THE PLANETARY REPORT

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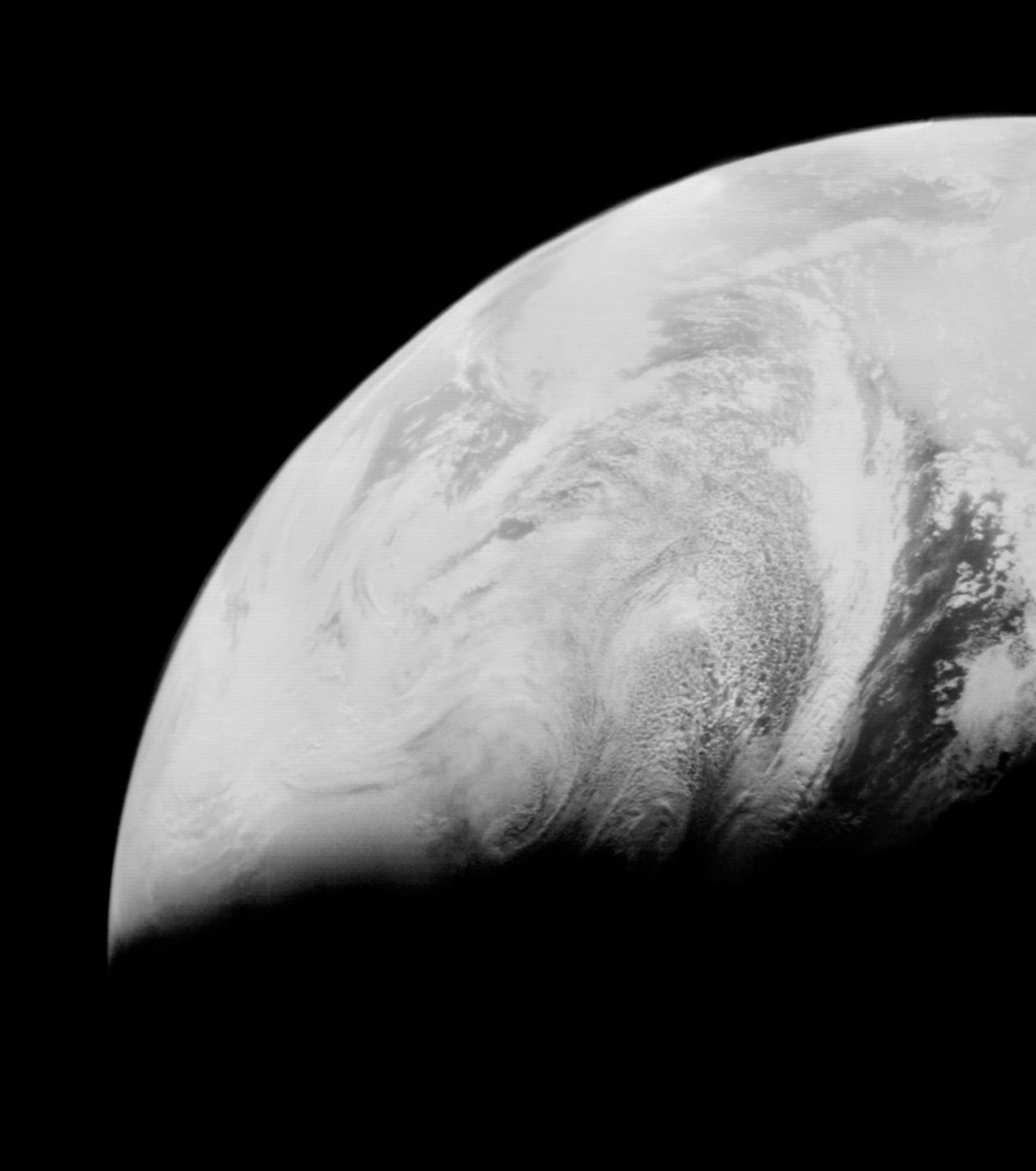
CRADLE AND COMPASS

HOW EARTH SHAPES OUR EXPLORATION OF OTHER WORLDS

THE PLANETARY SOCIETY 45 CELEBRATING 45 YEARS



The Moon

The first Earth image taken from the vicinity of the Moon, captured by NASA's Lunar Orbiter 1 spacecraft in 1966.

NASA/LOIRP

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ON THE COVER
Spacecraft destined for other worlds sometimes test their instruments on Earth while en route. On its way to Mercury, NASA's MESSENGER spacecraft pointed its cameras at Earth. The resulting image shows South America and portions of North America and Africa through visible and near-infrared light filters. Near-infrared light is shown as red in this image. The dense foliage of the Amazon rainforest looks strikingly red here because plants strongly reflect near-infrared light.

NASA/Johns Hopkins University Applied Physics Laboratory

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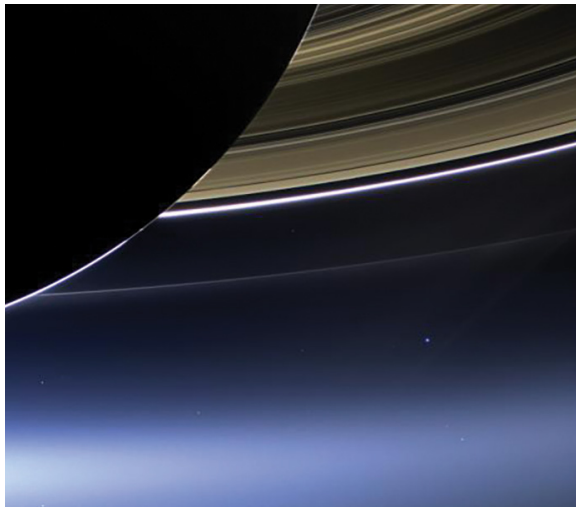
SEEKING WORLDS TO KNOW OUR OWN



NASA's Cassini spacecraft captured this image of Saturn, its rings, and Earth in the distance in 2013. Earth, which is 1.44 billion kilometers (898 million miles) away in this image, appears as a blue dot at center right.

NASA/JPL-Caltech/Space Science Institute

An Earthling's perspective

by Bill Nye

In this issue, we look at Earth. It has a special place in space exploration. I understand that some readers may be surprised by the focus, given The Planetary Society's decades-long focus on other worlds. But understanding Earth is not a departure from our mission — it's deeply connected to it. Planetary exploration and understanding Earth are inextricably linked.

People have pondered our place in space from a planetary perspective for some time. When we collect data about other worlds — their surface temperatures, the chemistry of their atmospheres, their magnetic fields, even just their sheer mass — it tells us quite a bit about those planetary bodies. But those numbers become especially significant when they're compared with those of our own world. This is what we call comparative planetology.

When we study how changes in Venus' atmosphere turned the planet from a hospitable place to a toxic hellscape, we learn more about the threat of climate change here on Earth. When we note that Mars doesn't have much of an atmosphere and not much of a magnetic field, we come to understand the role of Earth's magnetic field in protecting us from atmosphere-scraping particles streaming our way in the solar wind. When we study planets around other stars, we learn how rare planets like ours might be. And if you've been part of The Planetary Society for long, you may have heard (or read) a proposition I've suggested many times: If we discover life out there, it will forever change our world and the way we think about ourselves.

We explore other worlds because we want to know more about them and our larger cosmic neighborhood. But even so, Earth will always be at the center of space exploration. Where did we come from? Are we alone in the Universe? These are the deep questions that space exploration aims to answer. Let's go.

LOOKING UP FROM HERE ON EARTH

For many people who are passionate about space, it's easy to picture yourself out there seeing it all firsthand. But in truth, the vast majority of humans experience space from here on Earth.

We look through telescopes at distant planets, enjoy images sent home from far-flung spacecraft, and cheer on astronauts as they venture into space on behalf of all humanity — all from the comfort of our planet. Some may think that's limiting, but for others, it's something to be appreciated. Earth is, after all, a beautiful place.

These Planetary Society members captured that beauty especially well in their photos of cosmic views with Earthly context. When we appreciate where we're looking up from, it adds to the enjoyment of our place in space.

These member photos were submitted in a call for astrophotography in The Planetary Society's members-only online community. Log in today at **community.planetary.org**.

▲ *Rebecca Bennett, USA*

▲ *Daphnee Ouellet, Canada*

▲ *Rhiannon Youel, United Kingdom*

THE PALE BLUE DOT

35 years later, an iconic image still speaks to us

by Kate Howells

"That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives... on a mote of dust suspended in a sunbeam."

Carl Sagan, PhD, wrote these words about one of the most famous planetary self-portraits ever taken. The pale blue dot, as the image came to be known, was captured by NASA's Voyager 1 spacecraft 35 years ago, on Feb. 14, 1990. The probe was more than 6 billion kilometers (4 billion miles) away from Earth, having completed its flybys of Jupiter and Saturn. Earth is seen as a tiny point of light caught in the center of one of the scattered light rays resulting from taking the image so close to the Sun. This image was one of the last that Voyager 1 took before powering down its cameras forever to save energy for the rest of its extended mission.

The photo was taken at the suggestion of Sagan, a Planetary Society co-founder who was a member of the Voyager imaging team at the time. He knew that at such a huge distance, Earth would barely show up in the image. But that was the point — to show Earth in the context of the vastness of space to underscore how tiny and fragile our planet really is.

"There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world," Sagan later wrote about the image. "To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known."

For some people, the pale blue dot's depiction of Earth alone in the vast emptiness of space makes our planet seem insignificant. We're all just floating through the Universe on a relatively tiny rock, inconceivably far from even our closest neighbors — let alone any other living things. It can be seen as a tremendously lonely image.

But it also conveys how special our planet is. As a world that is home to living beings, including conscious ones, Earth is extraordinarily special. We may be floating out here in relative isolation, but we are far from insignificant.

The pale blue dot also speaks to the need to explore. We know that the Universe is vast and largely empty. But we also know that amid all that emptiness, there are billions of worlds like ours — whether that means planets similar to our own or vastly different places that share our most important quality: life.

We are almost certainly not alone in the Cosmos, but only by exploring can we find out for sure. And along the way, we'll discover amazing things.

In 2020, for the 30th anniversary of the iconic photo, JPL engineer and image processing enthusiast Kevin M. Gill reprocessed the pale blue dot image using modern image software.

NASA/JPL-Caltech/Kevin M. Gill

OTHER EARTHS

Astronomers are closing in on planets that might be like our own

by Jonathan O'Callaghan

▲ An artist's concept of the planets in the TRAPPIST-1 system. (Modified) *NASA/JPL-Caltech*

The odds of there being other planets like Earth in the Universe are heavily stacked in our favor. If every planet in our galaxy were the size of a basketball, you could stretch them in a line from Earth to Mars and back again. If you included every planet in every galaxy, that line would stretch to the edge of the observable Universe. Among those, chances are there will be worlds of a similar size to ours, orbiting stars like our Sun in a similar position.

The only problem is finding them. To date, we have found more than 7,000 planets orbiting other stars (known as exoplanets), but our efforts have focused on relatively easy-to-discover worlds. That includes large gaseous planets like Jupiter or rocky worlds orbiting small and dim stars known as red dwarfs.

Hunting for worlds truer to our own planet is often much more difficult because these stars are large and the planets are comparatively small. Moreover, if we wanted to find planets exactly like Earth on year-long orbits, we would need to watch the star for a long time to see the planet swing around multiple times and confirm its existence. That's one of the major reasons why, to date, we have never found such a world. No exact Earth 2.0 replica has ever been seen.

That might be all set to change in the coming years. A new European Space Agency (ESA) telescope launching next year, called PLATO (Planetary Transits and Oscillations of Stars), is expected to find dozens of Earthlike planets in the habitable zone of Sunlike stars, the position from the star where temperatures could be just right for liquid water to exist on the surface, like on our planet.

At the same time, new ground-based telescopes that should aid in the hunt are coming online. Further afield, all eyes are on NASA's thrilling Habitable Worlds Observatory (HWO), set to launch in the 2040s with a clear goal in mind: produce images of Earthlike planets around other stars and look for signs of life.

"We are actually at a very special time," says Vikki Meadows, PhD, an astrobiologist at the University of Washington who also runs NASA's Virtual Planetary Laboratory, which studies exoplanet habitability. "For millennia, we have wondered: Are we alone in the Universe? It's only now [that] we have both the scientific knowledge and the technology to try and answer that question."

We hunt for exoplanets in a number of ways. One is by watching for wobbles in a star's position caused by the gravitational tug of an orbiting planet, known as the radial velocity method. Another is by watching for the dip in

a star's light as a planet passes in front, known as the transit method. This method is relatively simple and allows you to watch many stars at once for dips in light but relies on the system being oriented to us in just the right way for a transit to occur.

Our Milky Way galaxy is home to an estimated 400 billion stars, the majority of which likely host at least one planet and often more. PLATO will use 26 cameras to stare at more than 200,000 stars in our galaxy, many of which will be bright Sunlike stars, for at least two years. In doing so, it will be capable of detecting many small rocky worlds transiting these stars.

Were it looking at our Solar System, the telescope would see "Mercury, Venus, and Earth," says Ana Heras, PhD, an astronomer at ESA in the Netherlands and project scientist for PLATO.

While the exact number of rocky planets the telescope will find isn't known for certain, Heras says the team estimates they might find "tens of exoplanets" similar to Earth, orbiting stars like our Sun on similar orbits, among many other planets.

How plentiful Earthlike planets are in the galaxy remains an open question, but so far, rocky worlds in the habitable zones of smaller red dwarf stars seem to be "pretty common," says Meadows. One of the most notable examples is the TRAPPIST-1 system about 40 light-years away, where seven rocky planets orbit a red dwarf star, three in its habitable zone. Because red dwarf stars are smaller and dimmer than our Sun and more prone to extreme flaring events, it is not yet known how hospitable they are to life.

Efforts to examine the atmospheres of these planets to look for hints of life are ongoing using telescopes like the James Webb Space Telescope. These efforts will be aided by large new telescopes being built on Earth, like the Extremely Large Telescope, set to begin observations from Chile in 2029. These telescopes are looking in the atmospheres of planets for hints of gases like carbon dioxide, oxygen, and methane, which could be biosignatures for life.

We will need more advanced telescopes to learn more about truer Earth analogs like the worlds PLATO may find. In Europe, a proposed fleet of spacecraft called LIFE (Large Interferometer For Exoplanets) could hunt for life on dozens of Earthlike worlds, although the idea remains conceptual. More concrete is NASA's HWO, which is currently in the planning stage ahead of a proposed launch in the 2040s.

HWO would use an advanced coronagraph and a large mirror to block out the light of Sunlike stars and directly image planets in orbit around them. The goal is to produce images of at least 25 Earth analogs and pick apart their atmospheres to look for signs of life. The telescope might even see the reflected light of vegetation and oceans. "With direct imaging, we can go all the way down to the surface," says Meadows. "We will see these pale blue dots."

Until then, astronomers will continue to pick apart and probe planets less similar to Earth but still with the potential for habitability. Perhaps the first truly Earthlike planet discovered won't be much like Earth at all but rather a seemingly inhabited world around a much different star than our own.

An artist's impression of ESA's PLATO spacecraft and other star systems.

OHB-System-AG

RETHINKING THE ATOMS OF LIFE

What ancient Earth and alternate biochemistries could teach us about alien life

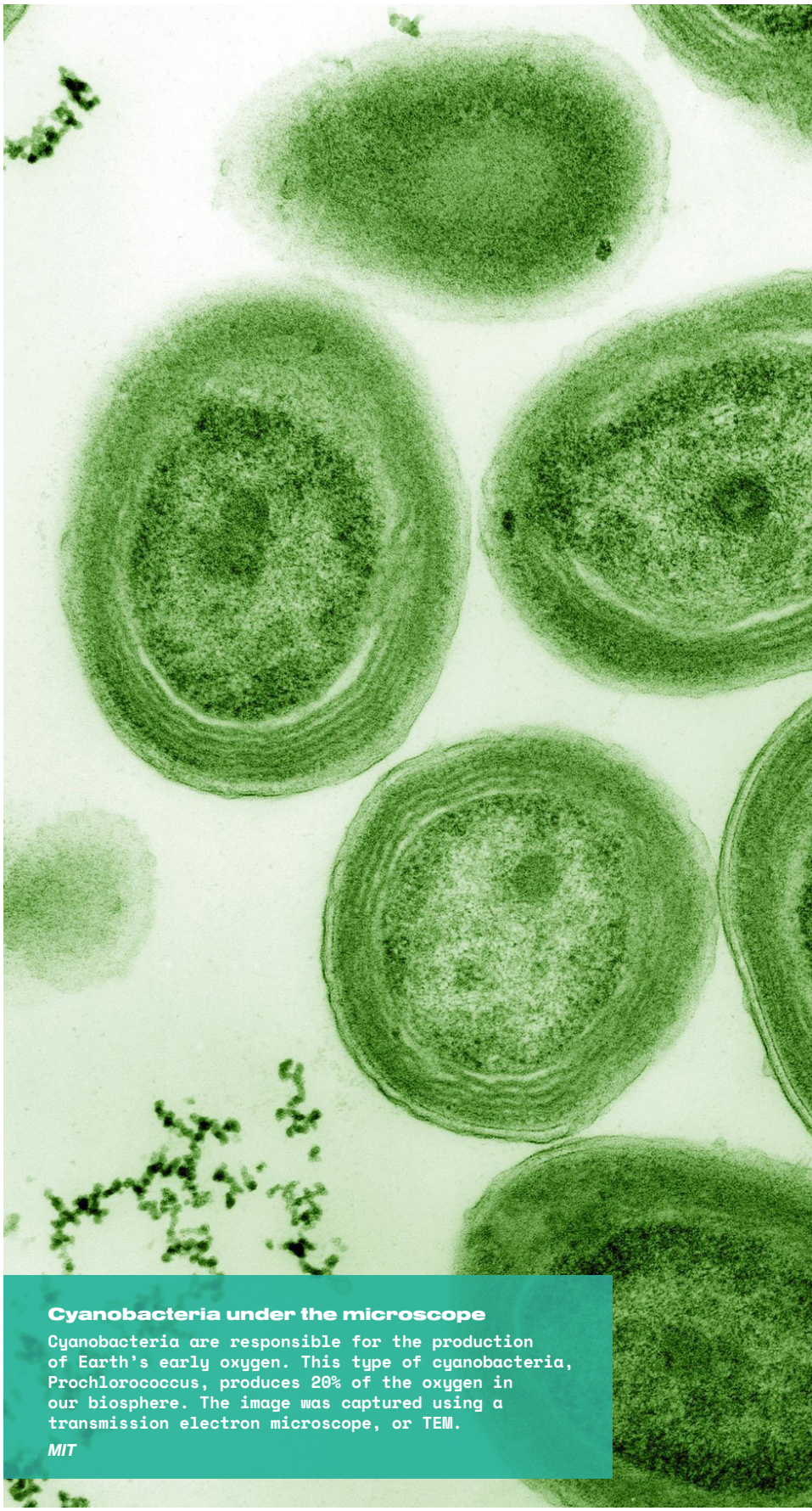
by Asa Stahl, PhD

When an astrobiologist says "life is hard," they may be speaking on a cosmic level. They could mean that life itself is a puzzle we are nowhere near solving.

"We're like second graders when it comes to understanding life," says Betül Kaçar, PhD, professor of bacteriology at the University of Wisconsin-Madison. "We don't know much."

It might sound strange in an era of genetic engineering and antibiotics, but to those exploring the possibility of life beyond Earth, our ideas about biology appear far from complete. We don't have a full picture of what life can be made of, where it can thrive, or what it might look like throughout the Universe. To search for alien life, scientists make do with what we know. That is almost entirely based on life on Earth.

Yet there are hints that creatures beyond our planet, if they exist, could be very different. By exploring these alternatives in the lab — and even resurrecting extinct forms of life — researchers are now challenging some of our most basic assumptions about the search for life. Their work may not only change how we think about aliens but what we know about ourselves.



Cyanobacteria under the microscope

Cyanobacteria are responsible for the production of Earth's early oxygen. This type of cyanobacteria, Prochlorococcus, produces 20% of the oxygen in our biosphere. The image was captured using a transmission electron microscope, or TEM.

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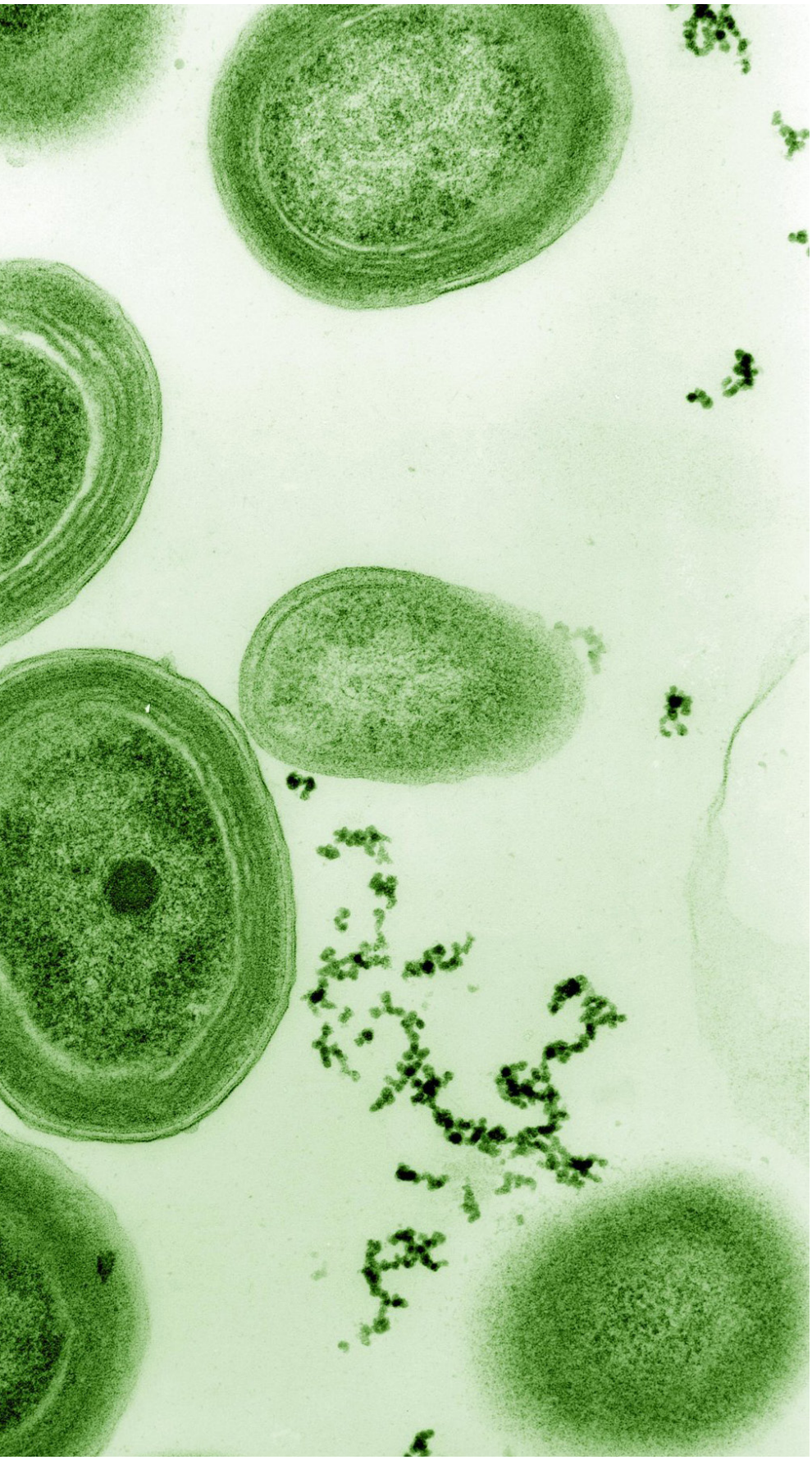


LIVING ATOMS

As the only planet proven to be habitable, Earth has a special place in the search for life. It stands as an ideal, one we compare worlds to in hopes of finding somewhere as lush.

If scientists only cared about finding Earth's twin, though, they might miss out on unfamiliar forms of life. The most common kind of creatures in the Universe might thrive in environments we consider toxic. They could be based on a completely different chemistry, and they might look nothing like us.

"It's very possible — unfamiliar planets and their unfamiliar molecules creating life," says Kaçar.

Kaçar's work is dedicated to exploring these alternatives. To her, life as we know it is a starting point: something to learn from but also to push past.

"If we are to discover life as we do not know it, we must challenge our deepest assumptions. We need to consider the very atoms that make life possible," Kaçar adds.

On Earth, these atoms mostly come down to just six chemical elements: carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur — or CHNOPS for short. Add in trace amounts of other elements, like potassium and iron, and you can make all the chemicals that are crucial to our lives. That includes molecules like DNA and RNA for storing information, proteins to jump-start chemical reactions, carbohydrates for energy, and membranes to keep things separate and organized. All are brought together by water, which allows other chemicals to mix and interact.

What we don't know is how inevitable any of this is. Different chemistries might be able to create life in different environments. Even on Earth, we're not sure whether it is the only way life could have ended up.

MAIN INGREDIENTS

Scientists have thought of many possible alternatives to the way life works on our planet. Each has its own basic building block like a main ingredient in a recipe.

On Earth, this is carbon. Carbon underpins the chemistry of all known organisms, and it is particularly good at building long, complex structures like proteins and DNA. Like any good main ingredient, carbon is also readily available. It is the fourth-most-abundant element in the entire Universe.

But experiments suggest other building blocks might work too. Sulfur is relatively common on other worlds, and sulfur-based chemistry can provide ways for life to gain energy and store information. Today, clusters of iron and sulfur are a widespread and important part of Earth biology. This might mean they were once essential to the origin of life.

Boron-based lifeforms could be another possibility. Like sulfur, boron is used by life today and may have played a role in the beginning of life as we know it. But unlike sulfur, boron tends to lock itself together with oxygen in ways that aren't useful for building life. Boron is also relatively rare in the Cosmos, though it might still work as a building block on planets without much oxygen.

Then there's silicon, the most sci-fi-famous alternative to carbon-based life. Unfortunately, research shows that silicon is unlikely to form life even in very alien environments. Almost anywhere silicon-based life has a chance of blooming, carbon-based life would stand a better chance because its life-fostering reactions tend to cost less energy. At best, silicon might work alongside carbon as a sort of joint building block.

PRIMORDIAL SOUP STOCK

Whatever life's ingredients are, they need a way to mix and react in order to thrive. This is the other defining factor for any chemistry of life: its medium. Scientists almost always imagine a liquid playing this role. Because water is excellent at dissolving things and encouraging them to interact, it is by far the astrobiologist's favorite.

Yet some researchers think life on our own planet didn't begin in water. Instead, a different liquid called formamide may have acted as both a crucial ingredient and a medium for life's early chemistry. Though this is far from proven, formamide's potential to have supported life on Earth makes it a good candidate for sustaining similar organisms on other worlds.

Liquid methane, which fills entire lakes on the surface of Saturn's moon Titan, offers a more alien alternative. Hydrocarbons like methane don't dissolve the same substances that water does, so lakes of them could foster lifeforms that are very unlike those found on Earth. Instead of using DNA, creatures on Titan might store information using the number of electrons attached to molecules or by patterning pairs of atoms into binary code. They could have cell membranes made of chemicals that would be carcinogens and industrial solvents on Earth.

Other alternatives to water include sulfuric acid, which clouds up the skies of Venus, and ammonia, which might puddle in the icy crusts of worlds like Saturn's moon Enceladus.

Both chemicals could only support exotic kinds of life. Ammonia rips apart some molecules crucial for life as we know it, and sulfuric acid is even more destructive. But a mix of ammonia and water might be the most habitable place for creatures on worlds like Enceladus. On Venus, life built jointly on carbon and silicon could potentially thrive in sulfuric acid.

OLD RECIPES

While scientists often test these chemistries by whipping them up in the lab, Kaçar explores what alien life might look like a little differently. Rather than just trying out ingredients, she focuses on the recipe.

For life, that means genomes. By looking at the genes of organisms today and reconstructing what their ancestors were like in the past, researchers can see how life's chemistry changed over time. They can pick out which parts of the recipe have been flexible and which parts have always been essential.

This process, called ancestral sequence reconstruction (ASR), uses computer models to predict the genomes of extinct species from their living descendants. Researchers can then study those genes to learn what long-dead organisms were once like. Scientists have learned when mammals evolved to be nocturnal, for instance, by tracing genes related to how sensitive we are to light.

THE WORLDS OF THE PAST

Kaçar's team is among a handful who take this one step further. Instead of just predicting the genes of the past, they bring them back to life. They make real, living organisms express parts of their ancestors' genetic code.

So far, Kaçar's group has mainly used ASR to track how microbes "ate" carbon and nitrogen billions of years ago. Back then, our planet was very different, with almost no oxygen in its atmosphere and fewer ingredients for life available. ASR allows Kaçar to access this version of Earth as a kind of alien world in itself — one that we know hosts life.

"We are able to imagine different atmospheres, different temperatures, different oceans," Kaçar says.

Kaçar's research has found instances where life's core chemistry seemed to change in response to its environment, but she has also been surprised to discover how much about life seems to be set early on. Kaçar says it's like life was "put on railroad tracks" after a certain point. That would

make understanding Earth's ancient conditions valuable in a whole new way

EXPANDING THE SEARCH

All of these exotic possibilities, including those contained within our past, are changing how we search for life beyond Earth.

Already, treating the ancient Earth like another planet has taught us about other worlds that might be out there. In a recent study, Kaçar and her collaborators reconstructed aspects of the chemistry that ancient marine life once used to perform photosynthesis, then predicted how their signs of life would have looked from space. With this information, astronomers could decide not only if a planet looks like Earth today but if it looks like the kind of world that Earth was billions of years ago.

All of this is building to a more complete universal definition of habitability. By exploring different ingredients and recipes, scientists like Kaçar are slowly defining the edges of a broader search for life. They are preparing us to interpret new signs of life, whether from a planet just like our own or from strange, undiscovered worlds.

And if we don't find aliens? Life on Earth would be all the more special, and understanding how life formed here would be even more important.

"Ultimately, it will tell us more about ourselves," says Kaçar. "What better way to honor our own ancestors?"

Dallol, Ethiopia

Hydrothermal chimneys, salt pillars, and terraces in Dallol, Ethiopia. This region has conditions analogous in some ways to the surface of Venus, including sulfur springs and extreme temperatures.

Electra Kotopoulou

Milky Way behind Earth

A long exposure image of Earth as it partially eclipses the Milky Way, taken from the International Space Station.

NASA / Don Pettit

A TEST BED IN THE SEARCH FOR LIFE

Earthly lakes as stand-ins for alien environments

by Kate Howells

In 2021, The Planetary Society launched a new program to fund innovative science and technology projects: STEP (Science and Technology Empowered by the Public) Grants. STEP Grants are competitively awarded through an open international process every two years. Winning projects relate to the Society's core interests of exploring other worlds, finding life, and defending Earth from dangerous asteroids.

One project that was awarded a STEP Grant in May 2023 involves studying super-salty lakes on Earth as analogs for environments we think likely exist on other worlds like Mars, Europa, and Enceladus.

Led by Jacob Buffo, PhD, of Dartmouth College, the project has been conducting field studies in a group of hypersaline lakes in British Columbia, Canada. Two of these studies took place in the late summer, when these lakes are drier than usual and therefore saltier — "what we believe concentrated ephemeral lakes on Mars could have looked like," says Buffo. Ancient Mars was a warm, wet planet, and as it became colder and lost its surface water, it's possible that hypersaline lakes were the last to dry up. If so, these could have provided "the last hypersaline refuges for any potential organisms," according to Buffo.

The other two expeditions revisited these same sites in the dead of winter, when the lakes were frozen over and icy layers formed. These environments could be similar to those on moons like Europa and Enceladus that are thought to hide oceans of salty liquid water under their ice crusts. If life exists anywhere else in the Solar System today, it could well be on moons like this, making the hypersaline lakes great targets in analog studies of habitability.

So far, the team has collected more than 400 unique samples of lake ice, salt, brine, and sediment. These samples are being analyzed for microbial life, organic content, and ecological structure to better understand how the physics, chemistry, and biology of these extreme environments interact.

A major goal of the research is to pinpoint where the richest microhabitats exist within these extreme lake systems. Another goal is to identify the kinds of

LEARN MORE

Information about our STEP Grant program can be found at planetary.org/sci-tech/step-grants.

biosignatures that we might be able to spot when we visit those places. Essentially, the research is helping us better understand where and how to look for signs of life on other worlds.

One result Buffo's team has found so far is that hyperspectral drone imagery has been useful in mapping key features like brine pools and mineral ridges in lakes like this. This might support the use of flying spacecraft like NASA's Ingenuity or Dragonfly helicopters to scope out where to search more thoroughly for signs of life.

By testing out techniques, tools, and theories here on Earth, Buffo and his research team are helping make sure that when we go out to search for life on other worlds, we're as prepared as we can be.

▼ Scientist Emmy Hughes at Basque Lake 3.
Jacob Buffo

FROM THE CHIEF SCIENTIST

A cosmic roundup from The Planetary Society's chief scientist

by Bruce Betts, PhD

IN THE SKY

The Geminid meteor shower peaks the night of 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. When the shower peaks, a 30% full Moon will rise around 2:00 a.m., washing out some of the meteors. In the evening sky, reddish Mars is low to the horizon in the west, sinking below the horizon during October. In September, yellowish Saturn is just rising in the east in the early evening, and by December, it is high overhead in the evening. Super-bright Venus is in the predawn east, but it drops lower as the weeks pass, becoming very tough to see by November. Mercury makes an appearance low in the predawn east in late November and early December. By December, northern winter constellations such as Orion are shining brightly in the evening skies.

For more night sky tips, you can always check out **planetary.org/night-sky.**

TRIVIA CONTEST

Our March Equinox contest winner is Pete Benttinen of Duxbury, Massachusetts, USA. Congratulations!

The question was: ***What was the last mission to fly by Jupiter on its way to somewhere else?***

The answer: ***New Horizons in 2007 on its way to the Pluto system and beyond.***

Try to win a copy of the new book "Earth: Our Home Planet with The Planetary Society" by Bruce Betts and a Planetary Radio T-shirt by answering this question:

In kilometers or in miles, how much bigger is Earth's equatorial radius compared to its polar radius?

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, 2025. One entry per person. The winner will be chosen in a random drawing from among all the correct entries received.

RANDOM SPACE FACT

For every human on Earth, there are (very approximately) 30 stars in the Milky Way galaxy.

A COSMIC PERSPECTIVE WORTH FIGHTING FOR

What abandoning space science would really mean

by Casey Dreier, Chief of Space Policy

In fighting the unprecedented, unstrategic, and wasteful cuts facing NASA's science projects, it's easy to fixate on the numbers: the billions of dollars cut, the jobs lost, the dozens of missions canceled. It's understandable; we tend to talk about things we can quantify. But to focus solely on these numbers is to miss an opportunity to reflect on why we care about counting them in the first place.

Bearing witness to space exploration makes us feel something. We see a vista of the Martian surface and we feel the urge to climb the next hill in the distance. We feel the thrill of being among the first humans to see the Plutonian mountain ranges gleaming in a cold and distant Sun. We feel the humility and reverence that quiets the mind when falling into the Hubble deep field image, each point a galaxy of worlds.

As a reader of The Planetary Report, you probably resonate with this experience. Our co-founder, Carl Sagan, certainly did. He understood that the sublime — the flashes of awe or wonder that capture our hearts — is fundamental to the human experience. And the Cosmos, in its unfathomable and ancient vastness, provides access to that experience for anyone of any culture. I believe this feeling is among the foremost "benefits" of space exploration but the most difficult to express in words. But that shouldn't stop us from trying.

I've noticed a trend over the past decade in how we talk about space: an obsession with practical utility, extraction, profit, and how space will enable our material consumption. None of these perspectives is inherently wrong or even undesirable. But to fixate solely on utilitarianism is an impoverished mindset and is ultimately emotionally empty.

How we advocate for space reflects this to varying degrees. Jobs, economic impacts, and workforce development are all important and truly beneficial. But I've come to believe that this framing is too narrow. And in so doing, we (including the larger society) have lost the skill at defending, or perhaps even accepting, unquantifiable values. Values like beauty, curiosity, and discovery are inherent in the very act of peaceful space exploration.

This is why space has been a public responsibility for so long. It is rich in opportunities and value that defy our terrestrial expectations of quarterly earnings reports, market cycles, and customer growth curves. This is not to deny the astonishing progress made by the private sector in a number of space activities, but there are limits. The purely commercial markets in space are communications and remote sensing — in other words, in areas where you go up into space in order to point back down, literally reflecting our own thoughts back to ourselves. There's a lot more to the Cosmos than this.

For nearly 70 years, NASA did the other things — sometimes on its own and more recently, with partners across the globe and in the commercial sector. Discovery-driven science remains a public activity, a unique activity even among other public responsibilities. The tools have changed but not the financial reality. If NASA gets less funding to pursue science, less science will be done.

To countless generations, "space" was the night sky: familiar yet deeply alien, vast yet inaccessible. It inspired them to wonder, to create stories explaining what they saw. These were the heavens, perceived as forever guarding their secrets, lording over humanity. Over time, we improved at deciphering some of these secrets. We grew more clever, and our tools became more sophisticated, but the night sky itself remained out of reach.

Only in the last 67 years has that changed. Our national space agencies, intended to both serve and reflect the public itself, are thus a projection of shared identity into the literal heavens. The symbolism is powerful and universal. NASA is more than a space agency; it's a mirror of the United States back onto itself. What NASA does — or does not do — is itself a reflection of what our society does — or does not — value.

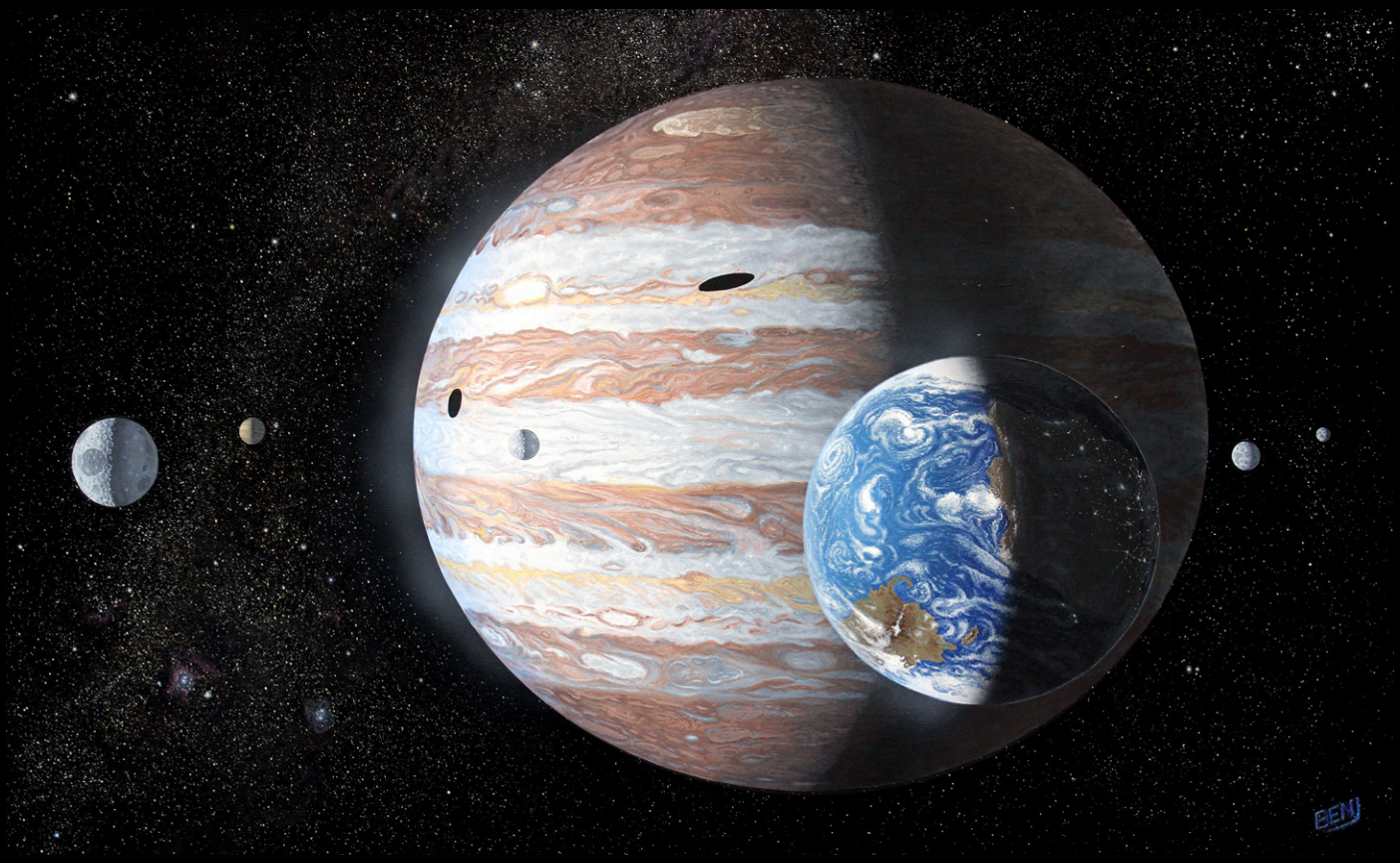
This is why Sagan helped found The Planetary Society: to fight for the activities in space that ennoble and inspire us, in addition to those that provide immediate practical value. This perspective demands that we reframe the question "What can we take from the Cosmos?" to "What can the Cosmos give to us if we bother to look?"

THE DAY OF ACTION

This is not a normal year for space advocacy, so we are going all in. The Planetary Society is working with several partner organizations to convene a special "Save NASA Science" Day of Action on Oct. 6 in Washington, D.C. Registration closes in the last week of September, so sign up today at planetary.org/dayofaction.

This view of nearly 10,000 galaxies is called the Hubble Ultra Deep Field. The Hubble Space Telescope captured 800 exposures over 400 orbits around Earth, totaling 11.3 days between Sept. 24, 2003, and Jan. 16, 2004.

NASA/ESA/S. Beckwith (STScI)/HUDF team



John S. Benjamin

EARTH-LIKE MOON

This painting by longtime Planetary Society member John S. Benjamin shows an imagined gas giant planet circled by an Earthlike moon. The moon's nightside shows signs of artificial lighting — an indicator that it is home to an advanced civilization. "It strikes me," says Benjamin, "that one of the goals of groups like The Planetary Society is to find just such a world."

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.

CELEBRATE SPACE AROUND THE WORLD

In October, join people around our planet to celebrate space together in two international events.

On Oct. 4, look up at our cosmic companion for the NASA-led International Observe the Moon Night. Everyone on Earth is invited to learn about lunar science and exploration, take part in celestial observations, and honor cultural and personal connections to the Moon. Go to **moon.nasa.gov/observe-the-moon-night** to learn more.

And that same day kicks off World Space Week, an international celebration of science and technology and their contribution to the betterment of the human condition. World Space Week 2025 takes place Oct. 4–10. Go to **worldspaceweek.org** to learn more.

The Planetary Society is proud to partner with both events, which include in-person and virtual events, educational resources, and fun activities for all ages.

Photo illustration: ariaï

TUNE IN TO PLANETARY RADIO

Sept. 30 is International Podcast Day. Have you given Planetary Radio a listen yet?

The Planetary Society's weekly podcast takes you to the outer reaches of the Solar System and beyond. Host Sarah Al-Ahmed visits with scientists, engineers, mission leaders, astronauts, advocates, and writers who provide their unique and exciting perspectives on the exploration of our Universe. New episodes are published every Wednesday.

Our monthly Planetary Radio: Space Policy Edition brings you in-depth interviews between The Planetary Society's Chief of Space Policy Casey Dreier and special guests, diving deep into the policy and politics behind what we do and where we go in space. New episodes are published on the first Friday of every month.

Go to **planetary.org/radio** or find Planetary Radio wherever you stream podcasts.

THE AMERICA'S FAVORITE TEACHER COMPETITION

This year, The Planetary Society partnered with the America's Favorite Teacher competition, hosted by Colossal. The 2025 winner, second-grade teacher Jonathan Koch from Newark, New Jersey, earned $25,000, a dream getaway to Hawaii, a school assembly hosted by Bill Nye, and an appearance in Reader's Digest. Through the competition, Colossal raised a whopping $3.2 million for The Planetary Society to support our work in educating and inspiring the next generation.

NASA BUDGET WATCH

News leaked in April of this year that the Trump administration was planning drastic cuts to NASA's budget. In May, that news was confirmed: The president's 2026 budget request includes a staggering 47% cut to NASA's science programs as part of a 25% cut to NASA overall.

In response to these threats to the U.S. space program and all the science it enables, The Planetary Society began one of the largest advocacy campaigns in our organization's history. We have organized public petitions, letter-writing campaigns, and events in Washington, D.C., and we have coordinated advocacy efforts with the Congressional Planetary Science Caucus and many science institutions around the United States. In response to these threats, The Planetary Society began our largest-ever advocacy campaign. Within months, we facilitated nearly 100,000 messages to Congress, led hundreds of advocates to Washington, D.C., organized joint statements by major scientific and commercial space organizations, and briefed hundreds of media outlets and congressional staff. Our strategy: get Congress to reject the cuts by being bipartisan, data-driven, and consensus-oriented.

To see the latest developments and take action, go to **planetary.org/save-nasa-science.**

And Congress listened. In July, the House and Senate each approved funding bills that rejected the full extent of the proposed cuts.

This initial success is due to the energy and passion of our advocates. But much lies ahead, and we cannot stop now. This funding legislation still must be signed into law. Until then, the risk of massive cuts to space science remains. Your voice as an advocate is more important than ever.

THE COSMOS AWARD

The Planetary Society established the Cosmos Award for Outstanding Public Presentation of Science in 2005. Only six individuals have received it since then. They include James Cameron, Neil deGrasse Tyson, Alan Stern, Paula Apsel, and Stephen Hawking.

This year, we were proud to add acclaimed author Dava Sobel to that distinguished list — a storyteller who embodies the spirit of science communication with grace, clarity, and curiosity.

Dava joined Bill Nye, our board of directors, and special guests in Washington, D.C., on May 30 to receive the award. We congratulate her and thank her for carrying us along on this voyage that is advancing our own vision: to know the Cosmos and our place within it.

Planetary Society CEO Bill Nye presented the Cosmos Award to Dava Sobel on May 30, 2025.
The Planetary Society

SOCIETY TRAVEL

We invite you to join other members and friends of The Planetary Society to discover the world on a Betchart Expeditions adventure!

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

MAR. 15–21, 2026

ALASKA AURORA BOREALIS

Come see the greatest light show on Earth! Explore Anchorage and then take the train past Denali to Fairbanks and delight in the ice festival, sled dogs, and the aurora borealis in the night sky!

APR. 18–25, 2026

ARIZONA SKIES & LYRID METEOR SHOWER

Explore the astronomical and natural wonders of this desert paradise. Visit Four Corners, Canyon de Chelly, Sunset Crater, Lowell Observatory, and more. With excellent leadership by an archaeoastronomer specializing in Native American studies, enjoy special lectures and observe the Lyrid meteor shower where dark skies make the Milky Way amazing to see!

AUG. 3–13, 2026

MAJORCA, SPAIN & TOTAL SOLAR ECLIPSE

We invite you to join our Spain total solar eclipse adventure, which includes a special visit to Madrid's historic Royal Observatory, the Science Museum of Castilla-La Mancha in Cuenca, and the remarkable City of Arts and Sciences center in Valencia. Then, travel to the enchanting Mediterranean island of Majorca to see the total solar eclipse at sunset!

AUG. 8–16, 2026

WILD ICELAND & TOTAL SOLAR ECLIPSE

Come with us to discover the land of fire and ice in all its great beauty and see the total solar eclipse from Iceland's remote Westfjords! Spend days outdoors with long hours of sunlight exploring striking waterfalls, fjords, lava fields, hot springs, and charming small villages. With leadership by an excellent Icelandic naturalist and astronomer, this will be a memorable outdoor adventure!

Participants in a 2016 expedition to Iceland.

Oskar Halldorsson

AUG. 16–21, 2026

FAROE ISLANDS

This optional extension is just a short flight from Iceland! Explore the stunning scenery and learn about the unique natural and cultural heritage of this intriguing group of islands in the North Atlantic. With wild landscapes and cozy villages, it is certainly an experience of a lifetime.

THE PLANETARY SOCIETY
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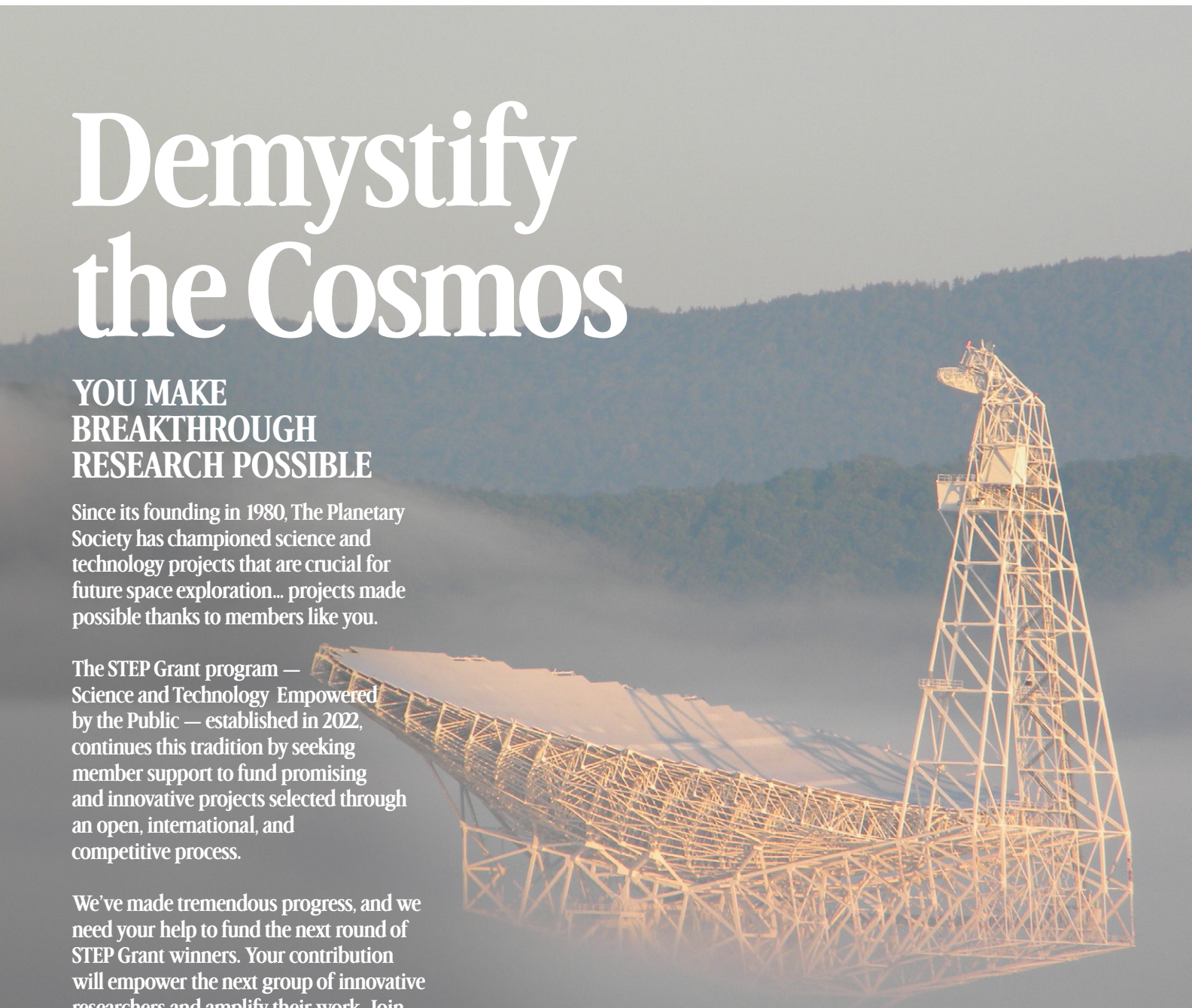
Demystify the Cosmos

YOU MAKE BREAKTHROUGH RESEARCH POSSIBLE

Since its founding in 1980, The Planetary Society has championed science and technology projects that are crucial for future space exploration... projects made possible thanks to members like you.

The STEP Grant program — Science and Technology Empowered by the Public — established in 2022, continues this tradition by seeking member support to fund promising and innovative projects selected through an open, international, and competitive process.

We've made tremendous progress, and we need your help to fund the next round of STEP Grant winners. Your contribution will empower the next group of innovative researchers and amplify their work. Join us in this crucial endeavor by making a gift at planetary.org/step today.



The Green Bank Telescope used by a 2022 STEP Grant winner.
NSF/AUI/NRAO, Dave Curry

THE PLANETARY SOCIETY