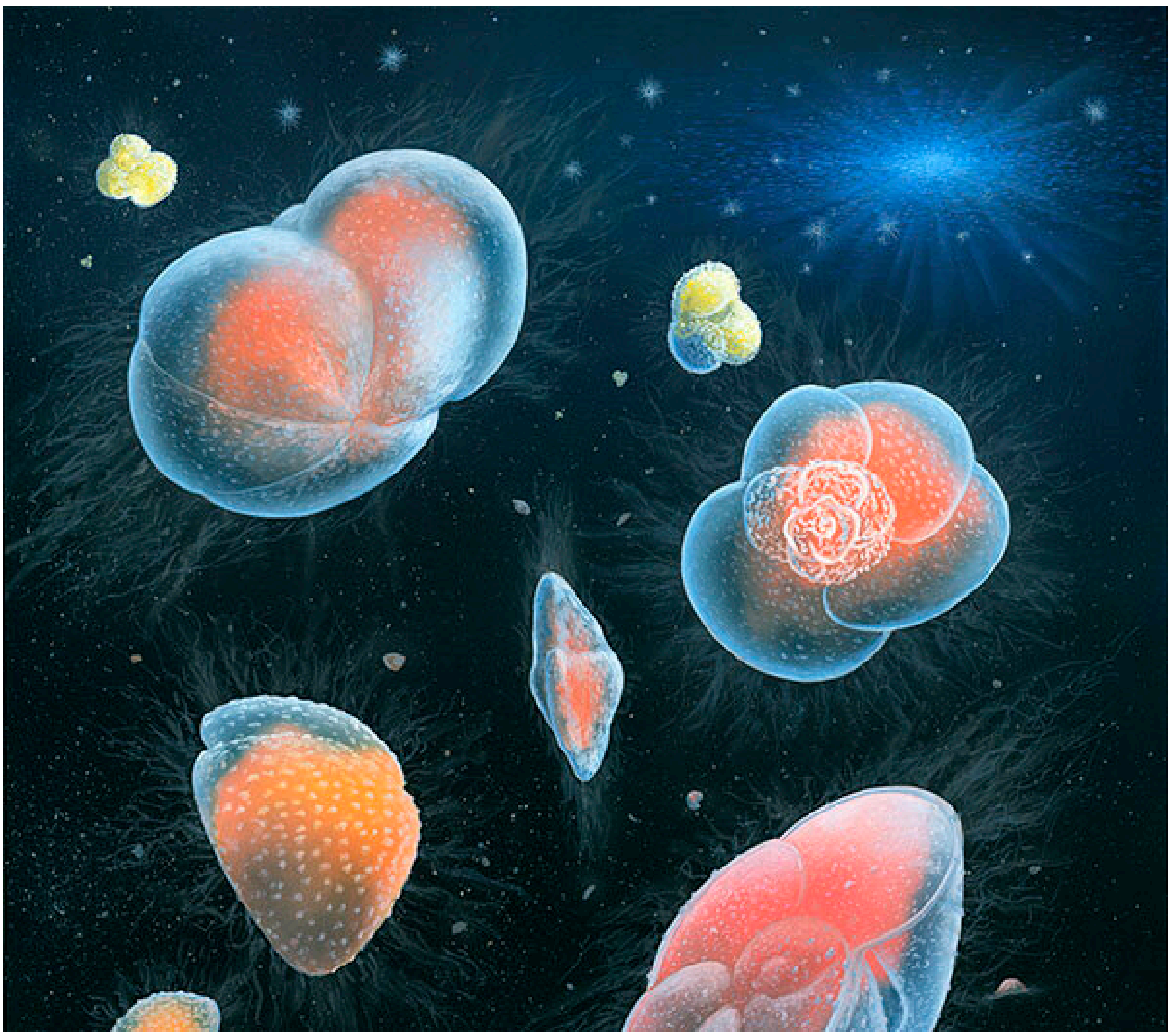
# Large-scale fossil study reveals origins of modern-day biodiversity gradient 15 million years ago

February 15 2023



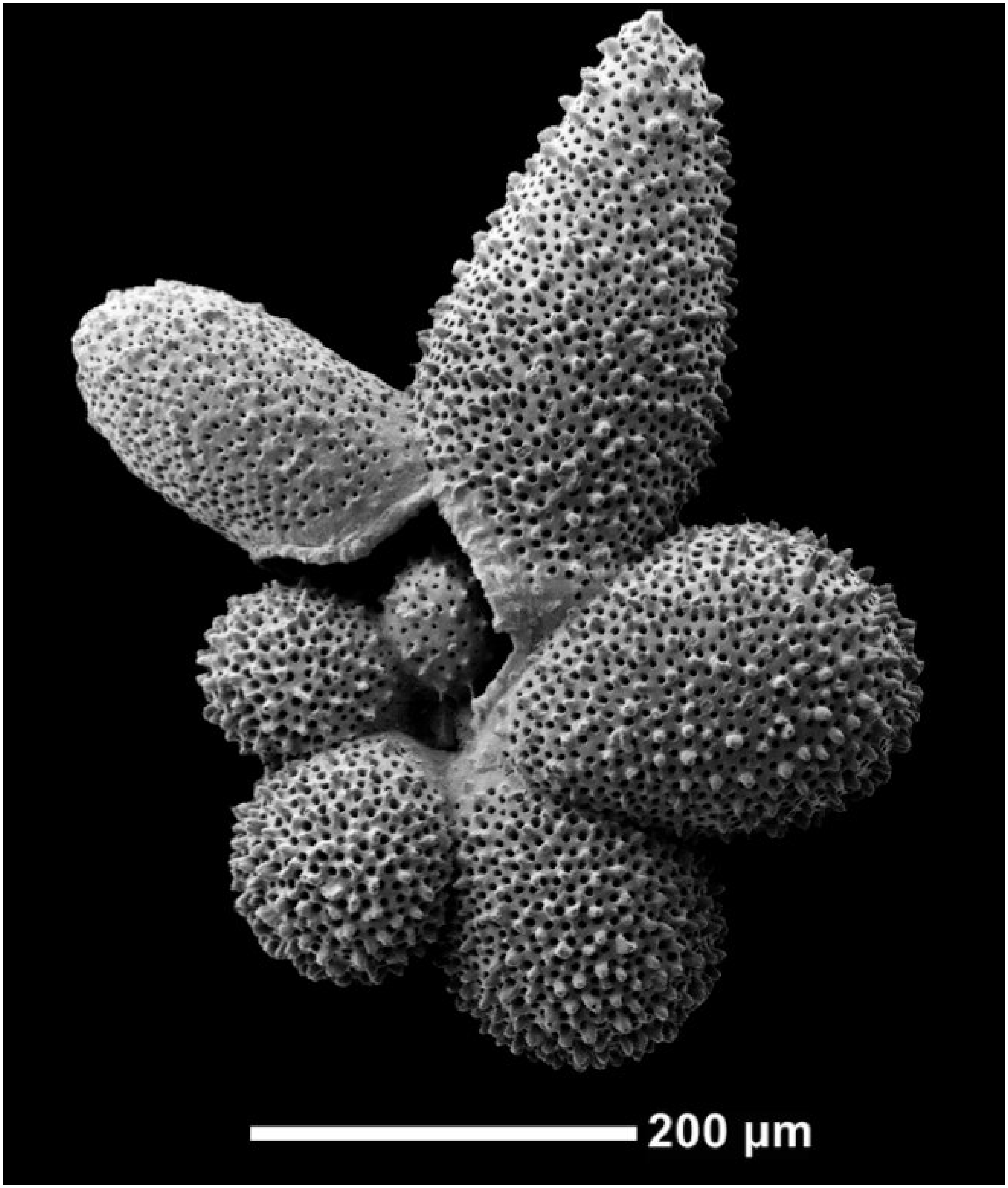
Depictions of present-day planktonic foraminifera floating in the deep sea.

Credit: Richard Bizley, BizleyArt.

Researchers have used nearly half a million fossils to solve a 200-year-old scientific mystery: why the number of different species is greatest near the equator and decreases steadily toward the polar regions. The results—published today in the journal *Nature*—give valuable insight into how biodiversity is generated over long timescales, and how climate change can affect global species richness.

It has long been known that in both marine and terrestrial systems species (including animals, plants, and single-celled organisms) show a "latitudinal diversity gradient," with biodiversity peaking at the equator. But until now, limited fossil data has prevented researchers from thoroughly investigating how this diversity gradient first arose.

In this new study, researchers at the Universities of Oxford, Leeds and Bristol, used a group of unicellular marine plankton called planktonic foraminifera. The team analyzed 434,113 entries in a global fossil database, covering the last 40 million years. They then investigated the relationship between the number of species over time and space, and potential drivers of the latitudinal diversity gradient, such as sea surface temperatures and ocean salinity levels.



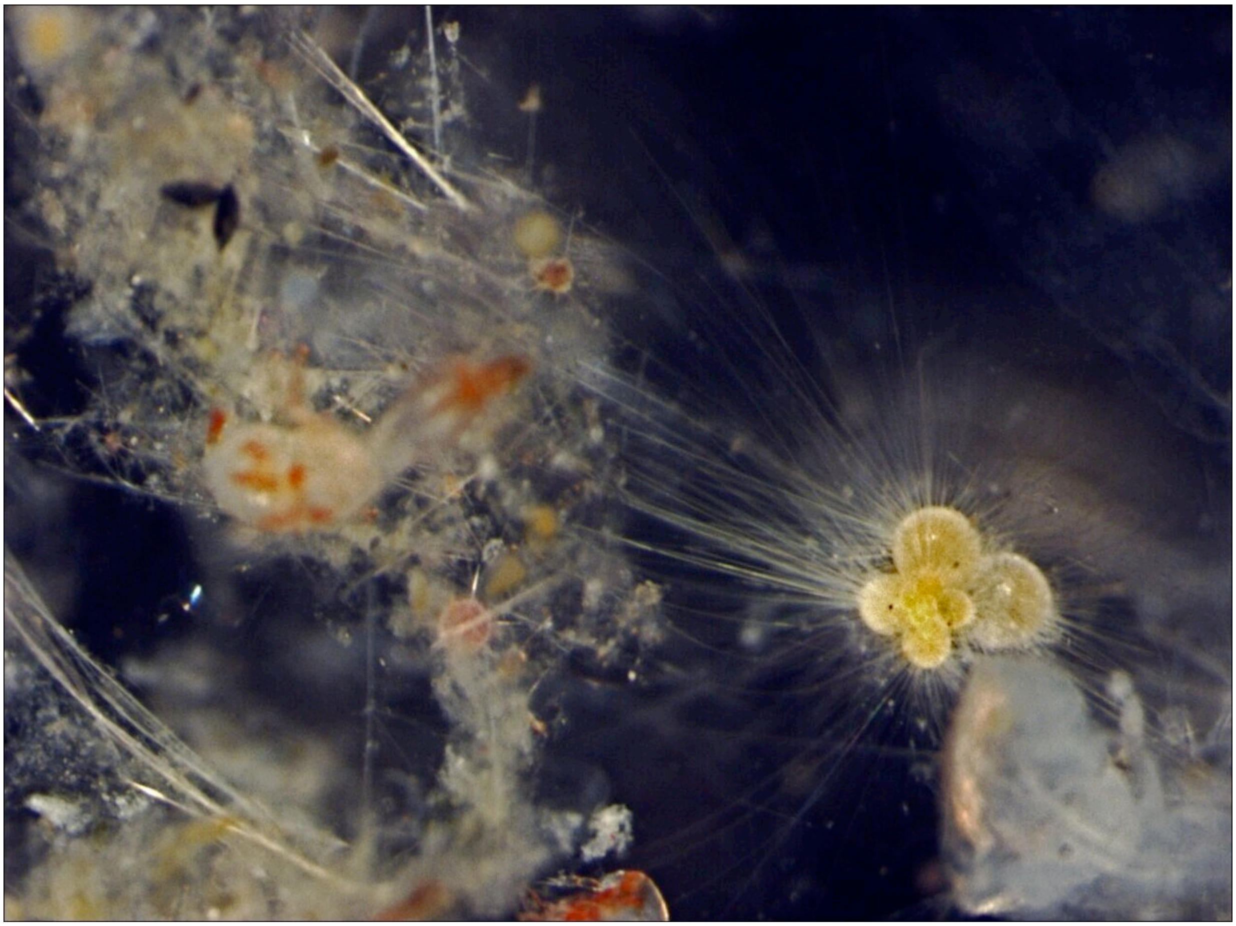

A scanning electron microscope image of the shell of the planktonic foraminifera species Globigerinella adamsi. This specimen was collected from sea floor sediments in the Southwest Indian Ocean aboard the GLOW Cruise. Credit: Tracy Aze, University of Leeds

**Key findings:**

- The modern-day latitudinal diversity gradient first started to emerge around 34 million years ago, as the Earth began to transition from a warmer to cooler climate.
- This gradient initially remained shallow, until around 15–10 million years ago, when it steepened significantly. This coincides with a significant increase in global cooling.
- Peak richness for planktonic foraminifera occurred at higher latitudes from 40–20 million years ago. By around 18 million years ago, however, peak richness shifted to between 10° to 20° latitude, consistent with the diversity pattern observed today.
- There was a strong positive relationship between species richness and sea surface temperatures—both when modeled over time at specific locations, or at different locations at a specific time.
- There was also a positive relationship between species richness and the strength of the thermocline: the temperature gradient that exists between the warmer mixed water at the ocean's surface and the cooler deep water below.

According to the researchers, these results indicate that the modern-day distribution of species richness for planktonic foraminifera could be explained by the steepening of the latitudinal temperature gradient from the equator to the poles over the last 15 million years. This may have opened up more ecological niches in tropical regions within the water column, compared with higher latitudes, promoting greater rates of speciation.

To test this hypothesis, the researchers examined the extent to which modern species of planktonic foraminifera live at different depths within the vertical water column. They found that in low latitudes closer to the equator, species today are more evenly distributed vertically within the water column, compared with high latitudes.



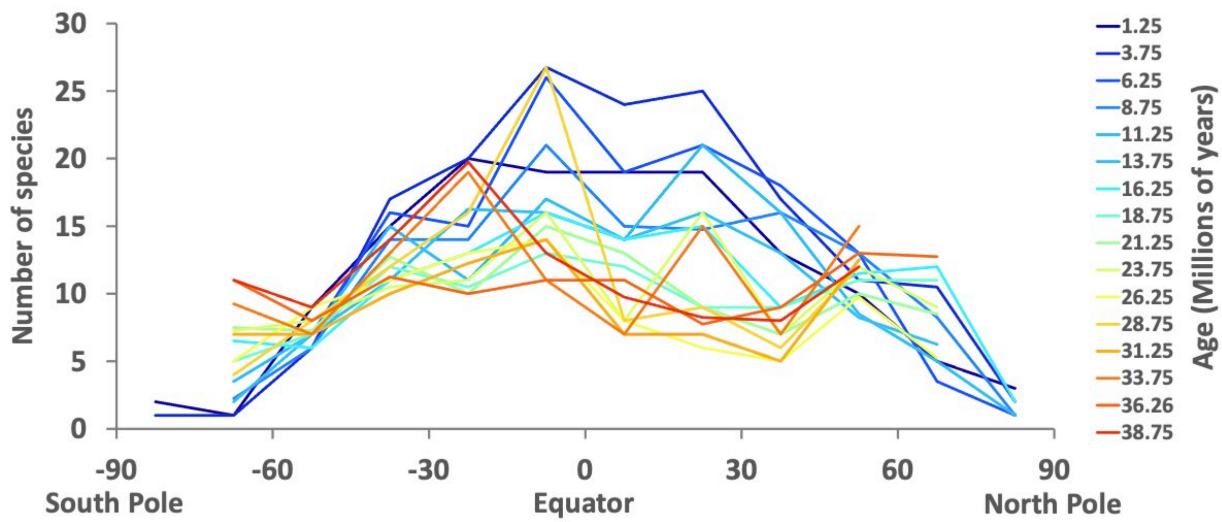
A light microscope image of a planktonic foraminifera (bottom right) surrounded by thin strands of its cytoplasm that extend into the surrounding environment. This living specimen had recently been collected from the water in the Southwest Indian Ocean aboard the GLOW Cruise. Credit: Tracy Aze, University of Leeds

This suggests that a key driver of the modern-day diversity gradient was a significant increase in the difference in sea surface temperatures between low- and high-latitude regions, and within the water column, from 15 million years onwards. The warmer waters at the tropics were able to support a broader range of different temperature habitats and ecological niches within the vertical water column, encouraging higher numbers of species to evolve.

This is supported by the fact that the tropics today are richer than the tropics of warmer time periods in the past (such as the Eocene and Miocene) when there was little or no vertical temperature gradient in the oceans.

In addition, cooling sea temperatures at high latitudes likely caused many regional populations of species to become extinct, contributing to the modern diversity gradient.

Planktonic foraminifera originate from the Early to Middle Jurassic period (around 170 million years ago). They are found in oceans all over the world—from polar regions to the equator—and occupy a range of ecological niches in the upper two kilometers of the oceans. Because they produce hard outer shells, they can be preserved in large numbers. The global abundance of planktonic foraminifera and their exceptional fossil record from the last 66 million years made them an ideal group for this study.




Graph to show how the number of different planktonic foraminifera species varies with latitude at different points in the Earth's history. Credit: Fenton et al *Nature*, 2023

Dr. Erin Saupe (Department of Earth Sciences, University of Oxford), lead author for the study, said, "By resolving how spatial patterns of biodiversity have varied through deep time, we provide valuable information crucial for understanding how biodiversity is generated and maintained over geological timescales, beyond the scope of modern-day ecological studies."

Associate Professor Tracy Aze (School of Earth and Environment, University of Leeds), a co-author for the study, added, "Although they are small enough to fit on the head of a pin, planktonic foraminifera have one of the most complete species-level fossil records known to science. Our research builds on 60 years of deep-sea sample collection and the diligent counting and recording of hundreds of thousands of specimens by research scientists. It's fantastic to be able to produce such important results about the drivers of species distributions through time and to do justice this wonderful fossil archive."

Study co-author Dr. Alex Farnsworth, Senior Research Associate at the Department of Geographical Sciences, University of Bristol, said, "Understanding why species in ancient history were more diverse and plentiful nearer the equator and less so nearer the poles can give important insights how marine species, such as plankton, might respond in future. These tiny single-celled organisms are a vital link in the marine food chain, so studying their reactions to changing climates may help us better predict how they will likely be affected as temperatures continue to warm with the increasing onset of climate change.

"This has potentially large implications for marine food webs, such as fish and aquatic mammals like seals and whales, and could be used to inform future measures to protect sea life and preserve biodiversity."

**More information:** Origination of the modern-style diversity gradient 15 million years ago, *Nature* (2023). DOI: 10.1038/s41586-023-05712-6

Provided by University of Oxford

Citation: Large-scale fossil study reveals origins of modern-day biodiversity gradient 15 million years ago (2023, February 15) retrieved 3 May 2024 from https://phys.org/news/2023-02-large-scale-fossil-reveals-modern-day-biodiversity.html