The 1.635-billion-year-old Chuanlinggou Formation in China (above) yielded microscopic, algalike fossils, including some with spores (below, top image).

PALEONTOLOGY

Tiny fossils upend timeline of multicellular life

Eukaryotes organized into multicellular forms 1.6 billion years ago

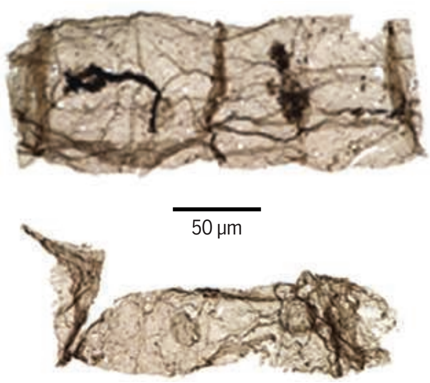
By **Elizabeth Pennisi**

A new study describing a microscopic, algalike fossil dating back more than 1.6 billion years supports the idea that one of the hallmarks of the complex life we see around us—multicellularity—is much older than previously thought. Together with other recent research, the fossil, reported this week in *Science Advances*, suggests the lineage known as eukaryotes—which features compartmentalized cells and includes everything from redwoods to jellies to people—became multicellular some 600 million years earlier than scientists once generally thought.

"It's a fantastic paper," says Michael Travisano, an evolutionary ecologist at the University of Minnesota who helped show that yeast can become multicellular in the lab. "This gives us a better idea of the grand vision of life."

Typically, biologists subdivide that grand vision into two categories: eukaryotes, with their DNA packaged into nuclei, and prokaryotes such as bacteria, which have free-floating DNA. Prokaryotes evolved first, up to 3.9 billion years ago; within a few hundred million years, some of them, the cyanobacteria, began to form chains of cells, considered an advance in life's complexity. About 2 billion years ago, much larger, single-cell eukaryotes bearing nuclei showed up. For decades, researchers thought eukaryotes didn't form simple multicellular structures until 1 billion years after they arose, and that once chain structures evolved, more elaborate body plans—animals with organs—appeared soon after. "There was this perception that multicellularity was hard [to evolve]," Travisano says.

Then in 1989, researchers described *Qingshania magnifica*, a microscopic fossil they suggested was a primitive green alga, a multicellular eukaryote. No one paid the discovery much mind, even though it came from the Chuanlinggou Formation in North China, which includes layers that are 1.6 billion years old. But since 2015, Maoyan Zhu and Lanyun Miao, paleobiologists at the Chinese Academy of Sciences's Nanjing Institute of Geology and Palaeontology, have collected rocks from the same area, dissolved them, and eventually uncovered 279 microscopic fossils, all but one of them specimens of *Q. magnifica*.



In this week's paper, they report that the fossils consist of strings of up to 20 cylindrical cells, with adjoining cell walls, like plants, visible under a microscope as dark rings. Several fossils had spores—with their own cell walls—suggesting the filaments had specialized reproductive structures.

"What's striking about these fossils is they are really rather enormous for that age, and they are multicellular," says Jochen Brocks, an organic geochemist at Australian National University. William Ratcliff, an evolutionary biologist at the Georgia Institute of Technology who also works on multicellular yeast, adds that he's impressed by the level of internal detail revealed in the ancient life. "I got a little dopamine hit seeing those internal sporelike compartments."

Miao performed chemical tests on the fossils and found the structures of their organic carbon compounds were different from those in cyanobacteria fossils in these rocks. Her team concluded the filaments were most likely green algae, similar to modern eukaryotes such as *Urospora wormskioldii*.

"The authors have done a commendable job of interpreting the fossils," says Stefan Bengtson, paleobiologist emeritus at the

PHOTOS: LANYUN MIAO *ET AL.*/CHINESE ACADEMY OF SCIENCES NANJING INSTITUTE OF GEOLOGY AND PALAEONTOLOGY

Swedish Museum of Natural History. "The hypothesis that these are filamentous green algae is a good start."

The new findings build on work Bengtson and colleagues reported in 2017, when they proposed that 1.6-billion-year-old fossils found in India represented red algae. In 2021, another team described "walled microfossils," which they interpreted as a diverse set of eukaryotes, in deposits from Canada dating back 1.57 billion years. And just last month, Leigh Anne Riedman and Susannah Porter, paleontologists at the University of California, Santa Barbara, and colleagues described what they say are several eukaryotic fossils found in 1.642-billion-year-old rocks from Australia.

The sheer diversity of body plans found in these early forms of multicellular life is astounding, Riedman notes. Some were cylindrical with chambers. Others were spherical. One had a lid that appeared to open, possibly to get rid of the cell's contents. "Every indication suggests eukaryotes were much more diverse and complex by this time than previously appreciated," she says.

If simple but diverse multicellular forms appeared so early, then complex multicellularity took a lot longer to evolve than most researchers had thought; the first creatures with organs and cells that did not have direct access to the outside environment didn't appear until less than 1 billion years ago. Such a delayed timeline makes sense to Shuhai Xiao, a geobiologist and a paleobiologist at the Virginia Polytechnic Institute and State University. Truly complex eukaryotes "have multiple cells that stay together, communicate with each other, and have different sizes, shapes, and functions," he explains. "It takes time [to make such advances]."

If the recent findings hold up, they are "remarkable" and transformative, says László Nagy, an evolutionary biologist at the Hungarian Research Network's Biological Research Centre. But he's cautious about claiming similarities to living algae. "It is challenging to compare a 1.6-billion-year-old organism to extant ones," Nagy says. "This is such a long time that any resemblance to extant organisms may be due to chance." And Ratcliff says these organisms may not even be eukaryotes: "It's possible that [these fossils] are just superweird bacteria that don't resemble extant species."

But Harvard University paleontologist Andrew Knoll, a co-author on the *Science Advances* paper, says the data and the presence of cell walls—which prokaryotes lack—are proof enough. "If this were found in [400-million-year-old] Devonian rocks, people would describe it as algae and no one would bat an eyelash," he says. ■

With reporting by Dennis Normile.

SCIENCE POLICY

Strong medicine for Argentina's beleaguered science

Daniel Salamone, the country's new science head, faces skepticism as he touts new priorities and entrepreneurship

By **María de los Ángeles Orfila**

Protests are a common sight in Buenos Aires amid Argentina's prolonged economic crisis. But lately the presidential palace and the Ministry of Economy haven't been the only scenes of turmoil. In recent weeks angry crowds have also gathered at the National Council of Scientific and Technical Research of Argentina (CONICET), the country's main science agency. CONICET's own scientists and administrators are marching with drums, megaphones, and banners, hoping their voices reach the agency's new and controversial head, veterinarian Daniel Salamone.

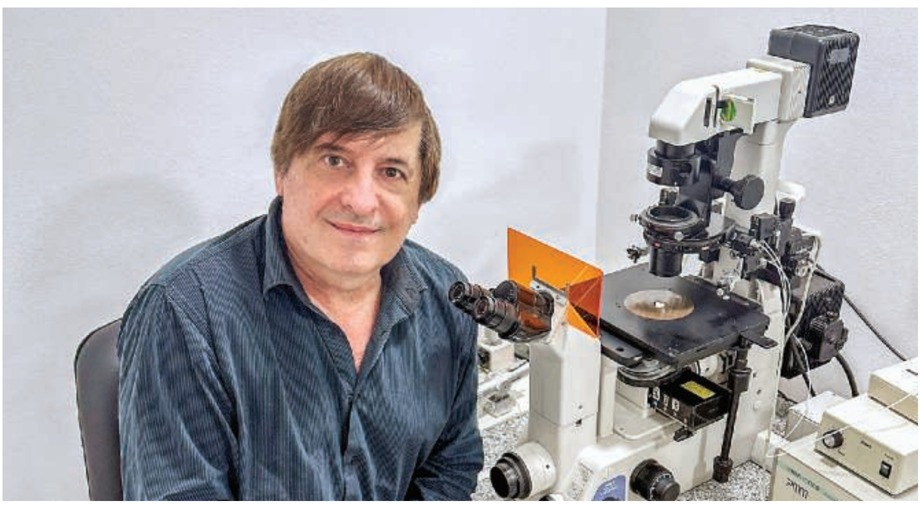
Appointed by Argentina's newly elected libertarian president, Javier Milei, Salamone took office at the end of 2023, facing formidable challenges. He reports to a president who abolished the Ministry of Science and, during the electoral campaign, accused CONICET of being "unproductive." One of the top science agencies in South America, with 11,800 researchers, CONICET lacks an approved budget. Even if the government matched the $400 million the agency received in 2023, the country's 200% annual inflation has sharply eroded its value.

Some Argentine scientists also question Salamone's ability—or desire—to defend their interests. But he accuses his critics of "a visceral response" to Milei. "It could be a biased viewpoint on my part, but previous governments haven't shown particular adeptness in managing science," he said in a recent interview with *Science*.

Salamone's high-profile work at CONICET on cloning and his experience in the private sector helped him catch Milei's eye. The Argentine president, who owns five cloned mastiffs, calls Salamone the "national cloner" for achievements that include cloning cows engineered to secrete human growth hormone in their milk, which could provide a cheap source of the hormone for medicines. His team also produced the first cloned horse in South America and created pigs that could be used for skin grafts because they lack key molecules that trigger immune rejection.

"Six companies emerged from our laboratory," Salamone says. One was Kheiron Biotech, which has already seen the birth of more than 400 horse clones and is approaching a production rate of 150 clones per year. Gabriel Vichera, a former student of Salamone's who co-founded the company, recalls him as "a highly pragmatic person who always seeks to ensure that his research finds practical application."

Salamone says his record of founding companies appealed to Milei, a free-market partisan. "[It aligned] with the direction he



Daniel Salamone's work on livestock won him a reputation as Argentina's "national cloner."

PHOTO: CONICET