The Planetary Society

THE PLANETARY REPORT

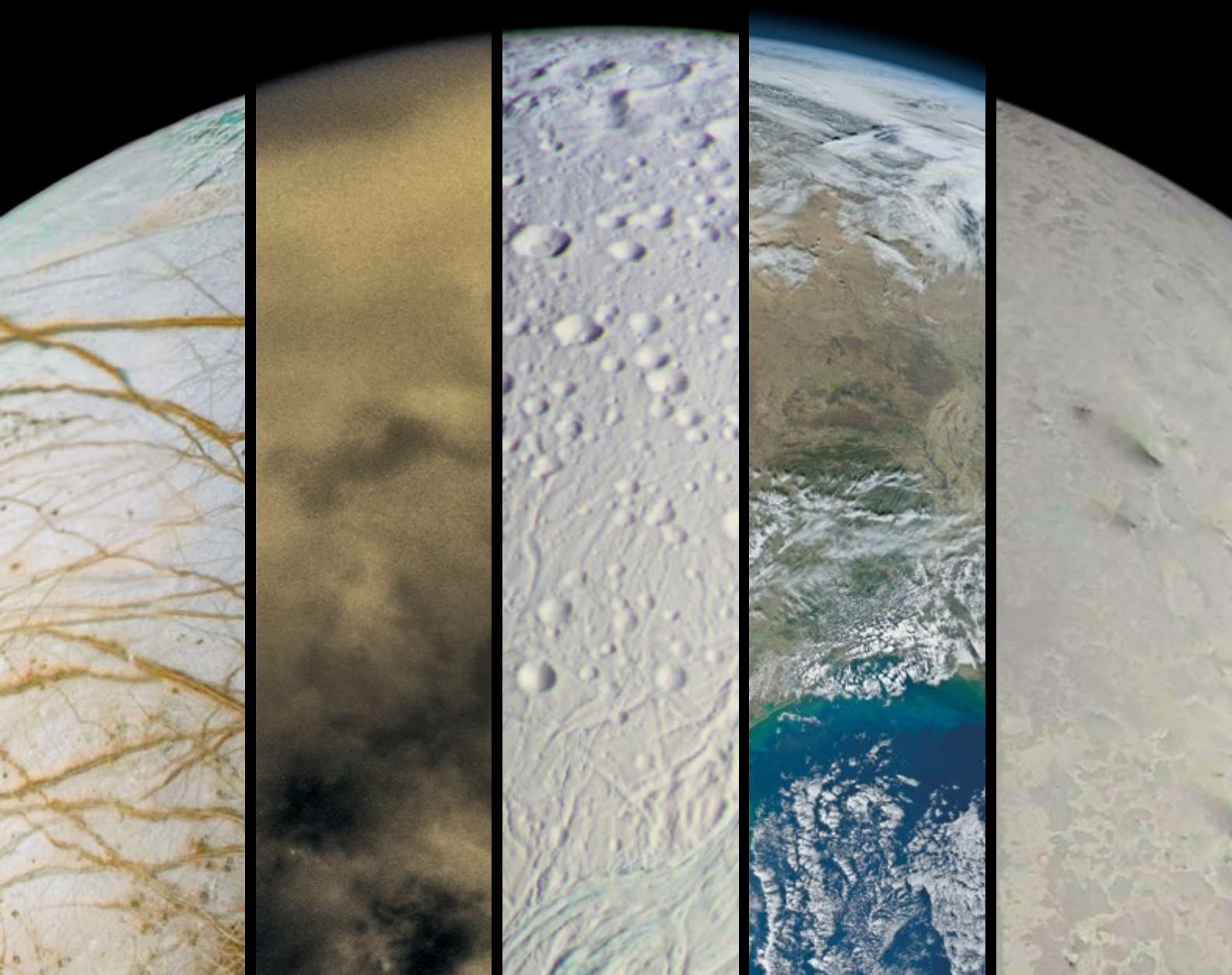
MARCH EQUINOX 2022

VOLUME 42, NUMBER 1

planetary.org

OCEAN WORLDS

EXPLORING THE WATERY PLANETS AND MOONS OF OUR COSMIC NEIGHBORHOOD



ONWARD TO OCEAN WORLDS

Decades of advocacy for exploring icy moons

by Bill Nye

IN THIS ISSUE of The Planetary Report, the subject matter is undeniably cool — cold, actually ... very, very cold. These pages take us on a tour of our solar system's "ocean worlds" — places where icy surfaces laced with webs of cracks, crevices and crevasses conceal vast oceans of liquid water. Here on Earth, where there's liquid water, there's life. Could the same be true on another world?

The discoveries celebrated in this issue have already changed our understanding of what kinds of worlds might exist in the cosmos. At The Planetary Society, we have a long history of advocating for missions to explore our solar system, and I'm very proud to say that the groundbreaking — well, maybe icebreaking — discoveries we showcase in this issue were made possible by members like you.

In 1983, Planetary Society President Carl Sagan wrote to NASA administrator James Beggs, urging the agency to send a mission to Saturn's moon Titan. Later that same year, NASA and ESA (the European Space Agency) agreed to build a single mission comprising two spacecraft — the enormously successful Cassini-Huygens mission. Cassini sent back reams of data and astonishing images before it dove into the gas giant more than 20 years later. The Huygens probe was the first spacecraft ever to land on another planet's moon. The data returned to us from both spacecraft are still being analyzed, and new discoveries may still be in store.

Just eight years ago, researchers announced that Jupiter's moon Europa is likely spouting its vaporized ocean water into space. Really? A moon of Jupiter, smaller than Earth's moon with twice as much seawater as is on our entire planet? And some of it is shooting into space like an ocean-size geyser? If there's liquid water, is there something alive? In 2014, we organized events in Washington, D.C. to educate lawmakers about the value of exploring Europa and worked with Congress to help get the mission funded. Planetary Society members rallied in support, sending tens of thousands of letters to their congressional representatives. NASA formally greenlit the Europa Clipper in 2015, and it will launch in 2024.

What about Saturn's satellite Enceladus? Covered with clean, very reflective ice, it's one more jewel among these mysterious, enigmatic moons. Right now, the nature of these watery worlds is on the other side of what our founder, Bruce Murray, often called "the unknown horizon." It's our job to help see what's beyond it. The discoveries that are yet to be made will be possible because of your support, so thank you. Now, let's have a look!

BILL NYE *is chief executive officer of The Planetary Society.*

ON THE COVER: On the cover: Five ocean worlds in our solar system. From left: Europa *(NASA/JPL-Caltech/Ted Stryk)*, Titan *(NASA/JPL-Caltech/SSI/Ian Regan)*, Enceladus *(NASA/JPL-Caltech/SSI/Kevin M. Gill)*, Earth *(NASA)*, Triton *(NASA/JPL/Ted Stryk)* ✻ The Planetary Report (ISSN 0736-3680) is published quarterly at the editorial offices of The Planetary Society, 60 South Los Robles Avenue, Pasadena, CA 91101-2016, 626-793-5100. It is available to members of The Planetary Society. Annual dues are $50 (U.S. dollars) for members in the United States as well as in Canada and other countries. Printed in the USA. Third-class postage at Pasadena, California and at an additional mailing office. Canada Post Agreement Number 87424. ✻ Viewpoints expressed in articles and editorials are those of the authors and do not necessarily represent positions of The Planetary Society, its officers or its advisers.

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LIQUID WATER MISSIONS?

IN OUR WEEKLY Downlink newsletter, we asked our members this question: "The moons Europa, Enceladus, Ganymede, Titan and Triton are all known to have oceans of liquid water beneath their surface. If you could send a robotic mission to explore one of these ocean worlds, which would you choose and why?" Here are some of our favorite responses.

"Titan. Titan has different types of oceans, water and hydrocarbons. The potential for life as we know it and as we don't know it is incredible to think about, not to mention all the interactions there could be between one ocean basically on top of another one. That would really make a splash!"
Thomas Pugh, USA

"Ganymede because it is the largest moon in the solar system. It has auroras, and it has been written about in science fiction so much."
Audrey Espinoza, USA

"Enceladus. It's got the potential for life, and a mission to sample its waters would just have to fly through its geysers. Plus, it's a great excuse to revisit Saturn!"
Caroline Bell, Australia

"Europa. I know Jupiter has a tough environment around it, but I'm impatient and nearly 60 years old! I think it's possible we could get to Jupiter sooner. (I'm already looking forward to JUICE.)"
Simon White, United Kingdom

"Triton. We need to make our first dedicated foray to study distant ice planets and their satellites. A mission to Neptune/Triton would open up an entire new front in our understanding of the solar system. And a Triton orbiter and/or lander would simply be a mind-boggling accomplishment!"
Ross Meisner, USA

"Titan because my dog's name is that."
Brandon Thomas Lemieux, Canada

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A FASCINATION WITH EUROPA

Remembering when the Voyager spacecraft sparked a love affair with an ocean moon

by Kate Howells

THEY SAY YOU SHOULD never judge a book by its cover. In planetary science, it's sometimes best to waive this rule of thumb. Surface features of planetary bodies can give us important hints about what's happening inside a world. In the case of Jupiter's moon Europa, what we saw on the surface opened whole new realms of possibility in the search for life.

When NASA's twin Voyager spacecraft passed through the Jupiter system in 1979, they sent back the first detailed images of the icy moon. These photos showed an unusually smooth surface, suggesting that some process was reworking the icy crust to erase craters and keep the surface young. The images also showed darker stripes crisscrossing the surface along with circular and elliptical lenticulae (Latin for "freckles") dotting the ice. These superficial observations hinted at something monumental: the possibility of a layer of liquid water beneath the surface.

Scientists had already predicted that Jupiter's moon Io might have molten rock beneath its surface because of how Jupiter and its other large moons gravitationally squeeze Io as it makes its way around its host planet. The images of Io that Voyager 1 and 2 sent home showed volcanic activity across the surface, proving that there was indeed a layer of magma beneath its yellowish outer shell.

Though the potential of lava was indeed exciting, much more important was the possibility that this same gravitational squeezing might melt the interior of an icy moon like Europa. When the Voyager probes sent back images of a smooth surface covered in cracks and freckles, the implication was clear: Features like this are caused by tectonic activity. When a solid crust floats on top of a liquid layer, it causes the crust to move, split and constantly resurface itself. Whereas on a rocky moon like Io the liquid layer is molten rock, on icy Europa, the liquid layer is molten ice — in other words, water.

This discovery opened the possibility that life beyond Earth could exist in the frigid far reaches of the solar system. The search for life generally focuses on looking for liquid water, which is an essential requirement for life as we know it. At Jupiter's distance from the Sun, temperatures are so low that water takes the form of ice as hard as granite. The expectation is that life would therefore not be able to exist in these conditions. But the tidal forces that squeeze and heat Europa's interior change the game and in doing so dramatically expand the range of where we might find life.

Further observations by spacecraft, like NASA's Galileo mission, added to our understanding of Europa's subsurface oceans. New discoveries reinforced the possibility that life could theoretically exist in Europa's waters, making this little world all the more important to the search for life. And as you'll read in this issue of The Planetary Report, Europa is not the only world that hides liquid water beneath its surface. Enceladus, Ganymede, Titan and even distant Triton all show signs of subsurface oceans.

The first detailed images of Europa that the Voyager missions sent back were the beginning of an exciting era of planetary science that continues to yield discoveries and intrigue scientists to this day. Future missions, like Europa Clipper, will help uncover more of these ocean worlds' secrets. And with so much yet to learn, we're still only scratching the surface.

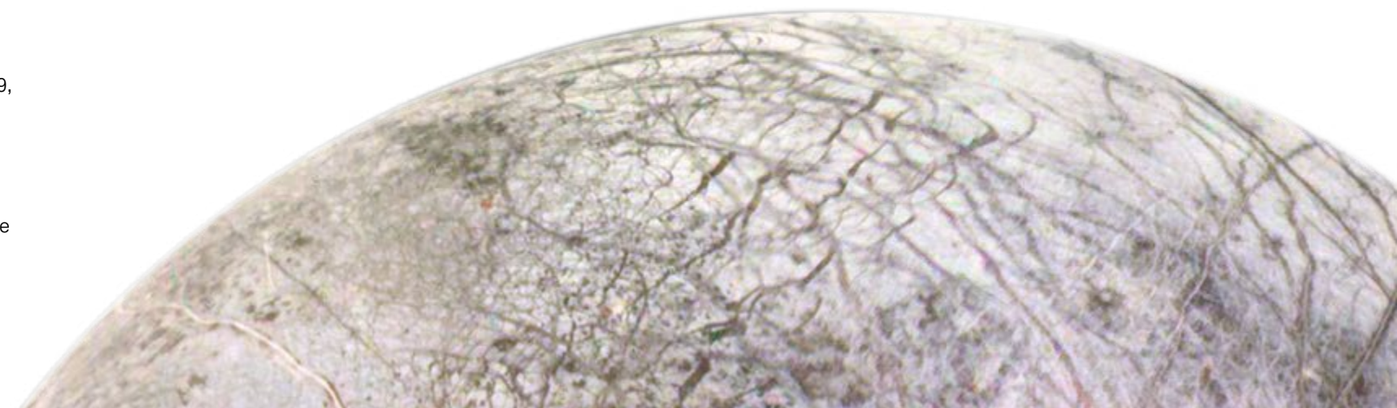
KATE HOWELLS *is communications strategy & Canadian space policy adviser for The Planetary Society.*

OPPOSITE *On March 3, 1979, Voyager 1 captured this view of Europa transiting over Jupiter's Great Red Spot. The image is composed of a 16-frame mosaic made of 41 individual images (16 orange filters and 25 violet filters).*

VOYAGER 1 IMAGING SCIENCE SUBSYSTEM (ISS): NASA/JPL-CALTECH/ ALEXIS TRANCHANDON/SOLARIS

BELOW *Voyager 2 captured the images used to make this high-resolution mosaic of Europa in 1979. The mosaic has been rotated 90 degrees clockwise from its original orientation.*

NASA/TED STRYK/EDITED BY THE PLANETARY SOCIETY



WHERE ARE THE OCEAN WORLDS IN OUR SOLAR SYSTEM?

by Rae Paoletta

OCEAN WORLDS ARE PLANETS, moons and rocky bodies in our solar system where there are large amounts of water.

Many of Saturn and Jupiter's moons — including Enceladus and Europa, respectively — have long been suspected of having oceans concealed beneath their surfaces. But there are other worlds at edges of our solar system that may hold secret oceans of their own, like Neptune's moon Triton.

Currently, Earth is the only ocean world we know of with absolute certainty. But other potential ocean worlds are worth studying and exploring for many reasons. For one thing, it's possible that ocean worlds are among the best candidates to search for life, since life on Earth may have begun in our oceans.

It's impossible to know exactly how many there may be, but the current information at our disposal presents a map — or at least scattered parts of one — to the watery worlds of our cosmic neighborhood.

EUROPA

Jupiter's smallest Galilean moon harbors a global ocean beneath the solar system's most impenetrable snowglobe.

Estimates say Europa's saltwater ocean holds more than twice the amount of water in all of Earth's oceans despite the moon itself being only a fraction of our planet's size. The ocean could plunge as deep as 60 to 150 kilometers (40 to 100 miles) and may have seafloor vents similar to those on early Earth.

Though Europa is one of the most well-known ocean worlds, its subsurface waters have never been directly imaged or explored — for understandable reasons. There would be nothing easy about such a mission; a hypothetical journey toward the center of Europa would've made Jules Verne wince.

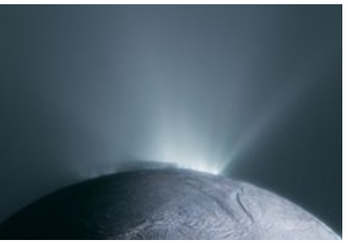
"On Europa, the ice is about 110 kelvins on the surface," said Mohamed Nassif, an aerospace engineering Ph.D. student at Georgia Institute of Technology who has worked on a Europa lander concept. "The hardness of the ice is comparable to a diamond."

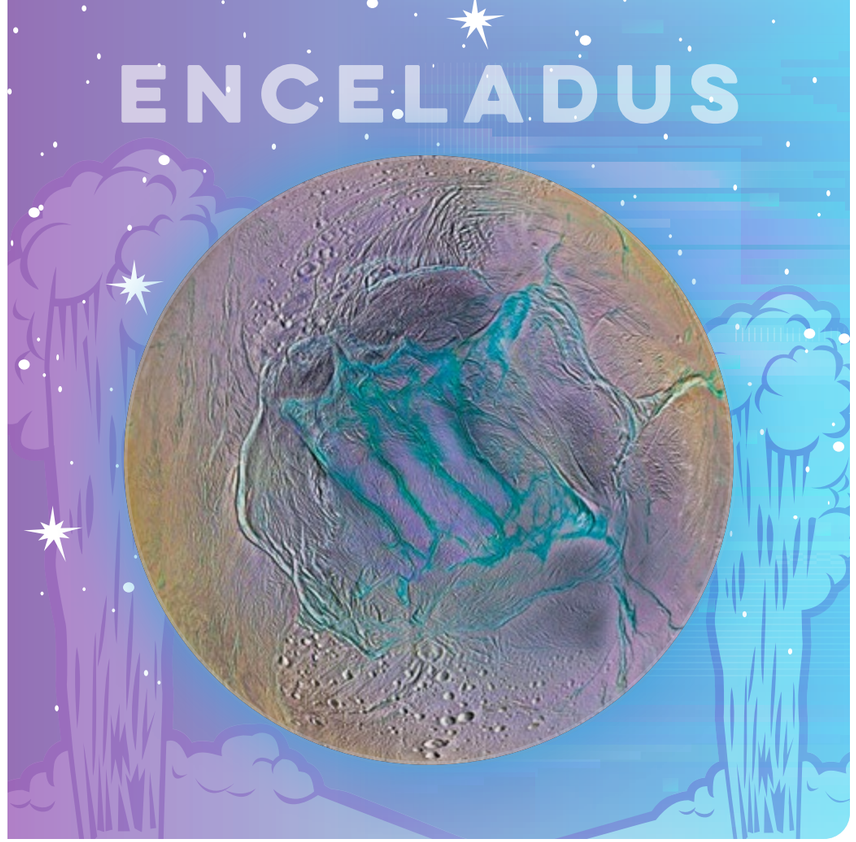
Not only is Europa's icy exterior extremely tough but it's also unclear how deep it really is, making the ocean beneath it even more elusive. NASA estimates that Europa's crust is about 15 to 25 kilometers (10 to 15 miles) thick, with some variation depending on the region. That might not seem large given the enormous scale of everything in space, but for context, the deepest hole ever dug on Earth, Russia's Kola Superdeep Borehole, plunged about 12 kilometers (7.5 miles). That project

ABOVE *Galileo captured this view of Europa on its 14th orbit of Jupiter on March 29, 1998. The image is a mosaic of five different pointings. The filters used for this image cover a broader range of the spectrum than human eyes can see. Galileo was 143,000 kilometers (89,000 miles) from Europa when it took this image at a phase angle of 77 degrees.*
NASA/JPL-CALTECH/TED STRYK

This close-up image of Jupiter's moon Europa shows cracks and ridges colored red by minerals — possibly salts — rising from beneath the icy surface.

NASA/JPL-CALTECH/KEVIN M. GILL





TOP *Enceladus is lit by reflected light from Saturn in this image captured by NASA's Cassini spacecraft.*
NASA/JPL-CALTECH/SSI/GORDAN UGARKOVIC

BOTTOM *Cassini peers across Enceladus' south pole through the moon's watery plumes in November 2010.*
NASA/JPL-CALTECH/SSI/JASON MAJOR

was considered so wildly dysfunctional and expensive that it had to be scrapped, so if we ever plan to perforate Europa's diamond tundra, we have work to do.

In the meantime, there's some progress already in motion. NASA's Europa Clipper, set to launch in 2024 and reach its destination in 2030, will investigate Europa's ocean from afar and assess whether Europa has the right conditions for life.

"Clipper will have 10 instruments, each having an important role," said Caitlin Ahrens, a NASA postdoc at Goddard Space Flight Center. "While the chemical analyses instruments will be used for searching for life on Europa, the spectrometers will also help guide us to where the 'life hotspots' may be."

ENCELADUS

Friendly rivalries can't help but extend all the way to Saturn, even with something as esoteric as saltwater worlds.

Though there are many neutral parties, Europa enthusiasts and fans of Saturn's moon Enceladus are generally happy to debate with each other — and the occasional bystander — about which one is more likely to harbor life. A major selling point for Enceladus is that some of its ocean spray has already been sampled, and the findings so far have been compelling.

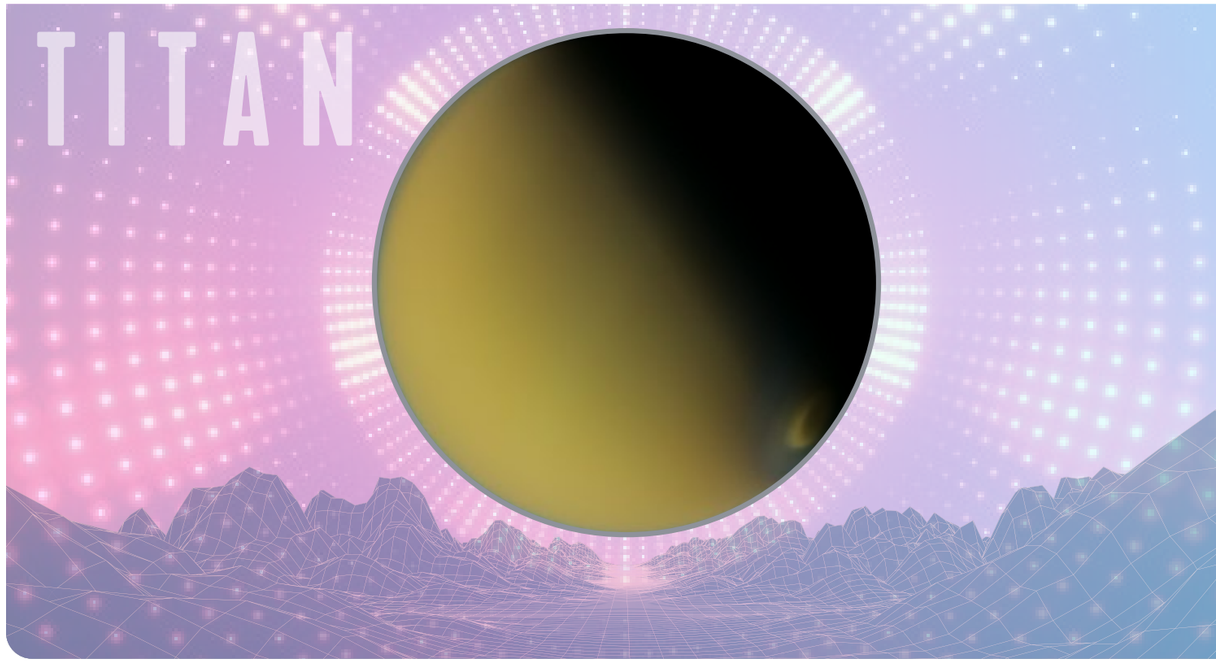
While a handful of spacecraft have visited the Saturn system, it was NASA's Cassini mission that gave us the most unprecedented detail of Enceladus' ocean. Between 2008 and 2015, the spacecraft swept through the moon's plumes, directly sampling its ocean spray. While it didn't detect life, Cassini's discoveries have elucidated Enceladus' ocean, making it an even more tantalizing destination for future study.

"Cassini basically sniffed Enceladus' plumes," Ahrens said. "What it found was not only evidence of liquid salt water but also that it was warm."

Another critical finding was that Enceladus' subsurface ocean has hydrothermal vents on its seafloor. It seems that as Saturn and possibly the planet's moon Dione pull on Enceladus, the tiny moon

LEFT *This view of Enceladus' south pole was created using data from NASA's Cassini spacecraft. To the human eye, Enceladus appears all white, but here, infrared and ultraviolet views have been included in color to highlight fractures where liquid water vents into space. The vents are commonly called "tiger stripes."*
NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE

THIS PAGE *Cassini captured this close-up of Enceladus' south polar vents in 2005.*
NASA/JPL-CALTECH/SSI/JASON MAJOR



flexes, causing material from these vents to eject out of fissures on Enceladus' Southern Hemisphere. Through these so-called "tiger stripes," ocean spray blasts into space.

Though scientists are still combing through Cassini data, it has also become clear that Enceladus' ocean contains molecular hydrogen — which NASA has called "candy for microbes" — as well as other building blocks for life, like carbon dioxide and methane. On paper, it's pretty similar to the conditions that allowed ocean life to propagate on early Earth.

Unfortunately, no space agency has announced concrete plans to return to Enceladus. But if life might be feasting around the moon's hydrothermal vents, perhaps more scientific snuffling is needed to make sure.

TITAN

Described as "bizarro Earth," Titan is arguably one of the most overlooked ocean worlds in the solar system. To be fair, it's easy to ignore what's going on underground when the moon has methane lakes and seas right on its surface. The largest of the latter, Kraken Mare, is a 305-meter-deep (1,000-feet-deep) pool of hydrocarbons. Clearly, it has earned its name.

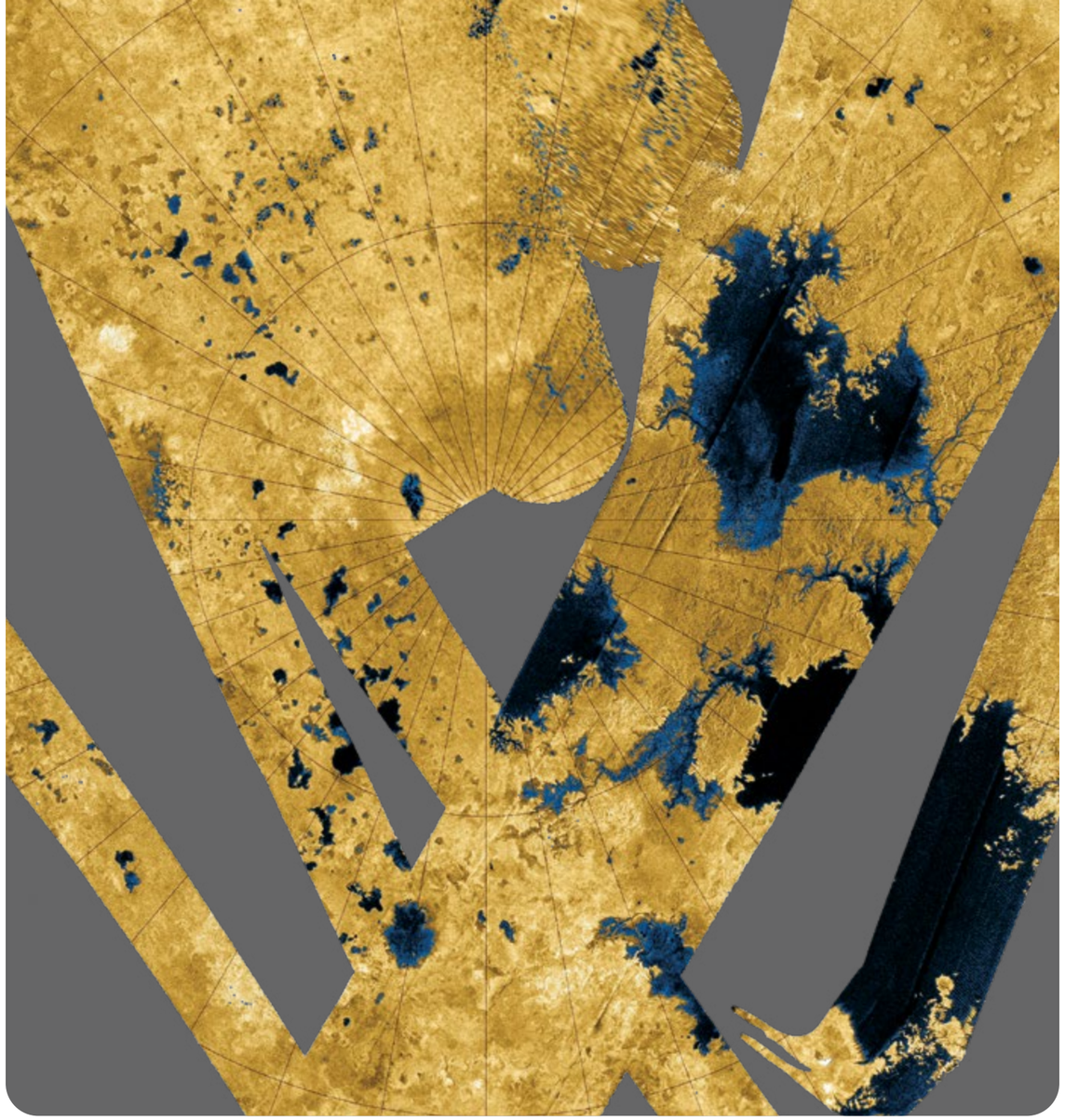
It's precisely Titan's twisted chemistry that makes its oceans — methane, ethane and liquid water — all the more fascinating. In the moon's thick, hazy atmosphere, nitrogen and methane react to form organic compounds that then fall to the surface, interacting with whatever they strike.

"There's this layer of organic deposits on the surface and then there's an ocean too," said Xinting Yu, a postdoc fellow at the University of California, Santa Cruz who is studying Titan. "The coolest thing is when you have a major impact, smashing the surface can get some of the water out from the ocean. And then that'll form a liquid pool for some time."

Some scientists think the organics found on Titan bode well for finding life in its subsurface ocean. Modeling has shown that the moon's liquid water ocean

ABOVE *This color composite of Saturn's moon Titan was made from images acquired by NASA's Cassini spacecraft in January 2013. During this period, a large ice cloud system had formed over the moon's south pole.*
NASA/JPL-CALTECH/SSI/CASSINI IMAGING TEAM/JASON MAJOR

OPPOSITE *Cassini viewed Titan's south polar regions in June 2005, seeing a few dark lakes, less dark lakebeds and bright clouds. The largest south polar lake, Ontario Lacus, is considerably smaller than the lakes at Titan's north pole.*
NASA/JPL-CALTECH/SSI/IAN REGAN



RIGHT *This mosaic is composed of radar maps of Titan's north polar regions captured by NASA's Cassini spacecraft. The radar images are grayscale; they have been colored here so that darker materials are blue and brighter materials are yellow. This color scheme highlights apparent lakes in dark blue and lakelike features in lighter blue.* NASA/JPL-CALTECH

may contain hydrogen and carbon — two key building blocks for life. But NASA's upcoming Dragonfly mission, expected to launch in 2027, will provide a wealth of data directly from the world itself. The quadcopter will search for signs of past or present life on Titan, in its atmosphere and within its underground reservoir.

"Part of the reason for sending Dragonfly is astrobiology-related," Yu said. "It's going to land on the rim of an ancient crater and then hop around, which should answer some questions about the different processes and prebiotic chemistry that could be happening on Titan's surface."

It's anyone's guess what Dragonfly will find in Titan's seas. But if there are methane-munching microbes, it would be nothing short of life altering.

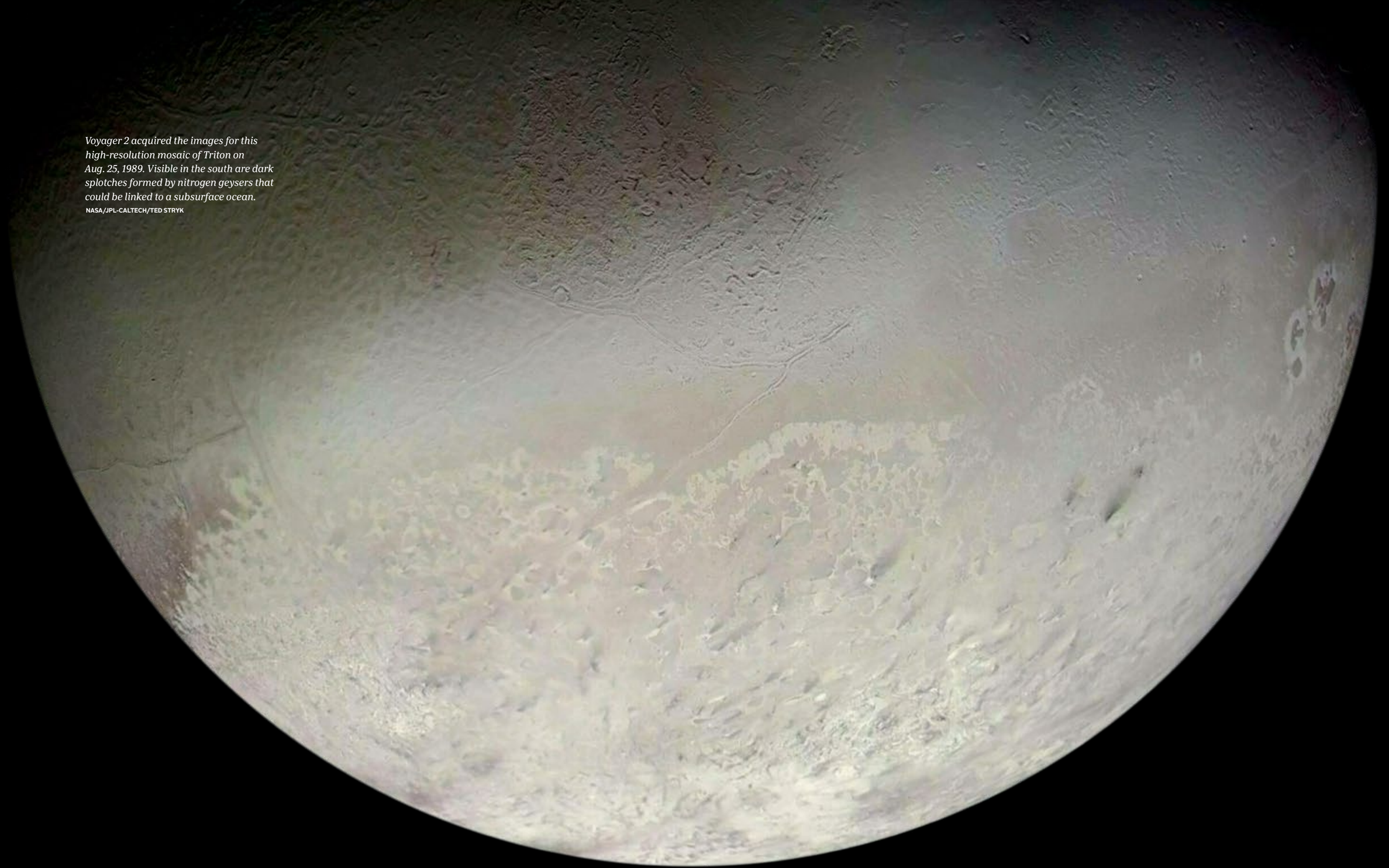
TRITON

The outermost stretches of our solar system are tragically underexplored, and the Neptune system is no exception. Its only visitor,

OCEAN WORLDS

*All water estimates are shown in zettaliters (ZL). 1 ZL = 1,000,000,000,000,000,000,000 liters or 1 billion cubic kilometers

	DIAMETER	MASS	APPROX. DISTANCE FROM THE SUN	ESTIMATED LIQUID WATER
Earth	12,756 km (7,926 mi)	5.97 x 10^{24} kg	149.6 million km (92.9 million mi)	1.3 ZL
Europa	3,100 km (1,940 mi)	4.80 x 10^{22} kg	780 million km (485 million mi)	2.6 ZL
Callisto	4,800 km (3,000 mi)	1.08 x 10^{23} kg	780 million km (485 million mi)	6.3 ZL
Ganymede	5,268 km (3,273 mi)	1.48 x 10^{23} kg	780 million km (485 million mi)	35.4 ZL
Enceladus	504 km (313 mi)	1.08 × 10^{20} kg	1.5 billion km (932 million mi)	0.01 ZL
Titan	5,150 km (3,200 mi)	1.35 × 10^{23} kg	1.5 billion km (932 million mi)	18.6 ZL
Triton	2,700 km (1,680 mi)	2.14 × 10^{22} kg	4.5 billion km (2.8 billion mi)	?
Ceres	945 km (587 mi)	9.47 × 10^{20} kg	413 million km (257 million mi)	?
Pluto	2,370 km (1,473 mi)	1.31 × 10^{22} kg	5.9 billion km (3.7 billion mi)	?



Voyager 2 acquired the images for this high-resolution mosaic of Triton on Aug. 25, 1989. Visible in the south are dark splotches formed by nitrogen geysers that could be linked to a subsurface ocean.
NASA/JPL-CALTECH/TED STRYK

ABOVE *These views of Neptune's moon Triton were captured by NASA's Voyager 2 spacecraft in August 1989.*
NASA/JPL-CALTECH/TED STRYK

Voyager 2, passed through in 1989. For this reason, we have severely limited information on Triton, a fascinating moon that may have a subsurface pool of its own. A secret ocean would certainly be on-brand for something in the realm of the Roman sea god.

While there's an obvious dearth of data, theoretical models suggest Triton could hold liquid water beneath its surface. Some of these models suggest tidal heating from Neptune's gravitational pull could allow Triton's interior to be warm enough to conceal a liquid ocean. In theory, the process is similar to what occurs in both Europa and Enceladus.

But the most compelling and controversial evidence for Triton's ocean comes from a mystery that has spanned more than 30 years. As it flew by Triton, Voyager 2 observed dark plumes shooting from the moon; for this reason, some scientists have compared Triton to Enceladus. However, others have theorized that geysers were a fleeting rarity caused by sunlight striking a specific region on Triton's surface.

That explanation still doesn't satisfy another one of Triton's mysteries: a disappearing act. Voyager images show the moon's surface is geographically young and surprisingly lacking in craters. One idea is that liquid water is "erasing" the craters, which would point to some sort of reservoir beneath Triton's crust.

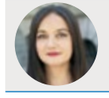
Regrettably, without more missions, Triton remains a scientific wild card.

WHAT THE FUTURE HOLDS (AND WHY IT'S GOOD TO HAVE HOPE)

There's a lot we don't know about the oceans of our solar system, but we're learning more all the time. In fact, we're on the precipice of an exciting new era of ocean world exploration.

In just a few years, Europa and Titan will get their own dedicated missions, which will undoubtedly solve old mysteries and spark new ones. The European Space Agency's JUICE mission, which will investigate three of Jupiter's icy moons, will also scope out Callisto, a so-called "dead moon" that may actually hold a thriving ocean.

So, the search continues, even if it's a slow crawl against the tides of time. May we be so lucky to find life along the way.



RAE PAOLETTA *is the editor for The Planetary Society.*

ABOVE *Amongst the Shoemaker Grant recipients were [top] The SONEAR (Southern Observatory for Near Earth Asteroids Research) Observatory located in Oliveira, Brazil, and [bottom] Fabrizio Bernardi, Maura Tombelli and their colleagues of Gr.A.M. (Gruppo Astrofili Montelupo) shown here gathering at the Beppe Forti Observatory in Italy.*

OPPOSITE *This image was named the best solar system image of the year by our members. It shows LightSail 2's solar sail in the foreground with French Guiana, Suriname, Guyana and the Atlantic Ocean visible in the background.*
THE PLANETARY SOCIETY

KEEPING EYES ON THE SKY

We are pleased to announce the latest round of winners in our Shoemaker Near-Earth Objects (NEO) Grant program, which supports very advanced amateur astronomers who help protect Earth from asteroid impact by finding, tracking and characterizing NEOs.

Thanks to our generous members, we were able to award more money to more recipients than ever before, totaling $74,375. The eight winners are from seven countries on three continents. Over the 24-year history of the program, approximately $515,000 has been granted to 70 winners in 21 countries on six continents. Here are summaries of the newest winners.

Vladimir Benishek of Sopot Astronomical Observatory in Serbia: $9,500 to purchase a 61-centimeter (24-inch) mirror optical set to use in a new telescope enabling observations of fainter asteroids.

Fabrizio Bernardi and Maura Tombelli of Gr.A.M. (Gruppo Astrofili Montelupo) at the Beppe Forti Observatory in Italy: $13,000 for a new camera with a larger CCD (charge-coupled device) detector that provides a much larger field of view.

Massimo Calabresi, Roberto Haver and Raniero Albanesi of Associazione Romana Astrofili in Italy: $7,329 for a more sensitive camera and new filters.

Gary Hug, David Cromer, Doug Goodin and Russell Valentine of the Northeast Kansas Amateur Astronomers League at Farpoint Observatory in the USA: $11,591 to replace their camera and obtain new filters for their 0.7-meter telescope.

Cristóvão Jacques, João Ribeiro and Eduardo Pimentel of SONEAR (Southern Observatory for Near Earth Asteroids Research) Observatory in Brazil: $9,195 for a new camera and a video card. They have discovered a very impressive 35 NEOs.

Korado Korlevic of Višnjan Observatory of Croatia: $12,000 for a new camera, improving sensitivity and download efficiency for their 1-meter telescope.

Florent Losse of France: $3,760 to replace a failed camera and obtain a new secondary mirror. Field of view and sensitivity will both be improved.

Alain Maury (Chile), **Georges Attard** (France) and **Daniel Parrot** (USA) of the MAP survey: $8,000 for two cameras to go from two telescopes to four. Their 33 NEOs discovered in their first 10 months is the highest discovery rate for any amateur observatory ever!

Thanks to our expert advisory and review panel: NEO Grant Coordinator Tim Spahr, NEO Sciences; Davide Farnocchia, JPL; Joanna Levine, NEO Sciences; Carrie Nugent, Olin College of Engineering; and Michael Schwartz, Tenagra Observatories.

Thank you, members, for your support in keeping Earth safe from impacts! For more information, go to **planetary.org/defense**.

ADVOCATING FOR THE FUTURE OF SPACE SCIENCE AND EXPLORATION

Planetary Society members helped keep NASA's budget on track for 2022 by writing to Congress in support of funding for the agency. Hundreds of people took part in the letter-writing campaign at the end of 2021. Members also supported an event in Washington, D.C. organized by The Planetary Society's space policy and advocacy team that brought together lawmakers and space policy experts.

LOOKING BACK ON AN IMPACTFUL YEAR

Space wasn't the only place where great things happened last year. The Planetary Society also had a tremendous year thanks to the support of members like you. Highlights included our LightSail 2 spacecraft being featured in the Smithsonian Institution's FUTURES exhibit in Washington, D.C.; virtual celebrations, like Asteroid Day and the phenomenal Planetfest '21; and our co-sponsorship of the biennial Planetary Defense Conference. There's much more on which members can look back with pride in our 2021 Impact Report at **planetary.org/impact2021**.

CELEBRATING THE BEST OF 2021

Last year may seem like a distant memory by now, but we're still cheering for the winners of our second annual Explorer's Choice Awards. In November, Planetary Society members and supporters voted for the best things space science and exploration brought us in 2021, and the winners reflect just how exciting a year it was. We're very proud that voters chose an image (above) from The Planetary Society's crowdfunded solar sailing spacecraft, LightSail 2, as the space image of the year. And it was no big surprise that NASA's newest Mars missions racked up wins for mission of the year (Perseverance) and most exciting moment in planetary science (Ingenuity's first flight). You can see the rest of the winners at **planetary.org/bestof2021**.

TAKING ACTION AROUND THE WORLD

The Planetary Society held our annual Day of Action on March 8, taking place once again in an entirely virtual format. Members registered to meet with their representatives and staffers in Congress to advocate for The Planetary Society's top space policy priorities: planetary exploration, planetary defense and the search for life. Across the country, thousands of other space advocates supported the Day of Action by emailing and calling Congress to strengthen the same messages. Around the world, Planetary Society members called on their governments to increase their involvement in international planetary defense efforts. By coming together under one shared banner, Planetary Society advocates made sure these important messages were heard by those in power.


ADVOCACY WORK IN WASHINGTON, D.C.

ADVANCING SPACE ADVOCACY

Right now, we're in the midst of a campaign to support our space policy and advocacy work. This crucial program makes sure that decision-makers in Washington, D.C. know how much the public values NASA and its efforts to explore the cosmos. And with increasing advocacy activities in other countries, this program is expanding its reach to make sure every nation does its part to defend our planet from asteroids and explore deep space. You can help keep our space policy and advocacy program going strong by making a gift today at **planetary.org/takeaction**.

There are also actions you can take right now to make your support for space science and exploration known. Go to **planetary.org/action-center** to learn more.

To learn more about our space policy and advocacy program and how you can get involved, keep an eye out for an email invitation to our upcoming members-only telecon, where you can hear directly from our chief advocate, Casey Dreier, and our director of Washington, D.C. operations, Brendan Curry. They'll share exclusive insights on U.S. space policy and the actions that you can take right now to make the future of space brighter.


YURI'S NIGHT PARTY

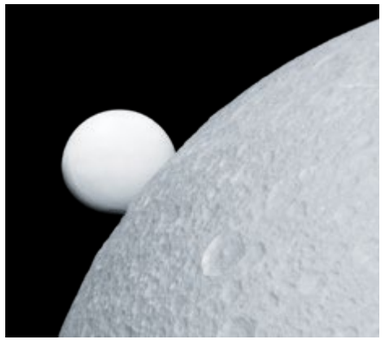
CELEBRATE SPACE ON YURI'S NIGHT!

One of the world's biggest annual celebrations of space is coming up! Every year on or around April 12, we are proud to partner with Yuri's Night, a celebration of all that humanity brings to the exploration of the cosmos: music, art, science, culture and each other. Yuri's Night brings people around the world together to celebrate space, inspire exploration and, of course, have fun. You can join virtual events, find tips for organizing your own celebrations and learn more at **yurisnight.net**.

ABOVE *Planetary Society members celebrating the launch of LightSail 2 together at Kennedy Space Center on June 25, 2019.*
THE PLANETARY SOCIETY

SPREAD THE JOY OF SPACE

Right now, we're calling on you to help us reach our goal of 75,000 members. If being a Planetary Society member has meant something to you, we ask you to tell your friends and family about it and invite them to join the Society. Our members have a direct role in creating the future of space science and exploration, including advocating for missions, sharing cool information about space with others and funding innovative science and technology projects all in collaboration with other leading space agencies and organizations around the world. With your support, we can grow our global community of space advocates and do even more to advance space science and exploration.



Although Dione (near) and Enceladus (far) are composed of nearly the same materials, Enceladus has a considerably higher reflectivity than Dione. As a result, it appears brighter against the dark night sky. This view looks toward the leading hemisphere of Enceladus. North on Enceladus is up and rotated 1 degree to the right. The image was taken in visible light with the Cassini spacecraft narrow-angle camera on Sept. 8, 2015.
NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE

WAKE UP TO PLANETS!

IN THE SKY

There is a pre-dawn planet party in the east. In late March and early April, extremely bright Venus, yellowish Saturn and reddish Mars form a tight cluster. On the morning of April 5, Mars and Saturn are particularly close. Then, Saturn will move up and Venus down as the weeks pass. Very bright Jupiter will join the fun, climbing up the sky over the weeks starting in April. It will be very close to even brighter Venus on April 30 and very near reddish Mars on May 29. Even Mercury joins the party below Venus for much of June. On April 30, a partial solar eclipse will be visible from the southeastern Pacific Ocean and southern South America. On May 16, a total lunar eclipse will be visible from North and South America and portions of western Europe and western Africa. For more night sky tips, you can always check out **planetary.org/night-sky**.

RANDOM SPACE FACT

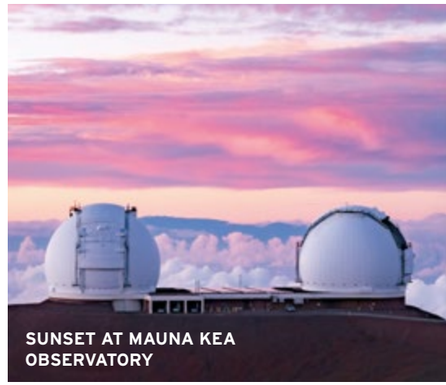
Saturn's moon Enceladus has the most reflective surface of any planetary body. Ice particles settling on the surface from the south polar plumes keep Enceladus reflecting about 80% of the sunlight that hits it.

TRIVIA CONTEST

Our September equinox contest winner is Gary Toller of Columbia, Maryland, USA. Congratulations! The question was: ***What was the James Webb Space Telescope called before being named for former NASA Administrator James Webb?*** The answer: ***The Next Generation Space Telescope, or NGST.***

Try to win a copy of "Astronomy for Kids" by Bruce Betts and a Planetary Radio T-shirt by answering this question: ***What chemical element is named after the Sun, and which is named after the Moon?***

Email your answer to planetaryreport@planetary.org or mail your answer to The Planetary Report, 60 S. Los Robles Ave., Pasadena, CA 91101. Make sure you include the answer and your name, mailing address and email address (if you have one). By entering this contest, you are authorizing The Planetary Report to publish your name and hometown. Submissions must be received by June 1, 2022. One entry per person. The winner will be chosen in a random drawing from among all the correct entries received. For a weekly dose of What's Up? complete with humor, a weekly trivia contest and a range of significant space and science fiction guests, listen to Planetary Radio at planetary.org/radio.


SUNSET AT MAUNA KEA OBSERVATORY

Please contact Terri or Taunya at Betchart Expeditions for brochures and updated information on COVID and travel. Call 1-800-252-4910 or go to betchartexpeditions.com.

Every year, members of The Planetary Society discover the world on Betchart Adventures! We hope you can join us this year.

ARIZONA SKIES AND NEW DISCOVERIES
APRIL 17-24, 2022
Explore the natural and astronomical wonders of this desert paradise!

WEST GREENLAND AND DISKO BAY
JUNE 23-30, 2022
Discover the fabulous landscapes of West Greenland, including the immense glacier at Disko Bay. A rare opportunity with a profusion of sled dogs!

HAWAII TOTAL LUNAR ECLIPSE
NOVEMBER 6-14, 2022
See the total lunar eclipse on the Big Island of Hawaii with astronomer Dr. Tyler Nordgren. Also visit Hawaii Volcano National Park and astronomical observatories that explore our solar system, galaxies, black holes and more!

BALI AND EAST TIMOR
TOTAL SOLAR ECLIPSE
APRIL 10-23, 2023
Enjoy the enchantment of Bali, see the Komodo dragons on Flores and then fly to East Timor to see the total solar eclipse.

ALASKA AURORA BOREALIS
MARCH 16-23, 2023
Discover magnificent Denali and the northern lights in the pristine splendor of Alaska in winter.

The Planetary Society

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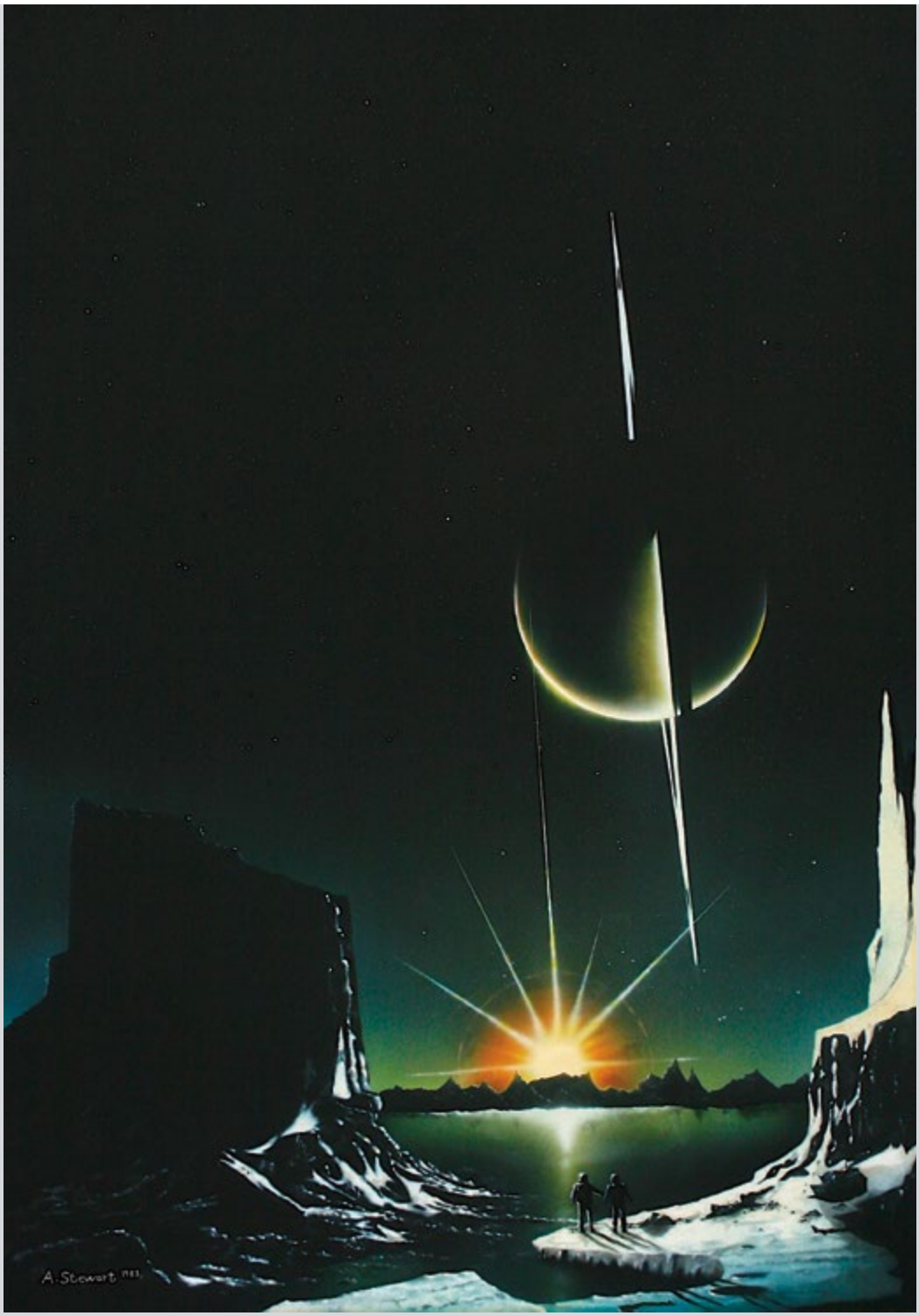
PASADENA CA 91101-2016 USA



Andrew Stewart, "Saturn Edge-On"

For now, spacecraft serve as humanity's eyes and ears in deep space. Still, when a robotic probe sends back an image from its position in orbit or on the surface of a distant world, we all imagine what it would be like to see that view for ourselves. This painting from Planetary Society member Andrew Stewart shows a view that any space advocate would dream of seeing. Two imagined astronauts stand on the surface of Titan, looking out across a great methane lake to see Saturn edge-on with the Sun's rays breaking beyond. Until humans can make it to such distant worlds, we'll keep advocating to send robotic emissaries out there to take in views like this on our behalf.

Do you want to see your artwork here? We love to feature our members throughout this magazine.
Send your original, space-related artwork to *connect@planetary.org*.