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An extraordinary discovery in the atmosphere of Venus

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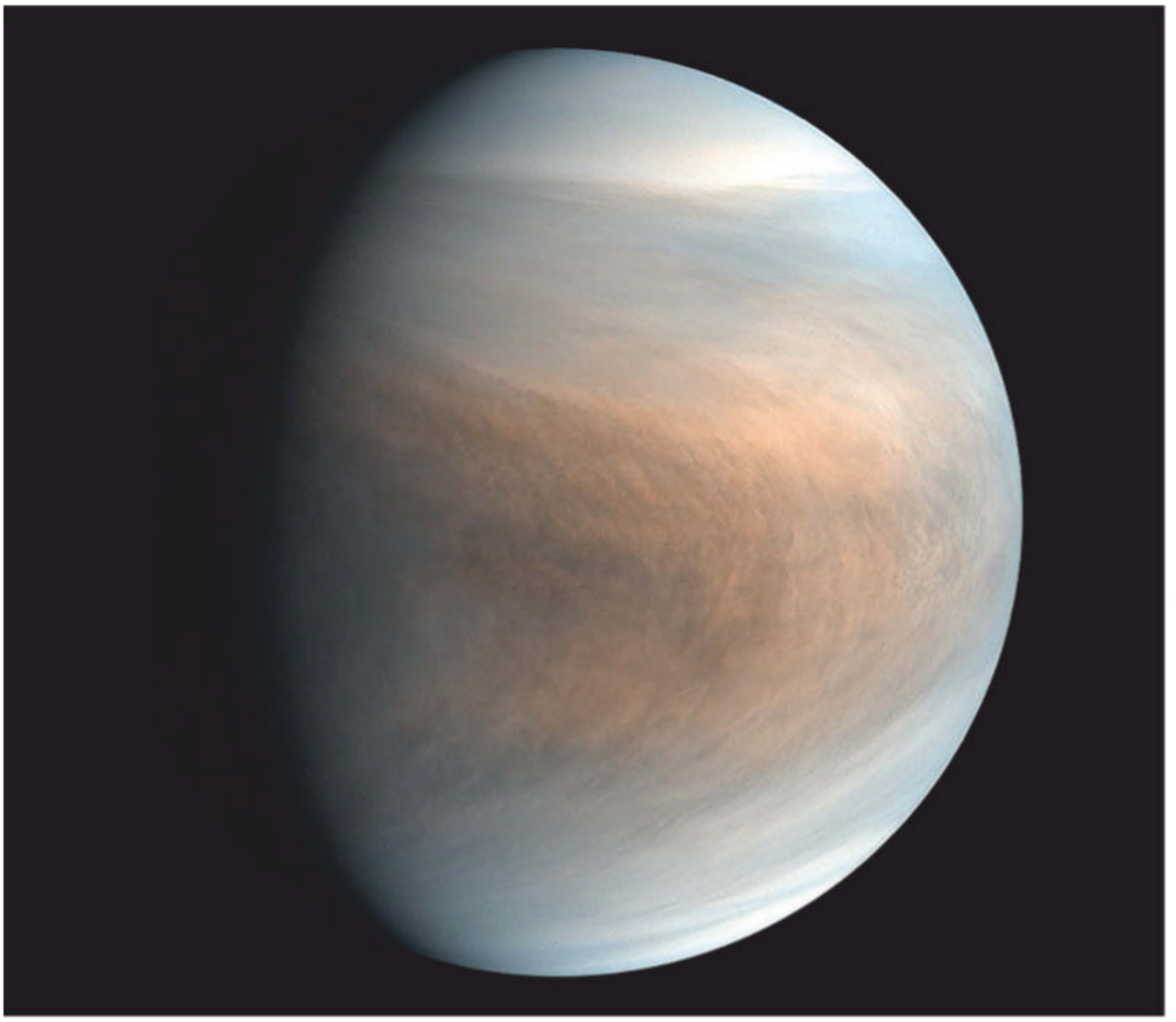

JAXA/ISAS/AKATSUKI PROJECT TEAM

There may be life swirling around in the Venusian atmosphere

Astrobiology

Signs of life on Venus?

The atmosphere of our sister planet contains a gas that hints at an extraordinary discovery, says **Leah Crane**

THE clouds of Venus may contain life. Some 50 to 60 kilometres above the planet's surface, there are small quantities of phosphine gas, a substance that is present in Earth's atmosphere because it is produced by microbes and by human technological processes. There are no known non-biological mechanisms for making this amount of gas on Venus, so it may be being produced by alien microbes.

Jane Greaves at Cardiff University, UK, led a team of astronomers who looked at Venus using the James Clerk Maxwell Telescope in Hawaii and the Atacama Large Millimeter/submillimeter Array in Chile. The data from both telescopes showed signs of phosphine gas in the Venusian clouds, which was completely unexpected.

"Phosphine in that environment is a weird thing to observe. It doesn't belong there," says David Grinspoon at the Planetary Science Institute in Arizona, who wasn't involved in this research. "It would get destroyed – there has to be a source." Somehow, the phosphine has to be continuously replenished.

The only way phosphine is made on Earth is in laboratories or by microbes. It also exists deep inside giant planets, but its formation requires conditions that don't exist on Venus.

The researchers tested a variety of ways to produce phosphine on Venus, from atmospheric chemistry to volcanism to delivery by meteorite, but they couldn't account for the amount of phosphine observed in the data.

"We thought of every process that could produce phosphine, and none of them produced phosphine in anywhere near the amounts that we found it," says team member Clara Sousa-Silva at the Massachusetts Institute of Technology. "We've exhausted the possibilities."

Only two scenarios remain: either there is something going on in Venus's clouds that we don't understand, or whatever is producing all that phosphine is alive (*Nature Astronomy*, DOI: 10.1038/s41550-020-1174-4).

"It's basically either not a big deal, or we just found Venusians and that's incredible," says Sousa-Silva. "The fact that it's even a possibility is really breathtaking to me."

"It's basically either not a big deal, or we just found Venusians and that's incredible"

The idea of life floating about in the Venusian clouds isn't entirely out of the blue. The surface may be crushingly dense and hot, but among the clouds it is relatively temperate. "For decades, people have argued that Venus may be habitable," says Paul Byrne at North Carolina State University. "Before it was just a conjecture, a place where biology could in theory be possible, but now we have this phosphine."

Greaves and her colleagues are now working on confirming the observations of phosphine with far more detailed measurements, but to be sure where it is coming from we will probably have to send a spacecraft to Venus to take a closer look.

"You want to get into the atmosphere and sample it to see what's there," says Byrne.

If those samples have life in them, even if it is tiny microbes, the planet next door could upend our ideas about what life can be and how it arises. ▮

Still have questions? See our readers' Q&A on page 8

Q&A

The Venusian enigma

This week's news from Venus left many of our readers with questions. Here our resident space expert, **Leah Crane**, tries to answer some of them

A TEAM of researchers has used two of the biggest telescopes on Earth, including the ALMA telescope in Chile (pictured right), to find signs of phosphine gas on Venus – a compound that is produced on our planet only by industrial processes and microbes – and raised many questions about whether we have just found alien life.

ESO/C. MALIN

How hot is Venus? Would any life there burn up?
There are a lot of different environments on Venus because of its thick atmosphere. The surface is absolutely miserable, with temperatures reaching 470°C and pressures 90 times that at sea level on Earth. But it is pretty temperate where the phosphine was found, at 50 to 60 kilometres above ground level, so the atmosphere could be conducive to life.

Why would the phosphine gas stay at this altitude?
The clouds of Venus aren't shifting and ephemeral like Earth's clouds. They are thick, their motions are driven by convection and the gas could just be floating around like plankton in Earth's ocean.

Do we know that this phosphine gas cannot be produced by anything other than biological processes?
It is impossible to prove a negative, so unless we can show definitively that this phosphine was produced by life, there will always be a chance that it was produced by a non-biological chemical process. But the team tested all the processes we know that could happen on Venus, and none made enough gas to account for the amount they have detected.

How big would an organism have to be to create what was found?
Not big at all. On Earth, phosphine is produced by microbes, so you might expect microbes to be able to make it on Venus too. If there is life there, it could be fairly simple.

Could it be that an organism made this gas in the past and is now extinct?
The exciting thing is that this isn't really an option. The researchers calculated that the lifetime of phosphine on Venus should be less than 1000 years before it is destroyed, so something must be continually replenishing it for it to exist in the concentrations we see.

If the organisms that may have produced it are now extinct, they must have been around until pretty recently. Given planetary timescales, it would be shockingly unlucky for them to have died out just as we became capable of finding them.

Any chance it could be tardigrades in Venus's atmosphere?
Although they can endure extreme temperatures, the microscopic, eight-legged Earth animals called tardigrades (also known as water bears) aren't known to produce phosphine, so if there is life on Venus it is probably something else.

Would this be an indication that there was life on the surface at one point?
It isn't an indication that there is life on the surface now, but if there is life in the atmosphere now, it could have interesting consequences for our understanding of what may have been on the surface back when it was – maybe – not so hot there.

50-60km
The altitude at which researchers detected phosphine gas on Venus

Could the phosphine have come from microbes carried by the Soviet Venera spacecraft, which visited Venus in the 1970s?
That isn't likely. The researchers found a large amount of phosphine, and the Venera landers were pretty small, so it is unlikely they carried enough microbes to seed this much of the gas.

What capabilities would a spacecraft need to investigate possible life on Venus?
You would want to be able to sample the atmosphere and chemically analyse it. A spacecraft would need to be able to look for life, which can show itself in patterns of materials consumed and released, but also to examine the atmosphere more generally in case the phosphine isn't biologically produced.

Could we use an atmospheric balloon to search for signs of life on Venus?
The hot, dense atmosphere makes it hard to send spacecraft to Venus, but several have made it down to the surface before they burned up. There have been a couple of balloons sent to Venus. It isn't impossible, it is just a tough engineering problem.

Is this a significant enough find that NASA might decide to focus on searching Venus for life, rather than Mars?
NASA has been very focused on Mars for a while, but we are at a point now where there aren't many more planned Mars missions, aside from still-very-theoretical crewed missions. While this news alone probably isn't enough to change NASA's course, it may be time for something new.

Do we have the capability to detect this quantity of phosphine on exoplanets – planets beyond the solar system?
This amount of phosphine – about 20 parts per billion – is right on the edge of what is detectable on planets outside the solar system. That means we probably can't spot it with any confidence at the moment, but if we did find it on an exoplanet it would be extremely exciting as a potential indicator of life. ▮