HEMING ZHAN

Xiushanosteus mirabilis **(reconstructed), an extinct species of armoured fish.**

How China is capturing attention with landmark research

From ancient sea species to clues on comets, papers by the country's talented scientists are regularly making headlines.

China's scientific rise is often illustrated by statistics, whether that be the trillions of dollars of research spending since 2000 or the hundreds of thousands of journal articles it now publishes each year. But Chinese science is also regularly making a splash in the news and on social media. Here we look at four papers that have had such an impact since 2021, according to scores tracked by Altmetric.

Fossil frontier

In recent efforts to make Xiushan county in southern China more accessible to tourists, roads and other infrastructure have been constructed around the region's precipitous mountain slopes. While digging around one of these construction sites in 2020, You-an Zhu and a crew of researchers from the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), in Beijing, chanced upon a trove of fish fossils that date back to roughly 436 million years ago. "It blew our minds that we found complete fish fossils, head to tail, and a lot of them stacked up altogether," says Zhu, a palaeontologist at the IVPP.

Described in a 2022 paper published by *Nature*[1], the find included the remains of placoderms, an extinct class of armoured fish that are thought to be one of the oldest known jawed vertebrates. The most abundant species found was the 3-centimetre long *Xiushanosteus mirabilis*. Zhu and his team also found remains of the oldest known shark-like fish, *Shenacanthus vermiformis*.

In the nearby Guizhou province, Zhu's team found tooth whorls (coils of serrated teeth) from another shark-like fish, *Qianodus duplicis*. Described in a separate *Nature* paper[2] in 2022, *Qianodus duplicis* is the earliest-known vertebrate with teeth, dating to 439 million years ago.

Researchers have suspected that the evolutionary timeline of jawed vertebrates stretches back 450 million years, based on spine and scale fragments found over the past two decades, but until Zhu and his colleagues' discovery, the earliest fossil records dated to 425 million years ago. The newly unearthed fossils push back the origins of teeth and jaws

by at least 14 million years.

The find also suggests that life in the early Silurian seas, millions of years before the Devonian period, or 'age of fishes', was more diverse than previously thought. "From preliminary work, we already know that there are more than 15 taxa of jawed fish and more jawless fish [at the time]," says Zhu. This diversity wasn't just at the species level — the fishes greatly varied in their form. "We found really slender ones, like modern pipefishes, and really flattened ones, like modern rays," says Zhu, referring to the fossil cache as "a lost aquarium of early Silurian fishes".

Jawed fishes from the early Silurian period are unlike those that appeared in the late Silurian, says John Long, a palaeontologist at Flinders University in Adelaide, South Australia, who was not involved in the study. This suggests that jawed fishes rapidly evolved in the period following a mass extinction event, roughly 444 million years ago. "So much evolutionary change was going on in this short time after jaws first evolved," says Long.

The work is among several significant palaeontological finds in China over the past 25 years, making it "one of the most exciting frontier lands for new fossil discoveries", says Long. "It also highlights the high quality of [China's] palaeontological research capabilities."

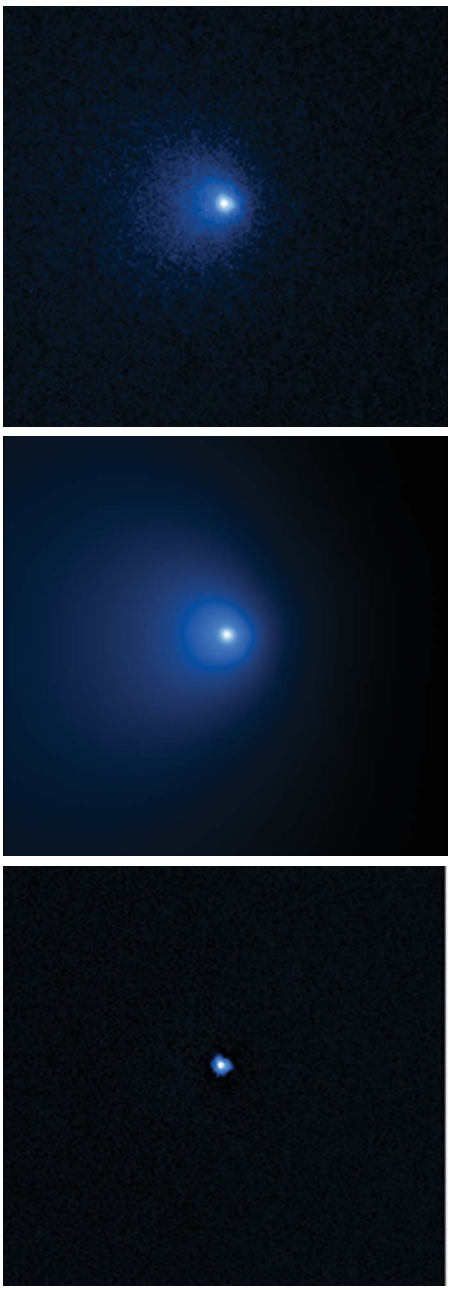
Further studies of these fossils could help researchers to elucidate which originated first, sharks or armoured fishes, and their relationship to today's bony fishes. "This is a major long-standing problem in vertebrate evolution," says Long. **Pratik Pawar**

Cosmic archive

On the frigid outskirts of the Solar System lie trillions of icy leftovers from the early days of planetary formation. Known as the Oort cloud, this enigmatic region is thought to be the birthplace of long-period comets, objects made of ancient ice, dust and gases that take more than 200 Earth years to complete their orbit around the Sun.

In 2021, astronomers Pedro Bernardinelli, at the University of Washington, in Seattle, and Gary Bernstein, at the University of Pennsylvania, in Philadelphia, announced[3] the discovery of one of these distant comets, C/2014 UN_{271} (Bernardinelli–Bernstein). They found the comet while scouring thousands of archival images between 2014 and 2018, which had been captured by the Dark Energy Survey at the Cerro Tololo Inter-American Observatory, in Chile.

The discovery intrigued Man-To Hui, an astronomer at the Macau University of Science and Technology. "We know so little about these distant comets," says Hui. "They're full of mysteries."



Researchers captured images of the Bernardinelli–Bernstein comet (top) and used computer modelling to separate a halo of gas and dust (centre) from its core (bottom).

NASA, ESA, MAN-TO HUI, DAVID JEWITT; IMAGE PROCESSING: ALYSSA PAGAN (STSCI)

In January 2022, Hui and his team captured five images of Bernardinelli–Bernstein with NASA's Hubble Space Telescope to measure the size of its solid core, or nucleus. They used a computer-modelling technique to separate the light signal of the nucleus from its coma, an enveloping halo of gas and dust. By comparing their images with radio observations collected by the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, they estimated that Bernardinelli–Bernstein's nucleus could be as large as 137 km in diameter, making it the largest comet nucleus on record. The results[4] were published in April 2022.

The comet's sheer size grabbed headlines, but Hui and his team are most interested in its activity, which is when a comet's icy nucleus heats up and releases the gases that form its coma. In most cases, comets become active when they reach the orbit of Jupiter where it's warm enough for water ice to convert into gas, says Hui. Conditions are too cold for this to happen at Bernardinelli–Bernstein's current location, roughly 2.7 billion kilometres from the Sun, yet the comet remains active. Hui suspects its activity is driven by supervolatiles such as carbon monoxide, which can switch from solid to gas at lower temperatures.

Bernardinelli–Bernstein and other distant comets were probably formed closer to the Sun billions of years ago, before being flung to the fringes of the Solar System through gravitational interactions with newborn giant planets, such as Jupiter, says Jonti Horner, an astrophysicist at the University of Southern Queensland, Australia, who was not involved in the research.

Such comets are important, as they contain reams of pristine information that allow researchers to peer into the past. "You're essentially getting something that has been held in cold storage since the formation of the Solar System," says Horner. **Gemma Conroy**

Hybrid embryos

In a 2021 study[5] published by *Cell*, scientists from China, Spain and the United States announced that they had grown in the lab the first human–monkey embryos, a step towards developing cells, tissues and organs for transplants. The controversial paper prompted heated debate over the ethics of growing chimaeras, animals composed of cells derived from more than one fertilized egg.

Led by Tao Tan, a biologist at the State Key Laboratory of Primate Biomedical Research at Kunming University of Science and Technology in Yunnan, China, the team grew early-stage cynomolgus monkey (*Macaca fascicularis*) embryos using a technique they had developed in 2019, which gives the embryos a lifespan of 20 days outside the womb[6].

Six days later, 25 human extended pluripotent stem cells, which can differentiate into several cell types, were injected into the embryos. Of the 132 embryos that had accepted the human cells, just three had survived by day 19.

The human cells proved resilient throughout the embryos' development and were detected in one-third of the chimaeras after 13 days. They also began to differentiate into cell types that would eventually develop into various tissues.

Additionally, there were signs that the human and monkey cells were communicating, a feature that has remained elusive in other chimaeras. In 2017, for instance, Tan's co-authors injected a different type of human stem cell into pig embryos and grew them inside surrogate pigs for three to four weeks. Unlike in the latest study, few human cells were present in the embryos and there were no signs of cellular interaction between human and pig cells[7].

Tan hopes the work will shed light on biological barriers to creating hybrids that mix human cells with those from other species, such as pigs and rats. "This will help to improve human chimerism in species that are more evolutionarily distant," he says. He adds that the aim of the research is to develop methods for growing human organ transplants, which could help to address the global shortage of donations.

Although the researchers limited their work to early-stage embryos that were not implanted into a uterus, the study raises myriad ethical questions about animal welfare, human consent and where to draw the line between humans and animals, says Nita Farahany, a neuroethicist at Duke University, North Carolina. Given the rapid pace of chimaera research in recent years, Farahany says ethical oversight needs to be embedded in the process. "We need greater transparency at an earlier stage," says Farahany, who co-authored a perspective article on the ethics of the study[8]. "Rather than just having an ethics hurdle that needs to be cleared, there needs to be integration of ethics from the get-go." **Gemma Conroy**

Pandemic pollution

The COVID-19 pandemic increased demand for single-use plastics and intensified pressure on an "already out-of-control" global waste problem, a widely cited 2021 *Proceedings of the National Academy of Sciences* study found[9]. A team led by Amina Schartup, an oceanographer and marine biogeochemist at Scripps Institution of Oceanography, in California, and Yanxu Zhang, a geochemist at Nanjing University's School of Atmospheric Sciences, in Nanjing, China, estimate that more than 7.25 million tonnes of pandemic-associated plastic waste, including packaging for medical equipment, was produced between March 2020 and August 2021. More than 22,000 tonnes of it probably ended up in the ocean, the authors report.

LAURA LEZZA/GETTY IMAGES

Single-use plastic waste generated during the pandemic made the ocean pollution crisis worse.

By calculating the number of patients treated in hospitals and the typical per-patient plastic waste generated around the world, Schartup and Zhang's teams estimated that 73% of pandemic-associated plastic discharged into the ocean came from hospitals. Their research also suggested that 72% of single-use plastic waste that ended up in the ocean originated in Asia.

"We need greater transparency at an earlier stage. There needs to be integration of ethics from the get-go."

Combining economic and epidemiological data with waste-management field studies, the researchers aggregated several data sets and converted them into a detailed emissions inventory, which informed a new ocean plastic transport model developed by Zhang's group. Students in Zhang's team did much of the work to pull the data together, says Schartup.

Schartup and Zhang's cross-border collaboration began 10 years ago, when they met as postdoctoral researchers at Harvard University in Cambridge, Massachusetts. "We are collaborating, in spite of difficulties that are being imposed by administrative roadblocks and the distance," says Schartup.

Denise Hardesty, senior environmental research scientist with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), who was not involved in the study, would like to see its conclusion supported by empirical data. "In general, we are hyper-careful about medical waste, and I would say even more so about the potential risk of pandemic-associated medical waste," she says. Most biohazardous hospital waste is incinerated, she adds, even in nations that might not have the most advanced waste infrastructure.

Schartup responded to Hardesty's comments by pointing to the lack of legislation and oversight in many countries for medical waste management, which could allow a lot of plastic waste that should have been disposed of responsibly to slip through the cracks. "We hope that our study provides yet another argument for stronger oversight of medical (and all) waste globally and encourages aggressive gathering of empirical data," says Schartup.

Zhang and Schartup co-authored a follow-up study in *Nature Communications*[10] in March 2023, analysing data on plastic waste on the ocean's surface from 2000 to 2015. The study highlighted the need for more accurate inventories, more data for plastic waste in the sea and more accurate model parameters to help researchers gain a better understanding of pollution's impact. **Sian Powell**

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