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Life on Venus? Scientists hunt for the truth

Interest in Earth's hellish neighbour explodes after the detection of phosphine, a potential marker of life.

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Venus's atmosphere is highly acidic and contains very little water.
Credit: NASA/JPL-Caltech

The surprise discovery of gas that could be a sign of life on Venus has reignited scientific interest in Earth's closest neighbour. Researchers and space agencies worldwide are now racing to turn their instruments — both on Earth and in space — towards the planet to confirm the presence of the gas, called phosphine, and to investigate whether it could really be coming from a biological source.

"Now that we've found phosphine, we need to understand whether it's true that it's an indicator of life," says Leonardo Testi, an astronomer at the European Southern Observatory in Garching, Germany.

On 14 September, scientists revealed that they had found phosphine in Venus's atmosphere, about 55 kilometres above the surface[1], using the Atacama Large Millimeter/submillimeter Array in Chile and the James Clerk Maxwell Telescope in Hawaii. The radio data showed that light was being absorbed at millimetre wavelengths that corresponded to a phosphine concentration of 20 parts per billion in the atmosphere.

Astrobiologists have flagged phosphine — a toxic compound of hydrogen and phosphorus — as a possible signature for life on other planets[2], and it is made by some organisms on Earth. "Anaerobic life produces it quite happily," says Clara Sousa-Silva, a molecular astrophysicist at the Massachusetts Institute of Technology in Cambridge, and co-author of the phosphine-detection study. But the gas should be broken down in Venus's harsh, highly acidic atmosphere. That led the discovery team to conclude that there must be some mechanism replenishing the gas, hinting at either biological production or an unknown chemical process that scientists cannot yet explain. Researchers have tentatively suggested[3] that in the region of the atmosphere where phosphine was found — away from the crushing pressures and scorching temperatures of the planet's surface — some airborne microbes could survive.

All eyes on Venus

Before seriously considering that possibility, scientists are eager to make sure that phosphine really is present on Venus. Not everyone is yet convinced by the team's observation. That's partly because the researchers identified only one absorption line for phosphine in their data, says Matthew Pasek, a cosmobiogeochemist at the University of South Florida in Tampa. "Someone else needs to confirm it."

Astronomers are now hoping to follow up on the detection using other telescopes on Earth. "We are proposing to use two instruments," says planetary scientist Jason Dittmann at the Massachusetts Institute of Technology, who plans to conduct observations with Sousa-Silva. One of the instruments is at the NASA Infrared Telescope Facility in Hawaii; the other is on NASA's Stratospheric Observatory for Infrared Astronomy, a plane that carries a telescope.

Observations in the infrared and other parts of the spectrum will enable scientists to look for other absorption lines associated with phosphine, providing a way to verify its presence. They could also offer more data on where the phosphine is located, and how its levels vary over days and weeks. Dittmann's team had hoped to observe Venus in July 2020, but

the coronavirus pandemic has pushed its telescope time back. “We’re hopeful we’ll start getting data in the near future,” he says.

Flying visit

Away from Earth, other plans are afoot. Three missions are scheduled to fly close to Venus in the coming months: Europe and Japan’s BepiColombo spacecraft, on its way to Mercury, and the European Space Agency’s Solar Orbiter and NASA’s Parker Solar Probe, both on their way to the Sun.

Observations by these spacecraft are advantageous because they would not be constrained by Earth’s atmosphere. But the crafts’ instruments are designed to look at other things, such as the surface of Mercury or the Sun, so it’s not clear whether they have the right sensitivity to detect phosphine in the Venusian atmosphere.

BepiColombo has a slim chance of detecting the gas in a fly-by this October, and a better chance next August, with its infrared instrument. The Parker Solar Probe, too, might be able to make a detection, with an instrument designed to study solar particles. “It is a low probability, but I would not completely rule it out,” says Nour Raouafi, an astrophysicist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, who is the project scientist on the mission.

There is also a spacecraft currently orbiting Venus: Japan’s Akatsuki mission, which entered orbit in 2015 and is studying Venus’s weather and searching for volcanism. Although it lacks the instrumentation required to spot phosphine directly, it could help in other ways. “The atmosphere and the clouds are the platform for life,” says project scientist Takehiko Satoh, a planetary scientist at the Japan Aerospace Exploration Agency in Sagamihara. “We can provide information about that.”

Future missions

More promising are likely to be missions still in development, which could be altered to support the detection of phosphine. The discovery strengthens the case for such missions, says Jörn Helbert at the German Aerospace Center, who is a member of the BepiColombo team.

The Indian Space Research Organisation (ISRO) has a Venus orbiter called Shukrayaan-1, planned to launch in 2025. ISRO did not respond to *Nature*’s request for comment about its plans for Venus. But Sanjay Limaye, a planetary scientist at the University of Wisconsin–Madison, says that ISRO has enough time to reconsider its instruments. “They would be mistaken if they don’t see that opportunity,” he says.

The United States and Europe also are contemplating missions to Venus that could provide useful data on the planet’s potential habitability — or even directly search for signs of life.

An addition to a proposed NASA mission called VERITAS that would investigate signs of life is a possibility, says Sue Smrekar at NASA’s Jet Propulsion Facility, the mission’s principal investigator. “VERITAS has hundreds of kilograms of excess launch mass that NASA could choose to use for auxiliary small spacecraft designed for that purpose,” she says.

In the meantime, if astronomers can confirm the detection of phosphine, they will want to rule out other plausible production methods before considering that it is being made by living organisms. That will include creating models to investigate non-biological routes of production, and conducting laboratory experiments to look for chemical pathways that were not considered in the initial study. “Modelling is a reasonable response right now,” says Pasek. “Most chemistry that we think of for Earth is dominated by water. On Venus, that’s not the case. So there’s a lot of experiments that no one has done.” Pasek is sceptical that phosphine on Venus indicates the presence of biology rather than an unknown chemical process. “I think it is possible, [but] I doubt it,” he says.

Only data can settle the debate. “Maybe Earth and Venus are two different paths that habitable planets can take in their evolution,” says Helbert, who is also part of the VERITAS proposal. “To answer that, we need to get the fundamental data sets for Venus that we have for Mars and even Mercury.”

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