Vicky Hamilton, a planetary scientist at the Southwest Research Institute in Boulder, Colorado, expressed disappointment that almost eight months after the independent review board released its report, the agency still lacks a solid plan for "a very valuable science goal".

Returning these samples would also demonstrate capability for a two-way trip to Mars before astronauts make the journey, says Bethany Ehlmann, a planetary scientist at the California Institute of Technology in Pasadena, California. "The sample-return technology is here, it exists," she says. "It's a matter of putting the pieces together."

Perseverance persists

But scientists were relieved about one announcement: Fox said the revised timeline for sample return will not affect the science goals for Perseverance, including plans for it to explore terrain beyond Jezero Crater.

Among samples collected outside the crater will be "some of the ancient crust of Mars, representing rocks older than we have seen yet in Jezero Crater, some of which may have been altered by near-surface water", says Meenakshi Wadhwa, a planetary scientist at Arizona State University in Tempe and principal scientist for the Mars sample return programme.

So far, the only Mars samples that scientists have been able to study on Earth are bits and pieces ejected from the red planet that made it to Earth as meteorites. All known Martian meteorites are igneous rocks, meaning that they solidified from lava, and all are very old. They provide valuable timestamps for parts of Mars's geological evolution, but carry little information about how the planet's surface was shaped by the water that once flowed across it.

"The sample-return technology is here, it exists. It's a matter of putting the pieces together."

To achieve the mission's main goal of searching for signs of past life, the real treasures are layered sedimentary rocks formed by minerals and organic matter deposited over the eons by water. Perseverance's instruments have already detected organic molecules in Martian samples, but whether those molecules are a marker of past life can be determined only by closer scrutiny in laboratories on Earth.

SCIENTISTS DISCOVER FIRST ALGAE THAT CAN FIX NITROGEN

Organelle that converts nitrogen gas into a useful form could pave the way for low-fertilizer plants.

By Carissa Wong

Researchers have discovered a type of organelle, a fundamental cellular structure, that can turn nitrogen gas into a form that is useful for cell growth. The discovery of the structure, called a nitroplast, in an algal species could bolster efforts to genetically engineer plants to convert, or 'fix', their own nitrogen, which could boost crop yields and reduce the need for fertilizers. The work was published in *Science* on 11 April[1].

"The textbooks say nitrogen fixation only occurs in bacteria and archaea," says ocean ecologist Jonathan Zehr at the University of California, Santa Cruz, a co-author of the study. This species of algae is the "first nitrogen-fixing eukaryote", he adds, referring to the group of organisms that includes plants and animals.

In 2012, Zehr and his colleagues reported that the marine alga *Braarudosphaera bigelowii* interacted closely with a bacterium called UCYN-A that seemed to live in, or on, the algal cells[2]. The researchers hypothesized that UCYN-A converts nitrogen gas into compounds that the algae use to grow, such as ammonia. In return, the bacteria were thought to gain a carbon-based energy source from the algae.

But in the latest study, Zehr and his colleagues conclude that UCYN-A should be classed as an organelle inside the alga, rather than as a separate organism. According to genetic analysis from a previous study[3], ancestors of the algae and bacteria entered a symbiotic relationship around 100 million years ago, says Zehr. Eventually, this gave rise to the nitroplast organelle, now seen in *B. bigelowii*.

Researchers use two key criteria to decide whether a bacterial cell has become an organelle in a host cell. First, the cell structure in question must be passed down through generations of the host cell. Second, the structure must be reliant on proteins provided by the host cell.

By imaging dozens of algal cells at various stages of cell division, the team found that the nitroplast splits in two just before the whole algal cell divides. In this way, one nitroplast is passed down from the parent cell to its offspring, as happens with other cell structures.

Next, the researchers found that the nitroplast gets the proteins it needs to grow from the wider algal cell. The nitroplast itself – which makes up more than 8% of the volume of each host cell – lacks key proteins required for photosynthesis and making genetic material, says Zehr. "A lot of these proteins [from the alga] are just filling those gaps in metabolism," he says.

The discovery was made possible thanks to work by study author Kyoko Hagino at Kochi University in Japan, who spent around a decade fine-tuning a way to grow the alga in the laboratory – which allowed it to be studied in more detail, says Zehr.

"It's quite remarkable," says Siv Andersson, who studies how organelles evolve at Uppsala University in Sweden. "They really see all these hallmarks that we think are characteristic of organelles."

Upgraded plants

Understanding how the nitroplast interacts with its host cell could support efforts to engineer crops that can fix their own nitrogen, says Zehr. This would reduce the need for nitrogen-based fertilizers and avoid some of the environmental damage they cause. "The tricks that are involved in making this system work could be used in engineering land plants," he says.

"Crop yields are majorly limited by availability of nitrogen," says Eva Nowack, who studies symbiotic bacteria at the Heinrich Heine University Düsseldorf in Germany. "Having a nitrogen-fixing organelle in a crop plant would be, of course, fantastic." But introducing this ability into plants will be no easy feat, she warns. Plant cells containing the genetic code for the nitroplast would need to be engineered in such a way that the genes are transferred stably from generation to generation, for example. "That would be the most difficult thing to do," she says.

"It's both a pleasure and very impressive to see this work build up to what is certainly a major stepping stone in understanding," says Jeffrey Elhai, a cell biologist at Virginia Commonwealth University in Richmond.

1. T. H. Coale *et al. Science* **384**, 217–222 (2024).
2. A. W. Thompson *et al. Science* **337**, 1546–1550 (2012).
3. Cornejo-Castillo, F. *et al. Nature Commun.* **7**, 11071 (2016).