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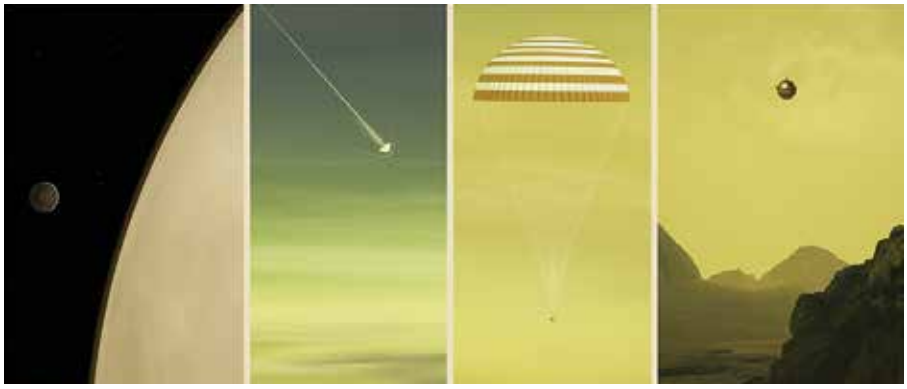
Mission to Venus Could Help Solve an Atmospheric Mystery

Floating along Venus's thick atmosphere are shadowy patches, morphing in shape and size, like huge algal blooms. Scientists first photographed these atmospheric features in 1927, and some researchers have suggested that these so-called unknown absorbers could be signs of life.

"For all we know [they] could be bacteria," said Sanjay Limaye, a planetary scientist at the University of Wisconsin–Madison. "Could there be life in the clouds?"

Although scientists have their hypotheses, no one has confirmed what is causing the dark areas in the atmosphere. NASA's new mission to Venus, DAVINCI+ (Deep Atmosphere Venus Investigation of Noble Gases, Chemistry, and Imaging), may bring scientists closer to an answer. (NASA is in the process of changing the mission name from DAVINCI+ to DAVINCI.)



DAVINCI+, one of NASA's latest missions to Venus, will study the planet from above and within. Credit: NASA GSFC visualization and CI Labs/Michael Lentz and colleagues

DAVINCI+ Answers the Call

The mission, announced in June, will drop a probe into Venus's clouds—a beach ball–sized titanium sphere that will dive through the atmosphere and, for more than an hour, collect data while falling about 70 kilometers (43.5 miles). This mission, scheduled to launch between 2028 and 2030, will be the first time a spacecraft will probe the planet's atmosphere in situ since 1985, when the Soviet Union's Vega 2 spacecraft investigated the planet's atmosphere.

> **"Could there be life in the clouds?"**

DAVINCI+ isn't designed to detect life. "We're still trying to get the right measurements to simply ask the right questions," said Jim Garvin, DAVINCI+'s principal investigator. But among the mission's other scientific goals, researchers hope it will help solve the mystery of these atmospheric patches and, more broadly, provide a deeper understanding of the atmosphere, which is crucial for determining Venus's habitability.

An Old, Unanswered Question

Is there life on Venus? Because Venus has many similarities to Earth—such as size and interior composition—many scientists once thought Venus could be an oasis for life. But when spacecraft began exploring the planet in the 1960s, they uncovered an inhospitable surface environment with temperatures hot enough to melt lead and a thick carbon dioxide atmosphere with crushing average pressures 92 times those at Earth's sea level and surface.

Then in 1967, Harold Morowitz and Carl Sagan proposed that although life can't survive on the surface, some microbes may survive in the clouds. Early Venus missions found evidence of water vapor in the atmosphere. In the cloud layers roughly 50 kilometers (30 miles) above the planet's surface, atmospheric pressures are comparable to those at Earth's sea level, and temperatures range between 100°C (212°F) and 60°C (140°F)—much cooler and more hospitable than the surface. On Earth, for instance, some organisms—such as microbes in hydrothermal vents—can survive in temperatures as high as 121°C (249.8°F).

In addition, the patches are created when something, perhaps microbes or some biological process, absorbs primarily ultraviolet light from the Sun amounting to about half the Sun's energy that reaches Venus, according to Limaye. In 2018, Limaye and his colleagues found that the patches absorbed light at many of the same wavelengths as some terrestrial bacteria and biological molecules, such as proteins.

> **"We're still trying to get the right measurements to simply ask the right questions."**

Using DAVINCI+ to Get One Step Closer

The unknown absorbers, of course, could be nonbiological. Scientists have already detected some sulfur-bearing compounds in Venus's atmosphere that absorb at least some of the ultraviolet light, and other similar chemical species might be the main cause of the dark patches, Garvin said. DAVINCI+ will try to help determine the chemistry that's producing the bulk of these dark patches and perhaps point sci-

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entists toward a biological or nonbiological origin.

During two flybys before it releases the probe, the DAVINCI+ carrier spacecraft will try to identify the absorbers using a high-resolution ultraviolet spectrometer. An ultraviolet camera will also take videos of the clouds at high resolution and study how the dark patches move.

"It is a great time to be interested in Venus... We're going to learn spectacular stuff."

If life does exist in the clouds, it likely would have originated the same way it did on Earth: in an ocean. Some computer models of Venus's ancient climate suggest that it did once have a shallow ocean, chemical traces of which might still exist in its atmosphere. An onboard mass spectrometer will measure hydrogen and its chemical sibling deuterium to reveal how much water Venus's surface has lost throughout history. The probe's laser spectrometer will not only help identify what's absorbing ultraviolet light but also measure chemicals important for determining habitability, such as sulfuric acid, water, and chemical nutrients.

Compared to the instruments that last visited Venus decades ago, the spectrometers "are an order of magnitude higher in resolution [and] precision," Garvin said.

DAVINCI+ won't be alone at Venus. In the next decade, NASA, the European Space Agency, and the Indian Space Research Organisation will send three more spacecraft—VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy), EnVision, and a to-be-named orbiter—to the planet, beginning a new era of Venus exploration. "It is a great time to be interested in Venus," Garvin said. "We're going to learn spectacular stuff."

By **Jaime Cordova** (@jaimecor_94), Science Writer

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When Rivers Are Contaminated, Floods Are Only the First Problem

Dioxins—the category of chemicals that includes Agent Orange—have been banned in the United States since 1979. But that doesn't mean they're gone. Dioxins and other banned chemicals are buried just beneath the surface waiting to be unearthed.

A new perspective paper published in *Journal of Hazardous Materials* calls attention to an understudied area: the remobilization of pollutants buried in riverbeds (bit.ly/riverbed-pollutants). Chemicals have a knack for binding to sediments, meaning that chemical spills in rivers frequently seep into sediments instead of flowing downstream. Future layers of silt bury the pollutants and hide the problem.

But persistent chemicals in riverbeds are "ticking time bombs," warned Sarah Crawford, an environmental toxicologist at Goethe University Frankfurt and lead author of the paper. The buried chemicals can easily be remobilized. "It just takes one flood event," she said.

Little Pockets of Pollution

The paper comes from an interdisciplinary research team based mostly in Germany, a country that faced catastrophic floods this year that defied comparison. As the climate warms, similarly intense storms are expected to increase. Floods cause immediate turmoil, but chemical remobilization can prolong the disaster.

"Cohesive sediments are really stable over long ranges of flow velocities, but at some point the sediment bed just fails," said Markus Brinkmann, an ecotoxicologist at the University of Saskatchewan and a coauthor of the paper.

"Little pockets of contamination are really easily dispersed by flood events."

When the riverbed fails, the turbulent water fills with sediment. That churning water can spread toxins widely. After Germany's Elbe river flooded in 2002, for example, hexachlorocyclohexane concentrations in fish were 20 times higher than they were

Hurricane Harvey flooded or damaged at least 13 Superfund sites in 2017, sending cancer-causing compounds into Texas waterways. Credit: S.Sgt. Daniel J. Martinez, U.S. Air National Guard