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JAXA scientists retrieve a capsule carrying the first samples of asteroid subsurface dropped by Hayabusa2 in southern Australia.

The heights and depths of Japan's dynamic partnerships

Striving to improve its collaborative record, a nation's ambitious scientific goals are bringing in the best from around the world. **By David McNeill**

Yuki Morono goes to work each day with a single overriding aim: to probe the limits of Earth's biosphere. "There should be some point where life stops," says the microbiologist, who works in the Geomicrobiology Research Group at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) in Kochi. He was astonished, therefore, to find a community of microbes that had survived for more than 100 million years in a dormant state, some 74.5 metres beneath the Pacific Ocean seabed.

With long-time collaborator Steven D'Hondt, an oceanographer at the University of Rhode Island in South Kingstown, Morono and his colleagues co-wrote a paper about the discovery, describing the remarkable tenacity of these ancient microbes (Y. Morono *et al. Nature Commun.* **11**, 3626; 2020). The implications, says D'Hondt, are profound. "If microbes can survive for 100 million years under the sea, it's not a stretch to think they could survive on Mars for a billion years," he says.

D'Hondt first met Morono through a mutual collaborator in the international drilling community more than a decade ago. Morono later built on research by Jens Kallmeyer, a postdoctoral student in D'Hondt's lab, who developed a way of separating cells from sediment, minimizing contamination and visualizing the results. "We would not have been able to do this without each other," says Morono.

Japan has become a "formidable" research partner in the international effort to study beneath the world's seabed, says D'Hondt. Besides supplying funding and knowledge, it provides *Chikyu*, its flagship ocean-drilling research vessel, as the workhorse of the International Ocean Discovery Program (and its predecessor, the Integrated Ocean Drilling Program). One of the world's longest-running Earth-science collaborations, the programme brings together scientists from 22 nations.

Strengthening Japan's international research ties could be an important factor in halting a slide in its research performance. In the Nature Index, which tracks output in 82 natural-sciences journals, Japan's adjusted Share

dropped by 19.1% in 2015–21. (Share, Nature Index's key metric, is adjusted to account for the small annual variation in the total number of articles in the Nature Index journals. Data for 2021 represent the period October 2020–September 2021.) This decline, although the largest among the leading five countries in the Index – the United States, China, Germany, United Kingdom and Japan – has slowed since 2019, which could be a sign that the nation's strategy of lavish and targeted funding for prestigious institutions is paying off.

Big ambitions

The University of Tokyo-based Kamiokande is an ambitious programme built on a series of ever-more powerful neutrino detectors. Launched almost 40 years ago, it has played an important role in establishing Japan as a key collaborative partner in physics research.

The T2K Collaboration, for example – a Japan-based particle-physics experiment involving about 500 physicists and engineers at more than 78 institutions from around the world – used Kamiokande data to demonstrate different behaviours in matter and antimatter. The results, released in 2020, could inform one of the greatest mysteries in physics: why there seems to be more matter than antimatter in the Universe, when the Big Bang should have created equal amounts of both (The T2K Collaboration *Nature* **580**, 339–344; 2020).

In 2019, the Japanese government approved ¥64.9 billion (US$600 million) to fund Hyper-Kamiokande – set to be the largest neutrino detector of its kind ever built. Some 75% of the funds will be contributed by Japan, with the remainder sourced from foreign partners. "Collaboration is critical," says Masato Shiozawa, a lead scientist on the project, which involves building the world's biggest underground water tank inside a vast cavern in Japan's Gifu prefecture.

The payoff could be huge. Neutrinos are one of the elementary particles of the Universe, but are notoriously difficult to observe. One of the achievements of Super-Kamiokande, the preceding phase of the project, was to prove that they have a small but finite mass. By 'catching' more of them, Hyper-Kamiokande could give a more detailed picture of the evolution of the cosmos by exploring the difference between neutrinos and antineutrinos. "Even at the ideas level, we need many people to design the detector and the project itself, to make devices and to analyse data," says Shiozawa.

Such ambitious science will demand ever greater global cooperation, says Motoo Ito, a cosmochemist who studies the origins of water at JAMSTEC. With teams at the Open University in Milton Keynes, UK, and the University of California, Los Angeles, Ito is analysing samples from the asteroid Ryugu. The samples were collected by the Hayabusa2 probe, launched by the Japanese state space agency JAXA, and returned to Earth in December 2020. Understanding Hayabusa's payload requires complex instrumentation from labs around the world, says Ito.

Among his colleagues is Keiko Nakamura-Messenger, a research scientist at NASA's Johnson Space Center in Houston, Texas. She works on Hayabusa2 and the OSIRIS-Rex, a NASA probe launched in 2016, which is returning to Earth with samples from the asteroid Bennu. The OSIRIS-Rex team helped JAXA scientists create 3D modelling and navigation plans that have made both missions "stronger and safer", says Nakamura-Messenger.

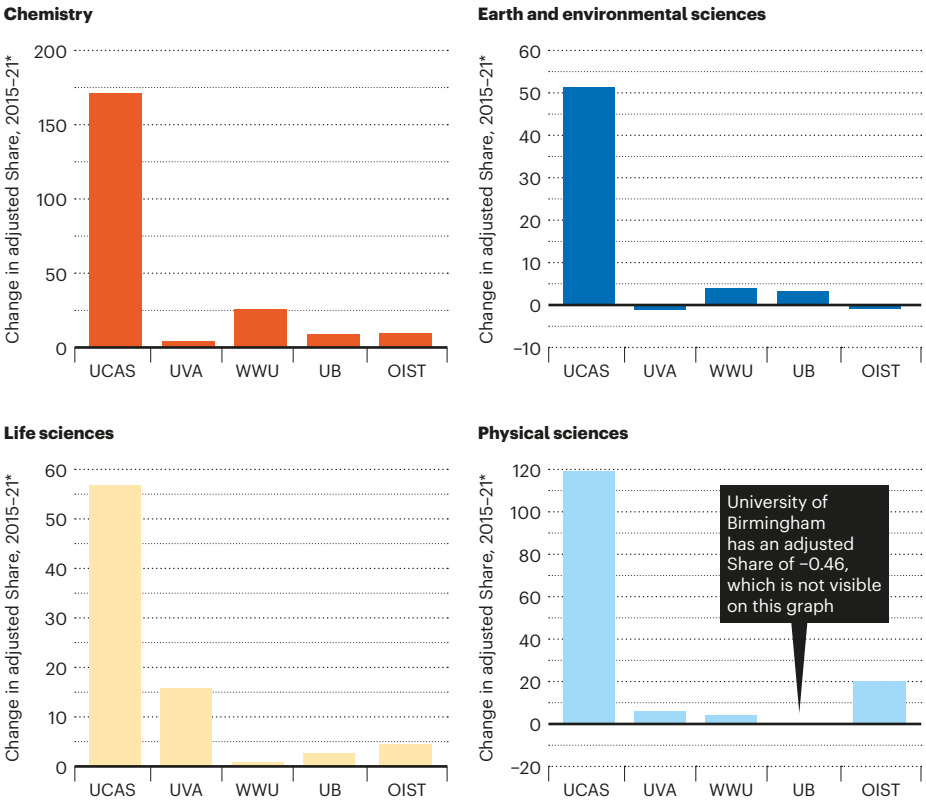
The Japanese academic system can be "unforgiving" for female researchers, says Nakamura-Messenger, who moved to the United States after gaining her PhD in materials science from Kobe University, Japan. Career progression in fundamental physics can be particularly difficult, she says, "unless you have an enormous amount of help from your family and partner".

David McNeill is a professor of communications at University of the Sacred Heart, Tokyo.

GAINING STRENGTH

The institution with the biggest Share increase for each of the Big 5 countries is shown. Each of the other top 20 fastest-rising institutions in China since 2015 (not shown) has achieved more than double the absolute Share increase of the fastest-rising institutions in the other Big 5 countries.

Institution	Location	Change in adjusted Share 2015–21	Adjusted Share 2021	National rank 2021
University of Chinese Academy of Sciences (UCAS)	China	353.10	477.09	2
University of Virginia (UVA)	United States	25.28	101.33	54
University of Münster (WWU)	Germany	34.85	154.73	6
University of Birmingham (UB)	United Kingdom	9.47	66.90	17
Okinawa Institute of Science and Technology Graduate University (OIST)	Japan	29.72	44.28	14



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