THE PLANETARY REPORT

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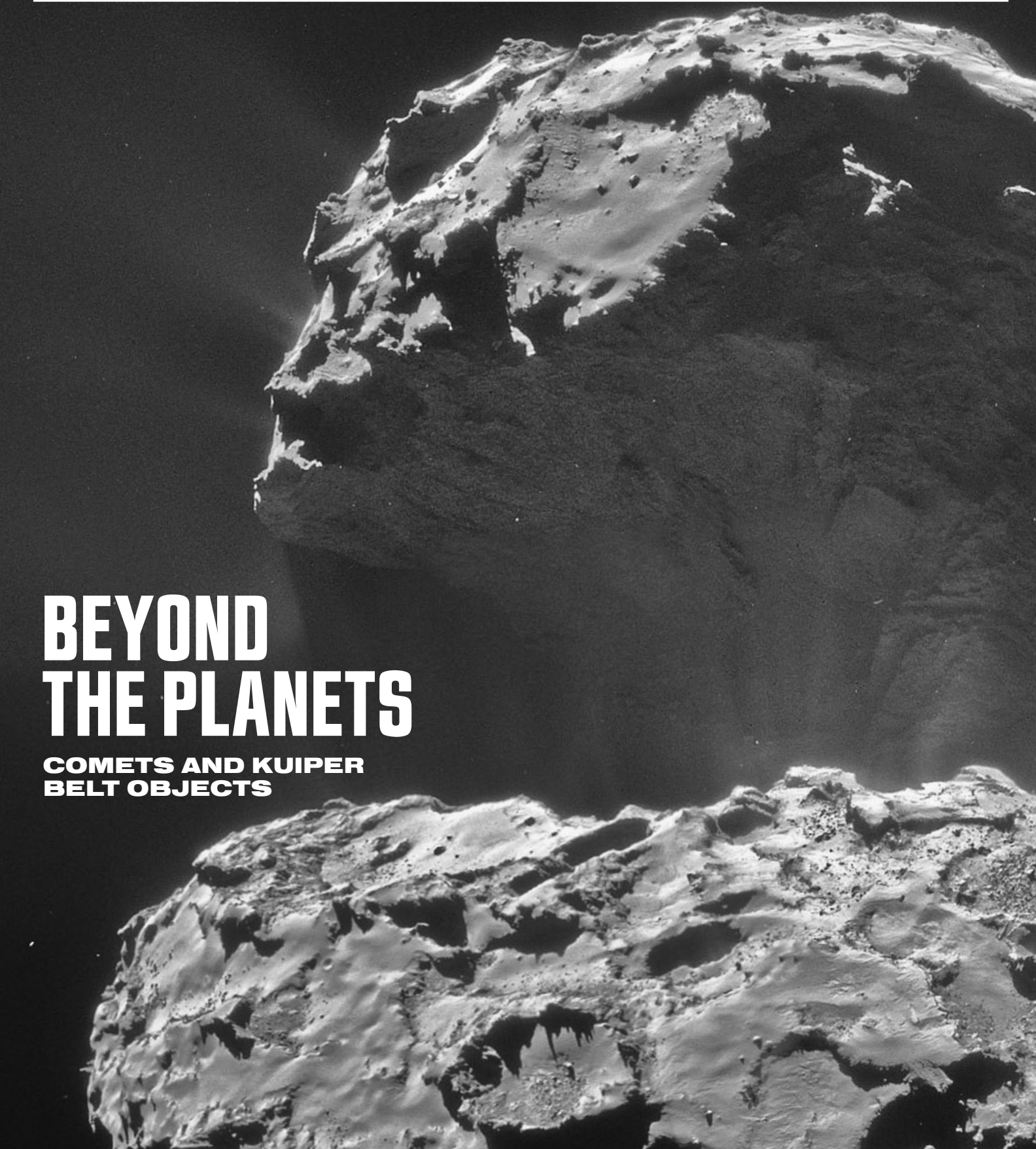
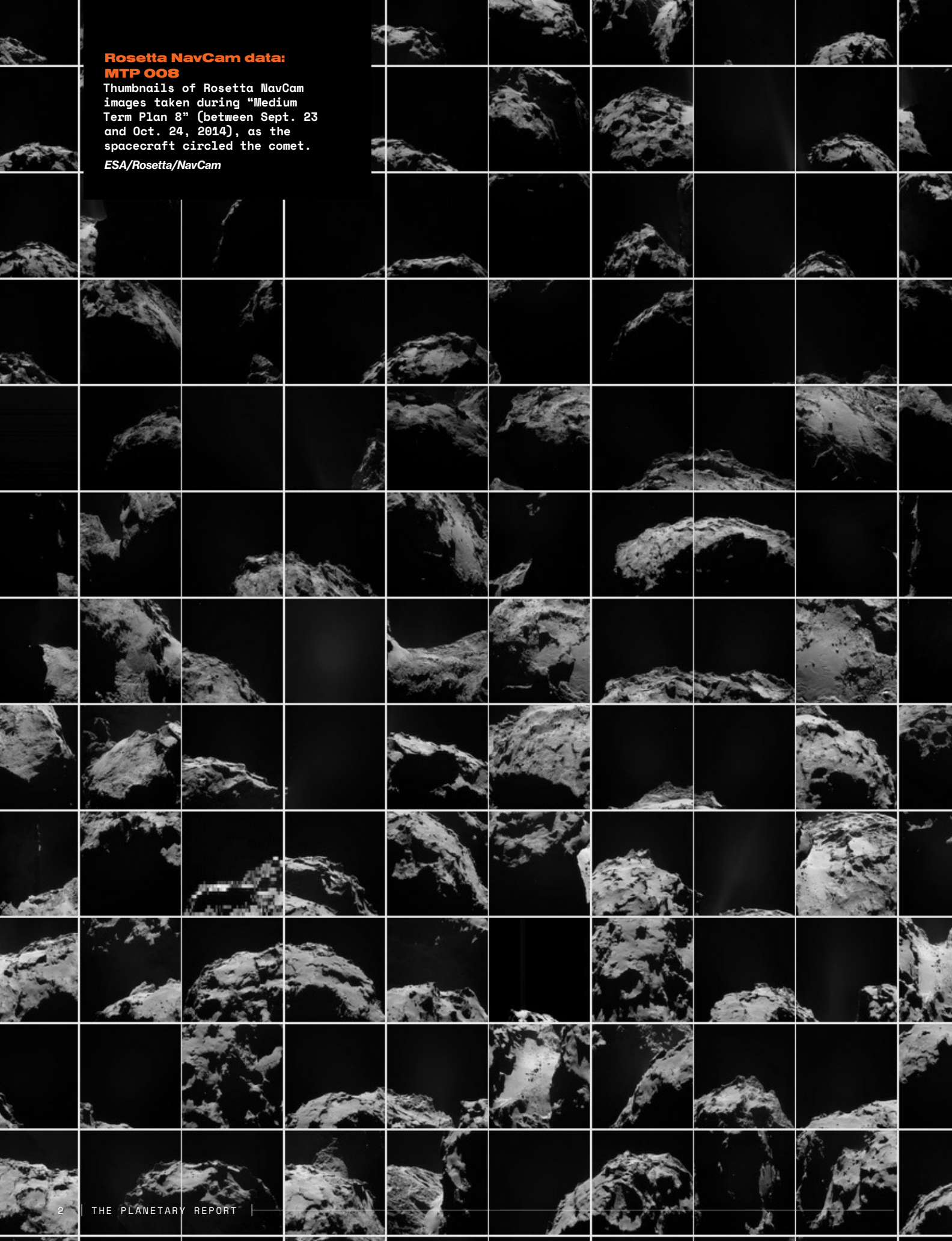


BEYOND THE PLANETS

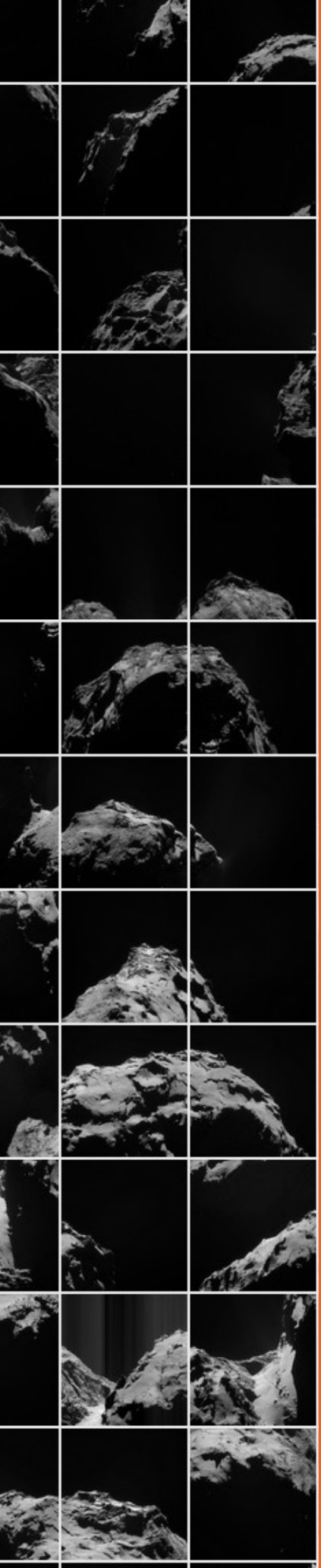
COMETS AND KUIPER BELT OBJECTS



Rosetta NavCam data: MTP 008

Thumbnails of Rosetta NavCam images taken during "Medium Term Plan 8" (between Sept. 23 and Oct. 24, 2014), as the spacecraft circled the comet.

ESA/Rosetta/NavCam



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On the cover
This view of comet 67P/Churyumov-Gerasimenko was taken by the European Space Agency's Rosetta spacecraft in 2015. The view is across the large end of the comet toward the underside of the smaller end. Although 67P doesn't go around the Sun beyond the orbits of the planets, it began its existence in the Kuiper belt.

ESA/Rosetta/NavCam/Elisabetta Bonora/ Marco Faccin

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THE NEXT CHAPTER BEGINS

Though passing the torch, our mission endures

by Bill Nye

After 15 years at the top of the org chart, I'm stepping down — or aside. I'm retiring from my role as CEO, but I'm thrilled to continue serving in a new role as our first chief ambassador. As we enter the start of our next strategic era, this feels like the right moment for transition — for the staff, for our members, and for me.

Our remarkable chief operating officer Jennifer Vaughn took over as CEO in February. Throughout my time as executive director and later as chief executive officer, Jenn has been my closest partner in leading the organization. This transition will be smooth indeed. There is no one in the Solar System more qualified than Jenn. She knows this place and the people who help keep it running. She will lead us into The Planetary Society's sixth decade.

As you may know, my time with the Society started when I took an undergraduate class from none other than Carl Sagan in the spring of 1977. When The Planetary Society was founded in 1980, I became a charter member. Years later, Carl's kids watched my Science Guy show, and Planetary Society co-founder Lou Friedman asked me to join the board of directors. Then, I became vice president. In 2010, the board asked me to serve as executive director. After his 30 years at the helm, Lou Friedman wanted to retire. My friends, I was taken (quite a ways) aback. I did not feel especially qualified. Oh, sure, I had held leadership roles before. And I had been a producer, host, and head writer of a kids' show. But none of these positions was quite the same as running the world's largest independent space-interest society. But the board had faith in me, and so I had faith I could do it. And here we are, 15 years on.

Over those years, I came to understand that we have a chance to change the world. Like millions of people, I was inspired by the vision of our founders. Bruce Murray could state the reason The Planetary Society exists with clarity. I hear his words every day. "There are two questions we all ask: Where did we come from? And are we alone in the Cosmos?" Those are the big ideas that every human on Earth has pondered at some time in their life.

Along with the two big questions, there are three things that have perpetually motivated me. I want to explore other worlds because we don't know what we're going to find. Ice on the Moon's south pole? Microbes under the sands of Mars? Aquatic creatures swimming around under the ice on Europa? Something extraordinary in the plumes shot into space by the jostling of the icy crust of Enceladus? The mind boggles.

The next thing: I don't want Earth to get hit with a seriously sizable asteroid. I like to tell every member of Congress and every member of their staff that an asteroid impact is the only preventable natural disaster. Such is not the case with an earthquake, volcanic eruption, hurricane, or twister. If it's an asteroid, with planning and international cooperation, we could do something.

The third thing that has kept me going and will keep going as long as I live: I want to find evidence of life — better yet, something still alive out there in the Cosmos. I referred to possibilities on Mars, Europa, and Enceladus. What about Titan? Or the cool clouds

in the Venusian atmosphere? What about an exoplanet? A discovery of life would, dare I say it, change the world. Everyone on Earth would feel something profound — something new, strange, and important about being alive in the Cosmos.

OK. Enough about where I, or we, have been. Let's talk about where we're going. Along with this smooth transition in leadership, how 'bout we change the world? Under Jennifer Vaughn's leadership, we will keep building on our successes. We're going to continue to invest in all of our science and technology programs. We're going to continue to develop and expand our educational outreach efforts. And we're going to keep showing up in the U.S. Congress both in person and through emails, letter-writing campaigns, and petitions. With your help, we're going to keep up the pressure to restore funding to NASA, and we're going to keep advocating for international cooperation in the scientific exploration of space. No other organization in space science advocacy matches our reach, our credibility, or our impact.

Though I am proudly passing the torch of the CEO role, I won't be stepping away from The Planetary Society. I'll continue serving on the board and will take on a new role as our first chief ambassador. In this position, I'll represent our organization publicly, keep in close communication with our members, and continue to champion space exploration in the halls of Congress at our annual Day of Action and beyond.

Meanwhile, Jenn will take the helm at the top of the org chart. We could not be in better hands. Jenn helped craft our mission, and she is a natural leader with a clear vision for the future. She has the full trust and respect of the staff. The main thing is that she is just plain good at this. She will lead us into the 2030s and help us grow and advance our mission to enable the citizens of Earth to advance the scientific exploration of space.

This has truly been the honor of a lifetime. My time as CEO has been wonderful; the friends I've made and the staff I've worked with have meant the world(s) — Earth and beyond — to me. At The Planetary Society today, we have the best team we've ever had. Our success is a product of each and every member of our team. I'm very proud to know 'em. And I'm especially proud to have served you, our members.

Let's change the world!

Bill Nye

A version of this article was also published on planetary.org in January 2025.

SKY WANDERERS TO DOMINANT ORBITERS

How our understanding of planets has changed over time

by Kate Howells

The field of planetary science isn't often plagued by drama, but there are occasional controversies. Perhaps the most famous was the 2006 reclassification of Pluto as a dwarf planet. Many people saw this as an unfair demotion of a full-fledged planet, but it wasn't the first time humanity had narrowed our definition of a planet to account for new information.

The earliest definition of a planet was simply any bright object that moved against the fixed backdrop of the stars. In ancient Greek astronomy, the planets included Mercury, Venus, Mars, Jupiter, Saturn, the Sun, and the Moon. Earth was not considered a planet; it was thought to be the stationary center of the Universe.

The Copernican revolution of the 16th century introduced a new definition: Planets were objects that orbited the Sun, including Earth. This view held for centuries.

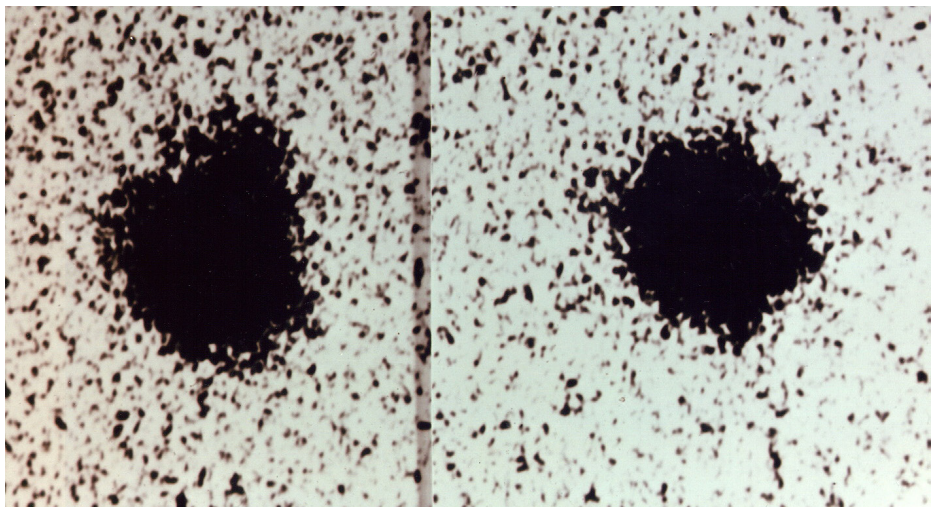
The planetary family expanded with the discovery of Uranus in 1781, and as telescopes improved, the list continued to grow. Beginning with the discovery of Ceres in 1801, astronomers found a succession of small bodies between Mars and Jupiter, including Pallas, Juno, and Vesta. At first, these were all considered planets. But as dozens more objects were detected in the same region, it became clear they formed a distinct population. By the mid-19th century, the classification of "asteroids" or "minor planets" shrank the list of planets to only the major bodies orbiting the Sun — including Neptune, discovered in 1846.

In 1930, astronomers thought they had found the ninth planet they had long predicted. They had spotted Pluto but had overestimated its size. The faint, fuzzy spot in their telescopes was actually Pluto and its companion Charon, blurred together by low telescopic resolution — an error not uncovered until 1978.

Decades later, improved measurements showed Pluto was much smaller than originally thought, and in the 1990s, astronomers began finding other icy bodies beyond Neptune. These Kuiper belt objects formed a large population to which Pluto clearly belonged, just as Ceres had belonged to the asteroid belt.

The issue came to a head in 2005 with the discovery of Eris, a scattered disk object (another more distant group of bodies) about the same size as Pluto. If Pluto were a planet, many argued, Eris must be one too. Instead of expanding the list of planets to include many more Pluto-size worlds, the International Astronomical Union decided in 2006 to refine the definition of "planet" again. For the first time, a formal scientific definition was established: A planet must orbit the Sun, be massive enough for gravity to pull it into a roughly spherical shape, and have cleared its orbit as the dominant object in its region. Pluto met the first two criteria but not the third, reclassifying it as a "dwarf planet" along with Eris and Ceres.

This decision sparked debate that continues today. But the IAU's definition doesn't limit what's worth studying. The worlds of the Cosmos are all fascinating regardless of size. And, as you'll learn in this issue, there is still much to be learned about the smallest objects in our Solar System.



▲ **Charon discovery**
These two images of Pluto were captured several days apart in 1978. The planet appears elongated on the left, which turned out to be due to the fact that these images captured both Pluto and its companion Charon.
U.S. Naval Observatory

Andrew C. Stewart

COMETS OF THE PAST

Planetary Society member Andrew C. Stewart of Nottingham, U.K., painted this depiction of a comet passing through space from the vantage point of an icy world — perhaps Earth during its last ice age.

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.

MESSENGERS OF ICE AND TIME

What comets could teach us about our place in space

by Jason Davis

Long before telescopes or space missions, our ancestors gazed up in wonder at comets that appeared in the night sky. These ghostly visitors were seen as omens, messengers, or divine portents. Today, we know comets not as harbingers but as ancient assemblages of ice and dust left over from the dawn of the Solar System — time capsules carrying water and organic compounds that predate Earth itself.

Our last mission to visit a comet was the European Space Agency's Rosetta mission, which orbited comet 67P/Churyumov-Gerasimenko from 2014 to 2016. Rosetta became the first spacecraft to accompany a comet as it journeyed around the Sun, studying how sunlight transformed its surface and atmosphere in real time. Rosetta's suite of instruments — including the ROSINA mass spectrometer, whose science team was led by Kathrin Altwegg at the University of Bern — revealed an unexpected richness of organic molecules, reshaping our view of comets as potential carriers of the ingredients for life on Earth.

"The organics in comets like 67P were mostly produced before the Solar System was born," said Altwegg. "These organics are universal. We can even observe some of them in dark molecular clouds and star-forming regions. This means whatever led to life on Earth can happen elsewhere in the Universe."

The results on water were more nuanced. Rosetta found that the deuterium-to-hydrogen ratio in comet 67P's water was not a match for Earth's oceans. Yet other comets carry water with Earth-like chemistry, suggesting that certain types of comets may have contributed to Earth's water, alongside asteroids.

The Space Age has transformed our understanding of comets and their potential role in delivering water and organics to Earth. Yet the few we've visited with spacecraft have been reshaped by repeated journeys through the inner Solar System. What secrets would a pristine comet hold? What could a sample-return mission reveal? Do comets have more to teach about our origins?

Surface of a comet

In October 2014, the Rosetta spacecraft captured this image of the surface of comet 67P/Churyumov-Gerasimenko from closer than the cruising altitude of an average passenger plane.

ESA et al.

An abundance of organics

When the Sun and planets formed from a giant cloud of gas and dust 4.6 billion years ago, the leftover material became the asteroids and comets we see today. Close to the young Sun, it was too hot for volatile ices to survive. But farther out, temperatures dropped low enough for icy planetesimals to form.

Some of these icy bodies settled into the Kuiper belt, home to short-period comets that periodically enter the inner Solar System on orbits lasting up to about 200 years. Others were thrown outward by the giant planets into elongated, tilted paths that form the scattered disk, a transitional region extending far beyond the Kuiper belt. The most dramatically flung objects populated the distant, spherical Oort cloud, which may stretch halfway to our nearest star, Proxima Centauri. If Proxima has its own Oort cloud, its outer edges might overlap with ours.

So far, all the comets we've visited — Giacobini-Zinner, Halley, Grigg-Skjellerup, Borrelly, Wild 2, Tempel 1, Hartley 2, and 67P — have been short-period comets, baked and altered by repeated cycles of sunlight. But even these dynamic worlds have revealed remarkable chemistry.

At 67P, Rosetta's ROSINA instrument detected glycine, an amino acid found in proteins, and phosphorus, a key ingredient in DNA and cell membranes. In a recent paper, Altwegg and her co-authors found heterocycles, ring-shaped molecules that play crucial roles in the biochemistry of carbon-based life. Another analysis led by Altwegg used 67P's composition to extrapolate how much organic material comets could have carried to Earth billions of years ago. The conclusion: Comet-delivered organics could have matched or equaled the total biomass on Earth today, increasing the likelihood that comets played a role in life's origins.

While Rosetta revolutionized comet science, Altwegg said key mysteries remain. "We mostly investigated the coma — the dust and gas from the surface. We still don't know how the ice and dust are distributed inside or how homogeneous comets really are," she said. "To answer that, we need to visit more comets."

Comet 67P
Comet 67P/Churyumov-Gerasimenko imaged by ESA's Rosetta spacecraft in 2015.
ESA et al.

Comet Interceptor: A waiting game

Ideally, scientists would study a pristine comet — one entering the inner Solar System from the Oort cloud for the first time before sunlight cooks its surface and drives away its volatile ices. That's the goal of Comet Interceptor, an ESA mission set to launch in 2029. The spacecraft will park itself at the Sun–Earth L2 point, about 1.5 million kilometers (930,000 miles) away, ready to intercept a long-period comet or even an interstellar object.

"We can realistically wait for a few years," said Colin Snodgrass, an interdisciplinary scientist on the mission and a professor of planetary astronomy at the University of Edinburgh. "The limit comes from the budget cap rather than any physical one — the mission is meant to be done inside of six years, including waiting, cruise, encounter, and data downlink."

If an interstellar object such as the headline-making comet 3I/ATLAS appears, Snodgrass said the team would jump at the chance to rendezvous with it. "If there's an interstellar object we can actually reach, there's unanimous support for going for it. It would be too good an opportunity to miss," he said. "But it's unlikely we can reach one with our limited fuel budget — it would need to come quite close to Earth."

Even among potential long-period comets, selecting a target is complex and fraught with trade-offs. "There are lots of competing factors," Snodgrass said. "We'd want one whose orbit suggests a higher probability of being dynamically new, and a larger nucleus — those tend to be more active."

The mission's ultimate goal is to compare pristine comets to ones already altered by sunlight. "We want to learn about the processes involved in comet evolution and their formation," Snodgrass said. "Whether comets show signs of forming early or later in the Solar System's history tells us a lot about how solid bodies formed in the planetary disk."

If no suitable new comet or interstellar object appears in time, Comet Interceptor can redirect to a known short-period comet as a guaranteed target, ensuring valuable science no matter what the Cosmos delivers.

Warm comets

Not every comet fits neatly into “short” or “long” categories. Some orbit within the main asteroid belt, while others skim the Sun or fade into dormant, rocky relics. These transitional worlds blur the line between asteroids and comets, revealing how one population evolves into the other.

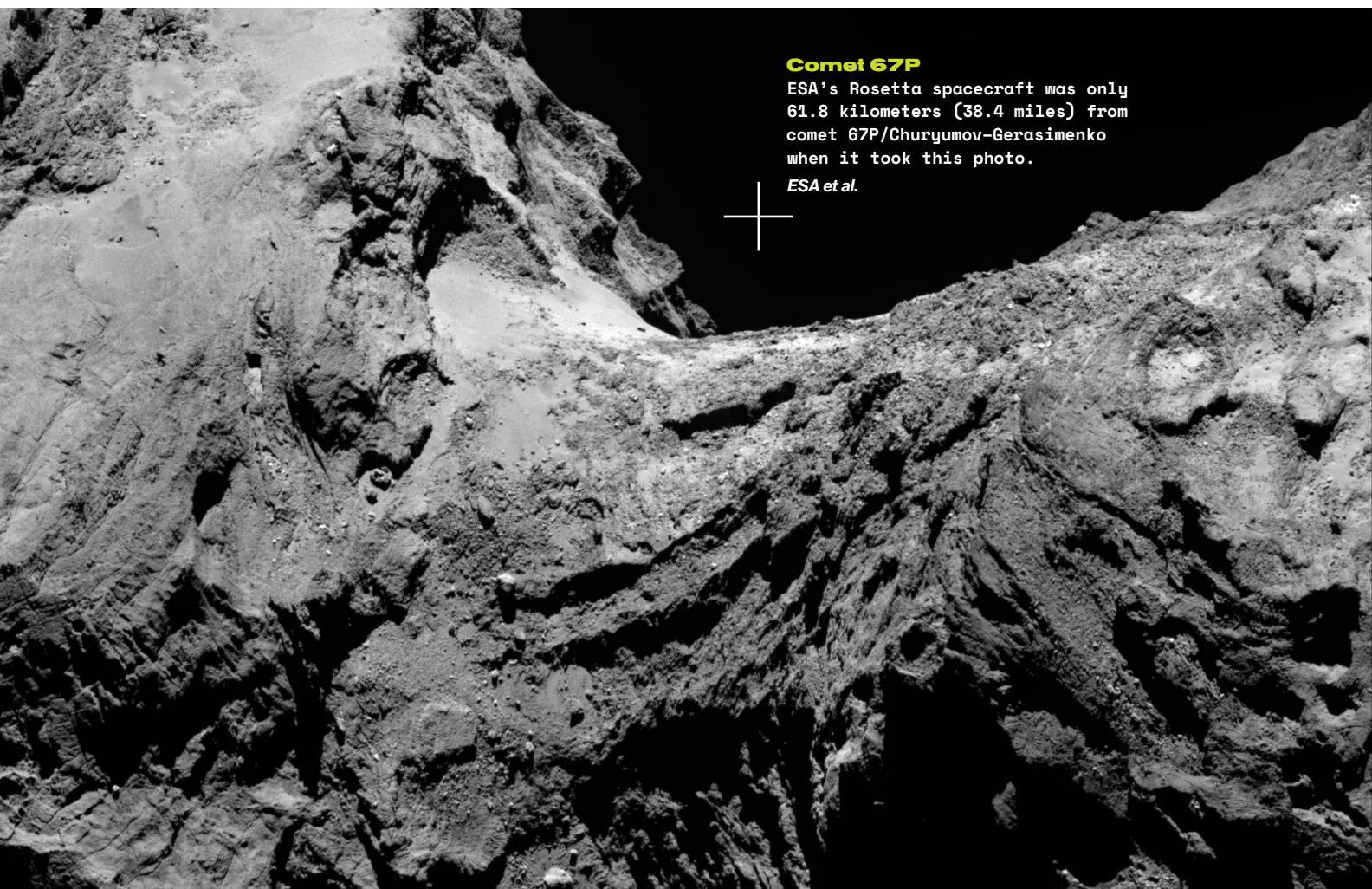
In 2023, the James Webb Space Telescope observed main-belt comet 238P/Read and detected water vapor — the first unambiguous detection of water in a comet that orbits entirely within the asteroid belt. But JWST also found something unexpected: no carbon dioxide, a staple ingredient of most comets.

“Main-belt comets like 238P/Read help us understand where and how water is distributed in the inner Solar System and how long the water can survive,” said Heidi Hammel, vice president of The Planetary Society’s board of directors, who used JWST to study comet Read. Meteorites and telescope data had long suggested that some asteroids formed in the presence of water, she said, “but we haven’t known how long that water can last in the asteroid belt region.”

JWST’s sensitivity finally provided the answer. “The JWST observations demonstrated that water is responsible for its activity, but they also showed that Read lacks carbon dioxide,” Hammel said. “Either it formed in a warm, close-in part of the Solar System or it formed with carbon dioxide, but the gas has been baked out while the comet orbited the Sun in the asteroid belt.”

Both scenarios imply something important: 238P/Read is not an interloper from distant comet reservoirs — it has been part of the inner Solar System for a very long time. “The detection of water indicates that water ice from the primordial Solar System can be preserved in that region for a very long time,” Hammel said.

Opportunities to study these comets are rare. “At last count, there were just 11 main-belt comets,” Hammel noted. JWST is the only observatory sensitive enough to study their chemistry in detail — and the competition for observing time is intense. “The most recent call for proposals garnered a record-breaking number of requests,” she said. “Fingers crossed that main-belt comets and other types of comets make the cut!”



Comet 67P
ESA’s Rosetta spacecraft was only 61.8 kilometers (38.4 miles) from comet 67P/Churyumov-Gerasimenko when it took this photo.
ESA et al.

12P/Pons-Brooks
An astrophotographer captured this image of comet 12P/Pons-Brooks as it neared its closest approach to Earth in March 2024.
Nielander

What lies beneath

Comets are geologically active worlds: porous mixtures of dust, rock, and ice with cliffs, pits, and plains sculpted by sunlight. But what lies beneath their surface? How ices, dust, and organics are mixed and whether they form layers or a patchwork remains one of the biggest mysteries in comet science.

A proposed NASA mission called CAESAR (Comet Astrobiology Exploration Sample Return) would have attempted to answer some of those questions. CAESAR aimed to revisit 67P, collecting a sample and returning it to Earth. While it wouldn't have probed the comet's interior directly, it would have offered the clearest window yet into its composition — the mix of ices, dust, and complex organics that Rosetta could only sample in situ. CAESAR was ultimately passed over in favor of NASA's Dragonfly mission to Titan, but it remains a blueprint for possible comet sample-return efforts.

Another mission concept, Comet Hopper, would have taken a more mobile approach. Designed to land and hop to multiple sites on a single comet, it could have drilled beneath the surface and analyzed material from different regions. "Such a lander could finally tell us how the ice and dust are distributed — whether they're layered around grains, mixed in pores, or separated into larger voids," said Altwegg. "It was a Discovery-class concept that made it to NASA's top three but wasn't selected at the time."

Altwegg sees efforts like Comet Hopper and CAESAR as stepping stones to more advanced future missions. "Ideally, we'd have a cryogenic sample-return mission that keeps the material frozen at around 30 kelvins all the way back to Earth," she said. "That's not feasible today, but a mobile lander could move, drill, and analyze samples deep down. That's how we could finally answer how comets formed and maybe even find more amino acids, perhaps with the same chirality as those on Earth."

Each comet we study is a messenger from the Solar System's earliest days. They carry the raw ingredients that built planets, oceans, and perhaps life itself, preserved in ice and dust for billions of years. By examining these icy travelers, we glimpse the processes that shaped Earth and the worlds around us. We can't return to those first moments, but through comets, we can hear the whispers of our cosmic origins.

Vera C. Rubin Observatory
The Vera C. Rubin Observatory atop Cerro Pachón in Chile, with a time-lapse image of stars passing behind it.

SwRI/Johns Hopkins APL/NOIRLab

BEYOND THE UNKNOWN

The coming Kuiper belt revolution

by Dr. Asa Stahl

If space is the final frontier, then it's easy to imagine the Kuiper belt as the wilderness beyond the last ghost town. Out in the far reaches of the Solar System, there are up to millions of unidentified objects, probably a dozen undiscovered Pluto-size worlds, and — maybe — a long-lost ninth planet. Rather than a barren wasteland, the Kuiper belt is the Solar System's great unknown. Only one dedicated mission has ever ventured there, and we know of more worlds around other stars than we do beyond the orbit of Neptune.

But change is coming. In the near future, a flood of Kuiper belt discoveries is set to revolutionize our census of the Solar System and help unveil its ancient past. Though these worlds may live in our own backyard, what we learn from them could transform how we think about the entire Cosmos.

The outer wilds

"The Solar System does not end at Pluto," said Jim Bell, board member of The Planetary Society and professor in the School of Earth and Space Exploration at Arizona State University.

As Bell explained, many scientists consider some denizens of the Kuiper belt to be just as compelling as the more famous worlds that live closer to the Sun. The belt, which is really more of a donut-shaped region past the orbit of Neptune, contains thousands of known members. These are called Kuiper belt objects (KBOs), though that term is also often applied to other scattered icy objects farther away.

The largest KBOs are surprisingly complex, and some are downright strange. There's Haumea, an oblong dwarf planet with moons and rings that rotates once every four hours — faster than any other object of its size in the Solar System. There's 307261 Máni, which might have a mountain taller than Olympus Mons despite being nearly 10 times smaller than Mars. And some Kuiper belt worlds are predicted to freeze out their entire atmospheres and then regain them as their orbits take them closer to or farther from the Sun.

Of all these, Pluto might be the crown jewel. NASA's New Horizons spacecraft flew by

the dwarf planet in 2015, unveiling a surprisingly active world. Pluto hosts jagged mountains, sweeping dunes, and the largest glacier in the Solar System. Ice volcanoes may rise from its surface, and an ocean of liquid water might lurk below.

Recent findings hint that the Kuiper belt is actually full of such surprises. In 2024, researchers using the NASA/ESA/CSA James Webb Space Telescope found that two members of the Kuiper belt, Eris and Makemake, may also show signs of geologic activity. That could mean there are other feature-rich KBOs out there, possibly even with subsurface oceans of their own.

The suggestion has been met with some skepticism by the scientific community, though. "Everybody wants things to be geologically active," said Mike Brown, professor of planetary astronomy at the California Institute of Technology. "They might be, but I think the evidence is pretty sparse."

Brown argued that we would need a mission to visit these KBOs to know for sure one way or another. Even if the worlds do host subsurface oceans, he added, they might not make for compelling habitats if their water does not interact with a rocky ocean floor.

"I just don't buy this idea that the magical phrase 'ocean world' suddenly means that you're at this special place where unicorns swim around with the whales or something," Brown added.

With no new missions to the Kuiper belt currently planned, scientists don't expect this debate to end anytime soon.

Cold cases and clues

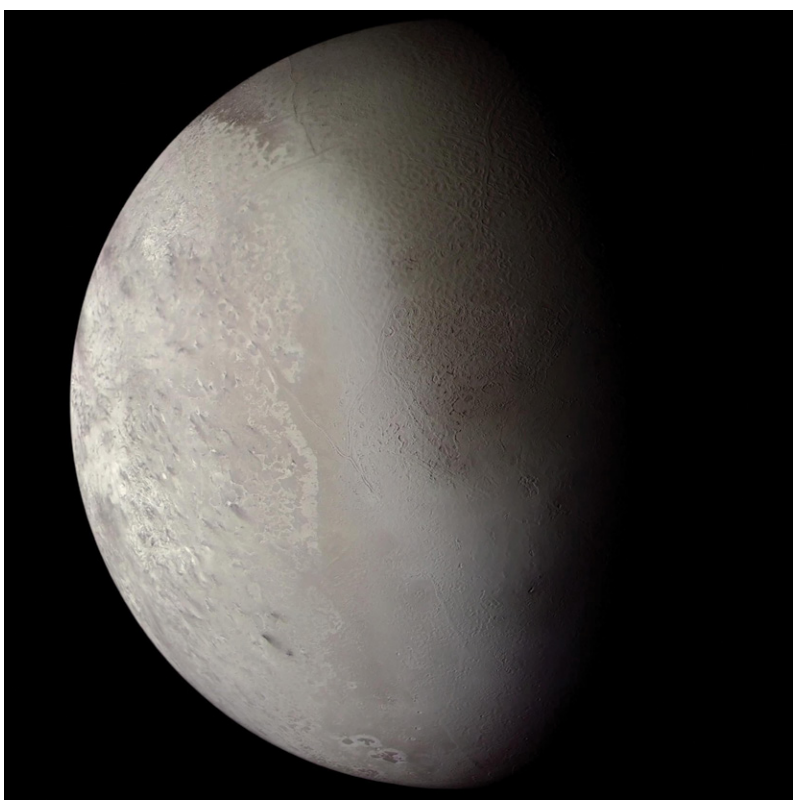
But whether or not these worlds harbor oceans, they also offer something else. The same things that make the Kuiper belt hard to explore — that it's sparse, dark, and distant — also make it a trove for Solar System archaeology. Compared to worlds closer to the Sun, many KBOs have remained virtually unchanged since their birth.

"They hold little pictures of what the early Solar System was like, and you can read those stories," said Brown.

When New Horizons flew by Arrokoth, for example, it discovered the KBO had a snowmanlike shape. This showed that Arrokoth may have formed gently from smaller components rather than through violent collisions. This lent support to the idea that the building blocks of worlds can form as loose piles of "pebbles," which has helped astronomers predict what planets are like throughout the galaxy.

There is another chapter of our cosmic history that KBOs can shine light on too. As it turns out, the creation of the Kuiper belt itself was one of the most cataclysmic episodes in the story of the Solar System. Exploring its worlds gives us a glimpse into this massive upheaval that left its imprint everywhere, from the asteroid belt to Neptune.

Pluto
Pluto from New Horizons in colorized infrared.
NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/ZLDoyle



Triton
Voyager 2 captured this image of Triton in 1989.
NASA/JPL/Ted Stryk Laboratory/ Southwest Research Institute/ZLDoyle

Solar System shuffle

It all began within the first 100 million years or so after Earth was born. At that time, there was no Kuiper belt. Instead, a much more massive disk of debris circled the Sun, possibly hosting up to thousands of Pluto-size worlds.

Then, as the giant planets settled into their current positions and Neptune migrated outward, gravitational changes tore this disk apart. Some pieces careened inward and smashed into other worlds. Others were captured into stable orbits as asteroids and comets, while one remnant likely became Neptune's moon Triton. Much of the rest flew out of the Solar System entirely, turning into interstellar objects — perhaps some other star system's 3I/ATLAS or 'Oumuamua, one day.

Only a tiny fraction of the disk survived in the outermost Solar System. That debris formed the Kuiper belt plus a number of farther-off scattered worlds.

This drama, known as the Nice model (after the city in France), connects the Kuiper belt's faraway worlds to others throughout the Solar System. Thanks to those pieces of the old disk, some moons of the giant planets still host massive craters today. Certain satellites may have even been disrupted by the collisions and then re-formed multiple times.

Without the Kuiper belt, the orbits of the giant planets would be different. We wouldn't have the same Oort cloud. Captured objects like those that help make up the two groups of asteroids that share Jupiter's orbit (called the Trojans) wouldn't exist.

"All of these things are somehow keyed into what was going on in the earliest Kuiper belt," said Bill Bottke, senior research scientist at Southwest Research Institute. "You can't have one without the other."

Lost worlds

The Nice model has become the leading framework for understanding the Kuiper belt's origins. When scientists study the current orbits of KBOs for clues to this past, though, they find that the Nice model can't explain everything they see. Something else shaped the Kuiper belt. We don't yet know what.

One proposal is that the Solar System hosts another undiscovered planet: a "Planet Nine" several times more massive than Earth. This world might have formed among several others, the rest of which were later scattered or thrown out of the Solar System. Debate over Planet Nine has raged for years, with evidence sometimes seeming to point one way, then another.

"Both sides are really smart, so I don't know exactly who is going to win this," Bottke said. "The stakes are high."

Regardless of whether Planet Nine is real, Bottke thinks the Kuiper belt's history also hints at a lost planet of a different kind. According to Bottke, it's much easier to explain the captured KBOs we see today if, as the Kuiper belt formed, the Solar System ejected a major planet.

"I really do think our system once had five giant planets," Bottke said. "I think we've lost a gas giant."

There are other possibilities on top of these. The early Solar System might have been affected by the gravity of a nearby star or a large interstellar object. Or it could have ejected two giant planets instead of one.

Confirming any one of these ideas would utterly shift humanity's sense of its own past. But for now, they remain just that — ideas. It will take new ongoing efforts to test each alternate history.

> **"The diversity of worlds is going to expand dramatically, and there will be surprises."**
>
> *– Jim Bell*

The great unknown

Last year, atop a remote mountain in Chile, the Vera C. Rubin Observatory began a decade-long survey of the night sky. Equipped with the largest digital camera in the world, Rubin is expected to discover about 35,000 new KBOs and increase the known population of the Kuiper belt nearly tenfold. Most of these discoveries will come in the first year or two of data.

"It won't be slow and steady — it's going to be a firehose," said Bottke.

The results are expected to place strong limits on the Nice model, including whether an interstellar object helped rearrange the ancient Solar System. Within its first year, Rubin could also solve the mystery of Planet Nine for good.

"We will have either found Planet Nine or we will have found definitive evidence that it does or does not exist," Brown said. "One of those three things is definitely happening."

More Kuiper belt discoveries may be on the horizon too. NASA's Lucy spacecraft, launched in 2021, is currently on its way to explore several of Jupiter's Trojan asteroids. By studying whether these worlds are actually captured

remnants of the old debris disk, Lucy will help us understand how the Solar System rearranged over time. And if we're lucky, New Horizons could fly by another KBO before it ends its mission. That depends on (among other things) whether Rubin discovers an appropriate target in time.

While each of these efforts would help investigate the Kuiper belt, Rubin is likely to be the most transformative. Bell said Rubin could mark a revolution for KBOs similar to what NASA's Kepler mission did for planets around other stars. Just like with exoplanets in the pre-Kepler era, right now we are limited to a "tiny snapshot" of the population of the Kuiper belt, he explained. That snapshot might be representative, or the most easy-to-spot KBOs might be nothing like the others.

The Kuiper belt already hosts oblong worlds, seasonal atmospheres, and giant glaciers. There is no telling what unexpected wonders remain to be discovered.

"The diversity of worlds is going to expand dramatically," said Bell, "and there will be surprises."

FROM THE CHIEF SCIENTIST

A cosmic roundup from The Planetary Society's chief scientist

by Dr. Bruce Betts

IN THE SKY

Super-bright Venus is low in the west after sunset. Very bright Jupiter is high in the sky in March, growing closer to Venus as the weeks pass. On June 9, they will be very close together. In June, Mercury is up in the west below Venus and Jupiter. The crescent Moon joins the three planets on June 16. In the predawn east, reddish Mars, yellowish Saturn, and Mercury are all close together in mid to late April, but they are very low to the eastern horizon, rising shortly before dawn. In the following weeks, Mercury will drop below the horizon while Saturn and Mars get higher in the sky. The medium-strength Lyrid meteor shower peaks April 21-22. The crescent Moon sets early during the peak, so it will not interfere with viewing. The Eta Aquariids peak on May 5-6. It is a strong shower when viewed from the Southern Hemisphere, but it is weaker in the Northern Hemisphere. A nearly full Moon will interfere with viewing wherever you are.

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

TRIVIA CONTEST

Our September Equinox contest winner is Joel Brown from Marathon, New York, USA. Congratulations!

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

The answer: ***22 kilometers (14 miles)***

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

In college, when Bill Nye took Introduction to Astronomy, who was his professor?

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 May 15, 2026. One entry per person. The winner will be chosen in a random drawing from among all the correct entries received.

RANDOM SPACE FACT

The mass of the Sun compared to the mass of Earth is about the same ratio as the mass of a large elephant compared to the mass of a small mouse.

MEET JENNIFER VAUGHN

An introduction to The Planetary Society's new chief executive officer

by Danielle Gunn

In February 2026, Jennifer Vaughn took the helm as chief executive officer of The Planetary Society.

Jenn first joined the Society's staff in 1997 as an editorial assistant for The Planetary Report, later rising to managing editor and then director of publications. Eventually, her passion for the Society and talent for bringing people and ideas together led her to become the organization's first chief operating officer. Now, as she steps into her new role, we invite you to get to know our passionate, dedicated leader.

Danielle Gunn: Carl Sagan once said of space science, "When you're in love, you want to tell the world." What made you fall in love with space?

Jennifer Vaughn: I joined The Planetary Society just months before Pathfinder landed on Mars. To celebrate the landing, we held an event called Planetfest. There were 5,000 of us gathered in a convention hall, all eyes fixed on a giant screen showing mission control. The anticipation was electric. We held our breath together, and when the landing was confirmed, the room erupted with cheers and happy tears.

Then came the first image from the landing site. We watched as it slowly revealed itself on the giant screen. In that moment, I realized we weren't just witnessing exploration — we were part of it. That's the heart of The Planetary Society. We are all explorers.

DG: What's your favorite world?

JV: I always start with Earth — it's my favorite place to live. But looking farther out, I'm fascinated by many of the moons of the Solar System. Titan was the first to draw me in — I cannot wait for Dragonfly! — and I'm equally fascinated by Europa, Enceladus, and Triton.

DG: If you could witness any future space milestone firsthand, what would it be?

JV: Finding life — past or present — beyond Earth.

I want to see the Mars samples brought to Earth. I want humanity to explore the oceans beneath Europa's ice and study the geysers of Enceladus. I want to deepen our understanding of the countless exoplanets in our galaxy. Any discovery of life anywhere would redefine our place in the Universe.

DG: What's one of your favorite personal memories from working at The Planetary Society?

JV: The launch of LightSail 1. LightSail 2 was the full mission, but LightSail 1 was the moment that meant the most to me. We had poured so much of ourselves into that project — years of effort, setbacks, twists, and persistence. Watching the rocket lift off with our little spacecraft aboard was one of the most profound moments of my life.

DG: What's your vision for the future of The Planetary Society?

JV: Our founders had a powerful, clear vision: demonstrate public support for scientific exploration and use that support to propel humanity deeper into the Cosmos. My vision builds directly on theirs. Our work is to bring people together, harness our collective passion and resources, and ensure that bold scientific space exploration continues to thrive. We are at our best when we ignite the public's imagination and turn that inspiration into real progress.

DG: What does The Planetary Society's community of members mean to you personally?

JV: Our members are The Planetary Society. I'm a proud member myself, and together — tens of thousands strong — we shape future space exploration.

Our members power everything we do: the fight to save NASA science, the LightSail missions, our grants and educational programs, our reporting and radio show, and so much more. The support of our members allows us to independently advocate for scientific exploration of space without the pressures of government or corporate interests. To say we couldn't do it without them is an understatement. Their passion for space is the engine of this organization.

DG: What do you like most about working at The Planetary Society?

JV: The optimism. Space exploration is inherently hopeful — and at The Planetary Society, optimism is one of our core values. Even in challenging times, we look for solutions; we bring people together; and we honor the passion, beauty, and joy that space discovery brings. The Planetary Society is a beacon of hope, and I'm grateful every day to be part of it.

DG: When you're not at The Planetary Society, what would we find you doing?

JV: Spending time with my partner and our dogs, listening to music and dancing, cooking and baking, making things with my hands, having long calls with my best friend, and taking time to truly relax.

DG: You've worked closely with Bill for 14 years. What lessons will you carry forward?

JV: Bill is an excellent person — and an extraordinary one. I could go on for quite a while about what I admire and what I've learned from him, but for now, I'll pick just a few:

“Everyone you meet knows something you don’t”

This is one of Bill’s regular phrases, and he lives by this value. Again and again, I’ve watched him approach people with genuine curiosity and respect. I’m committed to continuing that practice.

Monotasking

He is one of the busiest people I know, yet when he’s spending time with you, he’s fully present. He’s not checking his phone or glancing at his email. And when he doesn’t have time, he’s direct about that too. I’m often amazed by how much he is able to accomplish, and I suspect his commitment to monotasking is a big part of why.

Have fun

Bill prioritizes joy. He makes time for gratitude, curiosity, and delight. He’ll often pause in the middle of a busy day and say something like, “Let’s take a moment to notice what we’re doing — we’re working on the future of space exploration, people! How cool is that?” It’s a simple reminder to look up from the immediate work and see the awesomeness of The Planetary Society’s mission.

Leave things better than you found them

This is another phrase I’ve heard from Bill over the years, and it’s one that will stay with me for the rest of my life. When it comes to The Planetary Society, Bill has done exactly that — the organization is stronger than ever, allowing us to move toward our mission more effectively. As I step in to steward this precious Society, I will work each and every day to honor that commitment: to strengthen what’s been built, to nurture what needs care, and to leave this organization even more resilient, vibrant, and ready for the future.

YOUR IMPACT

Saving NASA's budget

by Casey Dreier

In January, the U.S. Congress approved a 2026 budget that firmly rejected the White House's proposed cuts to NASA. Lawmakers provided $24.4 billion for NASA and $7.25 billion for the Science Mission Directorate — only slightly below 2025 levels and far better than the proposed 24% cut to NASA and 47% cut to NASA Science. This action saved more than a dozen missions from needless termination.

This outcome is a major victory. It was driven by grassroots advocacy led by The Planetary Society and its partners. Tens of thousands of supporters in every state and congressional district sent 100,000 messages to Congress; 346 participants attended our two Days of Action on Capitol Hill and made the case directly to their elected officials.

We need to keep this up. A new budget cycle starts this spring, and the White House could propose to cut science again. But we know that advocacy works. It's why The Planetary Society exists. So thank you to every member who took action. I'm proud of our work, and I'm confident we can do it again, if necessary.

FUNDRAISING SUCCESS!

We are happy to announce that thanks to the generous support of members like you, we surpassed our year-end fundraising goal at the end of 2025. Together, members raised $425,000 to support The Planetary Society's year-round work. Thank you for making 2025 another successful year!

INTRODUCING OUR D.C. OFFICE

In 2025, The Planetary Society established our first satellite office in Washington, D.C. Led by Director of Government Relations Jack Kiraly, this office will serve as home base for our activities in the nation's capital. From high-profile events and important meetings to casual member get-togethers and celebrations, this new permanent presence will elevate our work in D.C.

THE SPACENEWS ICON AWARD

In December 2025, Planetary Society Chief of Space Policy Casey Dreier was honored with the SpaceNews Icon Award for Individual Achievement. This award recognizes individuals whose leadership and innovation have set new benchmarks for excellence and inspired progress across the space community. Fellow nominees were Jarrett Jones, senior vice president for Blue Origin's New Glenn Heavy-Lift Orbital Launch Vehicle, and Josef Aschbacher, director general of the European Space Agency.

▲ Casey Dreier and The Planetary Society's policy team with the 2025 SpaceNews Icon Award.
Jason Dixson for SpaceNews

The latest space-related travel opportunities from partners of The Planetary Society

BETCHART EXPEDITIONS

(800) 252-4910 / (408) 252-4910
BetchartTerri@gmail.com / betchartexpeditions.com

Oct. 1 – 10, 2026

FALL COLORS AND RED ROCK CANYONS OF THE WEST

Join us to explore landscapes of great beauty, including the north rim of the Grand Canyon, Capitol Reef National Park, Grand Staircase-Escalante, Bryce Canyon National Park, and more! Delight in these geologic wonderlands, fall colors, indigenous cultural sites, and petroglyphs. View star-studded night skies. Look for coyotes, foxes, and other wildlife. Discover the rich cultural and natural heritage of this fascinating western Colorado plateau region with leadership by an excellent archaeoastronomer and an outstanding geologist.

Betchart Travel

Callanish Photography

July 28 – Aug. 7, 2027

DISCOVER MALTA, SICILY, AND CAPRI BY YACHT: TOTAL SOLAR ECLIPSE EXPEDITION

Embark on a journey from Valetta, the captivating capital of Malta, to Naples, Italy. Visit the impressive sites, cities, and beaches of Syracuse, Catania, Lipari, and Capri with scenic cruising along the famed Amalfi Coast and the volcanic island of Stromboli to watch sparks of lava light up the night sky! On Aug. 2, 2027, we will position the yacht in the center of the Moon's shadow, approximately 135 nautical miles from Valetta, to observe the total solar eclipse with almost six minutes of totality. Leading this expedition will be Dr. Joe Llama. An astronomer at Lowell Observatory, Joe is a keen photographer and popular expedition leader.

SIRIUS TRAVEL

(303) 872-7313
siriustravel@siriustravel.com

September 2026

Sirius Travel's September 2026 Scotland tour invites Planetary Society members on a captivating journey through the ancient heart of the Highlands, where misty landscapes, enigmatic stone circles, and time-worn standing stones reveal a world shaped by both sky and story.

Designed especially for travelers fascinated by the deep connections between ancient peoples and the heavens, this immersive adventure places Scotland's extraordinary megalithic heritage at center stage. Guided by an expert archaeoastronomer, you'll explore some of the most iconic and mysterious sites in the country: stone rings aligned to the solstices, monoliths marking forgotten rituals, and prehistoric sanctuaries that have watched the stars wheel overhead for millennia. From the atmospheric circles of Kilmartin Glen to the windswept monuments of the Orkney Isles, each visit becomes a portal into the minds of ancient skywatchers, enriched by engaging explanations of celestial alignments, archaeological findings, and the cultural significance of these sacred landscapes.

BLM Utah

Sirius Travel

Along the way, you'll also experience the charm and depth of Scotland's history. Stroll through Edinburgh's medieval Old Town; savor whisky at a renowned distillery; and admire the rugged beauty of glens, lochs, and coastal cliffs glowing with early autumn colors. Evenings may offer opportunities to gaze upward at Scotland's dark skies, connecting your own experience to that of the ancient builders. With a perfect blend of cultural exploration, scenic wonder, and scientific insight, Sirius Travel's Scotland tour transforms the past into a vivid, personal journey. Discover the land where stone, sky, and story meet — and let the ancient world speak to you.

THE PLANETARY SOCIETY
60 SOUTH LOS ROBLES AVE
PASADENA CA 91101-2016 USA

It's time to multiply our efforts... Are you in?

Thank you for being with us this past year as we expanded our advocacy efforts. You've been there every step of the way, taking action for space when it matters most. Still, our work together is far from over.

Your support today directly benefits future space science. With your gift of any amount, we'll continue to organize Days of Action, expand our training programs, and build rapid-response tools so we can act quickly when new challenges arise.

Your contribution ensures that we are ready to respond to whatever comes next.

Visit planetary.org/takeaction to donate now!