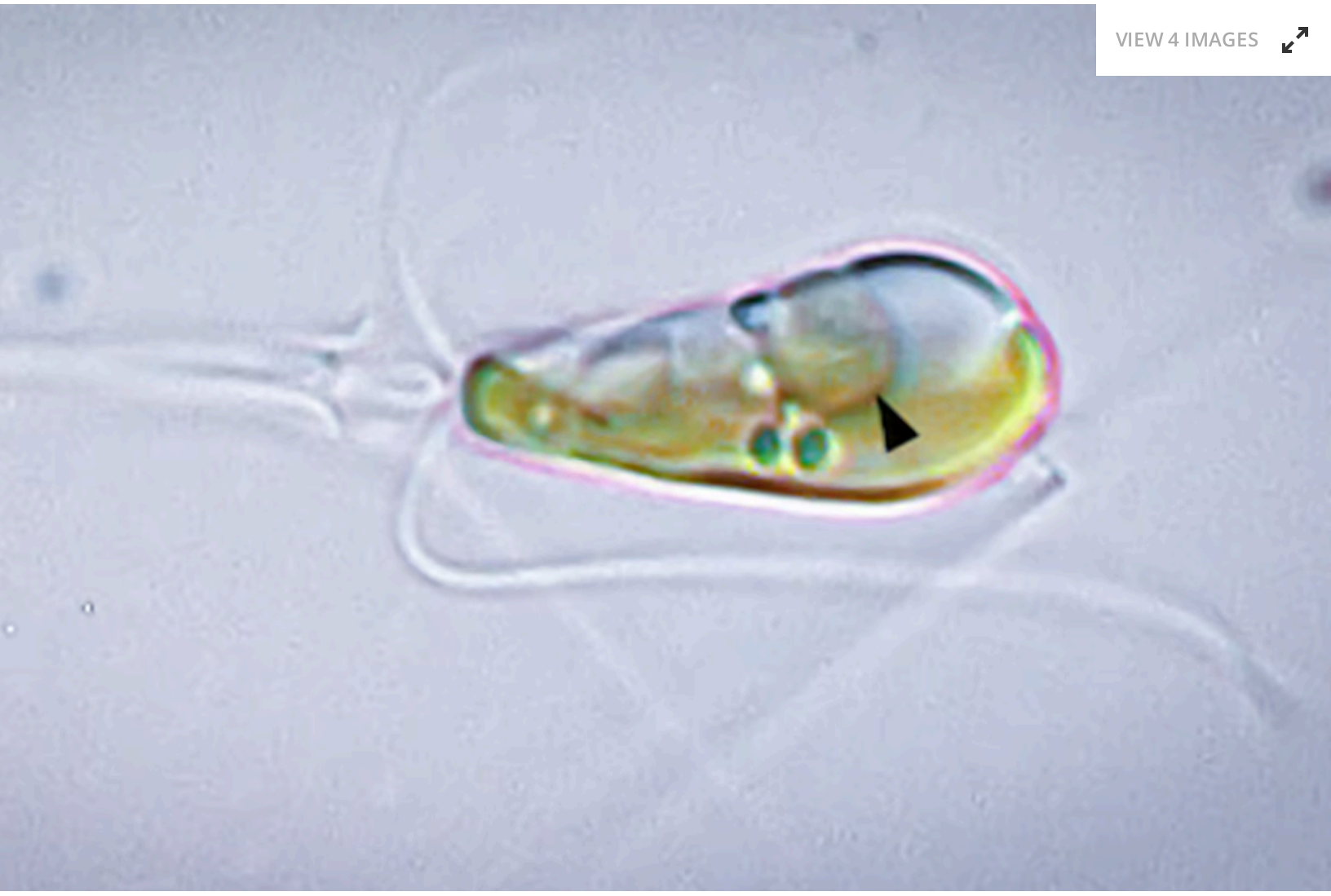
BIOLOGY

Two lifeforms merge in once-in-a-billion-years evolutionary event

By Michael Irving
April 18, 2024



The algae Braarudosphaera bigelowii has been found to have absorbed a cyanobacteria called UCYN-A, which may be a huge step forward for evolution Tyler Coale

Scientists have caught a once-in-a-billion-years evolutionary event in progress, as two lifeforms have merged into one organism that boasts abilities its peers would envy. Last time this happened, Earth got plants.

The phenomenon is called primary endosymbiosis, and it occurs when one microbial organism engulfs another, and starts using it like an internal organ. In exchange, the host cell provides nutrients, energy, protection and other benefits to the symbiote, until eventually it can no longer survive on its own and essentially ends up *becoming* an organ for the host – or what's known as an organelle in microbial cells.

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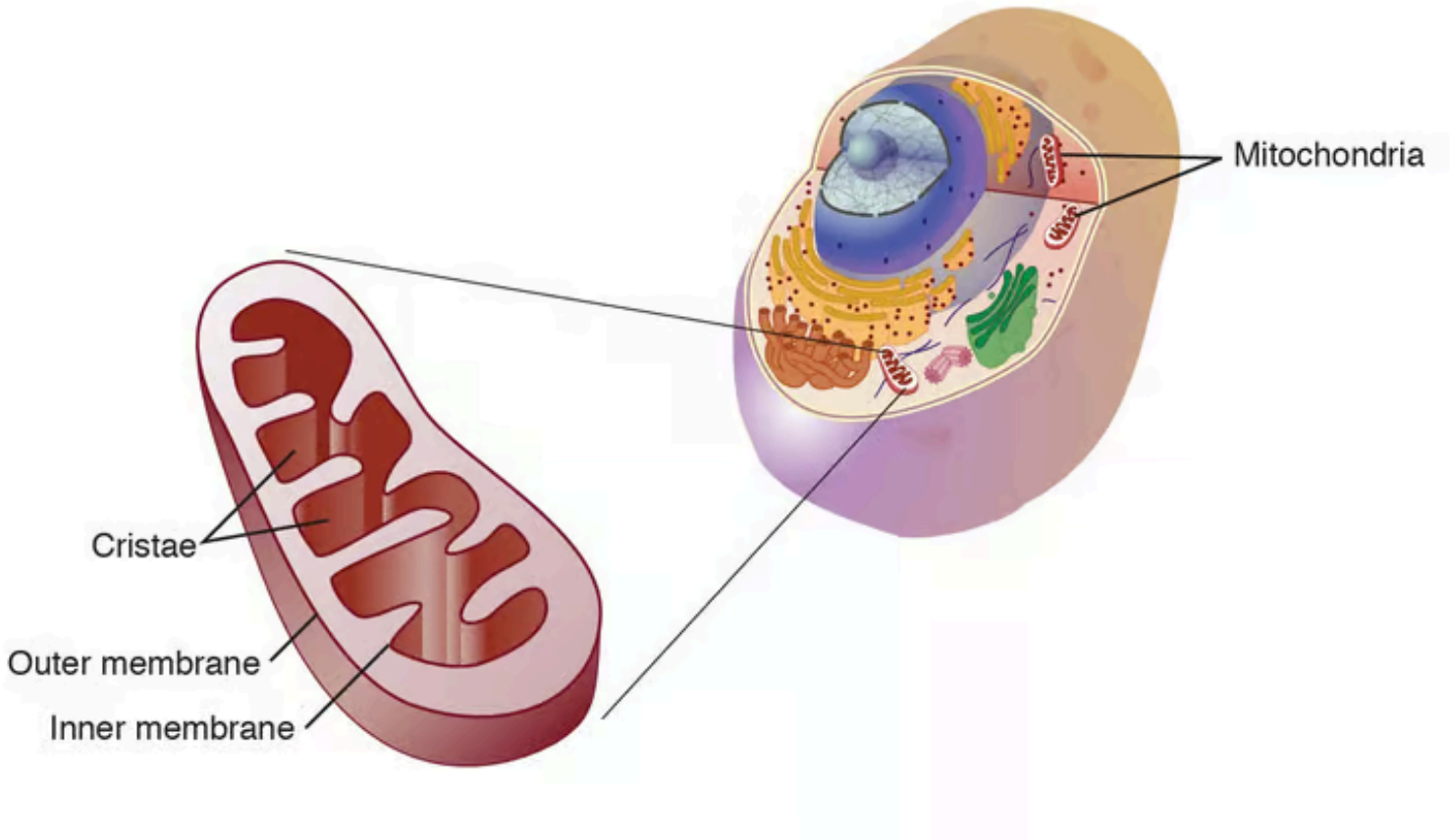
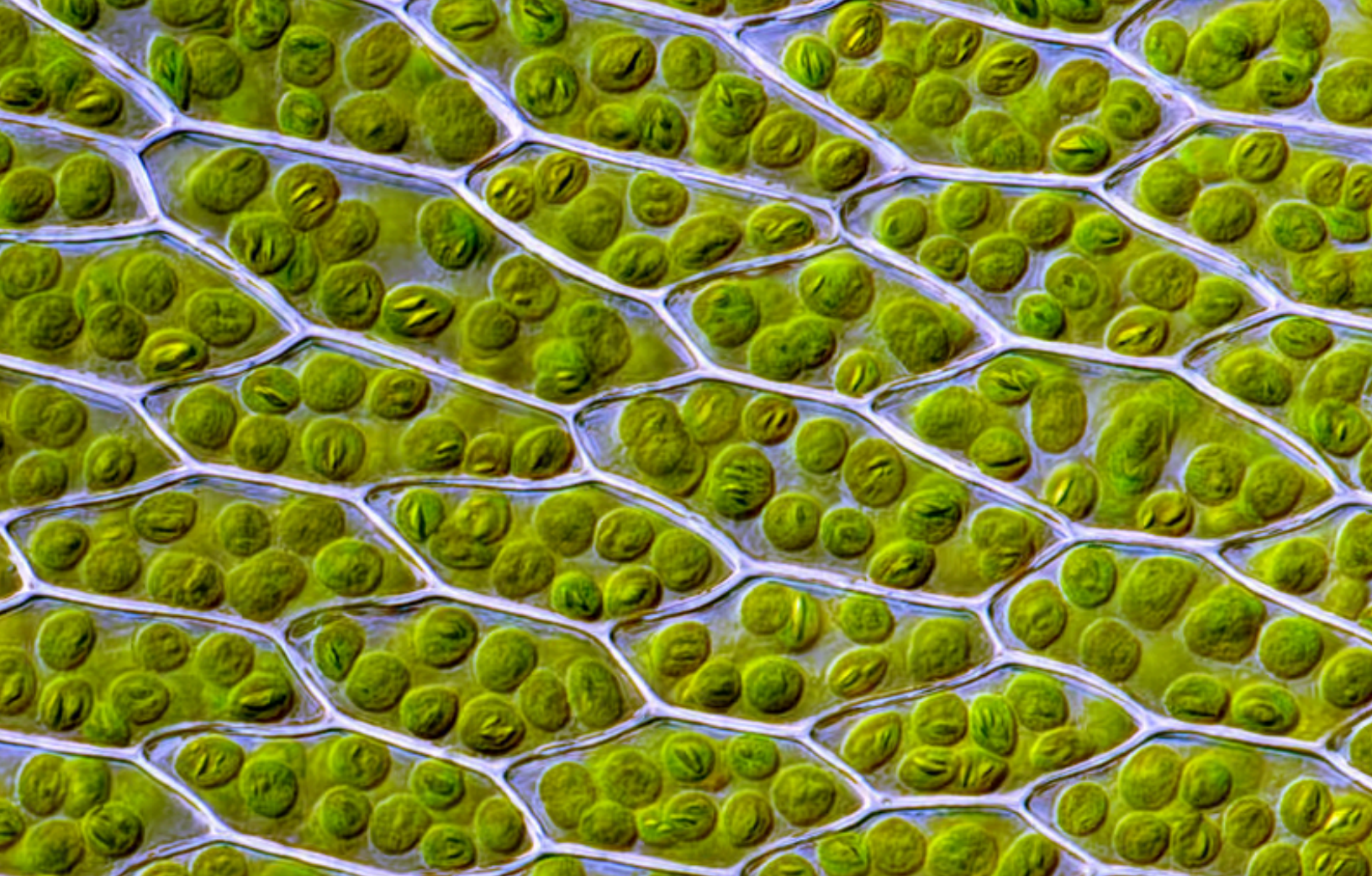
Imagine if kidneys were actually little animals running around, and humans had to manually filter their blood through a dialysis machine. Then one day some guy somehow gets one of these kidney critters stuck... Internally (who are we to judge how?) – and realizes he no longer needs his dialysis machine. Neither do his kids, until eventually we're all born with these helpful little fellas inside us. That's kind of what's happening here.



A diagram of the mitochondria in a cell National Human Genome Research Institute

In the 4-billion-odd-year history of life on Earth, primary endosymbiosis is thought to have only happened twice that we know of, and each time was a massive breakthrough for evolution. The first occurred about 2.2 billion years ago, when an archaea swallowed a bacterium that became the mitochondria. This specialized energy-producing organelle allowed for basically all complex forms of life to evolve. It remains the heralded "powerhouse of the cell" to this day.

The second time happened about 1.6 billion years ago, when some of these more advanced cells absorbed cyanobacteria that could harvest energy from sunlight. These became organelles called chloroplasts, which gave sunlight-harvesting abilities, as well as a fetching green color, to a group of lifeforms you might have heard of – plants.



Live moss cells under a microscope, showing their chloroplasts (green circles) Des_Callaghan/CC BY-SA 4.0

And now, scientists have discovered that it's happening again. A species of algae called *Braarudosphaera*

Nitrogen is a key nutrient, and normally plants and algae get theirs through symbiotic relationships with bacteria that remain separate. At first it was thought that *B. bigelowii* had hooked up this kind of situation with a bacterium called UCYN-A, but on closer inspection, scientists discovered that the two have gotten far more intimate.

In one recent study, a team found that the size ratio between the algae and UCYN-A stays similar across different related species of the algae. Their growth appears to be controlled by the exchange of nutrients, leading to linked metabolisms.

“That’s exactly what happens with organelles,” said Jonathan Zehr, an author of the studies. “If you look at the mitochondria and the chloroplast, it’s the same thing: they scale with the cell.”

In a follow-up study, the team and other collaborators used a powerful X-ray imaging technique to view the interior of the living algae cells. This revealed that the replication and cell division was synchronized between the host and symbiote – more evidence of primary endosymbiosis at work.

X-ray images of Braarudosphaera bigelowii at different stages of cell division. The newly identified nitroplast is highlighted in cyan, the algae nucleus is blue, mitochondria are green and chloroplasts are purple Valentina Loconte/Berkeley Lab

And finally, the team compared the proteins of isolated UCYN-A to those inside the algal cells. They found that the isolated bacterium can only produce about half of the proteins it needs, relying on the algal host to provide the rest.

"That's one of the hallmarks of something moving from an endosymbiont to an organelle," said Zehr. "They start throwing away pieces of DNA, and their genomes get smaller and smaller, and they start depending on the mother cell for those gene products – or the protein itself – to be transported into the cell."

Altogether, the team says this indicates UCYN-A is a full organelle, which is given the name of nitroplast. It appears that this began to evolve around 100 million years ago, which sounds like an incredibly long time but is a blink of an eye compared to mitochondria and chloroplasts.

The researchers plan to continue studying nitroplasts, to find out if they're present in other cells and what effects they may have. One possible benefit is that it could give scientists a new avenue to incorporate nitrogen-fixing into plants to grow better crops.

The research was published in the journals *Cell* and *Science*.

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Michael Irving

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Pierre Collet APRIL 18, 2024 04:43 AM

Wow... Could this evolve (in xxx million years) into living "animals" (we may need to find another term, such as "nitromals") that could "eat" (ingest and process nutrients) simply by breathing the air? (The air is made of 21% oxygen, 78% NITROGEN (that "we" (animals) can't use) + other gasses such as argon, carbon dioxide + whatever you fart after a good dinner).

veryken APRIL 18, 2024 08:58 AM

More tricks from Nature that Man will copy soon into instant eugenics... ah, err, ahem... I mean Corrective Medical Genome Editing.

TechGazer APRIL 18, 2024 09:02 AM

Quite exciting really. While it's unlikely to have a major effect on the ecosystem via natural evolution, this ability might be easier to splice into existing life forms than to develop from scratch. Imagine swapping this organelle into maize or rice or wheat? <insert conspiracy story involving fertilizer corporations kidnapping or assassinating researchers to maintain their profitable monopoly>

Ewlg APRIL 18, 2024 03:19 PM

Paul L APRIL 18, 2024 04:36 PM

While new to us, the recent discovery of the algae Braarudosphaera bigelowii absorbing a cyanobacteria is not entirely a new and likely started a long time ago. It's just in the "news" because we're just observing this now for our first time.

Tanker_Man APRIL 18, 2024 05:22 PM

Sounds like the movie Venom.

Tim Higgins APRIL 19, 2024 01:43 AM

Isn't this called symbiosis as the two organisms will still have their own separate DNA.

Steve Jones APRIL 19, 2024 01:44 AM

I'm told that it's also plausible that the first cell to gain a nucleus did so via endosymbiosis.
That would mean that it's happened at least four times on Earth and that has significant implications for the possibility of complex lifeforms existing on other planets, because complex life seems extremely rare (possibly unique to Earth) because a living cell is relatively likely to occur, but a complex cell which can evolve into multi-cellular life is almost impossible... based on the observation that it only happened maybe once, as had appeared to be the case.

BozoTheBrown APRIL 19, 2024 04:37 AM

They are still two completely different organisms. This is no different than saying I am evolving if I get a tape worm.

spectrum APRIL 19, 2024 07:40 AM

BozoTheBrown, nothing like you ingesting a tape worm. "The phenomenon is called primary endosymbiosis, and it occurs when one microbial organism engulfs another, and starts using it like an internal organ."

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