THE PLANETARY SOCIETY

THE PLANETARY REPORT

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THE SEARCH FOR LIFE

HOW LIFE ON EARTH SHAPES THE HUNT FOR LIFE OUT THERE

WONDERING WANDERERS SEEKING THE SAME

Searching for life in all its possible forms

by Bill Nye

AS A LIVING THING here on Earth, I've always been fascinated with the idea that both Charles Darwin and Alfred Wallace reasoned that all life on Earth must have arisen from a single common ancestor. In their time, they were called "naturalists" — investigators working to know nature and its ways.

After studying as many living things as they could get their hands (and eyes) on, Darwin and Wallace figured it would be extraordinarily unlikely that two completely different types of living things showed up at the same moment here on Earth, maintaining their metabolisms and reproducing. They reached the conclusion that all life must have come from a single being. But other researchers speculate that there may have been or even still is a whole other form of life on Earth, and we just haven't found it yet — some undiscovered microorganism living in cracks in rocks deep underground, or something.

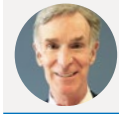
I cannot help but remember the time I wandered onto the third floor of the space sciences building in college and came across a very large, nearly spherical glass vessel with electrodes sparking away, in which researchers were trying to coax chemicals to start living. It was a form of the famous Miller-Urey experiment, testing the hypothesis of life beginning when lightning struck certain self-organizing compounds in a "primordial soup" in ancient Earth's ocean. This setup doesn't quite do the trick. Researchers pondering the problem are now working with extraordinary gene sequencing machines and other instruments to tease out the missing details of the molecular arrangements that may have led to us. The question remains: Where did Earth's life come from? It's something to consider as we explore worlds and learn more about what it takes to stay alive on our own world.

As I write, astrobiologists around the world are trying to understand the process by which we all came to be so that we can extend that understanding to the search for life in the Cosmos. By the way, when the search for extraterrestrial life started being taken seriously, the discipline was called "exobiology" rather than "astrobiology." Perhaps the prefix "ex" had an "it's-already-over" connotation, so it didn't catch on. But of course, the excitement about the possibility of life elsewhere in the Universe is stronger than ever.

In February, The Planetary Society held a Search For Life Symposium at our headquarters. Experts from universities and space agencies — including those whose expertise is featured in this issue — came together to share their research and ideas. For me, this was utterly fascinating.

If we came across another self-replicating form out there, how would we know that it's alive — or what we think of as alive? Is it something akin to a mineral or crystal that grows and throws our reasoning off course? Does this growing form wonder about wandering forms like us? It's the search for life writ large as can be. That search gets to us all. It's intimately connected with what we do here at The Planetary Society.

Thank you for your support and for helping us all ponder our origin and our place in space.



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

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ABOVE *This is a composite image from NASA's Chandra X-ray Observatory and the James Webb Space Telescope. Pictured is Rho Ophiuchi at a distance of about 390 light-years from Earth. Rho Ophiuchi is a cloud complex filled with gas and stars of different sizes and ages. Being one of the closest star-forming regions, Rho Ophiuchi is a great place for astronomers to study young stars. In this image, X-rays from Chandra are purple and reveal the hot outer atmospheres of infant stars. Infrared data from Webb's NIRCam is red, yellow, cyan, light blue, and darker blue and provides views of the spectacular regions of gas and dust.*

X-RAY: NASA/CXC/MIT/C. CANIZARES; IR: NASA/ESA/CSA/STSCI/K. PONTOPPIDAN; IMAGE PROCESSING: NASA/ESA/STSCI/ALYSSA PAGAN, NASA/CXC/SAO/L. FRATTARE AND J. MAJOR

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EARTHLINGS AS ALIENS

Looking at life on Earth from another perspective

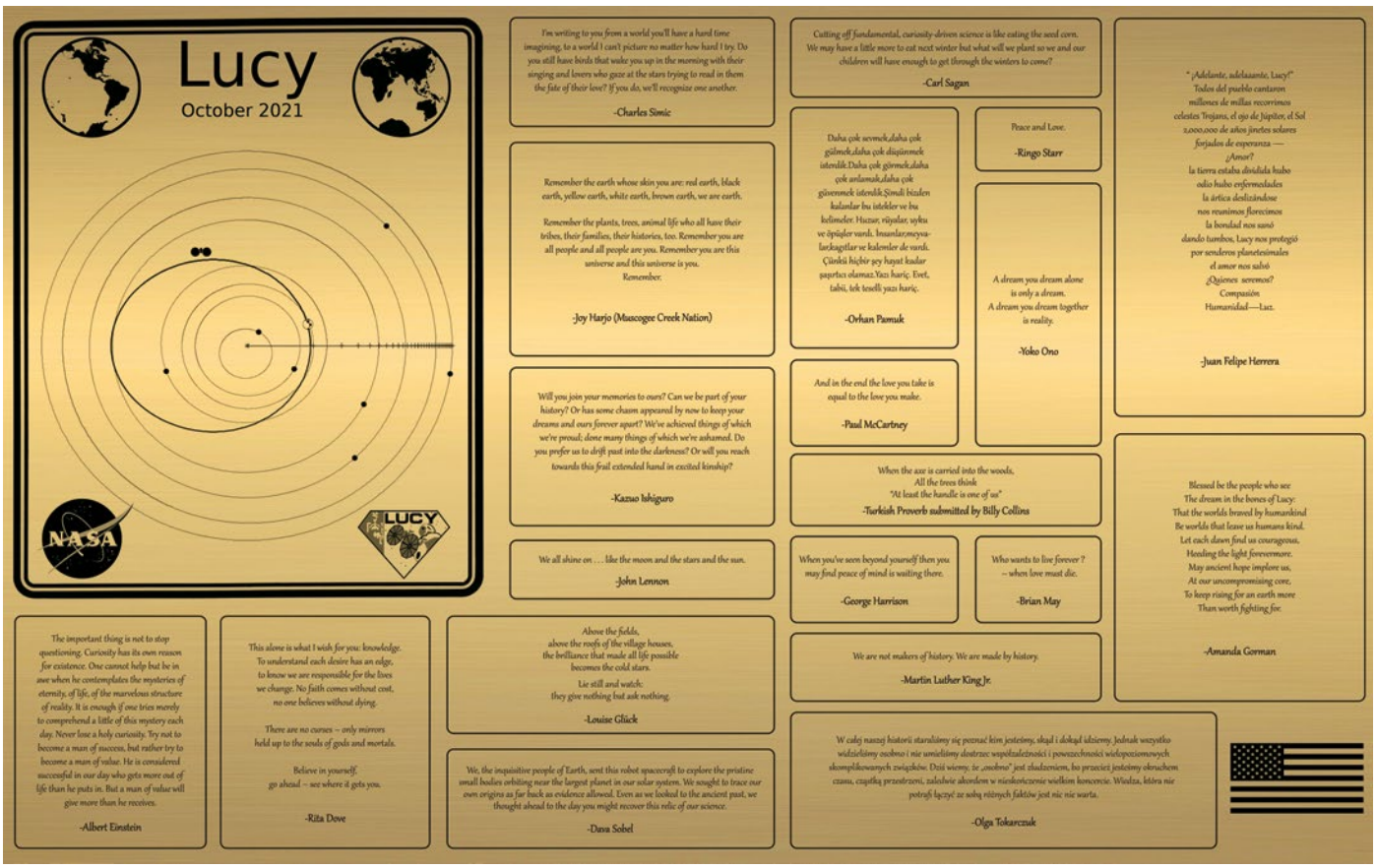
by Kate Howells

PART OF WHAT makes the search for life so fascinating is the way it contextualizes our existence here on Earth. If there is indeed intelligent life out there, those beings may be searching for us just as we are searching for them.

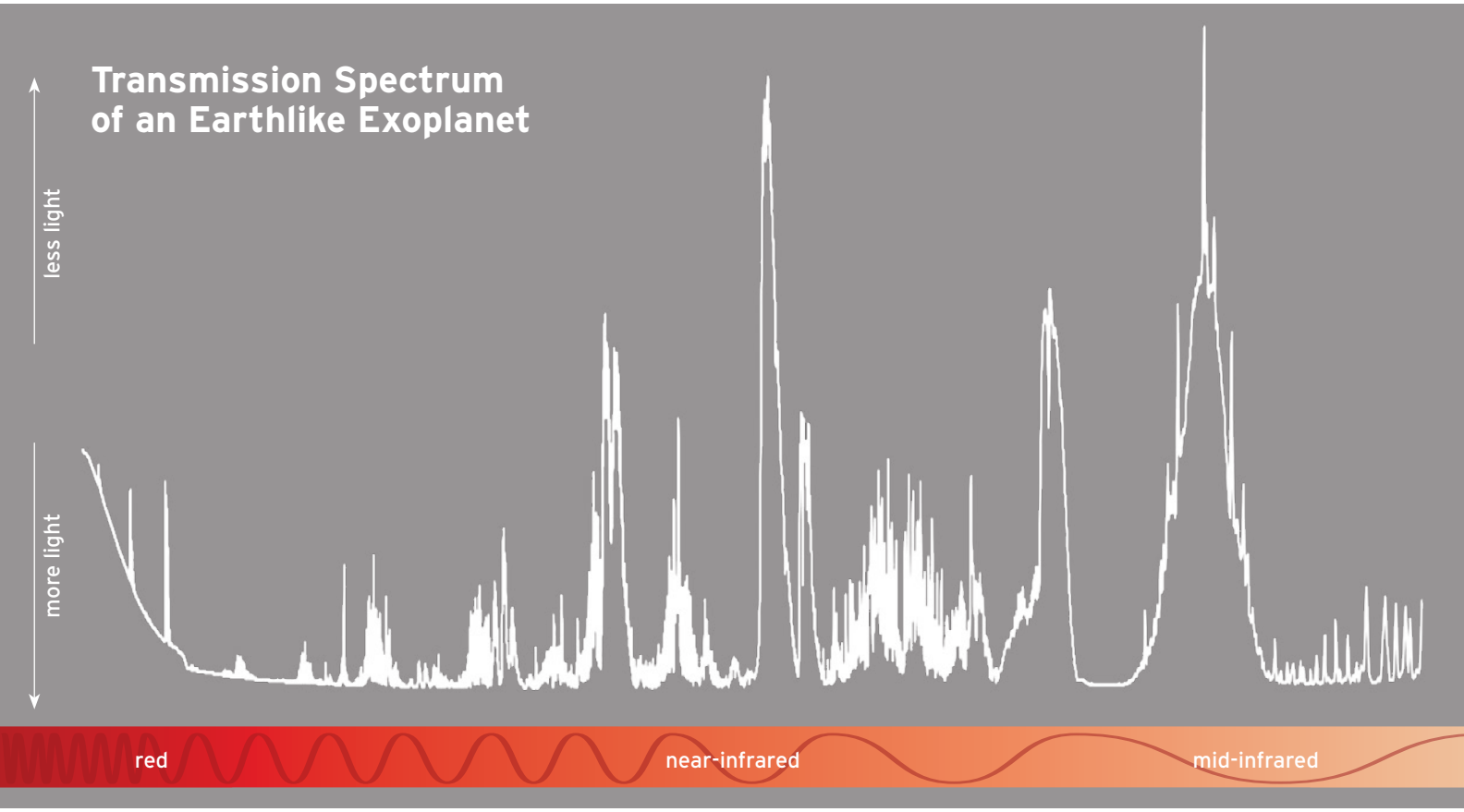
So, if aliens were to detect our presence, what might they find?

Imagine an alien civilization light-years away from Earth at about the same level of technological development as humans. They may detect Earth's existence — an exoplanet from their perspective. They'd know that it is at the right distance from the Sun to support liquid water on the planet's surface, and if those aliens were water-based life forms like us, they might see this as a promising sign of habitability.

If they focused their observations on us using an instrument akin to the James Webb Space Telescope or Habitable Worlds Observatory, they could potentially analyze



BELOW *The Lucy spacecraft carries a plaque as a time capsule, including messages from prominent thinkers of our time and a diagram showing the positions of the planets on the date of Lucy's launch.* **NASA**



our atmosphere and discover oxygen (a potential sign of biological activity) and perhaps industrial pollutants (good indicators of technological activity). If they pointed radio telescopes at us, they might pick up transmissions we've sent out over the years.

Another way aliens could discover evidence of human activity is through the artifacts we've sent into space. The Voyager and Pioneer probes are equipped with messages for any beings who might encounter them long after they leave the Solar System. Although the chances are slim that they'd be found in the vast emptiness of space, it's still possible. Some intelligent, space-exploring aliens could someday find these artifacts and learn about Earth, its creatures, and human cultures.

The Lucy spacecraft is a different kind of artifact. Right now, Lucy is on its way to study the Jupiter trojans, groups of asteroids that share Jupiter's orbit around the Sun. After it completes its study of its targets, Lucy will continue to orbit the Sun for millions of years. It carries a sort of time capsule from Earth just in case it's someday discovered by an alien species that comes to our Solar System in search of us, only to find that humans have long since gone extinct. This possibility may sound bleak, but it's another avenue for something deeply meaningful. Somehow, someday, our species and its capabilities might come to be known by others who share our most fundamental characteristic: life.

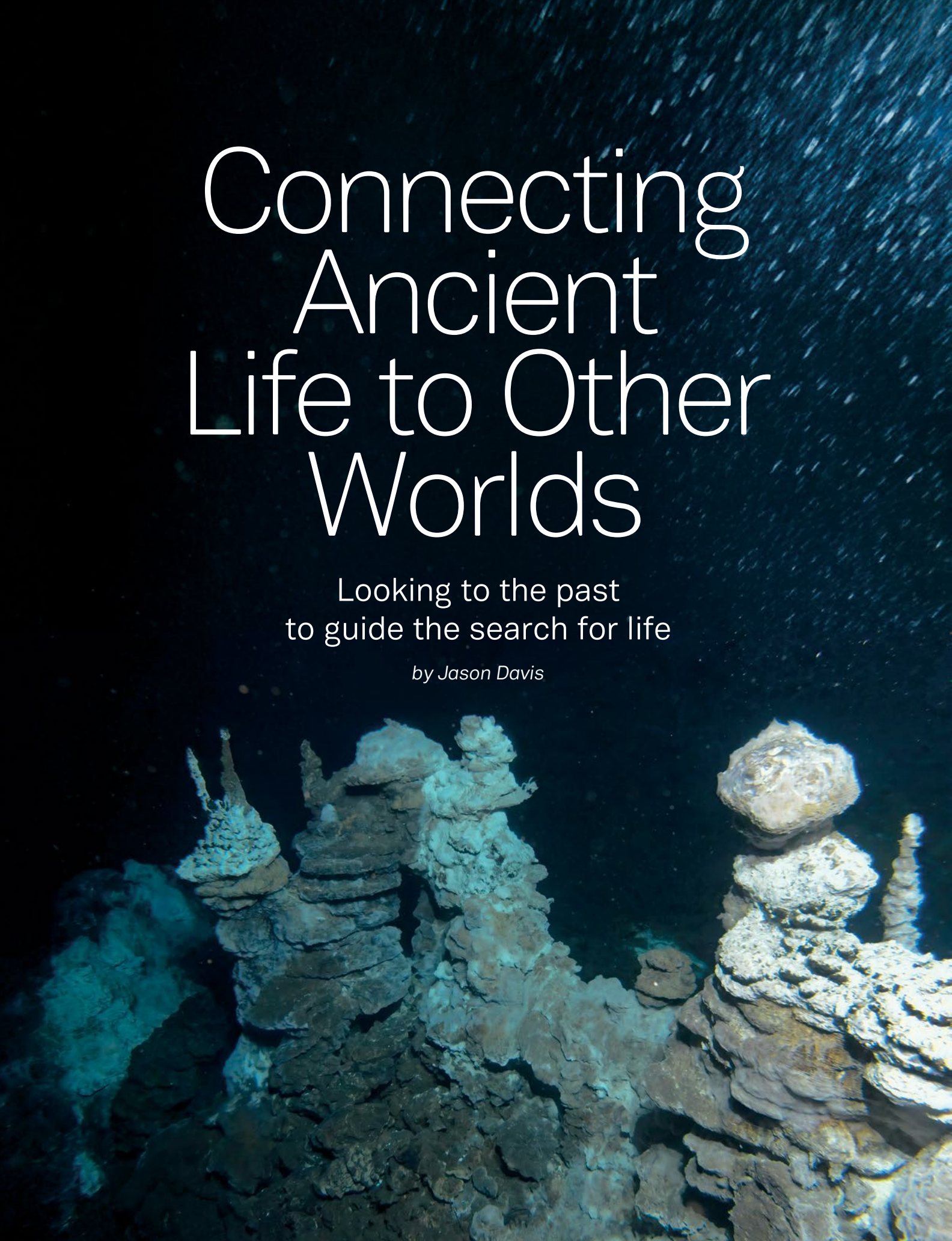
KATE HOWELLS *is the public education specialist for The Planetary Society and editor of The Planetary Report.*

ABOVE *This graph shows what a red to mid-infrared transmission spectrum of an Earthlike exoplanet would look like to the James Webb Space Telescope. As sunlight is filtered through the planet's atmosphere, different relative amounts of each wavelength of light make it through.*
MODEL DATA FROM T. ROBINSON, NAU

Connecting Ancient Life to Other Worlds

Looking to the past to guide the search for life

by Jason Davis



IN THE FINAL EPISODE of "Star Trek: The Next Generation," Captain Picard and the godlike entity Q travel to Earth's ancient past. Volcanoes dominate the landscape, and sulfur fills the air. Q points out a green puddle where a group of amino acids is about to combine and form the first protein, marking the beginning of life on Earth.

"This is you," Q says as he dips his hand into the puddle. "Everything you know, your entire civilization, it all begins right here in this little pond of goo."

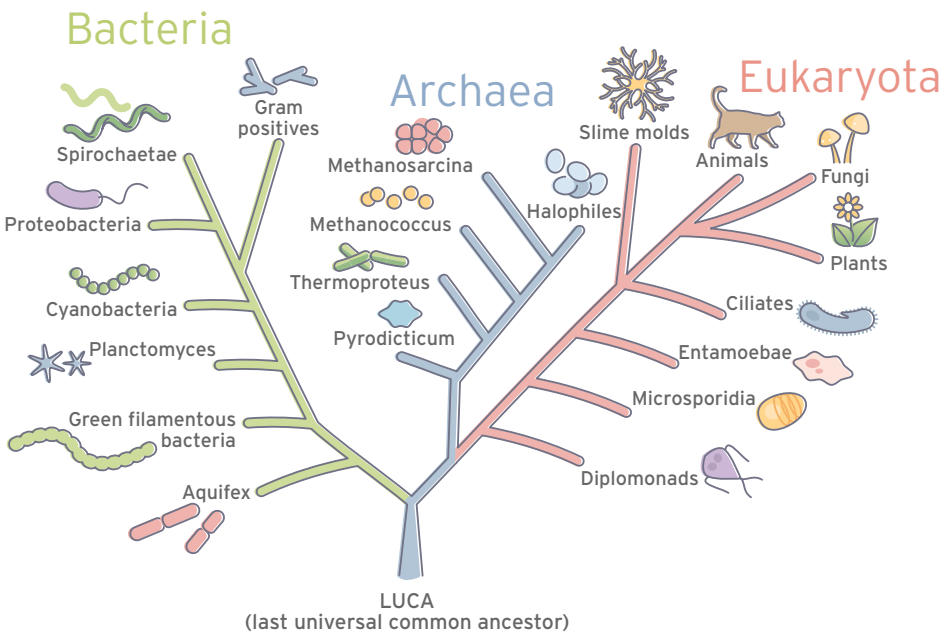
At The Planetary Society's Search for Life Symposium in February 2024, Betül Kaçar used an image from this scene in her presentation on how understanding ancient Earth life can help us search for life on other worlds.

Kaçar is an associate professor of bacteriology at the University of Wisconsin-Madison, where she and her colleagues are using artificial DNA to reconstruct some of the earliest living organisms and study how they may have evolved into life as we know it today. What they learn will be helpful as we examine the atmospheres of Earthlike exoplanets, looking for signs of life as we know it and how it may have existed billions of years in the past.

"As someone who studies the origin of life and its early evolution, I'm interested in connecting what we learn from our past to finding life elsewhere," Kaçar said. "'Star Trek' has been quite influential."

SEARCHING FOR LUCA

In 1952, the chemists Stanley Miller and Harold Urey conducted a series of now-famous experiments in which they replicated the conditions of early Earth. Using a system of glass flasks and tubes, they applied sparks of electricity to a mixture of methane, ammonia, hydrogen, and water. After about a week, they discovered the chemicals had organized themselves into amino acids, some of which are found in all living things. The implication was that a soup of basic chemicals may be able to evolve into life if given the right conditions — a theory called abiogenesis.



When can you call a puddle of chemicals life? While this philosophical question has long been debated, Kaçar said that life can be thought of as "chemical intelligence," or chemistry with memory that allows it to respond to challenges in the same way over time.

Kaçar is interested not only in how life began but how it evolved into LUCA, our last universal common ancestor. LUCA was an ancient population of organisms with a shared set of traits that became the ancestor of all living things. From it sprung bacteria (single-celled organisms) and archaea (similar to bacteria but can live in more extreme conditions). Eukaryotes, organisms that contain cells

ABOVE *Proposed phylogenetic tree linking all major groups of living organisms, namely the Bacteria, Archaea, and Eukaryota, with the last universal common ancestor (LUCA) shown at the root.*
GETTY IMAGES/LOREN A. ROBERTS

OPPOSITE *The field of hydrothermal vents known as Loki's Castle is located in the North Atlantic Ocean, where scientists found archaea believed to be related to the archaea that created eukaryotes through symbiosis with bacteria.*
R.B. PEDERSEN/CENTRE FOR GEOBIOLOGY

with a nucleus, such as plants, animals, and humans, either evolved directly from LUCA or as part of a symbiotic relationship between bacteria and archaea.

"It's not just about having the right chemistry at the right time in the right condition," Kaçar said. "You also need to understand how to bridge the origin of life to our last universal common ancestor. Biology offers observational and experimental testbeds of genuine, multilevel complexity in a way that no other chemical or physical system alone can."

ABOVE *Betül Kaçar, speaking at TED in 2021, discusses how a deeper understanding of chemistry could lead to the recipe for life on other worlds.* **TED (CC BY-NC-ND 4.0)**

Scientists have been attempting to construct a genetic portrait of LUCA by tracing the genes of living things back through time. In recent years, they have hypothesized that it may have lived near hydrothermal vents on the ocean floor, where all it required were water, rocks, and heat. A similar situation could be happening deep within the subsurface oceans of moons like Europa or Enceladus.

Kaçar believes that figuring out how the first life on Earth evolved can lead to unique biotechnological applications. She and her colleagues use artificial DNA to reconstruct ancient life in the lab and then study it in the chemical conditions that may have existed on early Earth. Her group recently created a cookbook of hundreds of chemical recipes with the potential to give rise to life. This will help them put together a more complete picture of how chemical intelligence actually evolved. Her lab is one of the few in the world to combine synthetic biology and evolutionary engineering to understand the origins and early evolution of life on Earth.

UNIVERSAL CHEMISTRY

Chemistry, as far as we know, is universal throughout the Cosmos. That means if we can get a clearer picture of how life evolved on early Earth, we can apply that knowledge to other worlds. Kaçar said this will come down to understanding how evolution operates at the dawn of life.

With missions like JWST already scanning the atmospheres of Earthlike exoplanets and new powerful ground- and space-based telescopes coming online in the future, scientists will need all the help they can get to interpret what they are seeing.

"When our colleagues look through their amazing telescopes, we want to be able to guide them properly: 'Here are the possible chemistries that can lead to life, and here are feasible environments in which that chemistry can exist,'" Kaçar said.

With so many promising tools and technologies available, there's never been a better time to explore our origins.

"We are at the cusp of figuring out something quite fundamental about ourselves and life on Earth," said Kaçar. "And that will profoundly shape the way we look for life in the Universe and ultimately, our place in it."

JASON DAVIS *is the senior editor for The Planetary Society.*

EXTRATERRESTRIAL ARTIFACTS

Could the Solar System host traces of other intelligent life?

by Asa Stahl

THE SEARCH FOR LIFE beyond Earth is as diverse and wide-ranging as life itself. Some scientists hunt for simple organisms, like microbes, by looking for signs of biological activity. Others search for technology, hoping full-fledged intelligent life is out there with abilities comparable to our own. When most people think of the search for extraterrestrial intelligence (SETI), though, they may only think of one thing: scanning the galaxy for communication signals from distant worlds.

But not all searches for alien technology look to other stars. Whether hunting for radar anomalies or unnatural glints from another world, the search for extraterrestrial artifacts (SETA) is dedicated to scouring our very own Solar System. This is what distinguishes SETA from more traditional searches for alien intelligence.

SPOTTING ALIEN ARTIFACTS

Could evidence of alien technology, even long defunct, truly exist within the Solar System? According to Jacob Haqq-Misra, senior research investigator at the Blue Marble Space Institute of Science and a participant in The Planetary Society's Search for Life Symposium, it's a feasible possibility, and that means it's worth scientific investigation.

Consider the timescales involved. The planets of the Solar System have been around for 4.5 billion years, and the galaxy itself is about 9 billion years old. As Haqq-Misra puts it, that's "plenty of time" for

ABOVE *The SETI Institute's Allen Telescope Array in northern California searches the sky for radio signals from an alien intelligence.*
THE SETI INSTITUTE

ABOVE *This artist's impression shows the first detected interstellar asteroid: 'Oumuamua. This unique object was discovered on Oct. 19, 2017, by the Pan-STARRS 1 telescope in Hawai'i. 'Oumuamua seems to be a dark red, highly elongated metallic or rocky object about 400 meters (1,300 feet) long and is unlike anything normally found in the Solar System.*
ESO/M. KORNMESSER

alien life to arise and then leave evidence of itself here. There are a few different scenarios for how exactly that might have happened, according to SETA scientists. Intelligent life might have previously inhabited the Solar System, leaving behind evidence of their presence. Lifeforms from elsewhere might have sent a probe to our system that is still here but no longer works, or maybe they could have even sent a probe here that remains active to this day.

"How would we know?" asks Haqq-Misra. "How would we recognize extraterrestrial technology if we found it?"

This is what motivates Haqq-Misra and his colleagues' work. They develop and test ideas for what signs of alien technology — also known as "technosignatures" — might look like. Some pieces of evidence, like an intact alien probe, would clearly advertise their extraterrestrial nature. Others would be more subtle, like discovering chemical anomalies in Martian soil that hint at the past use of nuclear fuel or refined metals. Radar surveys could also look for unnaturally shaped objects, searches in visible light could find particularly reflective surfaces that might be artificial, and infrared telescopes could detect waste heat from machines. Many of these efforts could get started using data that scientists already have in hand.

To date, though, Haqq-Misra says he can count the number of SETA research papers on two hands. One group searched for anomalies in a broad survey of the sky. Others performed radio studies of 'Oumuamua, an unusual interstellar object that would later be best explained as an icy fragment of a planet from another star system. Another looked for artificial objects that share Earth's orbit. And most recently, a collaboration used machine learning algorithms to search for anomalies on the surface of the Moon.

"That's it," says Haqq-Misra. "There's tons of work to be done."

A SHIFT TOWARD SETA

For years, lack of interest and recognition from the wider scientific community, especially in the form of funding opportunities, has prevented SETA from doing more. "There's been stigma," explains Haqq-Misra. After all, if SETA relies on the notion that aliens at one point interacted with the Solar System, it's not a huge leap to project that interaction onto Earth itself. But unlike unidentified aerial

phenomena (UAP) conspiracy theorists, SETA researchers apply the scientific method to data collected in controlled experiments, testing their hypotheses and fitting them into a wider research dialogue.

For Haqq-Misra, this stigma is part of what drove him to pursue these research projects in the first place.

"When you tell me 'don't study something,'" he says, "then — well, let's study that thing!"

Haqq-Misra and his colleagues have been working to shift scientific culture away from this stigmatization. They have spread the word about the potential value of technosignatures through both research papers and conversations with other scientists. The status quo may now be starting to shift. At the direction of the United States Congress, NASA opened up funding opportunities for technosignature research a few years ago. Haqq-Misra's collaboration received one of the first grants related to nonradio technosignatures.

"Things have changed," he says. "We can talk about Solar System SETI in a completely detached way from anything in pop culture."

TO SEARCH OR NOT TO SEARCH

Stigma aside, SETA still has its detractors. One issue is timing. The more time an artifact spends in the Solar System, the less likely it is to survive to the present day unscathed. On geologically active worlds, surface artifacts would be destroyed (or at least buried) by volcanism, tectonics, and erosion. Even on inactive worlds, asteroid impacts could destroy most artifacts within hundreds of millions of years. And orbiting artifacts, like lurkers, might eventually be knocked out of their orbits or damaged by impacts and radiation. This makes the long lifetime of the Solar System a double-edged sword: The farther back in the past you consider, the more time alien civilizations would have had to arise and send probes in our direction — but the slimmer the odds that any resulting artifact would have survived to this day.

Another argument is that the odds of any of this happening in the first place — intelligent extraterrestrials existing, intelligent extraterrestrials leaving some piece of technology within the Solar System, and our being able to detect it — are too slim to be worth investigating.

Haqq-Misra responds that there's no way to know that for sure. As long as his ideas are potentially feasible, he argues, it's worth testing them to try to learn something concrete.

"I don't like to assign likelihoods," he adds, "until we have data."

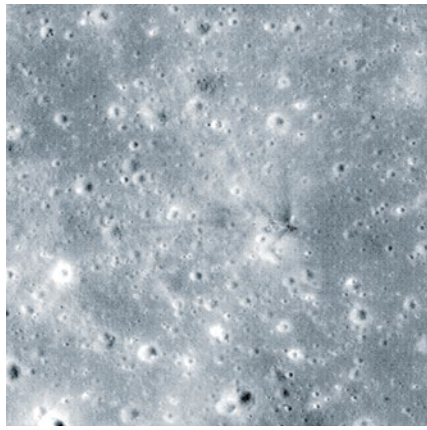
THE FUTURE

SETA researchers have a few milestones they hope to achieve in the not-so-distant future. One is to check whether any artificial structures larger than 10 meters (33 feet) exist on any solid surfaces within the Solar System, which would be no small feat. Another goal is to search thoroughly for any waste heat that might be emitted by technological artifacts on these worlds.

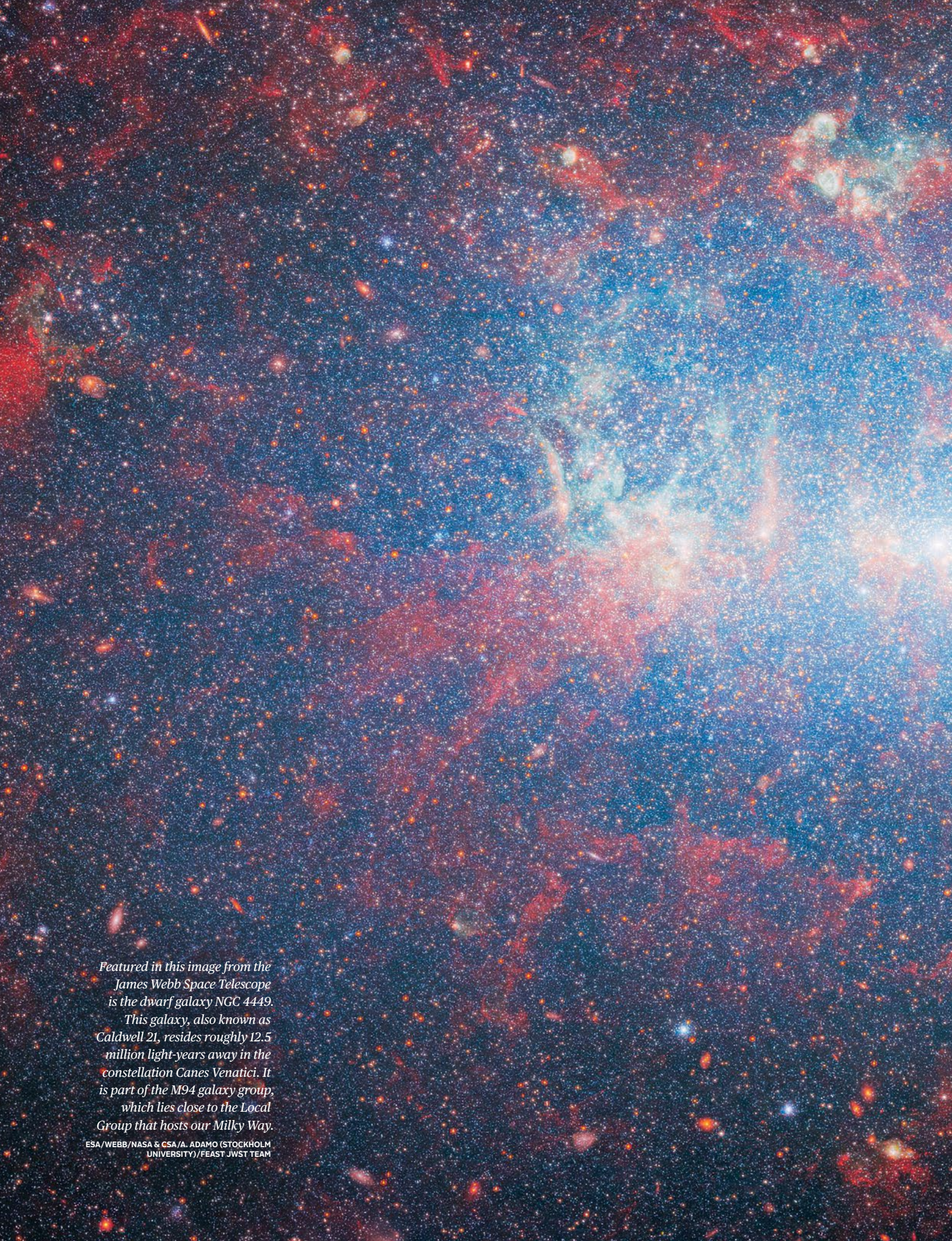
Haqq-Misra is especially excited at the prospect of more machine learning studies of planetary surfaces as well as searches for technosignatures at gravitationally stable regions called Lagrange points, where artifacts would be able to more easily sustain orbits for long periods of time. But these are only a few projects, and SETA is just getting started.

"At this stage," Haqq-Misra says, "we should do it all."

ASA STAHL *is the science editor for The Planetary Society.*



ABOVE
Part of an image from the Lunar Reconnaissance Orbiter showing the Apollo 14 Lunar Module ascent stage impact site – an alien artifact on the Moon (ours).
NASA/GSFC/ASU



Featured in this image from the James Webb Space Telescope is the dwarf galaxy NGC 4449. This galaxy, also known as Caldwell 21, resides roughly 12.5 million light-years away in the constellation Canes Venatici. It is part of the M94 galaxy group, which lies close to the Local Group that hosts our Milky Way.

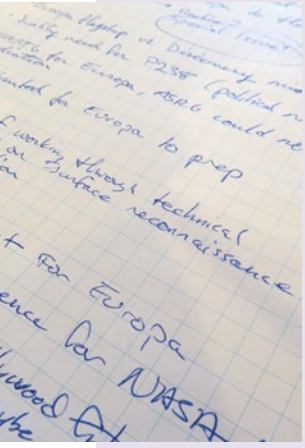
ESA/WEBB/NASA & CSA/A. ADAMO (STOCKHOLM UNIVERSITY)/FEAST JWST TEAM

EXPLORING EUROPA, THANKS TO YOU

by Casey Dreier

JUPITER'S MOON EUROPA is one of the most promising targets in the search for life beyond Earth. Beneath its icy crust lies a layer of liquid water that may be hospitable to life as we know it. The Europa Clipper mission, which at the time of writing is due to launch in early October 2024, will make at least 45 flybys of Europa, maybe even soaring through plumes of water that shoot through the moon's crust.

Although NASA has stated that Europa Clipper is not officially a life-detection mission, it still holds the potential to expand our understanding of whether alien life in our Solar System is possible. While this mission is exciting and promising, its journey to the launch pad has been long and arduous. And without the efforts of The Planetary Society and members like you, the mission might never have happened.



Chief of Space Policy Casey Dreier's notes from a January 2013 meeting in which The Planetary Society decided to commit to Europa as the organization's advocacy priority.
CASEY DREIER

In the summer of 2012, NASA's budget was shrinking, a divided government had all but frozen Congress, and the U.S. was pulling back from planetary exploration. It was a tough time for space advocates, and the ambitious, exciting missions outlined in the decadal survey — to begin a Mars Sample Return campaign and to explore the ocean world of Europa — felt like impossible dreams.

The successful landing of the Curiosity rover would spur NASA to move forward with what became the Perseverance mission to Mars. But a mission to Europa was not yet a reality. So, in January 2013, during a strategy session in preparation for the upcoming NASA budget cycle, The Planetary Society made a bold decision. Despite myriad political obstacles, we resolved to fully commit to Europa as one of our priority advocacy goals.

Despite the challenges, we felt confident about our prospects. The compelling nature of the mission was undeniable: to better understand a potential abode for "living" life by scouting an ocean moon of Jupiter. How could one not get excited about that? The scientific community had blessed it as one of their top recommendations from the respected decadal survey process, the mission had been reimagined as a multiflyby concept (rather than an orbiter) to make it cheaper, and we found strange political bedfellows in the form of Representatives Adam Schiff (D-CA) and John Culberson (R-TX), the latter of whom was rapidly becoming a Europa apostle in his own right.

For the following three years, it felt like every other word out of my mouth was "Europa." We published Europa-themed issues of The Planetary Report, blog articles, and op-eds. We held numerous standing-room-only events on Capitol Hill to promote the mission. Bill Nye and I walked what felt like hundreds of miles of hallways in the Capitol, meeting with members to build support and spread the word. Bill even made a direct pitch to President Obama himself during a helicopter ride to an Earth Day event in 2015 (it didn't work, but it was worth a shot).

Planetary Society members also participated en masse. Between 2013 and 2016, you all sent 384,949 messages to Congress and the White House to support planetary exploration and Europa — a record number that stands to this day.

At times it felt Sisyphean: Congress would add tens of millions of dollars to NASA's budget for Europa only to have the agency redirect it to other missions. But we kept pushing. The White House's budget office (which flatly refused to fund the mission) began to express annoyance at the sustained efforts in their NASA budget documents, asserting that "NASA is not able to support the development of an outer planets flagship for the foreseeable future" in the fiscal year 2014 request.

The next year, NASA formally requested money for the Europa Clipper mission. Though it was a paltry $15 million, it was a start. John Culberson, now the powerful chair of the

House Commerce, Justice, and Science Appropriations Subcommittee, gave NASA $100 million instead. The following year, NASA asked for another paltry amount, slow-walking the mission despite obvious political support. Culberson provided $175 million. The White House resisted until the end, with its final budget requesting a mere $49 million. Culberson ensured it got $275 million. It wasn't until the 2018 budget request that NASA finally asked for the funding it needed to launch Europa Clipper by 2024. Since then, Congress has obliged the request every year.

Many people worked to ensure Europa gets the exploration it deserves, and many more have spent countless hours designing, building, and testing the spacecraft that should launch this fall. Nonetheless, as Europa Clipper starts off on its long and storied mission, I hope that every Planetary Society member takes a moment to pat yourself on the back. Europa does not give up its secrets easily, but now, for the first time in human history, we will seek them out — not because of fate but because we decided to go.

BOARD OF DIRECTORS UPDATE

Welcoming Dr. Newton Campbell Jr. and saying farewell to Dr. John Logsdon

WE ARE PLEASED to announce the appointment of Dr. Newton Campbell Jr. to The Planetary Society's board of directors. Newton, a renowned leader in the space industry, serves as the director of space programs at the Australian Remote Operations for Space and Earth (AROSE) Consortium. His extensive background in artificial intelligence (AI) significantly contributed to advancements in space exploration and remote operations technologies. Prior to joining AROSE, Newton was an AI expert at NASA, where he led various innovative projects in urban air mobility, geomagnetism, space radiation, virtual reality, and high-performance computing.

In parallel, we are also announcing the departure of Dr. John Logsdon from the board. His service to The Planetary Society has had a profound impact. Professor emeritus of political science and international affairs at George Washington University's (GWU) Elliott School of International Affairs, John was a pioneering figure in space policy and is one of the world's preeminent space historians. He founded and directed GWU's Space Policy Institute, significantly influencing U.S. and international space activities. John's distinguished career included numerous publications and prestigious awards, reflecting his exceptional contributions to the space community. He authored seminal works such as "John F. Kennedy and the Race to the Moon" and "After Apollo? Richard Nixon and the American Space Program."

The Planetary Society's board now includes 13 members: Jim Bell, Newton Campbell Jr., Bethany Ehlmann, Daniel T. Geraci, John Grunsfeld, Heidi Hammel, Bijal "Bee" Hayes-Thakore, Lon Levin, Bill Nye, Robert Picardo, Britney Schmidt, Dipak Srinivasan, and Lorne Trottier.

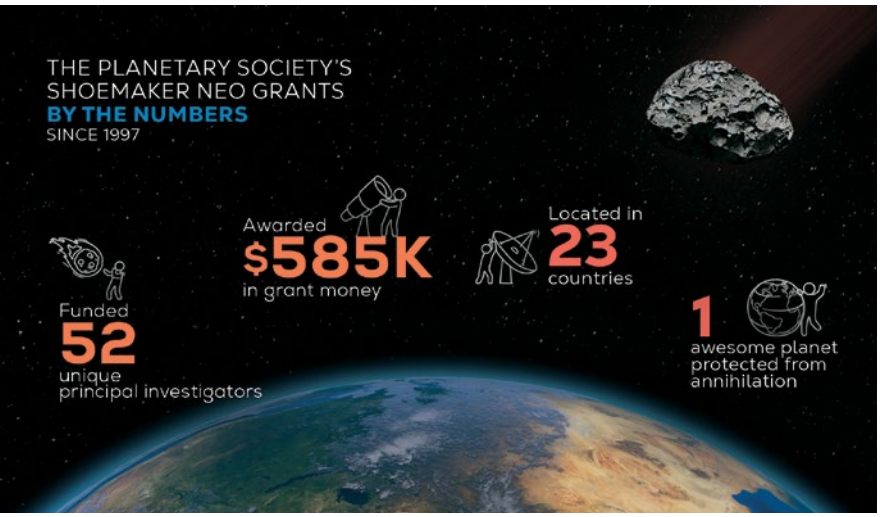
LEFT *Planetary Society CEO Bill Nye explains the need to explore Europa at a Society-organized event on Capitol Hill in 2014.*
TUSHAR DAYAL

Dr. Newton Campbell Jr.

Dr. John Logsdon

LIFE MAY EXIST OUT THERE, BUT WE NEED TO DEFEND IT HERE

THE PLANETARY SOCIETY works to support the search for life in the Cosmos because it is inspiring, ambitious, and visionary; because it's an important endeavor that has the potential to change what it means to be an Earthling. But it can only happen if we're here to carry it out. That's why planetary defense is just as important to us. By finding, tracking, characterizing, and learning to deflect asteroids, we can ensure that humanity sticks around long enough to find our cosmic kin. Year-round, we support work to do just that. Here are some updates from the asteroid hunters and researchers whom we fund, thanks to the support of members like you.



ABOVE *Alain Maury and the MAPS project (Maury, Mari, Attard, Parrott, Signoret) in Chile have discovered 216 NEOs in total. Through the Shoemaker NEO Grant program, they were able to purchase four cameras, two focus motors, and adapters to mount the telescopes. Along with other adaptations, they can now get eight telescopes pointed at the sky to increase their discovery rate.*
ALAIN MAURY

SHOEMAKER NEO GRANT WINNER UPDATES

EVERY TWO YEARS, The Planetary Society awards a series of grants to asteroid hunters through our Shoemaker Near-Earth Object (NEO) Grant program. Grant recipients are typically very advanced amateur astronomers from around the world who track, characterize, and discover near-Earth objects. Since the grant program began in 1997, Shoemaker grantees have submitted hundreds of thousands of asteroid observations to the International Astronomical Union's Minor Planet Center, a clearinghouse for the world's asteroid observations. Below is a sampling of updates and photos from some of our recent grant recipients.

From Cristovao Jacques of the SONEAR (Southern Observatory for Near Earth Asteroids Research) Observatory in Brazil: "In 2021, we were awarded the Shoemaker Grant, which allowed us to purchase two items to upgrade our observation program. Since the start of use of the equipment, both the new camera and the synthetic tracking technique have allowed us to discover 12 NEOs."

From Gonzalo Fornas of Spain: "Thanks to the new camera, we've reported more measurements of NEOs to the Minor Planet Center, we're on the alert list for near-Earth asteroids 'Meerkat' by ESA, we've measured light curves of asteroids and calculated their poles, we've published in the Minor Planet Bulletin, and we've collaborated on the Exoclock project by measuring planetary transits."

From Grzegorz Duszanowicz in Sweden: "Thanks to the grant I received from you last year, I was able to launch an additional telescope, which I also use to look for NEOs. It was purchased and installed with your funds at the observatory in Namibia in September last

UPPER RIGHT *Vladimir Benishek with his 14-inch telescope at Sopot Observatory south of Belgrade, Serbia.*
VLADIMIR BENISHEK

LOWER RIGHT *Marian Urbaník in Slovakia was awarded $6,100 in the 2023 round of Shoemaker NEO Grants for a new camera and field rotator for use in follow-up astrometry as well as photometry at Kysuce Observatory. With a wider field of view and greater sensitivity, the new setup enables increased precision in photometry and in NEO follow-up tracking as well as tracking faster (and therefore closer) NEOs.*
MARIAN URBANÍK

year. The advantage of this new instrument is that it doubles the majority of searches each night and that on windy nights, it can still observe because it is less susceptible to wind. The equipment works practically every possible (observable) night."

From Florent Losse of France: "The observatory has followed up [on] more than 700 newly discovered NEOs since January 2023, making it one of the most prolific. This period has had some highlights, such as my second NEO discovery (2023 DE3) and the tracking of impactors 2023 CX1 and 2024 BX1 just minutes after their discovery by K88. These hit Earth's atmosphere over France and Germany respectively without any damage and provided valuable fragments found after the impact. Thanks again — these things would have been much more difficult or impossible without the help of The Planetary Society."

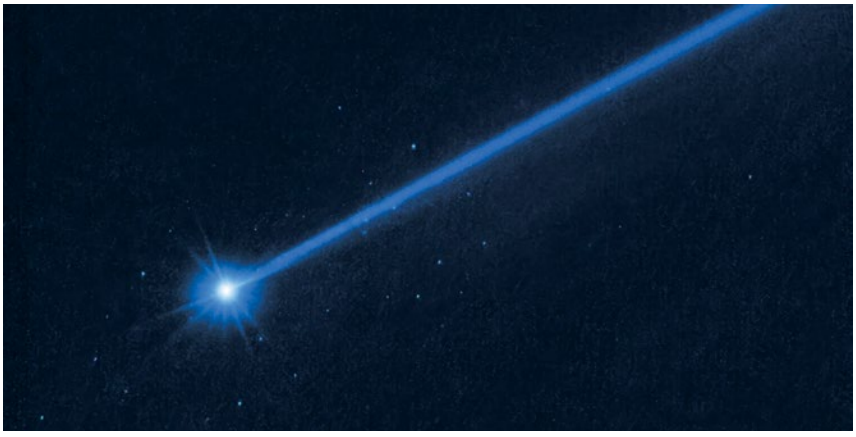
PARTNERING AND FUNDRAISING FOR PLANETARY DEFENSE

THE PLANETARY SOCIETY'S members came together to raise over $65,000 in June and July for our planetary defense program. It's through this program that we fund asteroid hunters, contribute to international coordination on asteroid research, educate the public and policymakers about the importance of planetary defense, and more. Thanks to your support, The Planetary Society will continue working hard to keep our planet safe from impacts.

As part of our overall planetary defense work, we partnered with Asteroid Day again this year to celebrate the international day of asteroid awareness. You can go to **asteroidday.org** to learn more about the global events that took place on June 30 this year.

NEW INSIGHTS INTO ASTEROID PROPERTIES: A STEP GRANT UPDATE

ONE OF THE first recipients of The Planetary Society's STEP (Science and Technology Empowered by the Public) Grant program was a project to better understand near-Earth asteroids. This year, that project achieved its main goals and scientific objectives.



ABOVE *This image from the Hubble Space Telescope shows boulders that were ejected from the asteroid Dimorphos after the DART spacecraft slammed into it in September 2022. The bright object with a tail is Dimorphos, and the tiny white dots clustered around it are boulders ranging in size from 1 to 6.7 meters (3 to 22 feet) in diameter.*
NASA/ESA/D. JEWITT (UCLA)

In 2022, The Planetary Society awarded a $44,842 grant to a team from the University of Belgrade, Serbia, led by Professor Bojan Novaković, for their proposal "Demystifying Near-Earth Asteroids." This project aimed to develop and apply a new method for determining the physical properties of asteroids with orbits that come close to Earth's orbit (also called near-Earth asteroids, or NEAs). Although tens of thousands of NEAs have been found, we only know the physical properties of a small percentage — from solid rock asteroids to collections of boulders to fluff balls.

Over the course of their two-year project, Novaković's team introduced an innovative tool named the Asteroid Thermal Inertia Analyzer (ASTERIA) to measure how well asteroids retain heat, giving insight into their composition and structure.

Unlike traditional thermo-physical modeling-based methods that involve complex calculations, ASTERIA simplifies the process using a random sampling approach to predict the thermal inertia based on how asteroids drift over time due to the Yarkovsky effect — a subtle force acting on rotating bodies in space caused by the emission of thermal photons. ASTERIA is especially useful for smaller asteroids, where traditional models struggle because they do not have enough data.

The project team tested ASTERIA on the well-studied asteroid Bennu and 10 other near-Earth asteroids. Their results were consistent with previous findings from other methods, validating the ASTERIA method while also proving it as a useful way of independently confirming findings from other techniques in the future.

One particular part of the project focused on the asteroid Didymos and its moonlet Dimorphos, which was the target of NASA's DART mission. When the DART spacecraft intentionally impacted Dimorphos in September 2022, it proved an asteroid deflection technique and in doing so, turned Dimorphos into an "active asteroid," ejecting debris that may have settled on both the moonlet and its host asteroid.

Novaković's team examined Didymos' thermal inertia before and after the impact, using ASTERIA to assess how Didymos' ability to retain heat might have shifted due to the reaccumulation of debris generated by the collision. The results suggested that Didymos' thermal inertia either remained the same or changed only slightly, below the threshold that their methodology could detect. These findings shed light on the question of how collisions might have altered the surfaces of these space rocks and add to the overall understanding of the physical properties of near-Earth asteroids.

This project, made possible by the support of The Planetary Society and our members, represents an important step forward in the global effort to understand asteroids that could someday pose a threat to our planet.

MEMBER COMMUNITY TALK

THE PLANETARY SOCIETY'S online member community at **community.planetary.org** is a great place to share ideas and discuss the big questions in space exploration. From time to time, we post questions to prompt discussion. Here are a few answers to some of those questions, from the deep and scientific to the silly and playful.

Where are you most excited for humanity to explore in hopes of finding life? Why?

I think in the immediate future, searching for life on Europa and Titan. To find life in our own Solar System would have profound implications given we have already found over 5,000 exoplanets, each with likely many moons themselves!

Kelsey Harkness-Jones, U.K.

If we found microbial life on another planet, how do you think this discovery would change our understanding of life in the Universe?

I think it would confirm my own suspicions about life in the Universe. My suspicion being that life is abundant in the Universe at least in simpler forms. I suspect that more complex and intelligent spacefaring life is exceedingly rare.

Phillip Leavenworth, USA

It would change everything. We would then have two models for life. What are the basic building blocks? Including what atoms and molecules are used by this life form. How does it reproduce? Certainly not using DNA. What is the mechanism? And on and on. A million questions to ask and a million answers to be sought to be discovered. It will be an amazing time.

Robert Danna, USA

How likely do you think it is that humanity will discover microbial extraterrestrial life in the next 100 years?

If "the truth is out there," we'll probably find it within a century. If life is extremely rare and Earth is the only inhabited place in our galaxy, it might never happen. Nevertheless, the quest is exciting and rewarding.

Sabine Vollenhofer-Schrumpf, Austria

Extremely likely! I think Europa Clipper is going to do the job.

Hugo Rodriguez, Mexico

If not extant life beyond Earth, perhaps we're as likely to find evidence of life gone extinct on other planets and/or moons. Hundreds of millions of years is a long time for life to come and go elsewhere. Perhaps simple life forms arose relatively quickly and abundantly back when conditions were more favorable on other bodies, but then failed as environmental conditions got too hostile. If this thinking has merit, I could imagine quite a future cottage industry for planetary archaeologists — studying the rise and fall of alien microbes (or even more sophisticated things) now long extinct.

Dale Davaz, USA

Imagine we make contact with an intelligent extraterrestrial civilization. What would be the first question you'd want to ask them?

Most people here are going to propose deep, important questions. But I am posting this at local dinnertime. Depending on the species, I would ask for their best recipe for plomeek soup, gakh, or tube grubs. I'm hungry. Also, do you have anyone on your planet similar to cats, and do they also, effectively, rule your world as ours do?

Mel Powell, USA

ABOVE *Planetary Society members also share their artwork in the online member community. This piece by member Laurey Foulkes is titled "Otherworldly Garden."*
LAUREY FOULKES

NASA's Curiosity rover has found new evidence preserved in rocks on Mars that suggests the planet could have supported ancient life. This self-portrait of NASA's Curiosity Mars rover shows the vehicle at the site from which it reached down to drill into a rock target called "Buckskin" on lower Mount Sharp.

NASA/JPL-CALTECH/MSSS

CALENDAR OF EVENTS

SEPTEMBER

8
Saturn at opposition

14
International Observe the Moon Night

17/18
Partial lunar eclipse

18
Super harvest Moon

22
September equinox

OCTOBER

2
Annular and partial solar eclipse in South America

4-10
World Space Week

7
Draconids meteor shower

8
Hera launch window opens

10
Europa Clipper launch window opens

17
Supermoon

21-22
Orionids meteor shower

NOVEMBER

4-5
Taurids meteor shower

15
Supermoon

16
Mercury at greatest eastern elongation (best viewing)

17
Uranus at opposition (best viewing)

17-18
Leonids meteor shower

DECEMBER

7
Jupiter at opposition (best viewing)

The Planetary Society's Science Editor Asa Stahl hosts "The Search for Life" in the online member community.
THE PLANETARY SOCIETY

BECOME AN EXPERT ON THE SEARCH FOR LIFE

Members have exclusive access to our newest online course, The Search for Life. This seven-part course takes students through an in-depth exploration of the ways humans are looking for life beyond our planet. The course features scientists and engineers working at the forefront of the search for life who'll teach you about new research, ambitious missions, the latest theories, and more. From Mars and Europa to exoplanets and far beyond, journey through the Cosmos with host Asa Stahl and become an expert on the search for life.

This course is available in The Planetary Society's online member community. Log in at **community.planetary.org**.

MORE TO EXPLORE IN THE MEMBER COMMUNITY

Check out your member community for lots of great ways to connect with other space enthusiasts, build your knowledge, and have fun! Highlights include our monthly virtual book club, Q&As with space experts, special events like space policy telecons, spaces to share artwork and astrophotography, a space job board, weekly space trivia, and so much more.

Go to **community.planetary.org** to log in and discover all the ways to engage with your space community.

NEW! A SERIES OF KIDS' BOOKS ALL ABOUT THE PLANETS

The Planetary Society has partnered with Lerner Publishing to produce a series of kids' books all about the planets. Written by Chief Scientist Bruce Betts, each book focuses on one of our Solar System's eight planets, with easy-to-understand content and cool pictures. You can order them now through Lerner Publishing.

Planetary Society members at the U.S. Capitol

SPACE ADVOCACY ALERT!

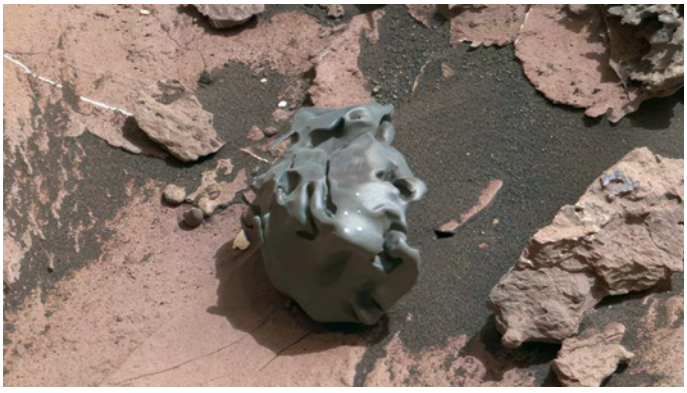
As a Planetary Society supporter, you're part of the world's largest and most influential nonprofit, space organization and you help create a bigger and bolder future for humankind.

Together, we're taking our advocacy work to the next level, and we need your support. Will you power our urgent efforts with a gift today? Plus, when you make a gift, your donation will be matched up to $75,000.

Visit **planetary.org/takeaction** to put your gift to work right away.

THE PLANETARY SOCIETY

FIND YOUR PLACE IN SPACE



LEFT *An iron meteorite on Mars named Aeolis Mons 001, this rock was initially nicknamed "Egg Rock."*
NASA/JPL-CALTECH/MSSS

IN THE SKY

Reddish Mars will rise in the east in the middle of the night in September and will rise earlier as the weeks pass. It is up in the evening by December. Watch it brighten as the days pass and Earth and Mars get closer in their orbits. By December, it will be almost as bright as the brightest star. Very bright Jupiter will rise in the east around sunset by December after rising later in the evening before then. Yellowish Saturn will rise early in the east after sunset, getting higher as the weeks go on. Mercury will be visible low to the western horizon soon after sunset in the west in mid-November. Super-bright Venus dominates the early evening west. On Oct. 2, an annular solar eclipse is visible from parts of Argentina and Chile. The Geminids meteor shower peaks Dec. 13/14, with increased activity several days before and after. The Geminids are usually the best shower of the year with 100+ meteors per hour from a dark site, but this year, a nearly full Moon will wash out many of the meteors. For more night sky tips, you can always check out **planetary.org/night-sky**.

RANDOM SPACE FACT

Nearly 300 meteorites found on Earth have been identified as coming from Mars, and rovers have found several meteorites on Mars that came from elsewhere.

TRIVIA CONTEST

Our March Equinox contest winner is Yvonne Tavalero of Rohnert Park, California, USA. Congratulations! The question was: ***Besides the USA and Russia, what country has had the most people go to the International Space Station?*** The answer: ***Japan.***

Try to win a copy of the new book "Casting Shadows: Solar and Lunar Eclipses with The Planetary Society" by Bruce Betts and a Planetary Radio T-shirt by answering this question:
What type of celestial object, when the first one was discovered, was nicknamed LGM-1, standing for Little Green Men-1?

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 Dec. 1, 2024. One entry per person. The winner will be chosen in a random drawing from among all the correct entries received.


PHOTO: TYLER NORDGREN

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

We invite you to join other members of The Planetary Society to discover the world on Betchart Adventures!

ALASKA AURORA BOREALIS
FEB. 23-MARCH 1, 2025
Come see the greatest light show on Earth! Explore the Kenai peninsula, take the train to Fairbanks, and delight in the ice festival and aurora borealis in the night sky!

TAHITI TOTAL LUNAR ECLIPSE
MARCH 6-16, 2025
A breathtaking opportunity to see the total lunar eclipse in this South Pacific paradise! We'll explore Tahiti and Moorea and then fly to legendary Bora Bora for the lunar eclipse. You have the option of staying in overwater bungalows in our lagoonside hotel!

MADAGASCAR LUNAR ECLIPSE
AUG. 27-SEPT. 10, 2025
Explore the unique heritage of Madagascar and see the lunar eclipse in the spectacular southern skies! Isolated from the African continent for over 30 million years, Madagascar is home to fauna and flora found nowhere else!

ARCTIC TOTAL SOLAR ECLIPSE VOYAGE
JULY 31-AUG. 16, 2026
A unique opportunity to see a cosmic wonder in an Arctic wonderland! From Spitsbergen to east Greenland's spectacular Scoresby Sund fjord system to Iceland, we'll explore some of the best areas for viewing polar bears, Arctic foxes, various seals, whales, and enormous icebergs. We'll see the total solar eclipse above the Arctic Circle!

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PASADENA CA 91101-2016 USA

ALDO SPADONI

"Cradle of Life"

Aldo Spadoni

"Cradle of Life" by Planetary Society member Aldo Spadoni was commissioned by and created for the National Radio Astronomy Observatory (NRAO). This piece symbolically portrays the proposed Next Generation Very Large Array (ngVLA) over the state of New Mexico, looking north. It represents the compelling future radio astronomy investigation areas being defined by the NRAO Cradle of Life Science Working Group. These areas include the study of star and planet formation and the evolution of protoplanetary disks as well as the investigation of the chemistry of planet-forming regions in interstellar space, a key to understanding the initial conditions that lead to the development of life. This fine art piece was created digitally.

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*.