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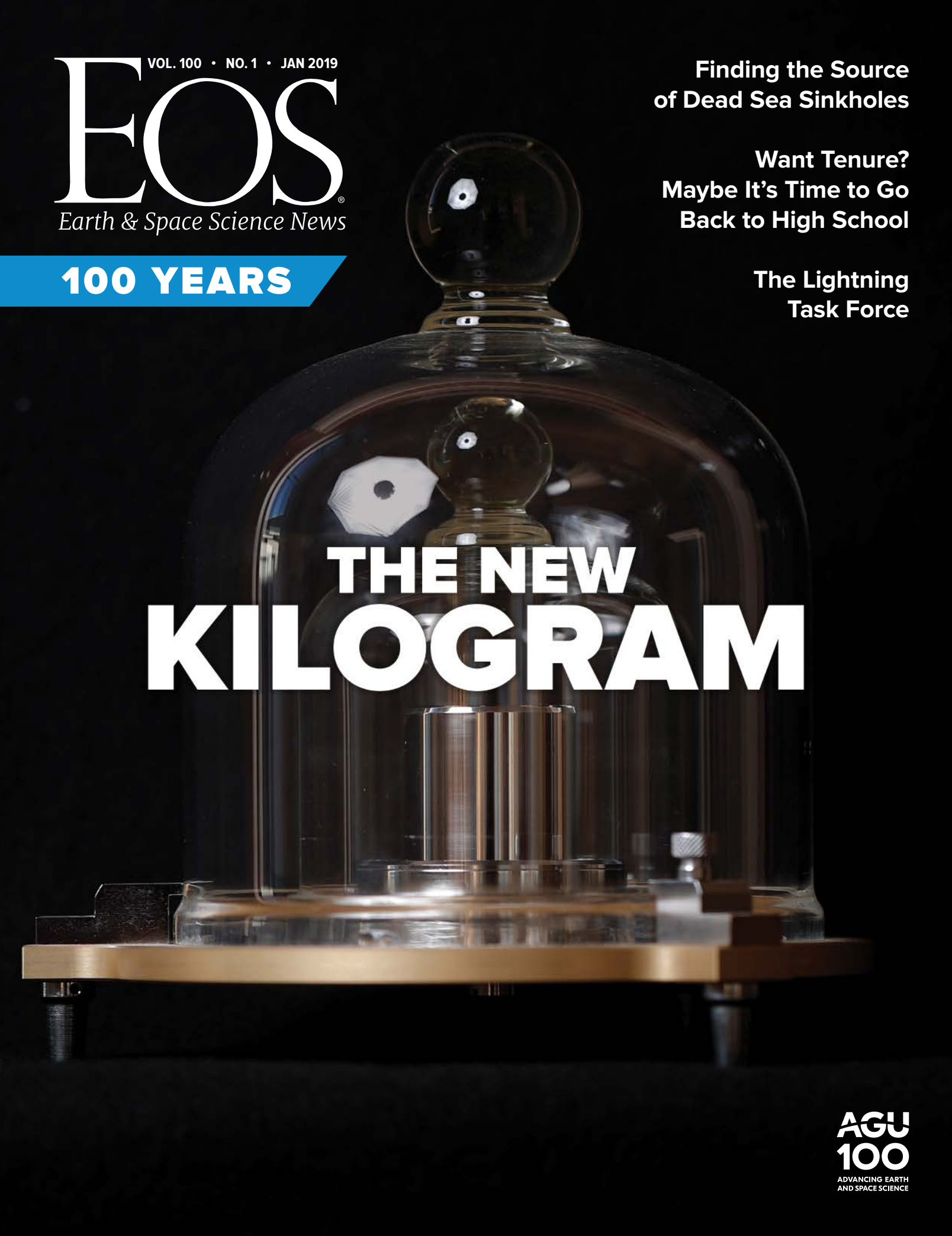

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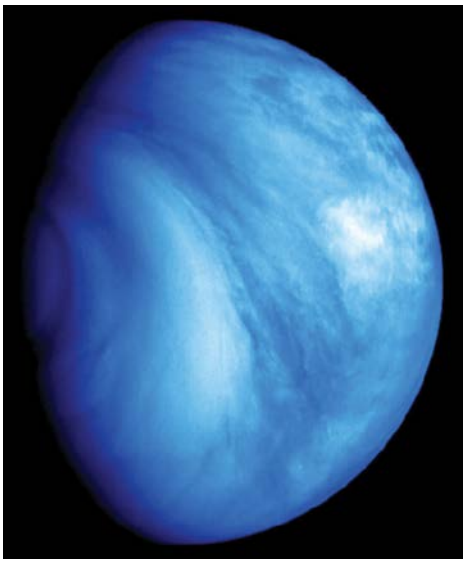
Could Life Be Floating in Venus's Clouds?

Mars, Europa, Titan: These familiar locations frequently pop up in discussions about life in the solar system. But what about the search for life on planetary neighbors closer to the Sun?

A recent study suggests that clouds in Venus's lower atmospheric layer might have the right conditions to support microorganisms. Furthermore, the existence of microbial life at those altitudes could help explain anomalous atmospheric patterns that scientists over the past century have seen in ultraviolet images of Venus.

"If you accept the arguments about water and life on Mars, then why shouldn't we include Venus in that?" Sanjay Limaye, a planetary scientist at the University of Wisconsin–Madison, told *Eos*. "Venus had liquid water. It could have had the chance to evolve or sustain life that could be living in the habitable clouds."

Limaye is lead author on a recent paper published in *Astrobiology* that discusses this idea (bit.ly/Venus-Life). The paper was part of a column that the journal calls Hypothesis Articles.



Venus's southern hemisphere is seen here in falsely colored ultraviolet light, from the planet's south pole (left) to its equator (right). Light and dark patches mark locations where UV light is preferentially reflected or absorbed. Credit: ESA © 2007 MPS/DLR-PF/IDA

Habitable Clouds

There's a good reason that Venus's surface is often ignored in discussions about life on the surfaces of other planets. With an average temperature of 465°C, an atmospheric pressure 89 times greater than that at Earth's sea level, and sulfuric acid rain, the Venusian surface is typically considered more of a hellscape than a viable habitat.

But Venus is more than its surface, Limaye noted. "We have chosen to define the habitable zone as the surface conditions, ignoring the planet's atmosphere completely" as a potential habitat, he said.

But Venus's lower atmosphere, 47.5–50.5 kilometers above the surface, checks all the boxes for habitability, the team noted. Pressures and temperatures at those altitudes are mild, 0.4–2 atmospheres and 0°C–60°C, respectively. For as long as 2 billion years, the planet may have sustained liquid surface water that is now present as water vapor in the atmosphere. Carbon dioxide, sulfuric acid compounds, and ultraviolet (UV) light would give microbes food and energy.

Moreover, the researchers noted, bacteria, mold spores, pollen, and algae have been discovered in Earth's atmosphere as high as 15 kilometers. These microorganisms likely reached such heights through evaporation, storms, eruptions, or meteor impacts, all processes that may have occurred on Venus, they said.

A Venusian Oddity

The dense clouds that cover all of Venus appear almost featureless in visible light. In the UV range, however, Venus's atmosphere looks decorated in dark patches and streaks. In those darker areas, which were first documented in 1927, an unknown substance absorbs up to 40% more UV light than surrounding areas do.

Earth-based, space-based, and Venus-orbiting imagers have shown that the size Ωand the contrast ratio of the UV dark patches evolve on a timescale of days, weeks, or months. Strong weather can sometimes cause similar variations on Earth, Limaye explained, but Venus has no seasons or seasonal weather.

Venus's UV patterns "evolve completely differently than anything else seen on Jupiter, on Saturn, on Neptune," Limaye said. "These dark patches are just bizarre."

The identity of the UV absorber itself has remained elusive. Could it be iron chloride or sulfur dioxide aerosols? Each is present in Venus's atmosphere and absorbs UV light in a pattern similar to that observed in the dark patches on Venus.

Unlikely, Limaye explained. Venus's sulfur is not abundant enough to produce such strong UV contrasts on its own, and iron chloride quickly reacts with even a small amount of sulfur, rendering it too volatile and short-lived to produce the observed patterns.

Could Microbes Be the Answer?

Venus's UV dark patches, Limaye noted, grow and shrink in extent, move around the globe, and become lighter or darker over time. In fact, the evolving UV patterns evoke images of bacteria growing in petri dishes or algae blooming in lakes and oceans, he added.

It's an intriguing idea that Limaye and his team couldn't shake. UV-absorbing microorganisms, they posit in their paper, might bloom, die, migrate, and drift in the atmosphere, changing the aerial extent and bright-dark contrast of Venus's atmosphere. The microbes might be similar to Earth's sulfur-eating, acid-resistant, and UV-absorbing bacteria, like *Acidithiobacillus ferrooxidans* or members of the genus *Stygiolobus*.

At last year's meeting of the American Astronomical Society's Division of Planetary Sciences, a researcher suggested that 1.4 billion tons, or about the biomass of Earth's oceans, could survive in Venus's atmosphere, given the pressures and temperatures known to exist at various altitudes (bit.ly/Venus-Biomass). The estimate, Limaye said, is consistent with his team's work.

Venus Mission Necessary

The concept that Venus's clouds could host life has been in circulation at least as far back as a 1967 journal article coauthored by Carl Sagan (bit.ly/Venus-1967). However, no spacecraft have gathered samples of Venus's atmosphere or performed long-term in situ measurements of its composition.

Such a spacecraft is needed, Limaye explained. "Spectroscopically, it is not easy to detect" these kinds of microbes from Earth, he said. "We have to actually go there to learn about these absorbers."

Finding life's signatures isn't the endgame for Limaye, however. "I won't be disappointed if we don't find any bacteria," he explained. "My curiosity is to know what is causing the absorption."

By **Kimberly M. S. Cartier** (@AstroKimCartier), Staff Writer