Cassini Spacecraft Delivers Biggest Revelation Yet: A Moon of Saturn Is Habitable; NASA scientists announced today that Enceladus, the sixth-largest moon of Saturn, has hydrothermal vents that are actively releasing hydrogen. Because such ecosystems are known to support life, the discovery confirms that Enceladus is a habitable environment

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From Opposing Viewpoints in Context

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Today Earthlings came one very giant step closer to finding life elsewhere in our solar system. In the final months of its 20-year mission, the spacecraft Cassini delivered its most noteworthy revelation yet: the ocean of Enceladus, a moon of Saturn, is releasing hydrogen, an energy source for some microorganisms. In other words, that ocean is inhabitable. "Enceladus," says Cornell University astrophysicist Jonathan Lunine, "is the place to go to look for life."

The ocean--made of liquid water and resembling a hybrid of the Atlantic Ocean, a desert mineral lake and the fluid found near hydrothermal vents--covers the entire surface of this moon. A thick shell of ice surrounds the entire body of water, though, leaving it dark and frigid. But something happening inside that ocean is strong enough to break through those miles of ice. At the moon's southern pole, a geyser-like plume spews water vapor, ice, salt and a mix of gases hundreds of miles into space at a force of 800 miles per hour.

Among the contents of the plume, one gas stands out: hydrogen. Although this element is abundant in the universe, it's usually bound to others, like oxygen. Rarely is hydrogen found alone. But the mere presence of pure hydrogen gas is not why scientists think Enceladus is habitable; it's the large amount of it. When Cassini flew past the plume in 2015, it detected pure hydrogen in quantities that could not be easily explained.

Hydrogen is the lightest element, readily escaping the gravitational pull of whatever planet or moon it came from. "Molecular hydrogen doesn't hang around for a long time," says Lunine. Because this nearly weightless gas floats away so easily, maintaining large amounts requires continual production. The hydrogen on Enceladus is not a relic of an old geological process. Something on that moon is making pure hydrogen gas now. "That's the exciting part," says Lunine.

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The team of researchers behind the Cassini mission examined all the possible explanations for what
could be generating such large quantities of hydrogen gas. Only one withstood the calculations: hydrothermal vents. Lunine and his co-authors on the Science study reporting the analysis believe that ocean water is reacting with rocks in hydrothermal vents on the seafloor to actively produce hydrogen.

Finding newly manufactured hydrogen on Enceladus is significant because the element can support life. The Earth has ample proof of that. In places where sunlight and oxygen are unavailable, microbial life forms live off hydrogen. These organisms, which first evolved billions of years ago, are among the most ancient forms of life on Earth, and are known as methanogenic archaea, or more simply methanogens, because they produce methane gas (a combination of hydrogen and carbon). Not all methane-producing microbes depend on hydrogen, but some do. In particular, methanogens buried deep inside of rocks eat hydrogen. So do those living in hydrothermal vents at the bottom of the ocean.

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Scientists searching for life elsewhere in the universe have latched onto methane-producing organisms as the likeliest fellow residents of our solar system. Planets and moons farther from the sun than Earth lack strong sunlight. So microorganisms like methanogenic archaea, which thrive in its absence, are the most plausible interplanetary life form. "They are my favorite organism," says NASA senior scientist Chris McKay, "and they are the darling of astrobiology."

Enceladus has been shocking space explorers since Cassini arrived at Saturn in 1997. "It's surprised us so many times that we should no longer be surprised," says Chris Glein, who researches space science and engineering at the Southwest Research Institute and is a co-author on the new study. First came the discovery of what was initially thought to be a small body of water beneath the surface at one of its poles. Despite being covered by ice, that water turned out to be in a liquid state. And the ocean was not confined to the polar region; it spans the entirety of the moon.

The presence of water stirred questions about the possibility of life on Enceladus. The next piece of evidence that goosed that speculation came in 2005, when Cassini made its closest approach yet to the moon. As the spacecraft flew through the plume, an instrument known as an ion and neutral mass spectrometer—"Think of it as a gas sniffer," says Glein—registered hydrogen among the gases it detected. But the source of that gas was a mystery. The ocean was a candidate, but not the only one. The force of the collision between spacecraft and plume, which releases gas at a force of 800 miles per hour, could also have generated the hydrogen, says Glein.

So in late 2015, when Cassini, on its loop through Saturn, its rings and several of its moons, returned to Enceladus for the last time, the astronomers directing the mission made sure to obtain the data needed to determine exactly where the hydrogen was coming from. Even after Cassini detected copious amounts of the element, several explanations were still plausible. "Jupiter and Saturn have hydrogen but they don't have hydrothermal vents," Glein says, and the birth of the solar system could have planted hydrogen inside the moon. Plus, hydrothermal vents are hot, which means some energy source would have to be present in the rocky core of Enceladus beneath the ocean. Again, there was reason to be skeptical that the moon had hydrothermal vents: a heat source big enough to power such an explosive process seemed unlikely for a moon that measures just 300 miles across.
After months of ruling out alternatives, the researchers came to the only conclusion that made sense: The ocean is making hydrogen. Ocean water reacting with minerals in hydrothermal vents is generating the element, an ecosystem found on Earth. "It has all the requirements for life," says McKay, who was not involved with the new study. "It's similar to Earth in ways you might not expect from a tiny little moon in the outer solar system," says study co-author Kelly Miller, who studies planetary formation at Southwest Research Institute.

Note that habitable is not the same as inhabited. Cassini was not designed to detect life, and will burn up in Saturn's orbit on September 15, 2017. Lunine and Glein are developing proposals for future missions, such as the Enceladus Life Finder, to search for life. The investigation would take at least 20 years--10 years out to Saturn and 10 years back--and even if NASA approves the mission, the soonest it would begin is the early 2020s. Lunine says the wait is worth it. "We should go back to Enceladus because there is the chance to discover there a truly alien biota," he says, a completely new kind of life. The first alien we meet could be a hydrogen-dependent organism that has evolved over billions of years on an ice-encased moon orbiting Saturn.

In addition to a return mission, though, scientists also need to find a safe way to carry Enceladean microbes back to Earth for study. Current technology can bring them close, but, says McKay, "we don't have the last-mile problem solved." That last mile is the one that includes landing on Earth, and scientists have not yet created a container guaranteed to remain intact during the severest possible impact. A broken container could release a potentially dangerous alien microbe. "If you're bringing back live bugs from Enceladus that love to live in the ocean and you crash, that is not acceptable," he says. The risk of contamination must be completely eliminated. Three spacecraft have brought material back to Earth, but those samples were not alive. And, McKay points out, one of those machines crashed.

While NASA considers its next outer space move, scientists are examining Earth-bound methane producers for clues about how such alien life could function. McKay is part of a team studying Lake Untersee, in Antarctica, which is a "dead ringer" for Enceladus. Their next mission is planned for December 2017. Astronomers are also continuing to study Titan, the largest of Saturn's 62 moons, and Europa, a moon of Jupiter, both of which have liquid water under ice.

However astronomers pursue the question of whether Enceladus is not only habitable but also inhabited, the pursuit must go on, says planetary scientist Carolyn Porco, who heads the Cassini imaging team. Porco, an expert on Enceladus (though not an author of the current study), is hoping for a return mission as soon as possible. "The next steps at Enceladus," she says, "could be the most consequential steps ever taken in the history of planetary exploration."

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