Water on the universe's many 'ocean worlds' may hold the answer to an age-old question

MAYBE ALIEN LIFE IS ALL WET

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Special for USA TODAY

Oceans are masters of deception. No matter how they appear on the surface — calm or chaotic, tranquil or tumultuous — what's taking place underneath is anyone's guess. In fact, the world beneath the oceans' shimmering surf remains one of Earth's biggest mysteries.

Although oceans cover about 70% of Earth's surface, the National Oceanic and Atmospheric Administration points out that less than 5% of their waters have actually been explored. In the other 95% are massive mountain ranges that have never been scaled, violent volcanoes that have never been observed and scads of unknown species that have never been discovered — like

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An image of Saturn's moon Enceladus from 2005 shows plumes of ice and water vapor venting into space. NASA scientists believe a liquid water ocean is under the frozen surface.
AP

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the only recently discovered *Mola tecta*, a pancake-shape sunfish that can reach up to 10 feet in length and over 2 tons in weight.

As compelling as they are, however, the secrets waiting to be discovered in Earth's oceans may be only a fraction as captivating as what could be swimming in extraterrestrial oceans, which are the latest frontier in humankind's search for alien life, according to Mary Voytek, NASA senior scientist for astrobiology and head of the agency's Astrobiology Program.

"From the very beginning of the agency, NASA has been interested in searching for life beyond Earth," Voytek says. "And, of course, one of our main thrusts has always been 'follow the water.' "

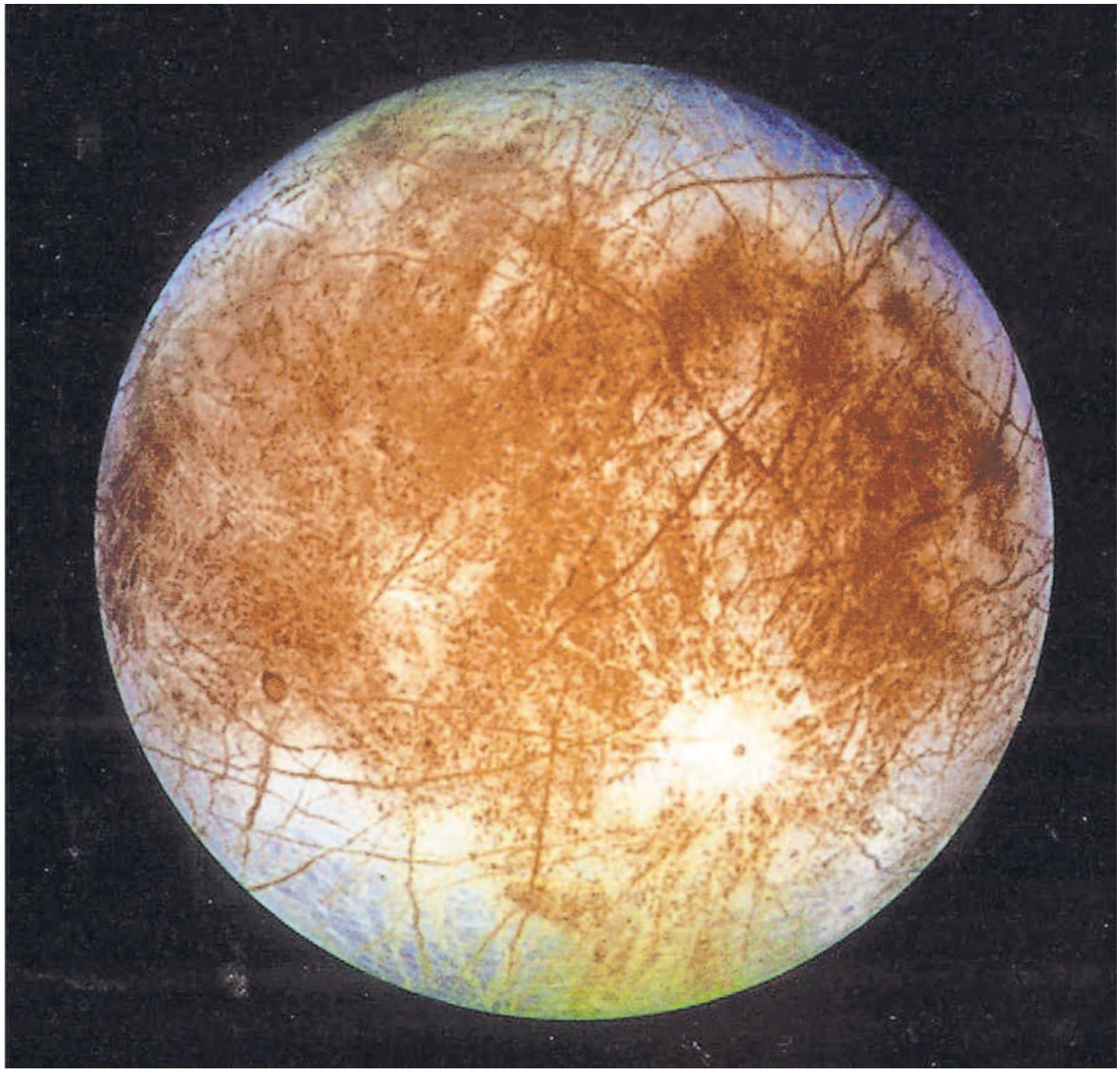
As recently as a decade ago, scientists presumed that liquid water was a relatively rare commodity in the heavens, and that watery bodies like Earth and Jupiter's icy moon Europa — where scientists have long suspected the presence of a salty ocean beneath the surface — were outliers. New evidence, however, suggests that water is actually quite common. So common that NASA had to come up with a new term for the growing number of bodies known to have it: ocean worlds.

"The concept of 'ocean worlds' didn't even exist a decade ago," says Curt Niebur, lead scientist for NASA's New Frontiers and Ocean Worlds programs. "A decade ago, all you had was Earth and Europa, and Europa was considered a one-off — a freak. But over the last seven or eight years we've discovered a lot of ocean worlds in our solar system."

Some of those worlds, like Mars, had liquid oceans long ago but have since lost them. But many have liquid oceans right now, including Saturn's moons Titan and Enceladus, Jupiter's moon Ganymede, and Pluto.

"What we're finding is that these environments are actually extraordinarily common," Niebur says.

Along with energy and elements like carbon, water is one of the three essential ingredients needed to sustain life — at least, as we understand it. Its presence in large quantities across the solar system, and perhaps beyond it, therefore adds new promise to the search for life beyond Earth.



If there's life elsewhere in our solar system, Jupiter's moon Europa is probably our best bet, as a liquid ocean is believed to lie beneath the icy surface. A mission to conduct a series of fly-bys of Europa will launch in the 2020s. That could be followed someday by a landing on the surface. NASA VIA AP

Looking for Life

In science fiction, aliens always seem to find us. In reality, however, it's just as likely that we would find them. And that process doesn't start with flying saucers. Instead, it starts with telescopes. One telescope, in particular: the space-based Kepler observatory, which orbits the sun tens of millions of miles from Earth. Kepler has been looking for exoplanets — planets outside our own solar system — since 2009. To date, it has identified nearly 2,500 of them, including 30 that are Earth-like in terms of size and distance from their respective suns.

"Scientifically, we have determined that ... almost every star in the galaxy has one or more planets around it. And in fact, the latest results from the Kepler space telescope show that we can expect every solar-type star to have one or more rocky planets in the habitable zone around it," says Paul Hertz, NASA's director of astrophysics. "That means the conditions that gave rise to life on our planet are happening billions of times on other planets in our galaxy."

Of course, just because the conditions for life are common doesn't mean life itself is. NASA's next big task, therefore, is determining how often life actually emerges from conditions that can sustain it: always, sometimes or never. To do that, it must get a better look at ocean worlds both in and outside our solar system.

One way it will do that is with new, more powerful telescopes. In March or June 2018, for instance, NASA will launch the Transiting Exoplanet Survey Satellite, which is expected to catalog more than 1,500 potential exoplanets, approximately 500 of which may be Earth-like. Succeeding that will be the James Webb Space Telescope and the Wide-Field Infrared Survey Telescope, launching in spring 2019 and mid-2020, respectively. Both will give NASA scientists more and better views of exoplanets

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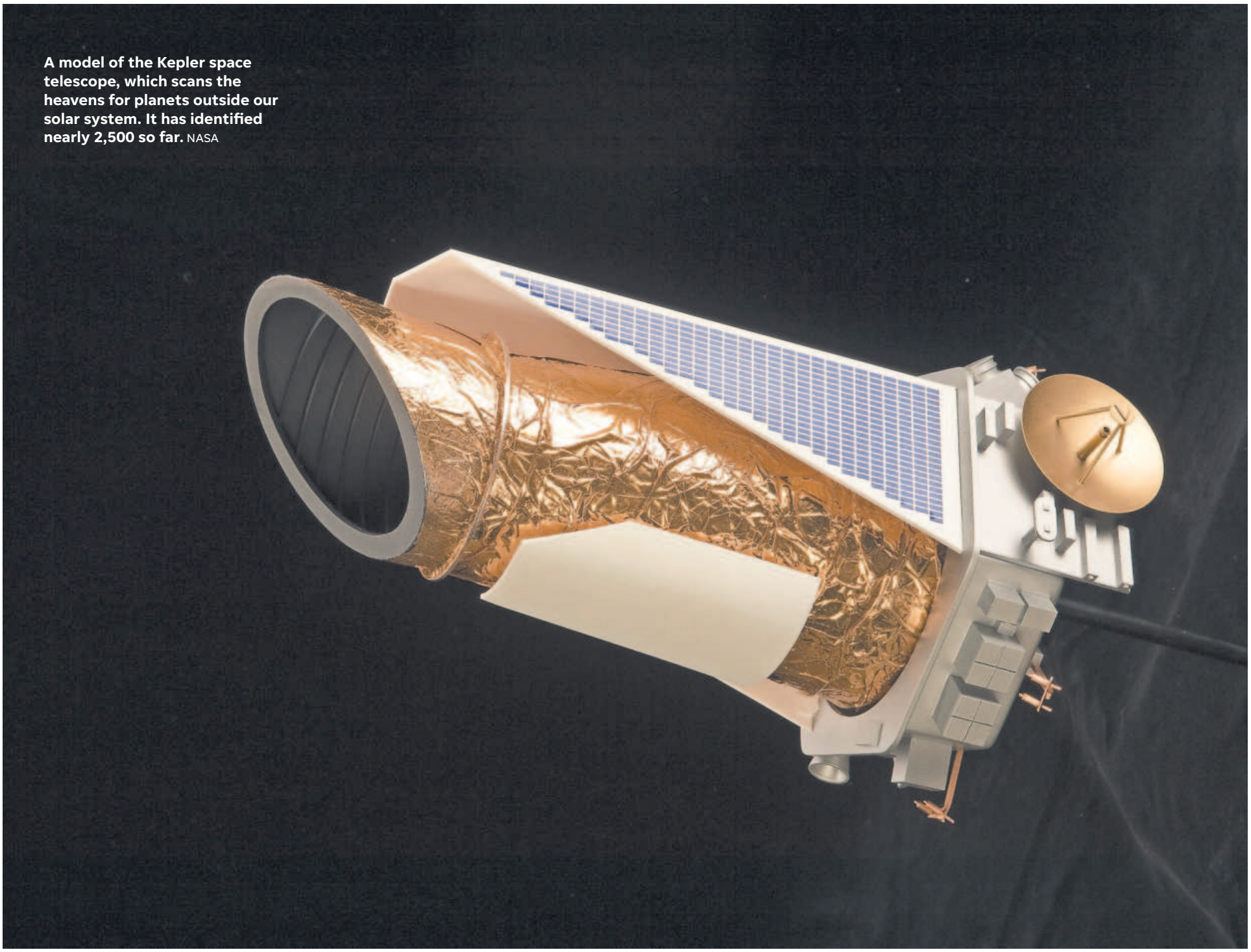

A model of the Kepler space telescope, which scans the heavens for planets outside our solar system. It has identified nearly 2,500 so far. NASA

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that they can scrutinize for signs of life, including atmospheric gases like oxygen, methane and carbon dioxide that are associated with life.

Although telescopes can find signs of life, seeing life itself will require more than viewing ocean worlds; it'll require visiting them. Of course, NASA has already landed on one: Mars.

"Mars is a fascinating place, but there is no doubt that it is not currently habitable. It was much more Earth-like in a distant past — billions of years ago," Niebur says. "If you want to find life that is alive today, you need to go to an environment that is habitable today."

There are at least two such environments that NASA can reach with current space technology: Enceladus and Europa, both of which are believed to have liquid water oceans beneath their frozen surfaces. Enceladus, however, is likely too young for life; whereas it took Earth approximately 500 million years to produce its first single-cell organism, Enceladus is only 100 million years old, according to Voytek. That leaves as NASA's best candidate Europa, which is 4.5 billion years old — roughly the same age as Earth.

"If we can sample (Europa's) ocean waters, maybe we'll find that the production of hydrogen and the presence of carbon dioxide resulted in microbial production of methane," Voytek says. He explains that NASA's recently concluded Cassini mission to Saturn detected on Enceladus deep-sea hydrothermal reactions that produce both hydrogen and carbon dioxide, which in Earth oceans can sustain microorganisms known as methanogens that produce methane as a byproduct. If life-sustaining geology that happens on Earth can happen on Enceladus, NASA posits, maybe it could also happen on Europa. "That would be fantastic, and it's one of the reasons we're extremely excited about going to Europa to look for evidence of life."

That will be the objective of Europa Clipper, a NASA mission launching sometime in the 2020s which will fly a spacecraft past Europa in two-week intervals to capture up-close images of the moon's icy surface.

"Europa Clipper will fly by Europa

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NASA could use an ice-penetrating probe like this one to explore beneath the ice of Europa or Enceladus. The copper tip of the probe heats up to 175-195 degrees Fahrenheit to melt through the ice.
NASA VIA AP

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about 45 different times," Niebur says. Europa Clipper's payload will include sensors capable of determining details about Europa's ocean such as its depth, salinity and chemical composition. "Our primary goal is to determine: Is Europa habitable? Clipper will definitively answer that question for us."

The Ultimate Question

But until NASA can collect physical samples from Europa's ocean — it's currently studying a mission to do exactly that, Niebur says — the biggest question of all will likely remain unanswered: Are we alone in the universe?

NASA isn't the only one that wants to find the answer. So does Congress, which used the space agency's 2017 budget legislation to amend NASA's mission to include "the search for life's origin, evolution, distribution and future in the universe."

"Searching for life ... has been one of our goals for quite a while, and we have received great support for that goal from previous administrations and from previous congressional committees," Hertz said. "But we're excited that it has now been written down as one of our agency's prime reasons and prime objectives."

Whether it fulfills that objective on Europa or one of the countless other ocean worlds in the universe, Voytek is confident NASA eventually will find what it's looking for.

"Here on Earth, we have organisms that can live at a pH of zero — the pH of battery acid is between 1 and 2 — and at a pH of 12 or 13, which is the pH of the soap and lye we use to clean our ovens. We have organisms that live in minus-20 degrees Celsius and up to 120 degrees Celsius. We have found organisms in the Great Salt Lake, in the ice of Antarctica and in the Atacama Desert (the driest place on Earth). Almost everywhere we look on our planet, we find organisms that are able to survive, persist and in some cases even thrive," Voytek says. "Given the examples of habitats in our own solar system and the addition of exoplanets where there are billions and billions of possibilities, as a microbiologist I am certain that we will find life somewhere else. Life as we know it is just too tenacious and too innovative."