Kyoto University
2021 Winter

KYOTO U Research News

Your support can make a difference

Covid-19 has had a major impact on Kyoto University. Since April 2020, many of our students have only had online classes. They are unable to communicate directly with their instructors and develop satisfying relationships with other students.

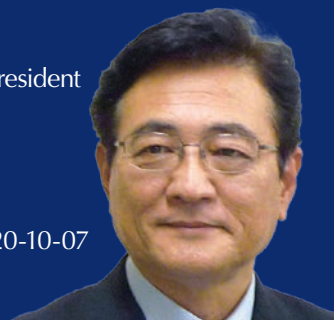
Tragically, some students are also facing financial difficulties due to the virus' impact on their income. We are concerned that such difficulties may eventually force some students to withdraw from the University. In addition to the government's emergency support program, KyotoU has launched its own emergency scholarship, and has expanded its framework for tuition exemption to ensure that all students will be able to continue their studies.

Kyoto University's Emergency Student Support Plan will require approximately one billion yen in total for this fiscal year. We are utilizing government-provided supplementary student support funds in addition to the University's regular budget, but these will still fall short. We therefore ask for your support.

The Fund for the Emergency Student Support Plan will be used to help ensure that students facing financial difficulties will not be forced to give up their studies. We ask all who are willing to support the University and its students to kindly make a donation to the fund.

If students in these dire circumstances are forced to give up their studies, it will be a great loss not only to Japan but to the world as a whole. We ask for your kind generosity and cooperation to help ensure that the next generation can thrive.

Nagahiro Minato, President



Please see:
kyoto-u.ac.jp/en/news/2020-10-07

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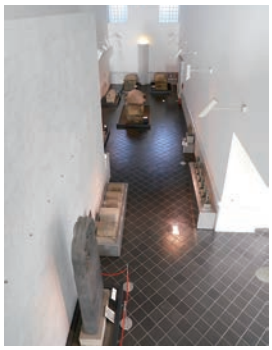

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On the cover
An *ukiyo-é* inspired reimagining of the University's museum, described in the lead story. Do you see anything familiar on exhibit? (Trais/Fujiwara)



On the cover: Backstage at the lab






Crossroads of the world & the mind

Ancient stone caskets. A Malaysian jungle. Hieroglyphic inscriptions. Medieval documents. Nobel prize work. Racks and racks of flora and fauna preserved in formaldehyde.

These are just a small fraction of the treasures housed in **the Kyoto University Museum**. Join current and former directors **Hidetoshi Nagamasu** and **Naoko Iwasaki** on an exclusive tour as they explain how and why they've broken the mold of the standard university museum.




Crossroads of the world & the mind

Crossroads of the natural and human sciences

The Kyoto University Museum of today — its vast halls filled with artifacts and natural objects from a broad expanse of human and natural history — has its origins in the early 20th Century, beginning as a repository for historical collections amassed by members of the then Faculty of Letters.

Even in those early days there were occasional exhibitions for the public, but by and large the repository was considered more as an archive for research, many of the items having been classified as valuable cultural property, putting them outside the scope of public display.

Attitudes began to change in the post-WWII era when the national Council for Science and Technology began contemplating the value of biological specimens as possible cultural property.

"There is still a debate about whether or not biological specimens can be considered valuable cultural property," explains museum director and botanist **Hidetoshi Nagamasu**.

"These objects tend to be undervalued and even get ignored or discarded as time goes by and leadership changes. The idea that these samples are equally as important as cultural artifacts was actually a strong impetus for establishing the current museum."

The crossing of the humanities and the natural sciences began in 1986 with the building of the current north wing, designed to house humanities collections. At the time, a separate 'natural history museum' was to be built nearby.

However, plans changed in 1997 when the University decided to merge the two buildings into a single unified university museum, which opened in 2001 with the humanities and the natural science wings connected by a large central lobby.

Crossroads of inner and outer

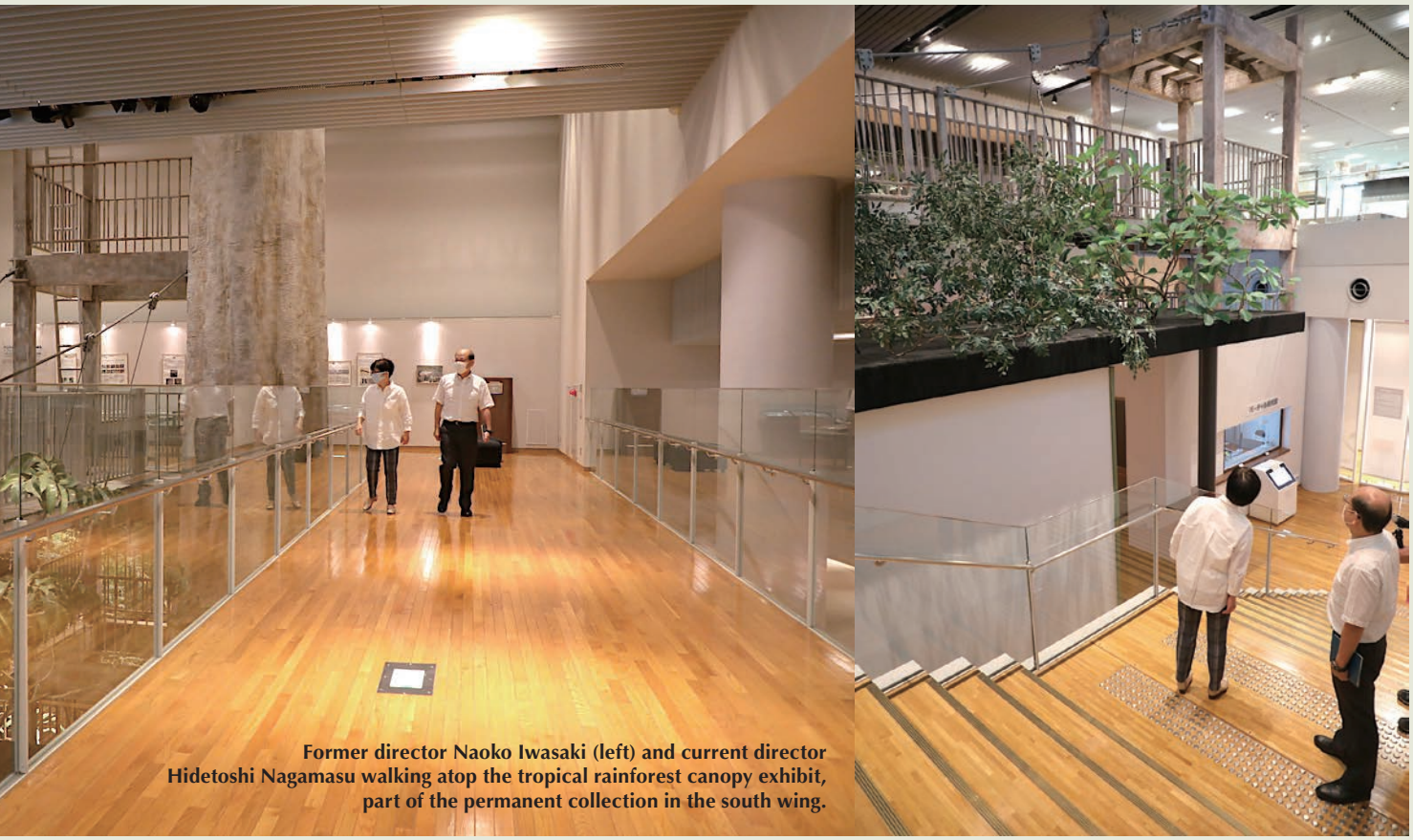
"One of the key features of our museum is that the main entrance faces west, opening onto the avenue of Higashiôji-dôri, one of the main north-south thoroughfares in this part of Kyoto," states **Naoko Iwasaki**, scholar of Japanese history and former museum director. "This was by design."

Typically, visitors to university museums must first set foot on the campus and then make their way through a maze of buildings in order to reach the entrance. The original plans for KyotoU's museum similarly called for an entrance facing east, toward the inside of the campus.

Ministry approval for construction, however, only came after the design was altered.

"How this happened is a bit of a mystery, but ministry decision

There is still a debate about whether or not biological specimens can be considered valuable cultural property.



Former director Naoko Iwasaki (left) and current director Hidetoshi Nagamasu walking atop the tropical rainforest canopy exhibit, part of the permanent collection in the south wing.

makers seem to have reasoned that the University's repositories are a collective good for all," Iwasaki explains, "and hence must be opened and shared with the public."

This thinking likely had its start with the 'lifelong learning' movement, spearheaded by UNESCO in the 1970s, pushing universities to become more open. Today, the museum's entrance stands proudly open, extending a warm welcome to the community with posters and banners for current exhibits.

Continues Iwasaki, "At the time we first opened, local taxi drivers didn't know where to go when asked to drive to the Kyoto University Museum. Now it's better known than the University's main gate."

Crossroads of research and education

So from all of the museum's vast collections, how to choose what to display?

As the museum was being designed — and continuing up to the present — what to show to the public has been a topic of heated debate. Most of the artifacts and samples, after all, were collected by researchers for their own work, but what is invaluable for scholars might not be appropriate or interesting to display to public visitors.

Active education programs have long been a key to the solution, especially when targeting younger visitors. Raising the academic rigor of the museum and merging the purpose of research with education have been found to effectively mark a pathway toward a meaningful answer.

"Displays and explanations at Japanese museums typically aim for a middle school level," says Nagamasu, "but our intention was to have everything, from the layout, design, and concept, presented at somewhere closer to high school level."

Part of this strategy is to have researchers whose work is being presented improve their communication skills, qualities

especially vital for graduate student volunteer docents at summer and weekend programs.

Surprisingly, however, these ideas initially met with some resistance.

There was little precedent for running such programs at a museum, and senior researchers were concerned whether their students' time would be effectively used. But quickly the benefits became apparent: not only did the students' communication and teaching skills improve, but the bond between the University and the Kyoto city community strengthened noticeably.

Nagamasu, who was involved in the creation of the museum in its current form, describes the immense task of modeling a tree in a Malaysian jungle using a life-sized cast.

How this happened is a bit of a mystery.

Iwasaki explains the origins of the museum's archaeology collection and the scientific methods used to preserve and catalog it, seeded by a grant of Egyptian artifacts from UCL.

"We now meet regularly with the city's Board of Education and work together to develop museum programs," explains Iwasaki. "This has continued for nearly 20 years, and I can image that some of our earliest visitors were inspired to apply to Kyoto University because of our work."

In part thanks to these initiatives, the museum has become a model for other institutions in Japan. And after so many years of success it is now doubtful whether the museum could exist without these programs. Strong community ties have made Kyoto University a pioneer in museum management in Japan.

Nagamasu continues, "One reason this was possible was our high degree of autonomy. Most departments and researchers at KyotoU are generally free to do what they want. This freedom gave us a good foundation to pioneer the museum model in our own way."

The museum continually benefits from a diverse group of researchers who are passionate about sharing their work, bringing in other interested individuals to spearhead unique exhibits.

"It always feels like a fresh learning experience. We constantly need to flex our imaginations to think of ways to best present certain research topics or exhibits. Thankfully, our curiosity and creativity have never let us down," says Nagamasu.

Crossroads of the future

What's next for the Kyoto University Museum?

Recent feature exhibitions have consisted of larger, more elaborate, and more interactive displays showcasing a broad range of disciplines. Curators and researchers are also exploring featuring more work from the humanities and the visual arts.

Meanwhile, collections continue to expand along with advances in the university's broad spectrum of inquiry. And the museum continues to forge ahead with its own research while communicating the results to the public.

"We've been challenging tradition for 20 years now, and we intend to keep up the pace in outreach and imagination. There are still numerous untapped resources throughout the university which we'll continue to explore and dig out for everybody to learn and enjoy."

Our curiosity and creativity have never let us down.

For visitor and other information, see: museum.kyoto-u.ac.jp/index_e.htm

KyotoU moving forward

Nagahiro Minato (left), *elected president of Kyoto University in July 2020, assumed office as the institution's 27th chief executive in October. Here he joins executive vice-president* ***Kyoko Inagaki****, whose portfolio includes international affairs, public relations, and gender balance, for a conversation on new directions and opportunities for the University in the wake of the pandemic and its disruptive effects on campus life.*

Minato: We definitely face a challenging situation as we begin our six-year term. Every facet of our society has been touched, exposing fundamental questions that we haven't faced in decades, including what role a university should play in relation to its students.

In the past there was a simple breakdown between education and research. But the pandemic has forced us to think about exactly *why* a university — specifically a research university — has students.

Inagaki: We know instinctively that education is at our core, but how that is manifested differs between private and public institutions. If you were merely to put numbers to it you could talk about tuition or operating costs, but that wouldn't tell the full story.

Minato: KyotoU's long history as a research institution means that our *education* is tightly intertwined with *research*, and we actively train students via courses of independent work. This integration — whether beneficial or not — is fundamental to both the university and the education the students receive.

Inagaki: Compared to that, universities in the West, even those with strong research output, place much more emphasis on active support of student education.

Minato: Our primary organizing principle has been research, but the pandemic has changed that. Our students are not on campus, so the resources they need to do their research are inaccessible. We have to admit that something large has been lost because students are not able to be physically present. We must re-think our role as a university and actively discuss what we can do for our students.

Inagaki: I very much agree. Education can be considered a service, but at KyotoU — because of our strong focus on research — education is inseparable from research. It's ingrained in our culture of academic freedom, where groups of students don't simply support their professors' projects but rather learn to build a foundation for pursuing their own original work.

Minato: Another obstacle is that our shared concepts of *academic freedom* (*gaku'mon-no-ji'yû*) and *KyotoU-ness* (*kyôdai-rashi'sa*) are poorly defined. One aim of my tenure is to make these commonly used ideas more clear.

Inagaki: And everybody has different definitions of these concepts!

Minato: Defining KyotoU-ness is no easy task: it'll take time. It's similar to a Nobel prize being awarded for work done decades earlier. The time we invest in defining the expression today will only pay off at a much later date.

Since most graduates won't become career researchers, we must first explain what research is, and why it is at the core of the curriculum.

The answers will come from understanding our stakeholders. As a public university, these are the citizens of the country, and our students are amongst them. I feel that our fundamental mission is to train citizens who can think critically and practice sound judgement. Using research as a pedagogical tool allows us to pursue this goal.

Traditionally, KyotoU hasn't been a training ground for policy makers or bureaucrats, but rather for scholars who know how to think, how to conduct research, and how to focus on contributing to the intellectual fabric of society.

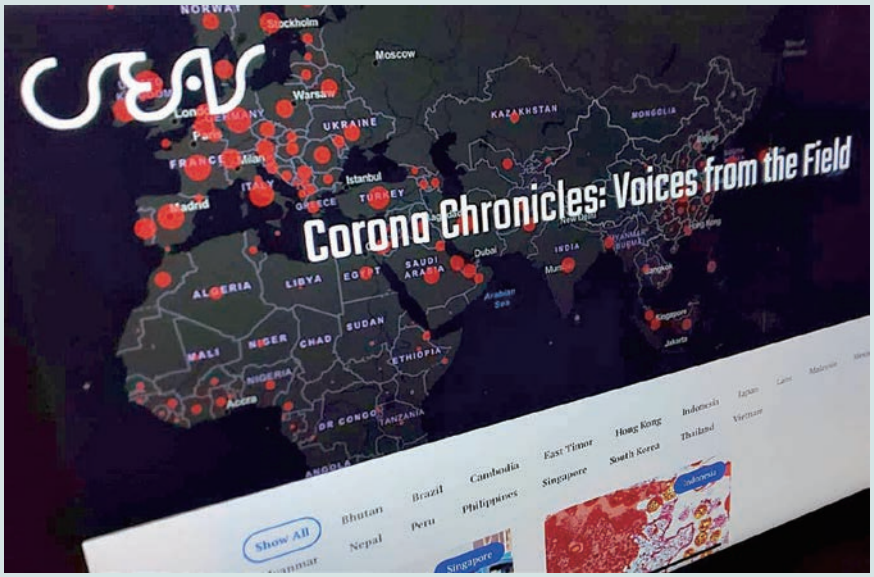
But in today's world that isn't enough. The pandemic has given us an opportunity to rethink everything.

Inagaki: This is a chance to reflect on the advantages of KyotoU and what made it the institution it is today.

Minato: And likewise an opportunity is to rethink our role in the world. While we must contribute globally, we must also focus on our place in the region. What role can Japan play culturally, socially, and economically in Asia? And within this framework, where does Kyoto University stand? As an institution, we've long been a part of the essential fabric of Asia, but where are we now? Where will we go? We need to know our place here if we are to continue contributing productively.

Inagaki: The university's approach to Asia has traditionally been based on relations with the West. But Asia's immense diversity — for example in differing paths to modernization — points to numerous alternatives, such as no longer catching up with the West but working to develop a post-modern Asian understanding of society. KyotoU has long developed that foundation almost subconsciously. Now we must bring it into the open.

Minato: What society most expects from us is KyotoU-ness: our innate curiosity, spirit of inquiry, hunger for knowledge, and urgent desire to do what's right for the world.



Feeling a strong need to do something to document the crisis, in early spring 2020 the University's **Center for Southeast Asian Studies** launched a special site devoted to on-the-ground accounts of life during the outbreak. Still accepting submissions at the time this magazine goes to print, the site has grown to encompass myriad views of life throughout Asia, trapped in the grip of this grim shared experience.

Coeditor and Center faculty member **Mario Lopez** says, "As with others, CSEAS has been deeply impacted by this unprecedented event. With this site we aim to present different perspectives and voices from Southeast Asia and the other regions where our researchers work. We don't limit these solely to academic analysis, but also welcome nuanced commentary from writers, filmmakers, journalists, health care experts, and others."

See:
covid-19chronicles.cseas.kyoto-u.ac.jp

In Covid's wake

Ripples of the pandemic can be found throughout this issue: little has been left untouched by Covid-19 during the past year. Briefly, two additional coronavirus items related to KyotoU.

As mythical beasts go, the ***amabie*** (*àma'bí'é*) that reputedly appeared off of the coast of Higo (modern Kumamoto, on the southern island of Kyushu) during Japan's feudal era was already relatively cute: certainly much more so than the older *amabiko* it was said to resemble.

But along with its appearance, its prophecy of good harvests and advice to draw its picture and show this to those stricken by contagion seemed to somehow fit perfectly with an era where artists on social media are constantly seeking the latest meme to spark their imaginations. Early in the pandemic, word began to spread that a period news flyer in the archives of KyotoU's main library depicted this miraculous messenger, and a movement was born. (Original in black and white; other images are from a summer 2020 exhibition of artwork inspired by the apparition.)

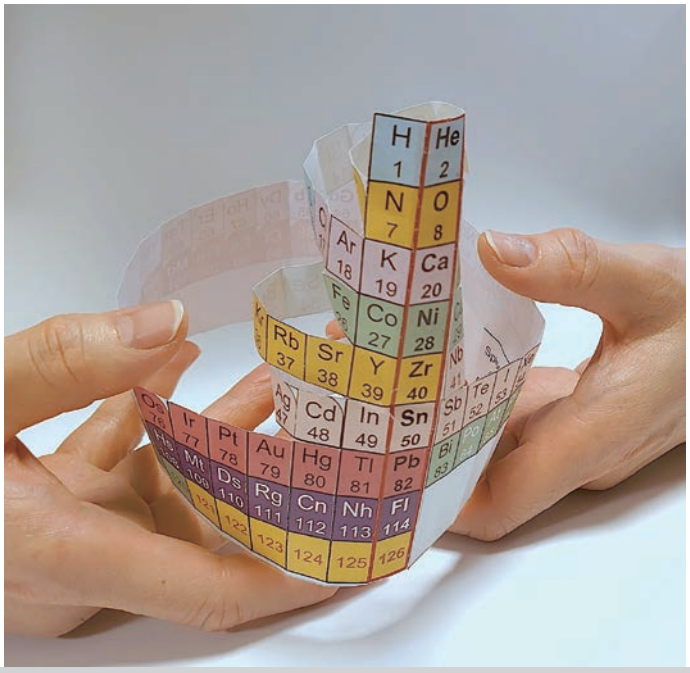
KyotoU and HeidelbergU scholar of modern Japanese culture **Björn-Ole Kamm** says of the meme, "The practice of fighting fire with fire somehow matches the spread of amabie as a countermeasure against the new coronavirus (or at least against the flood of depressing pandemic news). The once obscure Edo-period anti-plague *yôkai* jumped as a meme from one medium to the next, inspiring ever more people to copy, imitate, recreate, and remodel the beaked, once three-legged monkey into a cute mermaid. In *memetics* — the study of memes — these symbolic entities are characterized as viral phenomena that propagate and mutate, being transmitted from one host to the next. Even though a water creature, let's see if the virus-like meme amabie's fire prevails against Covid's."

A special elemental magic

A staple in every science classroom is the periodic table of elements, and for many students it is their first introduction to the vast mysteries of the natural world.

Now physicists from Kyoto University have unveiled a new table that provides a different perspective on the building blocks of the universe. While the traditional table is based on the behavior of *electrons* in an atom, this new table is based on the *protons* in the nucleus.

"The periodic table of the elements is one of the most significant achievements in science, and in its familiar form it is based on the shell structure of electron orbitals in atoms," explains Yoshiteru Maeno, one of the co-developers of the new table.



"But atoms are comprised of two types of charged particles that designate each element: electrons orbiting the core and protons in the core itself."

The team's new 'Nucle-touch' table — also available as a 3D model — was announced in the journal *Foundations of Chemistry*.

Over 150 years have passed since Dmitri Mendeleev discovered the periodic law that led him to propose the classic periodic table. He even had the foresight to add space for elements that were still unknown in his time.

"Fundamentally, it comes down to the electrons in each atom. Atoms are considered to be stable when electrons completely fill their 'shell' of orbits around the nucleus," continues Maeno.

"So-called 'noble gases', inert elements such as helium, neon, and argon, rarely react with other elements. Their most stable electron numbers are 2, 10, 18, 36, and so on."

Maeno describes these as atomic 'magic numbers', and importantly the same principle can also be applied to protons. Imagining that protons in a nucleus exist in 'orbits' may seem like a stretch, but the discovery of that concept was awarded the 1963 Nobel prize in physics.

Protons have different stable magic numbers: 2, 8, 20, 28, and so on. Among these are familiar elements such at helium, oxygen, and calcium. The Nucletouch table places these 'magic nuclei' at its center, providing a new perspective on the elements.

"Similar to electrons, when nuclear orbits are filled with protons, they form stable nuclei, analogous to the noble-gas elements," says collaborator Kouichi Hagino.

"In our nuclear periodic table, we also see that nuclei tend to be spherically-shaped near the magic numbers, but deformed as you move away from them."

The team made the table to highlight alternative ways to illustrate the laws of nature, and hopes that enthusiasts and academics alike will find something to enjoy and learn from this fresh new look at an old friend.

How do birds understand 'foreign' calls?

Fais attention! Serpent!

You may not speak French, but if someone behind you in a forest shouted this, you'd likely understand and become instantly alert.

And according to a report from KyotoU's Hakubi Center for Advanced Research, the same thing happens in birds.

Previous reports have shown that animals with shared predators can eavesdrop on and respond to each other's calls, indicating that they can partly understand other species. Toshitaka Suzuki, publishing in *Current Biology*, noticed a similar phenomenon among two different bird species while conducting field studies.

"Many birds have specific alarm calls, warning others about a predator," explains Suzuki. "I was studying how a specific call of a small bird named the Japanese tit, *Parus minor*, evokes a visual image of the predator in their

minds, in particular, a snake."

But he then observed that another bird, the coal tit or *Periparus ater*, also often approached the experimental area during these alarm calls.

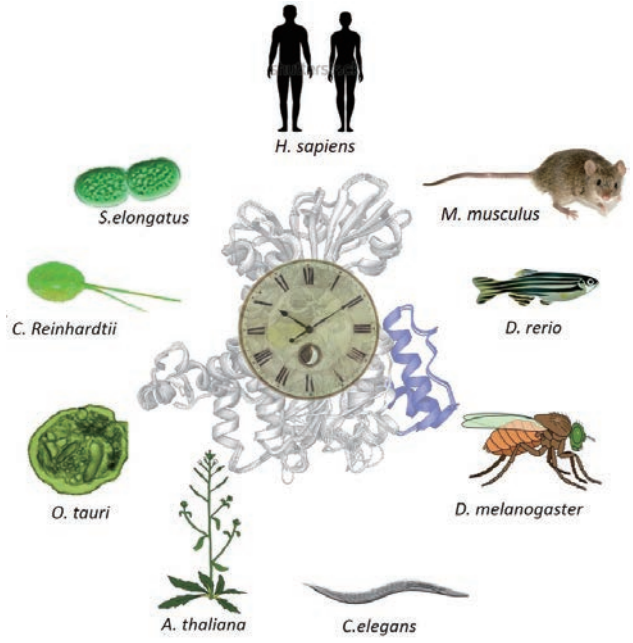
"I wondered if these other birds also mentally retrieve 'snake' images from these calls. While they are in the same taxonomic group, their calls are otherwise vastly different."

To demonstrate this, Suzuki set up an experiment under controlled conditions to investigate if the coal tits can anticipate and react appropriately even when they have not yet seen the predator in question. Snake-specific warning calls of the Japanese tit were played, and a stick was moved to mimic a snake gliding across the ground or up a tree.

"A variety of bird calls were played, but it was only the snake-specific ones which caused the coal tits to approach and inspect the stick," states Suzuki. "Additionally, when the stick was moved unlike a snake, such as in a rocking motion, none of the birds approached even when the warning calls were played."

These results show that the birds likely visualize a snake and react appropriately when they hear the snake-specific call from the other species, supported by visual confirmation. This work therefore represents the first evidence of visual search activity evoked via eavesdropping on another animal's alarm calls.

Suzuki intends to pursue this study to further explore how birds associate another species' calls with predators, hoping eventually to provide the basis for a new model for speech acquisition that may even be applicable to humans.



From bacteria to you: the biological reactions that sustain our rhythms

Every second of every day, countless biochemical reactions take place in our bodies' cells. The organization of this complex system is the result of billions of years of evolution, fine-tuning our functions since the first primordial organisms.

One such vital reaction is 'methylation', where a methyl group — a carbon atom linked to three hydrogen atoms — attaches itself to a target molecule. Methylation is involved in the regulation of everything from DNA to proteins, and it is so vital that it can be found in all living organisms.

In a paper published in *Communications Biology*, a team of researchers lead by Jean-Michel Fustin and Hitoshi Okamura from Kyoto University's Graduate School of Pharmaceutical Sciences has uncovered an intimate connection between methylation and the body's circadian rhythms: a link that exists even in organisms that don't traditionally 'sleep', such as bacteria.

"Disfunction in methylation can cause any number of pathologies, from atherosclerosis to cancer," explains Fustin. "Previously we discovered that inhibiting methylation in mice and human cells disrupted their body clocks."

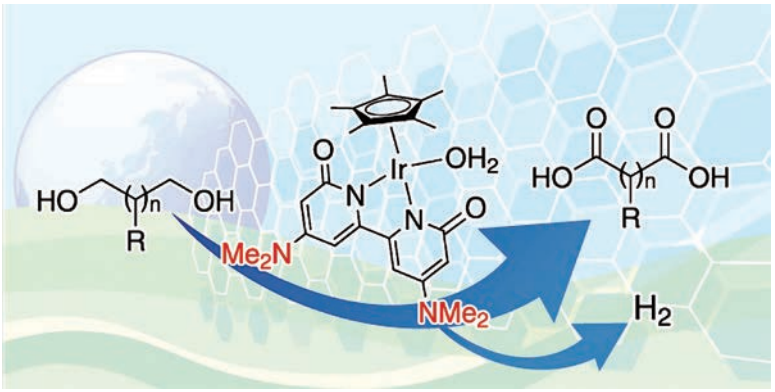
Methylation and the circadian rhythm, he adds, are ancient mechanisms retained in many organisms from bacteria to humans. "So, we hypothesized that the link between the two was also ancient."

The team began by collecting cells and tissue samples from different organisms and measuring their biological rhythms. On average, all organisms run on periods of 24 hours.

The next step was to find out what happens when methylation is disrupted, and as anticipated, significant alterations in the circadian clock were detected in all cell types, including in plants and algae. However, *cyanobacteria* — photosynthetic bacteria — seemed relatively resistant.

"The methylation pathway in bacteria is slightly different from other organisms. But

Two for the price of one



Every year, the chemical industry makes trillions of dollars synthesizing the countless chemical compounds we use every day.

From pharmaceuticals for keeping you healthy to polyester woven into your shirt, industrial processes turn simple chemicals into complex, valuable compounds. Researchers in turn work constantly to develop new substances as well as safer and more efficient methods of production.

In a paper published in *ChemSusChem*, researchers from KyotoU's Graduate School of Human and Environmental Studies describe how they have significantly improved the process that leads to polymers and plasticizers. And as an added bonus, their method generates hydrogen as a byproduct.

"We use renewable chemical compounds collectively known as diols to dramatically change the synthesis of dicarboxylic acids," explains corresponding author Ken-ichi Fujita. "These are needed to produce polymers, plasticizers, and lubricants."

Existing production methods, based on the oxidation of hydrocarbons using toxic oxidants, generate harmful waste products. Knowledge of this motivated the team to work on a new method of synthesis, changing the initial compound along with the catalyst.

"We began by looking at liquid solutions of diols, which are more renewable than starting materials previously used," continues Fujita.

"Then we needed to find a catalyst, and we settled on using iridium bound to a bipyridonate ligand."

The team were pleased to find that combining the diols with the new catalyst generated dicarboxylic acids with greater efficiency and significantly more yield, as well as four equivalents of hydrogen for every unit of diols.

Developing more efficient and safer methods of compound production is vital for industrial organic chemistry, and for the global environment.

"It is a pleasant surprise to see how efficient our new process is," concludes Fujita. "We hope to continue to improve safety and efficiency as we discover alternative chemical processes that are valuable to all humanity." ■

when an alternative compound inhibiting a different part of methylation was used, the circadian clock was indeed strongly affected there as well," Fustin continues.

Applying their findings, the team then took a gene that is key in controlling bacterial methylation and introduced it into mouse and human cells. Surprisingly, the bacterial gene was able to protect the cells from the first methylation inhibition compound, with no alterations observed in circadian rhythms.

"Not only did we find the evolutionarily conserved link between two ancient biological pathways — methyl metabolism and biological clocks — but we also opened the door to a possible new treatment for methylation deficiencies," concludes Okamura.

"All organisms are more alike than you might think, and knowledge about how we evolved will allow us to better understand ourselves and the natural world." ■

Flaring, massively

The cold, dark chaos of space is filled with mystery.

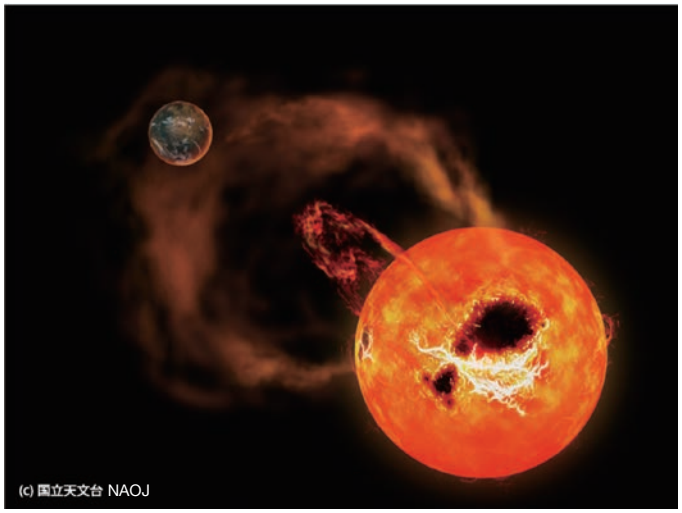
Fortunately, the ways in which we can peer into the mists of the void are increasing, and now include Kyoto University's 3.8 meter Seimei telescope.

Using this new instrument — located on a hilltop in Okayama to the west of Kyoto — astronomers from the Graduate School of Science and the National Astronomical Observatory of Japan have succeeded in detecting 12 stellar flare phenomena on AD Leonis, a red dwarf 16 light years away. In particular, one of these flares was 20 times larger than those emitted by our own sun.

"Solar flares are sudden explosions that emanate from the surfaces of stars, including our own sun," explains first author Kosuke Namekata.

"On rare occasions, an extremely large *superflare* will occur. These result in massive magnetic storms, which when emitted from our sun can significantly effect the earth's technological infrastructure."

Hence understanding the properties of superflares can be vital, but their rareness means that data from our sun is difficult to gather. This has led researchers to look for



exoplanets similar to earth, and to examine the stars they orbit.

Writing in the *Publications of the Astronomical Society of Japan*, the team reports on a long week of setting the sights of Seimei — along with other observational facilities — to AD Leonis.

This M-type red dwarf has temperatures lower than that of our sun, resulting in a high incidence of flares. The team expected a number of these to be large, and were astounded to then detect a superflare on their very first night of observations.

"Our analyses of the superflare resulted in some very intriguing data," Namekata explains.

Light from excited hydrogen atoms of the superflare exhibited an amount of high-energy electrons roughly one order of magnitude greater than typical flares from our sun.

"It's the first time this phenomenon has been reported, and it's thanks to the high precision of the Seimei telescope," says Namekata.

The team also observed flares where light from excited hydrogen atoms increased, but did not correspond with an increase in brightness across of the rest of the visible spectrum.

"This was new for us as well, because typical flare studies have observed the continuum of the light spectrum — the broad range of wavelengths — rather than energy coming from specific atoms," continues Namekata.

The high quality of these data was thanks to the new telescope, which the team hopes will open doors to new revelations regarding extreme space events.

Kazunari Shibata, leader of the study, concludes, "More information on these fundamental stellar phenomena will help us predict superflares, and possibly mitigate magnetic storm damage here on Earth."

"We may even be able to begin understanding how these emissions can affect the existence — or emergence — of life on other planets."

See the Autumn 2018 issue of this magazine for a detailed description of the innovative design and construction of the Seimei telescope.

Search for article titles
for paper, author details & more!

Order from chaos

Scanning lasers — from barcode scanners at the supermarket to cameras on newer smartphones — are an indispensable part of our daily lives, relying on lasers and detectors for pinpoint precision.

Distance and object recognition using LiDAR — a portmanteau of light and radar — is becoming increasingly common: reflected laser beams record the surrounding environment, providing crucial data for autonomous cars, agricultural machines, and factory robots.

Current technology bounces the laser beams off of moving mirrors, a mechanical method that results in slower scanning speeds and inaccuracies, not to mention the large physical size and complexity of devices housing a laser and mirrors.

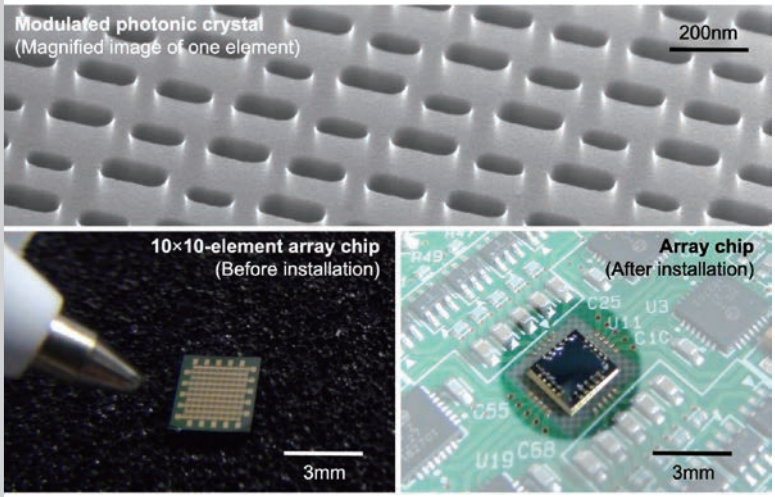
Publishing in *Nature Communications*, a research team from Kyoto University's Graduate School of Engineering describe a new beam scanning device utilizing 'photonic crystals', eliminating the need for moving parts.

Instead of arranging the lattice points of the crystals in an orderly array, the researchers found that varying the lattice points' shapes and positions caused the laser beam to be emitted in unique directions.

"What results is a lattice of photonic crystals that looks like a slab of Swiss cheese, where each crystal is calculated to emit the beam in a specific direction," explains Susumu Noda, who led the team.

"By eliminating mechanical mirrors, we've made a faster and more reliable beam-scanning device."

Photonic crystal lasers are a type of 'semiconductor laser' whose lattice points can be regarded as nanoscale antennae, which can be arranged to cause a laser beam to be emitted perpendicularly from the surface. But initially the beam would only go in a single direction on a two-dimensional plane; the team needed more area to be covered.



Arranging the antennae positions cyclically resulted in a successful direction change, but a decrease in power output and deformed shape made this solution unviable.

"Modulating the antennae positions caused light emitted from adjacent antennae to cancel each other out," continues Noda, "leading us to try changing antenna sizes."

"Eventually, we discovered that adjusting both position and size resulted in a seemingly random photonic crystal, producing an accurate beam without power loss. We called this a 'dually modulated photonic crystal'."

By organizing these crystals — each designed to emit a beam in a unique direction — in a matrix, the team was able to build a compact, switchable, two-dimensional beam scanner without the need for any mechanical parts.

The scientists have successfully constructed a scanner that can generate beams in one hundred different directions: a resolution of 10×10. This has also been combined with a diverging laser beam, resulting in a new type of LiDAR with enhanced scope to detect objects.

The team estimates that with further refinements, the resolution could be increased by a factor of 900: up to a 300×300 resolution range.

"At first there was a great deal of interest in whether a structure that is seemingly so random could actually work," concludes Noda. "We now believe that eventually we will be able to develop a LiDAR system small enough to hold on a fingertip."

Changing ties that naturally bind

Animals use social information for a variety of reasons, including identifying new foraging areas or threats from predators.

However, gaining this information requires physical contact among individuals, an action that risks spreading contagion. This leads to an evolutionary trade-off: what information does an individual stand to gain at the risk of possible infection?

Both social information and disease transmission are governed by our social structures, shaping how we live. Yet information and infection are rarely investigated as interactive factors driving social evolution.

Publishing in *Trends in Ecology and Evolution*, a collaborative research group from KyotoU's Primate Research Institute, Institut Universitaire de France, and the University of Strasbourg, describes the opposing evolutionary forces that give rise to the social networks of which we are a part.

"We live in an increasingly connected world, and these connections bind us together in nature," explains study coauthor Andrew MacIntosh.

"As such, we have always had to navigate the costs and benefits of social relationships, an experience that is shared with myriad other organisms that live in groups."

But what governs the structures of our social worlds? Sharing information and cooperation ties us together, but the current global pandemic reminds us that there are limits to our social connectedness, demanding changes in our behavior.

"Social animals face two key needs: access to information about key resources, and avoidance of pathogens that can make them sick," continues lead author Valéria Romano.

The team began by reviewing literature on social transmission and the strategies employed by animals to reduce the costs of connectedness. They found examples where evolution has resulted in potential solutions to our ongoing social dilemmas protecting us from infectious diseases.

Common strategies include individuals self-isolating, or uninfected individuals actively avoiding infected peers.

The team then introduced an integrative theoretical framework for studying social structure as a dynamic system in which individuals constantly update their social behaviors to reflect both the benefits and costs of interaction.

"British zoologist Robert Hinde — one of the great thinkers in animal behavior — established an evolutionary framework for studying the structures of animal societies," explains coauthor Cédric Sueur.

"But he missed assigning a role for deleterious forms of social transmission, like infectious diseases. By extending our analysis of 'connection costs' to Hinde's analysis, we've modernized his classic model."

Although humans have evolved with and developed tools to protect ourselves from the spread of diseases, our own social networks are embedded within a much broader ecological network.

"Covid-19 is the product not only of the global reach of our interactive networks, but also of our incautious exploitation of the natural world," MacIntosh concludes.

"Social distancing and digital communication can slow the spread of pathogens, but more responsible interaction with nature might have mitigated its emergence altogether."

Reducing the high social cost of death

How will you cope with the death of your mother or spouse? Their death may disturb your concentration, causing accidents or lowering your productivity. Some bereaved cannot sleep, and others cannot get out of bed. Some lose all appetite, while others binge eat constantly. Some grow alcoholic, and some suicidal. Our responses may depend on our family, culture, community, or belief-systems, but we all struggle to accept our loved ones' deaths.

The cost of grief is not confined to personal mental anguish. It reduces productivity, causes dependency on medicine and social services, and increases mortality risks for survivors. While this is well documented in Europe, we have little data for Japan, the world's most elderly country. To fill this gap, a research team led by Kyoto University is conducting a nationwide survey of bereavement.

"Japan's society is rapidly aging. By 2030, nearly everyone in Japan will suffer the death of a parent, elder relative, spouse, or close friend," explains lead author Carl Becker of the Center for the Promotion of Interdisciplinary Education and Research, who garnered the 2020 Educator Award from the international Association for Death Education and Counseling.

"Recent UK studies suggest that about 10% of bereaved individuals show significant decline in health, resulting in prolonged use of resources. If Japan faces the same percent, the impact will be catastrophic." The team decided to conduct similar surveys throughout Japan with additional questions focusing on economic and lifestyle changes.

Their pilot report — published in the journal *OMEGA* — shows that deeper grief correlates with an overarching decline in quality of life, seen in physical ailments, more down time, and higher rates of medical reliance. Interestingly, lower income families lost more productivity and pharmaceutical expenses, while lower satisfaction with funerals was linked to higher medical costs.

Results show that bereaved Japanese are similar to Europeans in their losses of everything from time, productivity, health, and medical expenses. Factors like the circumstances of death, the loss of income, lack of family or social support, and satisfaction with funeral proceedings can help predict who may need the most help in the future.

"By identifying key problems, we can begin to see what solutions are required to mitigate severe bereavement," states Tohoku University's Yozo Taniyama, second author of the study. "For example, better testing, medical care, and psychological treatment can help people handle unexpected death. More robust financial and social aid can help with the loss of income."

Tradition and rituals appear to facilitate better responses as well. Funeral services offer friends and relations a chance to reconnect and support the bereaved, reducing their loneliness and isolation. Moreover, rituals help the bereaved to come to terms with death.

The research team predicted that people with low or declining incomes would find funeral costs more burdensome. Although that group did lose more time and spend more on pharmaceuticals, they displayed little dissatisfaction with funeral costs. In fact, the people who expressed greater dissatisfaction were those who abbreviated funerals, who later tended to show higher rates of physical as well as psychological problems.

Becker concludes, "Japan has a tradition of ceremonies that bring people together to help the bereaved process their trauma. Much of the world is learning from Japan's traditions that value spiritual bonds with departed loved ones. It is healthier to revere our dead than to try to forget them." ■

Detect with PKAchu

Publishing in *PNAS*, biologists at Kyoto University report on a previously unknown mechanism in the retina that will perhaps lead to a better understanding of how our eyes see at night. The finding was made possible thanks to mice engineered to change

Terahertz zaps alter gene activity in stem cells

Terahertz light pulses change gene expression in stem cells, report researchers from KyotoU's Institute for Integrated Cell-Material Sciences (iCeMS) and Tokai University in the journal *Optics Letters*. The findings come thanks to a new tool, with implications for stem cell research and regenerative therapy development.

Terahertz waves fall in the far infrared/microwave part of the electromagnetic spectrum and can be produced by powerful lasers. Scientists have used terahertz pulses to control the properties of solid-state materials. They also have potential for manipulating living cells, as they don't damage them the way that ultraviolet or infrared light does. Research so far has led to contradictory findings about their effects on cells, possibly because of the way the experiments have been conducted.

iCeMS microengineer Ken-ichiro Kamei and physicist Hideki Hirori worked with colleagues to develop a better tool for investigating what happens when terahertz pulses are shone on human cells. The apparatus overcomes issues with previous techniques by placing cells in tiny microwells that have the same area as the terahertz light.

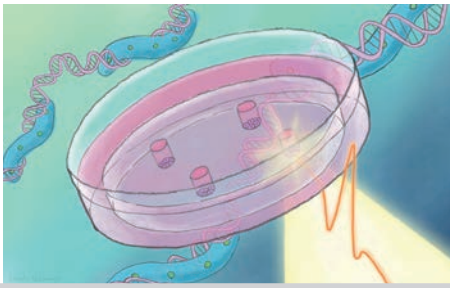
The team used the apparatus to explore the effects of terahertz radiation on induced pluripotent stem cells, or iPSCs. These are cells that have been taken from skin or blood and changed into stem cells. Scientists are seeking to turn them into other types of cells and tissues to help treat diseases like muscular dystrophy.

"Terahertz pulses can generate a strong electric field without touching or damaging cells," says Hirori. "We tested their effect on iPSCs and discovered that the activity of some gene networks changes as a result of terahertz light exposure."

For example, they found the pulses activated genes involved in motor neuron survival and mitochondrial function. They also deactivated genes involved in cell differentiation, the process in which stem cells change into specialized body cells.

Further investigation found that these genes were influenced by zinc-dependent transcription factors. The scientists believe the terahertz pulses generate an electric field that causes zinc ions to move inside cells, impacting the function of transcription factors, which in turn activate or deactivate the genes they are responsible for.

Hirori says the findings could aid efforts to develop a technology that can manipulate iPSC differentiation into specific cells by turning off specific genes while keeping others on, paving the way for regenerative therapies for a wide range of diseases.



fluorescence when a specific molecule — protein kinase A, or PKA — is activated.

These 'PKAchu' mice were developed to provide researchers with a way of visualizing the activation of one of the body's most essential and widely studied proteins.

"PKA is found in many cells and is involved in a wide variety of biological processes. It's natural that researchers would find a way to observe its activities," explains first author Shinya Sato of the Graduate School of Biostudies.

"PKAchu mice were developed in 2012 — 'chu' being Japanese for 'squeak'— to allow us to closely monitor how PKA acts during specific biological processes. I decided to apply this to my work in retina biology."

The team first developed a method for recording high-resolution microscopic images of living retinal tissue. They then observed how PKA reacts to light stimulation. Knowing the pathways involved, the team hypothesized that light would deactivate PKA.

But to their surprise, the exact opposite happened.

"We started with a six-second illumination of the tissue. Incredibly, this activated PKA in the selected area for nearly 15 minutes," continues Sato. "We then did a ten-minute illumination, during which PKA was inactive. But when the lights were turned off, PKA kicked into gear. It was as if the darkness had activated it."

Single-cell level analysis revealed that this lights-off PKA activation occurred only in rod cells, which are indispensable for our night vision.

Sato hypothesizes that this previously unknown mechanism of rod-specific PKA activation may be a key in boosting light sensitivity in our eyes, contributing to our night vision. Rod-type photoreceptor cells are thought to have evolved from color-sensing cone cells. PKA activation, it now appears, is rod-specific.

Michiyuki Matsuda, the study's senior author, concludes: "We have not only uncovered many interesting aspects of retinal cells, but the further utility of PKAchu mice as well. We are excited to uncover the mechanisms and purpose behind these new findings, and perhaps illuminate our understanding of conditions such as night blindness."

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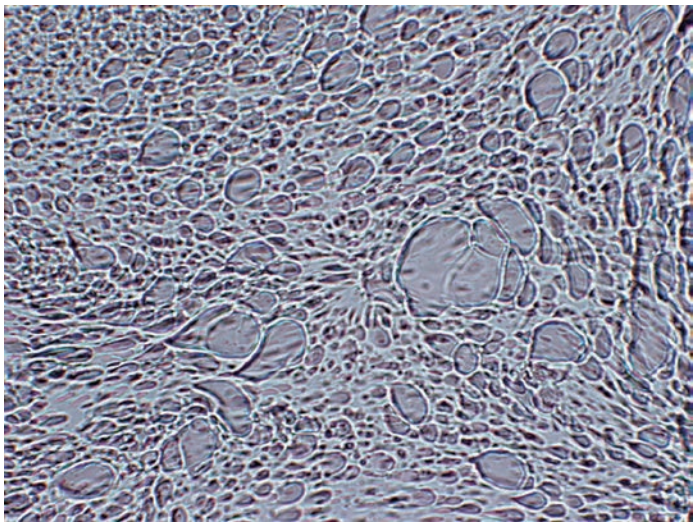
How does the spider spin its self-assembled silk?



Of all the exciting topics in the field of material and biochemical research, one of the hottest by far is unraveling the mysteries of spider silk.

Often claimed to be 'stronger than steel', the protein-based fibers have the potential to change the material world as we know it. However, despite decades of research, nobody has been able to mass produce spider silk, primarily because the exact method of how it's made is still shrouded in mystery.

In a step toward understanding its inner workings, researchers at KyotoU's Graduate School of Engineering report on a new model for spider silk assembly, reporting that the key to spider silk 'spinning' is a combination of acidification and a process known as liquid-liquid phase separation, or LLPS.

"Spider silk is made of proteins called spidroins. The spider has a gland that is densely filled with spidroins in a liquid state called dope," explains Ali D Malay, first author of the study, published in *Science Advances*.

"This liquid is rapidly converted into the tough and structurally complex silk. To investigate how exactly this is done, we decided to go back to the drawing board and look at spidroins itself. So we developed artificial spidroins that closely mimic the ones found in nature."

Developing the protein was no easy task, but they landed on using a specific spindrion called MaSp2, one of the more common spider silk proteins, that is water soluble.

After isolating their artificial spider silk protein, the team began observing its activity under different chemical conditions, intending to understand what key chemical changes are needed for the liquid phase to turn solid.

"We first saw the the protein gathering into small clusters. But when we added potassium phosphate it instantly began to condense into big, high-density droplets," explains Malay. "This is a phenomenon known as liquid-liquid phase separation — it happens quite often in cells — such as when liquid droplets change their size and density according to the surrounding environment."

But this was only one part of the puzzle. What does it take to make this liquid phase into the silk fibers we know so well? The key was pH. As the team lowered the pH of the solution, the globs began to fuse together, forming a fine network of fibers.

Both LLPS and fiber network formation happened so spontaneously that it was visible in real time. Moreover, when the fiber network was placed under mechanical stress it began to organize itself into a hierarchical structure just like spider silk.

"Spider silk often surpasses the most advanced manmade materials today, and making these synthetic fibers often relies on harmful organic solvents and high temperatures. What's incredible here is that we were able to form spider silk using water as solvent, and at ambient temperatures," concludes Keiji Numata who led the study.

"If we can learn to emulate the mechanisms of spider silk spinning, it could have a profound impact on the future of manufacturing." ■

Nano cellulose ride

Debuted at the 2019 Tokyo Motor Show, the prototype **nano cellulose vehicle** was commissioned by the Ministry of the Environment and built by a collaboration of 22 industry, government, and academic institutions led by Kyoto University. Major body components consist of a composite of *cellulose nanofiber*, a new plant-derived material with high strength and malleability at 1/5 the weight of steel. The elaborate interior showcases the work of traditional Kyoto crafts such as woodworking, lacquering, and silk weaving. For project details see: rish.kyoto-u.ac.jp/ncv ■

Kyoto University spans three campuses in the city of Kyoto, numerous offices, research facilities, and other operations around the country, and dozens of centers, liaison offices, and field stations across the globe. In this third section, learn of some of the latest developments from the forefronts of research, overseas offices and labs, and student life.

Science with industry

The forest and the trees: science supporting ASEAN

Ryuichi Fukuhara is not usually in KyotoU's Center for Southeast Asian Studies building this time of year. Normally he'd be coordinating the now second phase of JASTIP — Japan-ASEAN Science, Technology and Innovation Platform — at its headquarters in Bangkok.

JASTIP launched in September of 2015 with backing from the Japan Science and Technology Agency and coordination from Kyoto University. The brainchild of current vice-president for international strategy Yasuyuki Kono, the program aims to promote and utilize Japanese scientific and academic talent to support the ASEAN region.

KyotoU has an extensive history of cooperation with ASEAN member states, leading naturally to JASTIP's mission to find and institute actual sustainable solutions to world problems in three primary areas: energy and environment, bioresources and biodiversity, and disaster risk reduction.

To make this happen, Fukuhara must bring together stakeholders from academia, business, government, and society.

Fukuhara is a natural fit as program coordinator, a position to which he brings experience with Japanese national broadcaster NHK and a decade at the United Nations, including five years each at UNESCO and the UN Environment Programme.

"Working in television and at the UN taught me how to navigate between different organizations. Good relationships with private firms and the government are vital, but they will only corporate if they know the result will be concrete and positive for society. Consensus building is paramount to achieving success."

One recent project spearheaded by the biomaterials team created an integrated bio-refinery system for sugarcane trash, and included partners in Indonesia and Thailand.

"This effort is led by a group at KyotoU's Research Institute for Sustainable Humanosphere. It started with a small seed fund from JASTIP, combined with grants from industry partners in the region."

Leveraging KyotoU's expertise in data analysis, human connections, and deep regional experience, JASTIP aims to help coordinate more such projects to build a foundation for sustainable development throughout the region.

"Kyoto University's strengths in the basic sciences can be of great benefit to many ASEAN institutions. Providing a framework for scientific exchange via these startup projects is a key to building a foundation for constant innovation in sustainable development."

For more see jastip.org

New strategic partnerships established

Kyoto University concluded its first strategic partnership agreements with Bordeaux University in France and Vienna University in Austria in autumn 2019. Agreements followed in the summer of 2020 with Zurich University in Switzerland, Universität Hamburg in Germany, and National Taiwan University.

Through these executive-level partnerships, KyotoU aims to build relationships that are more than just typical exchange-based agreements, such as those it already has with many world-leading institutions, albeit the precise meaning of 'strategic' will vary depending on the nature of each counterpart university.

For example in the case of the **University of Bordeaux**, collaboration will be deepened to initiate interdisciplinary cooperation in the fields of African area studies, energy studies, and medicine. For the **University of Vienna**, the aim is to advance into innovative new spheres of study by strengthening ties within existing fields. The goal for the strategic partnership with the **University of Zurich** is to develop research fields essential for future societies. Initiatives with **Universität Hamburg** will seek to establish matching funds to deepen existing collaboration in various areas. And cooperative plans with **National Taiwan University** include the widening of support for early career researchers.

Exchanges will not be limited to research, but will also include staff and management-level cooperation as well as educational exchange projects.

These strategic partnerships reflect KyotoU's basic principle of being "a university open to the world [contributing] to the harmonious coexistence of the global society by deepening global exchange." A strong belief pervades the organization that strategic exchanges with the world's top universities will not only improve international competitiveness but also contribute to this philosophy of openness and support for diversity.

News from overseas centers

www.oc.kyoto-u.ac.jp/en/

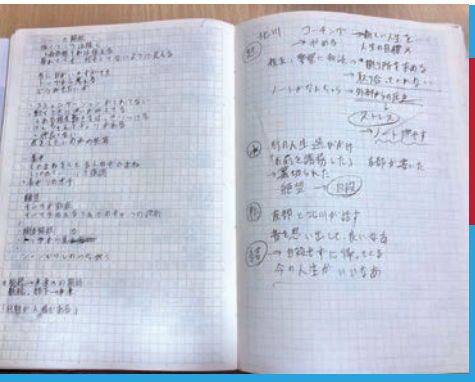
The era of the pandemic has been uniquely challenging for the internationalization of higher education. Not only traditional ways of teaching and conducting research have had to change, but also the ways in which universities connect with their partners. Staff members typically on site at the European Center, ASEAN Center, and North American Center all returned to Japan, where they continued to run their activities remotely.

The **European Center** has been actively supporting the establishment of the new strategic partnerships with counterparts in Zurich and Hamburg. In September 2020, the Center hosted an online event introducing KyotoU to students and administrative staff of European partner universities; former international students from Europe and KyotoU shared their experiences with encouraging messages for prospective students from 12 countries. The Center's monthly report — *The Heidelberg Tayori* — continues to provide updates on the state of affairs in the region.

The **ASEAN Center** in Bangkok organized a series of monthly seminars on "Science, Technology and Innovation Coordinators in Japan and ASEAN towards Grand Challenges", aiming to raise awareness about STI coordinators. The program served as a platform where attendees from the ASEAN Foundation, ASEAN Secretariat, JASTIP, and partner institutions could discuss the nurturing of human capital to support the development of a sustainable environment for STI. The Center also participated in online educational fairs such as "Online Study in Japan Weeks 2020" for Myanmar students organized by Okayama University. Support was also lent to KyotoU's International Undergraduate Program's recruiting activities through the "Kyoto iUP Online Session", where the Center director addressed students from Mahidol Wittayanusorn School. The Center is now working on a virtual-reality video which enables prospective and current students to experience KyotoU's fieldwork activities in an innovative and inspiring manner.

The **North American Center**, in collaboration with local alumni associations, aims to capitalize on connections in the region to boost the University's presence, promoting student mobility as well as research collaboration. To this end, the University plans to support academic cooperation with key institutions in the region through its On-site Laboratory initiative. Working closely with Friends of KU — an organization established by local alumni — the Center supports the "Kyoto University Voices Webinar" series of live broadcasts featuring speakers and moderators from among the University's leadership, faculty, and alumni, aiming to bring KyotoU's creative insights and inspiring ideas to the world.

Covid-19 may have significantly changed the way we work, but positive lessons from this time include the fact that connections remain strong, and that even from afar we can rely on technology to continue bridging and fostering opportunities for international cooperation.



Iwami's rehearsal notes, including areas of improvement that became clear through practice sessions, script interpretations, and other random thoughts.

Bringing stage ideas to life
Gekidan Keppeki (Keppeki Theater Company)

Chiho Iwami (2nd Year, Faculty of Agriculture)

Club building E, at the end of a long row of structures, stands out thanks to a sun-shaped prop decorating a second-floor window. Inside, books on theater and many more props overflow everywhere. Club member — and scriptwriter and director — Chiho Iwami's latest work has just seen its final curtain call.

Gekidan Keppeki — officially established 28 years ago — allows all members to plan and produce performances, a rarity in student theater in Kyoto. Aspiring playwrights join Keppeki from universities all over the city, not just from KyotoU.

"Some members join workshops held by professional actors to hone their skills," says Iwami, "but as a general principle, we don't invite professionals. New students learn the basics from upperclass members, and after that, it's all about practice."

Although still in her second year at the university, Iwami has already written and directed five plays, including works welcoming new students. Looking back on the first play she directed, *Be Here Now*, Iwami commented on the difficulties of being a director.

"We convey a loose idea, which is then shaped by the actors and staff members, so communication is extremely important. If we're too harsh with our words, the actors grow timid, but if we say yes to everything, we can't get our ideas across."

Iwami first took an interest in scriptwriting and directing after watching *A Ghost of a Chance*, a film by nationally acclaimed writer and director Kôki Mitani.

"Mr Mitani is adamant about using a style of scriptwriting known as *atégaki*, where he envisions specific scenes for specific actors. This has been helpful for writing scripts for Keppeki too, since we have a lot of very unique actors."

The troupe's latest play, *Sai'un no Kokoroé*, is not only directed but also written by Iwami.

"For *Be Here Now*, I was feeling my way around from start to finish, and too passive to say everything I wanted to say. For this play, I pushed myself to use ategaki, and communicated proactively with the actors. I made myself clear with direction as well as with lighting and costumes, so that we could create a perfect show."

Iwami's aspiration is now to support new students who are aiming to become directors. "Keppeki has over 100 members in total and around 30 to 50 are involved in a typical performance. The director supervises everything that happens onstage. By keeping your original purpose in mind and never giving up on it, you can create the play just as you imagined it in your head. You hear a lot of opinions about the script from the actors, but the important thing is not to lose your style."

From an interview conducted in late 2019. The magazine editors wish Iwami and her fellow students all the best in their endeavors as we continue to work through the challenges of the Covid-19 pandemic, which has brought many aspects of campus life to a halt.

A scene from *Be Here Now*. Based on a 1990 dramatic piece by Shôji Kôkami, the set was designed in shades of gray to make the central green object stand out.

Artwork by Kyoto University students, combined with artistic scenes as glimpsed by researchers.

おと

Recorder Club

From the Concerto for Two Violins (BWV 1043)
First Movement, *Vivace*
Composer: J S Bach

J S Bach composed this work for two violins. There are many high notes, requiring the performers to show great skill in exerting not just their fingers but also their legs. Listen to how the melodies played by the two parts blend together.

いろ

A Spring Day (translation below)

Calligraphy Club
Makoto Hara (1st Year MA, Graduate School of Science)

I believe creative expression is a process of taking what arises from inside (an impression) and pushing it out (as an expression). I wanted to express what I felt with the entirety of this composition, but my inexperience has left me unsatisfied with the result. I will continue to devote myself to the art.

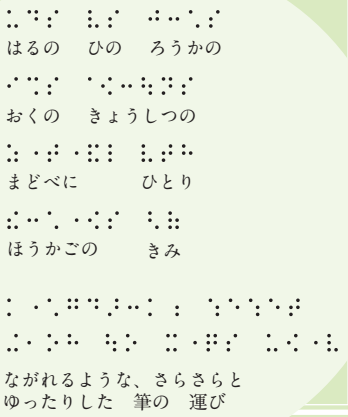
On a spring day
Down the hallway
In the far classroom
By the window
Alone
There you are
After class

(written with easy, flowing brushstrokes)

こころ ことば

Braille Club

Calligraphy provokes the imagination of viewers through the nuances of the brushstrokes and how the characters flow together. Braille, on the other hand, is just a monotonous line of letters. By translating not only the words but also *how* the words are written, we hope to elicit their sounds and convey an impression of their colors.



Celebrating the 125th

Founded in 1897, Kyoto University welcomes you to join us in marking an important milestone in 2022: our 125th anniversary.

The University has matured considerably since its early days. It has always been the second largest national university in Japan, but over the decades it has steadily grown and garnered international accolades making it one of the top-ranked educational and research institutions in the world.

A special website has been established for this occasion, including alumni profiles and reflections, University history, and anniversary events, with more being added constantly. We encourage you to pay us a visit and explore what makes KyotoU such a unique university in Japan and the world.

We have also established a special 125th fund. We ask your generosity in considering a donation to help our efforts to continue pursuing the highest possible standards in scholarship and teaching as we press forward into the future.

Please see:
125th.kyoto-u.ac.jp/en

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