of the most advantageous system for advance equipment sharing. The Center is operating and maintaining the research infrastructure on campus, and providing the contracting services such as for the instrumental analysis and for the development of the prototype machine. The Center is an Asian front runner in the field. The Center welcomes researchers from external research and business organizations. More than 150 different types of scientific equipment, instruments, and associated devices are available for use, including the only Isotope Imaging Microscope in the world, the 1.6-m diameter optical infrared telescope named "Pirka", the Next-Generation Sequencing system, and other cutting edge facilities (TEM, MS, NMR, etc.).

For more details, please email

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COLLABORATING WITH HOKKAIDO UNIVERSITY

Institute of Low Temperature Science
http://www.lowtem.hokudai.ac.jp/en/index.html

Research Institute for Electronic Science
http://www.es.hokudai.ac.jp/english/

Institute for Genetic Medicine
http://www.igm.hokudai.ac.jp/en/index.php

Institute for Catalysis
http://www.cat.hokudai.ac.jp/index-e.html

Slavic-Eurasian Research Center
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Information Initiative Center
http://www.iic.hokudai.ac.jp/En/index.html

Research Center for Zoonosis Control
http://www.czc.hokudai.ac.jp/en/index.html

Central Institute for Isotope Science
http://www.hokudai.ac.jp/radiois/index_eng.html

Research Center for Integrated Quantum Electronics
http://www.rciqe.hokudai.ac.jp/en/

Field Science Center for Northern Biosphere
https://www.fsc.hokudai.ac.jp/home_en/

Center for Advanced Tourism Studies
http://www.cats.hokudai.ac.jp/en/

Center for Ainu and Indigenous Studies
http://www.cais.hokudai.ac.jp/english/

Center for Experimental Research in Social Sciences
http://lynx.let.hokudai.ac.jp/cerss/en/

Center for Environmental and Health Sciences
http://www.cehs.hokudai.ac.jp/en/

Arctic Research Center
http://www.arc.hokudai.ac.jp/en/

Research Development Section

The aim of the Research Development Section is to promote research activities at Hokkaido University. This includes analyses of our institute's research outputs, providing support for large scale inter-departmental and cross disciplinary projects, and planning and organizing various research development schemes. The RDS can also act as a point of contact for international researchers wanting to learn more about collaborating with the university.

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