No signs (yet) of life on Venus

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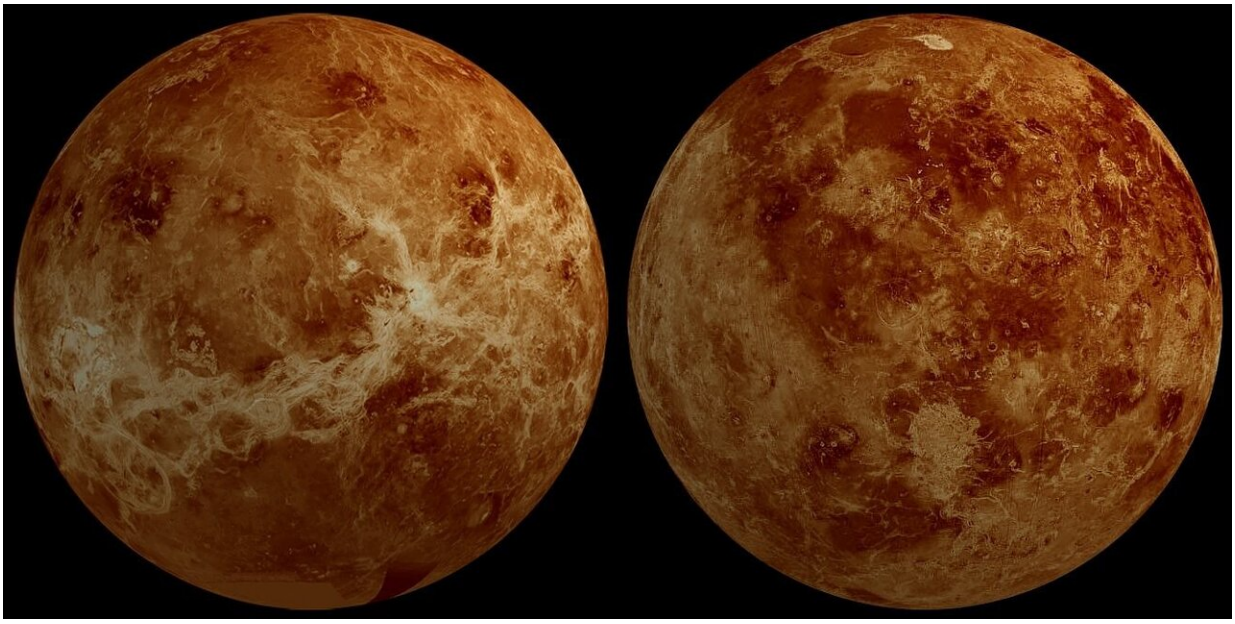

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The unusual behavior of sulfur in Venus' atmosphere cannot be explained by an "aerial" form of extra-terrestrial life, according to a new study.

Researchers from the University of Cambridge used a combination of biochemistry and atmospheric chemistry to test the "life in the clouds" hypothesis, which astronomers have speculated about for decades, and found that life cannot explain the composition of the Venusian atmosphere.

Any life form in sufficient abundance is expected to leave chemical fingerprints on a planet's atmosphere as it consumes food and expels waste. However, the Cambridge researchers found no evidence of these fingerprints on Venus.

Even if Venus is devoid of life, the researchers say their results, reported in the journal *Nature Communications*, could be useful for studying the atmospheres of similar planets throughout the galaxy, and the eventual detection of life outside our solar system.

"We've spent the past two years trying to explain the weird sulfur chemistry we see in the clouds of Venus," said co-author Dr. Paul Rimmer from Cambridge's Department of Earth Sciences. "Life is pretty good at weird chemistry, so we've been studying whether there's a way to make life a potential explanation for what we see."

The researchers used a combination of atmospheric and biochemical models to study the chemical reactions that are expected to occur, given the known sources of chemical energy in Venus's atmosphere.

"We looked at the sulfur-based 'food' available in the Venusian atmosphere—it's not anything you or I would want to eat, but it is the main available energy source," said Sean Jordan from Cambridge's Institute of Astronomy, the paper's first author. "If that food is being consumed by life, we should see evidence of that through specific chemicals being lost and gained in the atmosphere."

The models looked at a particular feature of the Venusian atmosphere—the abundance of sulfur dioxide (SO_2). On Earth, most SO_2 in the atmosphere comes from volcanic emissions. On Venus, there are high levels of SO_2 lower in the clouds, but it somehow gets "sucked out" of the atmosphere at higher altitudes.

"If life is present, it must be affecting the atmospheric chemistry," said co-author Dr. Oliver Shorttle from Cambridge's Department of Earth Sciences and Institute of Astronomy. "Could life be the reason that SO_2 levels on Venus get reduced so much?"

The models, developed by Jordan, include a list of metabolic reactions that the life forms would carry out in order to get their "food," and the waste by-products. The researchers ran the model to see if the reduction in SO_2 levels could be explained by these metabolic reactions.

They found that the metabolic reactions can result in a drop in SO_2 levels, but only by producing other molecules in very large amounts that aren't seen. The results set a hard limit on how much life could exist on Venus without blowing apart our understanding of how chemical reactions work in planetary atmospheres.

"If life was responsible for the SO_2 levels we see on Venus, it would also break everything we know about Venus's atmospheric chemistry," said Jordan. "We wanted life to be a potential explanation, but when we ran the models, it isn't a viable solution. But if life isn't responsible for what we see on Venus, it's still a problem to be solved—there's lots of strange chemistry to follow up on."

Although there's no evidence of sulfur-eating life hiding in the clouds of Venus, the researchers say their method of analyzing atmospheric signatures will be valuable when JWST, the successor to the Hubble Telescope, begins returning images of other planetary systems later this year. Some of the sulfur molecules in the current study are easy to see with JWST, so learning more about the chemical behavior of our next-door neighbor could help scientists figure out similar planets across the galaxy.

"To understand why some planets are alive, we need to understand why

other planets are dead," said Shorttle. "If life somehow managed to sneak into the Venusian clouds, it would totally change how we search for chemical signs of life on other planets."

"Even if 'our' Venus is dead, it's possible that Venus-like planets in other systems could host life," said Rimmer, who is also affiliated with Cambridge's Cavendish Laboratory. "We can take what we've learned here and apply it to exoplanetary systems—this is just the beginning."

More information: Sean Jordan, Proposed energy-metabolisms cannot explain the atmospheric chemistry of Venus, *Nature Communications* (2022). DOI: 10.1038/s41467-022-30804-8.
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