THE PLANETARY SOCIETY

THE PLANETARY REPORT

JUNE SOLSTICE 2023

VOLUME 43, NUMBER 2

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THE OSIRIS-REx ISSUE

ARRIVING SOON: THE UNITED STATES' FIRST ASTEROID SAMPLE RETURN MISSION

A COSMIC EMISSARY MAKES ITS WAY BACK HOME

OSIRIS-REx is coming back to Earth with all of us on board in spirit — and for many of us, in name

by Bill Nye

COME SEPTEMBER OF this year, a small amount of material from asteroid Bennu aboard NASA's OSIRIS-REx (that's the Origins Spectral Interpretation Resource Identification, Security, Regolith Explorer) spacecraft will come hurtling back to Earth (in Utah in the United States). I was at the launch in Cape Canaveral, which took place a little after 7:00 p.m. local time on Sept. 8, 2016. It was a picture-perfect flight that left a smoke trail from the exhaust and a perfectly straight dark shadow against a gorgeous blue Florida sky.

Bennu was named by Planetary Society member Mike Puzio, who was only in third grade at the time. He won the naming contest that The Planetary Society helped organize. NASA administrator Charlie Bolden met him at the launch and shook his hand. It was quite an evening.

OSIRIS-REx has been flying for the last 6 1/2 years. To get all the way to Bennu, it swung by Earth for a gravity assist. It managed to spend a year and a half (505 Earth days) at Bennu, taking pictures and finding a place suitable for a robotic arm scoop-by (that is my own coinage). Then, it went back to Bennu orbit before pogo-sticking (mission manager's coinage) into a return-to-Earth orbit.

The O in OSIRIS stands for Origins — our origins. Asteroids come in a variety of types with a variety of characteristics. Bennu, believed to have formed at the very beginning of our Solar System, has a great deal of carbon. That suggests it may have organic compounds, which in turn suggests it may have some of the fundamental molecules found in the organisms that are alive today. If we can find organic molecules aboard this species of asteroid, it may have remarkable implications about the origin of living things — like us.

The S in OSIRIS stands for Security. We want to learn about the orbits of objects like Bennu so we can prepare in case there's one incoming. We want our home to be secure. Stay tuned. Bennu has a slim chance of impacting Earth in the year 2182. With this mission, we'll learn more about asteroids and their orbits and how they may cross ours someday.

On board with the precious sample of regolith, there's a microchip carrying 442,803 encoded names of people like you. One might wonder why the people leading a mission to bring home such valuable cargo would bother adding something as seemingly frivolous as a collection of names. These names represent something deeply important. We sent this spacecraft out into the Solar System for the sake of all of us.

ON THE COVER: Artist's rendition of the OSIRIS-REx spacecraft at Bennu. *Image: University of Arizona/NASA Goddard Space Flight Center* ✳ *The Planetary Report (ISSN 0736-3680) is published quarterly at the editorial offices of The Planetary Society, 60 South Los Robles Avenue, Pasadena, CA 91101-2016, 626-793-5100. It is available to members of The Planetary Society. Annual dues are $50 (U.S. dollars) for members in the United States as well as in Canada and other countries. Printed in the USA. Third-class postage at Pasadena, California and at an additional mailing office. Canada Post Agreement Number 87424.* ✳ *Viewpoints expressed in articles and editorials are those of the authors and do not necessarily represent positions of The Planetary Society, its officers, or its advisers.*

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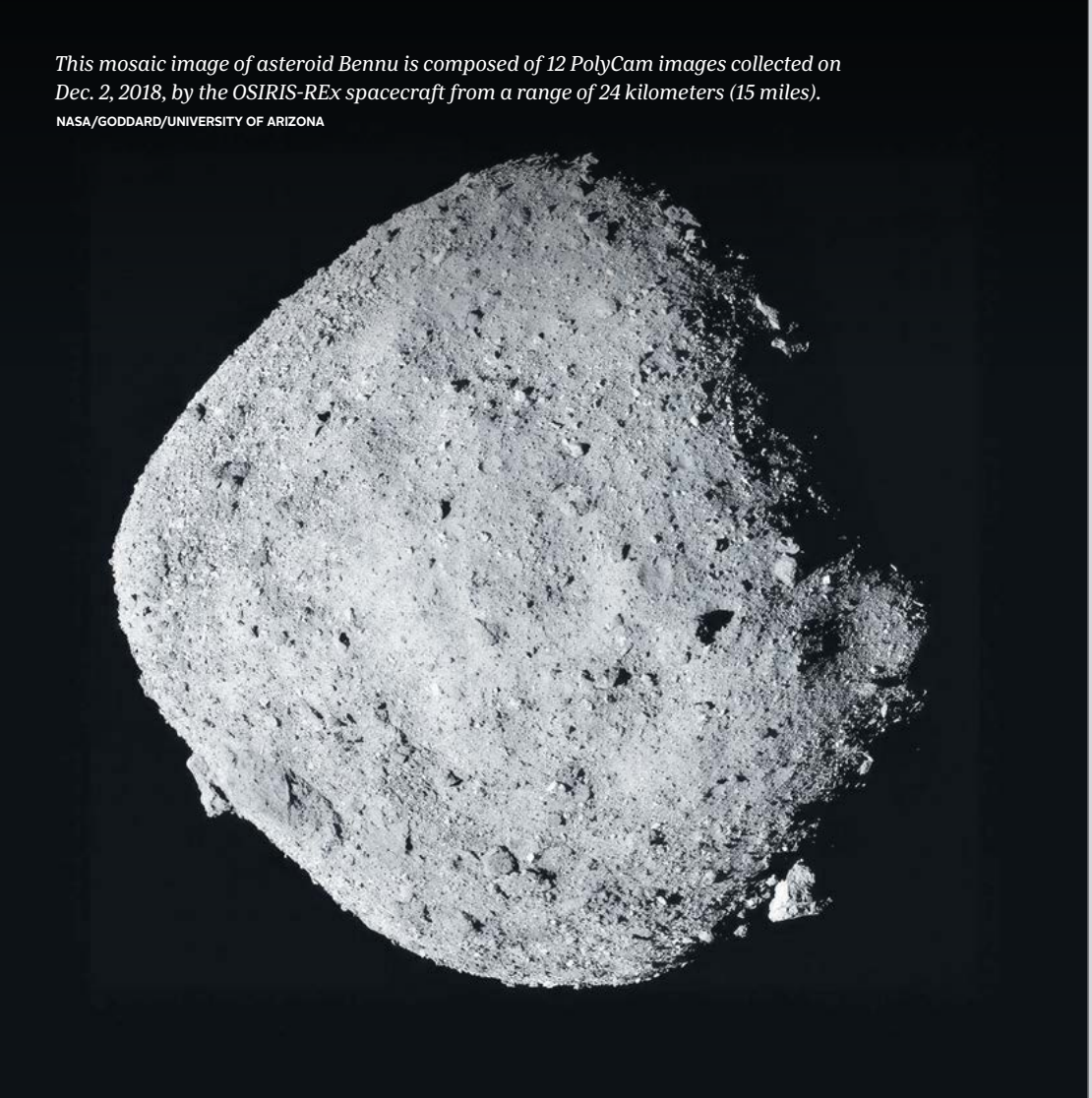
This mosaic image of asteroid Bennu is composed of 12 PolyCam images collected on Dec. 2, 2018, by the OSIRIS-REx spacecraft from a range of 24 kilometers (15 miles).
NASA/GODDARD/UNIVERSITY OF ARIZONA



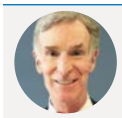
Every mission to explore space serves as an emissary for all of humankind, and the discoveries OSIRIS-REx will enable will benefit everyone here on Earth.

This is why The Planetary Society has a longstanding tradition of collecting names to send aboard spacecraft, including OSIRIS-REx. We want to emphasize the fact that everyone on this planet has a role to play in space exploration and that when a mission heads out into the Cosmos, we go with it in spirit.

Once OSIRIS-REx parachutes its Bennu sample back to Earth, scientists in the United States and around the world will start studying those little pieces of asteroid. As you'll read later in this issue, we've never collected material from this kind of asteroid before, so we don't yet know exactly what we'll discover. But when that new science does start coming in, we'll make sure you hear all about it and share in the wonder it inspires.

As a Planetary Society member, you share in missions like OSIRIS-REx. You help make them happen. You help these missions get funded, stay funded, and make it to the launch pad. You also help spread awareness of these amazing missions and the things they teach us about the Cosmos, inviting new people to experience the joy of exploration and discovery.

Bill Nye



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

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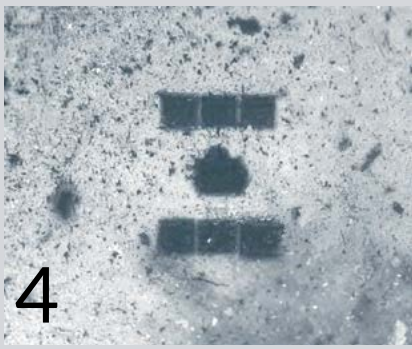

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WHY DID WE NEED OSIRIS-REx?

by Kate Howells

AS YOU'LL READ in this issue, NASA's OSIRIS-REx spacecraft is on its way back to Earth to drop off a sample of asteroid Bennu after a 7.1 billion-kilometer (4.4 billion-mile) round trip. Since JAXA's Hayabusa and Hayabusa2 missions have already visited the asteroids Itokawa and Ryugu, respectively, why did we need another asteroid sample return mission? For many planetary exploration enthusiasts, the "why" might not seem so important — the more missions, the merrier! But there are indeed some very good reasons why OSIRIS-REx's seven-year mission was worthwhile.

ABOVE *Hayabusa2 snapped this picture of Ryugu on Feb. 22, 2019, at 6:30 p.m. ET (22:30 UTC). The picture was taken during ascent from less than 30 meters (100 feet) immediately after touchdown with the ONC-W1 camera. Hayabusa2's shadow can be seen along with a dark splotch where the spacecraft's thrusters blew away lighter materials on Ryugu's surface.*

JAXA/TOKYO UNIVERSITY/KOCHI UNIVERSITY/ RIKKYO UNIVERSITY/NAGOYA UNIVERSITY/ CHIBA INSTITUTE OF TECHNOLOGY/MEIJI UNIVERSITY/AIZU UNIVERSITY/AIST

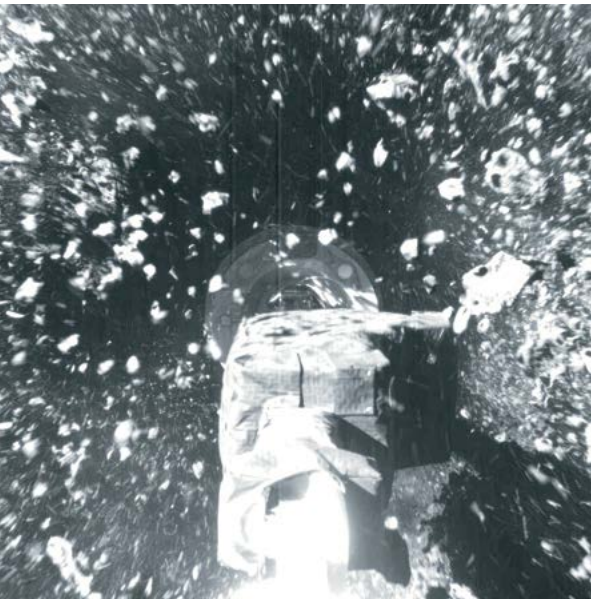
First, some context: In 2003, the Japanese Aerospace Exploration Agency (JAXA) launched a mission called Hayabusa to study the asteroid Itokawa up close. This was the first mission to land on an asteroid and attempt to collect a sample, although the sample collection mechanism malfunctioned, and the spacecraft was only able to collect a small amount of asteroid dust. JAXA's follow-up Hayabusa2 mission was more successful. It launched in 2014, arrived at the asteroid Ryugu in 2018, and returned samples to Earth in 2020.

The asteroids visited by the Hayabusa missions and OSIRIS-REx have a few things in common: all three are near-Earth, potentially hazardous, rubble-pile asteroids.

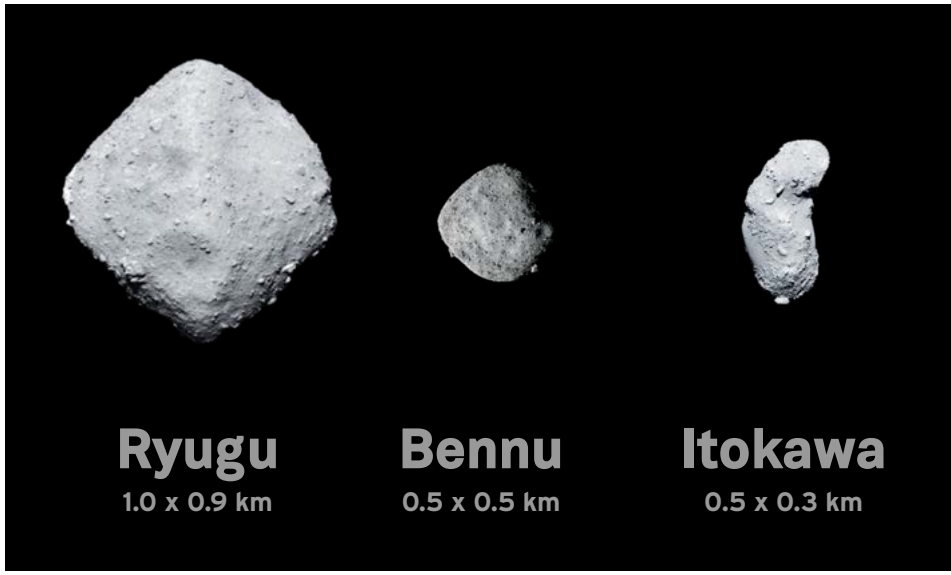
The near-Earth/potentially hazardous designations mean that Itokawa, Ryugu, and Bennu all have orbits around the Sun that bring them close enough to Earth to be considered a potential threat. Extensive observations have allowed us to calculate that two out of three of these asteroids are not on a collision course with Earth and that Bennu has a mere 1 in 1,800 chance of impacting our planet sometime between 2178 and 2290. Still, Itokawa, Ryugu, and Bennu are prime examples of the kind of asteroid that is most important to understand. The more we know about asteroids that come near Earth, the better prepared we will be to deflect one if it ever does come right at us.

The rubble-pile designation means that each asteroid isn't an entirely solid object, instead consisting of chunks of rock bound together gravitationally. Rubble-pile asteroids are thought to form when the remains of a larger asteroid that was destroyed in a collision come back together to form a new asteroid but without enough mass to gravitationally cohere. Since planets, moons, and asteroids all have to start from much smaller collections of material, rubble-pile asteroids might shed insights on the early stages of planetary formation.

The key difference between Bennu and the targets of JAXA's missions is that Bennu appears to be particularly ancient. Itokawa is thought to have formed from a collision between asteroids about 1.5 billion years ago. Ryugu's surface is thought to be even younger, about 9 million years old. Bennu, on the other hand, is thought to have formed in the first 10 million years of the Solar System's history, coasting through space undisturbed for over 4.5 billion years without undergoing any major composition-altering change.



This means that the surface material collected by OSIRIS-REx might be unchanged from the time of the asteroid's formation. This makes it a kind of time capsule, preserving the conditions of the early Solar System and therefore early Earth. When scientists study the samples that OSIRIS-REx will return from Bennu, they expect to find some of the same molecules that were present when life first formed on Earth. Because the origins of life are still a bit of a mystery, any additional clues we can get about the conditions in which life formed could completely change our understanding of how we all got here.



OSIRIS-REx also used a different sample collection technique than the Hayabusa missions. While JAXA's missions each fired a projectile into the asteroid's surface to create a crater and then collected samples of the ejected material, OSIRIS-REx performed what's called a touch-and-go maneuver to collect a sample from Bennu's surface, firing a burst of nitrogen gas to stir up the surface material and then making contact with that material using a sampling arm. This technique allowed OSIRIS-REx to collect a larger sample than the Hayabusa missions, meaning scientists on Earth will have more material to study.

In March 2023, studies of Hayabusa2's samples from Ryugu found many of the building blocks of life, including one of the components of RNA. This only adds to the excitement about what we might discover in the samples OSIRIS-REx returns from Bennu. Together, these three sample return missions are adding to humanity's understanding of asteroids, our Solar System's history, our own planet, and life itself. With such huge questions at stake, you can hardly have too many missions.

KATE HOWELLS *is the public education specialist for The Planetary Society.*

ABOVE *Bennu, Ryugu, and Itokawa are all near-Earth, potentially hazardous, rubble-pile asteroids.*

NASA/GODDARD/UNIVERSITY OF ARIZONA/JAXA/UNIVERSITY OF TOKYO/ KOCHI UNIVERSITY/RIKKYO UNIVERSITY/ NAGOYA UNIVERSITY/CHIBA INSTITUTE OF TECHNOLOGY/MEIJI UNIVERSITY/ UNIVERSITY OF AIZU/AIST/EDITED BY LOREN ROBERTS FOR THE PLANETARY SOCIETY

LEFT *Rocks fly off asteroid Bennu after NASA's OSIRIS-REx spacecraft touched the surface to collect a sample on Oct. 20, 2020.*

NASA/GODDARD/UNIVERSITY OF ARIZONA

OUR HOPES FOR OSIRIS-REx

IN OUR BRAND-NEW member community, Planetary Society members shared their excitement about the return of samples from OSIRIS-REx. Haven't joined the member community yet? Don't miss out. It's our newest perk for Planetary Society members: a place where you can learn about space and connect with a global community of space enthusiasts. Log in today at **community.planetary.org**.

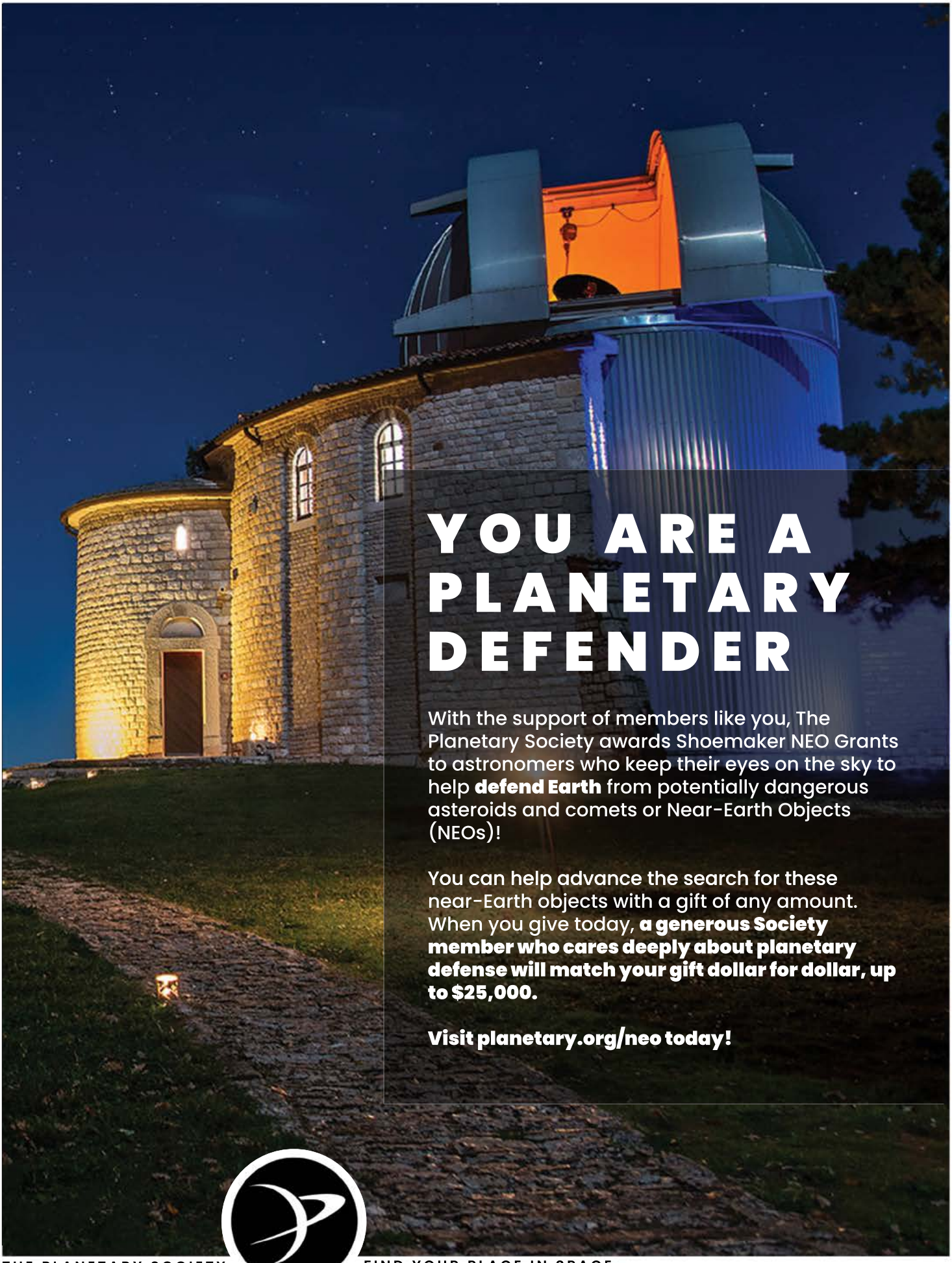
Not only do I hope we can learn how to better explore our local blip in the Universe but I hope we will learn more about our origins as well as the early life of our lil' blue dot. Whether it's evidence of organic molecules being ever present from the earliest times of Earth's existence or evidence that suggests our most base of building blocks was delivered from elsewhere, pummeling our planet with some "tough love" to get it ready to host life as we know it, I hope we will learn and seek more knowledge as a result. Alonzi Smyth, USA

I think I'm not alone in hoping that we will learn that asteroids like Bennu have complex organic life-building blocks. And I hope we learn more about water on Bennu. Robert Johannessen, Norway

I hope we learn if it is a fragment of a former planet, captured space debris from outside our Solar System, or anything that advances our knowledge of space. Alan Briley, USA

I'd love to learn more about Bennu's history, if its geology is in fact comparable to that of the Mars/Jupiter belt, and how it may have affected Earth in the past. Luke Dunlop, USA

I hope that we will learn about new elements and if there is any organic material. Joe Salinas, USA



YOU ARE A PLANETARY DEFENDER

With the support of members like you, The Planetary Society awards Shoemaker NEO Grants to astronomers who keep their eyes on the sky to help **defend Earth** from potentially dangerous asteroids and comets or Near-Earth Objects (NEOs)!

You can help advance the search for these near-Earth objects with a gift of any amount. When you give today, **a generous Society member who cares deeply about planetary defense will match your gift dollar for dollar, up to $25,000.**

Visit planetary.org/neo today!

THE PLANETARY SOCIETY FIND YOUR PLACE IN SPACE

An artist's interpretation shows OSIRIS-REx reaching Bennu.

UNIVERSITY OF ARIZONA/NASA GODDARD SPACE FLIGHT CENTER/ GETTY IMAGES/LOREN A. ROBERTS

Asteroid Samples from Another World

by Swapna Krishna

ON SEPT. 24, 2023, Earth will receive a visitor from another world.

It's not alien life; it's not even a natural occurrence. We'll be able to plan and anticipate its arrival down to the minute. And once it gets here, it may fundamentally change our understanding of life itself.

OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer), a NASA mission to the near-Earth asteroid Bennu, is on its way back to us with samples from its surface. In September, the sample return container will touch down in Utah and start a new journey, helping scientists unlock the secrets of the early Solar System and our understanding of near-Earth asteroids.

The main spacecraft will continue on past Earth. Thanks to a mission extension, it will become OSIRIS-APEX (OSIRIS-Apophis Explorer) and journey on to the near-Earth asteroid Apophis.

SETTING COURSE FOR EARTH

Here's how everything will unfold. When the dynamic duo is approximately four hours (or about 100,000 kilometers or 60,000 miles) from Earth, the sample return container will separate from the spacecraft. "You're a third of the way to the Moon, and you just have this spring that is ejecting the capsule and giving it a spin," explains Mike Moreau, flight dynamics system manager at NASA's Goddard Space Flight Center, who's in charge of the team handling OSIRIS-REx's navigation. "We don't do anything to control it. It's just like a really long three-point shot."

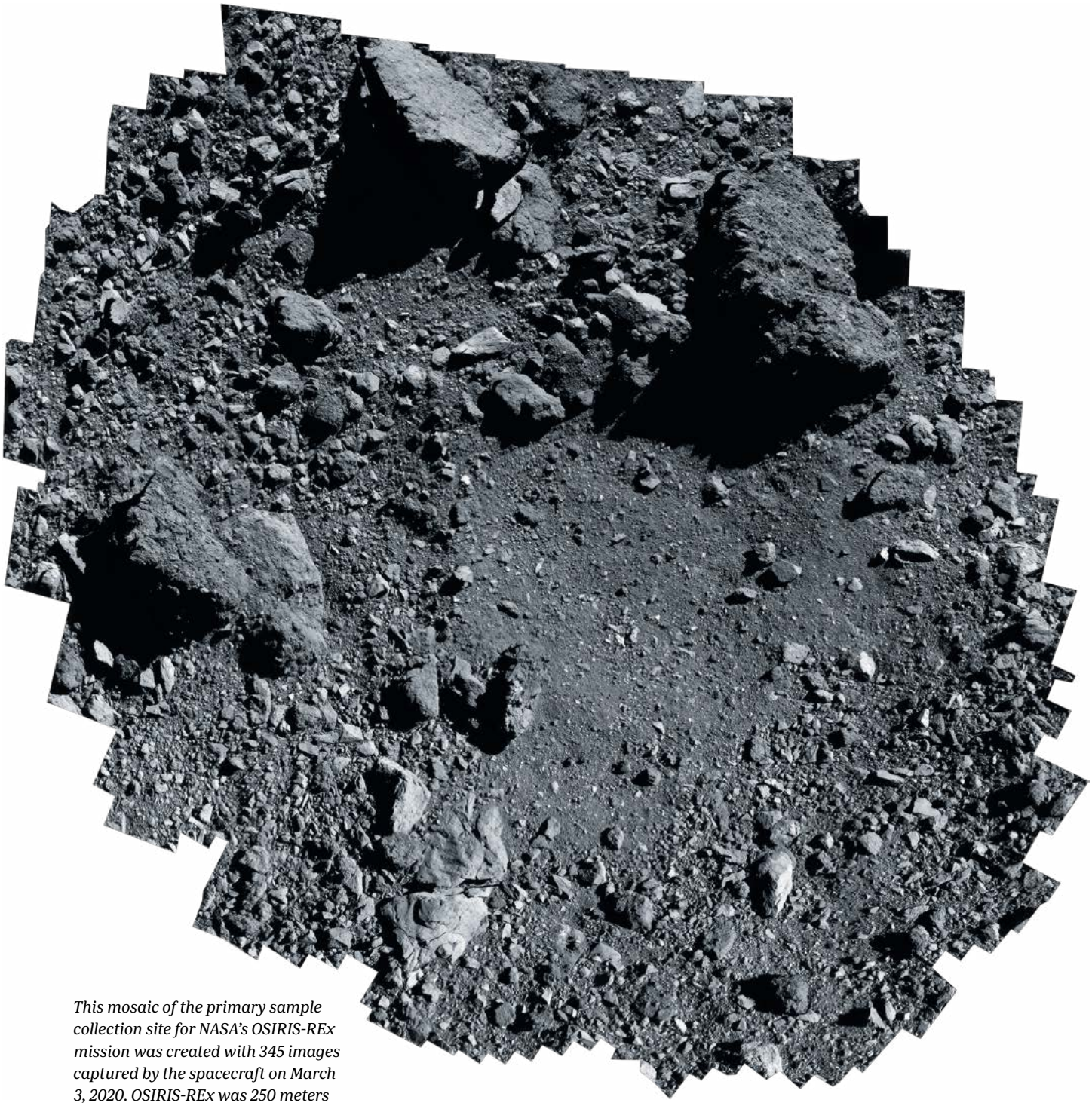
That's because the sample container itself doesn't have any engines or thrusters. The hard work to obtain a precision landing comes in the period before that separation. "All of the work to do the targeting is happening in those two weeks beforehand," says Moreau. At 14 days out from the sample return, OSIRIS-REx will fire its thrusters and perform a trajectory-correction maneuver, targeting a specific return area at the Utah Test and Training Range, approximately 130 kilometers (80 miles) southwest of Salt Lake City.

The landing site seems large: an ellipse roughly 20 kilometers by 80 kilometers (12 by 50 miles). But programming a spacecraft's navigation to hit such a precise target is challenging to say the least, and it happens in stages. "Last summer, we had to propagate our errors a whole year into the future. There's a large uncertainty because we're farther away from Earth," Moreau explains. But as the spacecraft has gotten closer to Earth, the flight dynamics team has refined their calculations, and that error has gotten smaller. By two weeks out, there should only be small changes necessary to achieve that narrow target window for entry. The team will have multiple opportunities to adjust that trajectory if necessary.

But by four hours out, they will have done everything they can do. "It's still kind of mind boggling that you release a thing on a spring 100,000 kilometers from Earth … and it's going through a window that's probably a couple kilometers wide in the atmosphere to hit your target," says Moreau.

EDL: ENTRY, DESCENT, AND LANDING

The sample return container is a capsule like the crew capsules from the Apollo program, with a blunt end and nose cone. The entire thing is



This mosaic of the primary sample collection site for NASA's OSIRIS-REx mission was created with 345 images captured by the spacecraft on March 3, 2020. OSIRIS-REx was 250 meters (820 feet) above the surface at the time. The specific collection site is the relatively rock-free area in the middle. The boulder in the upper right is 13 meters (45 feet) wide on its longest axis.

NASA/GODDARD/UNIVERSITY OF ARIZONA

just under 1 meter (3 feet) long. When it separates from the larger spacecraft, it will spin for stabilization. "I like to compare it to a quarterback throwing the perfect spiral pass downfield … you want it to travel through the air as efficiently as possible," explains Dante Lauretta, principal investigator for the mission.

"It's got a heat shield with the nose cone that's aerodynamically optimized for high velocity entry through the atmosphere," says Lauretta. That heat shield is what allows for one of the fastest reentries in history at just under 12.4 kilometers (7.7 miles) per second. This will happen at approximately 8:42 a.m. MT; there's just 0.3 seconds of uncertainty.

Within one minute, the sample return container will bleed its heat shield material as it enters its peak heating period. Simultaneously, it's undergoing aggressive deceleration thanks to atmospheric drag. Two minutes and 10 seconds after atmospheric entry, an initial drogue parachute will deploy. This will help stabilize the container as it speedily makes its way to the ground.

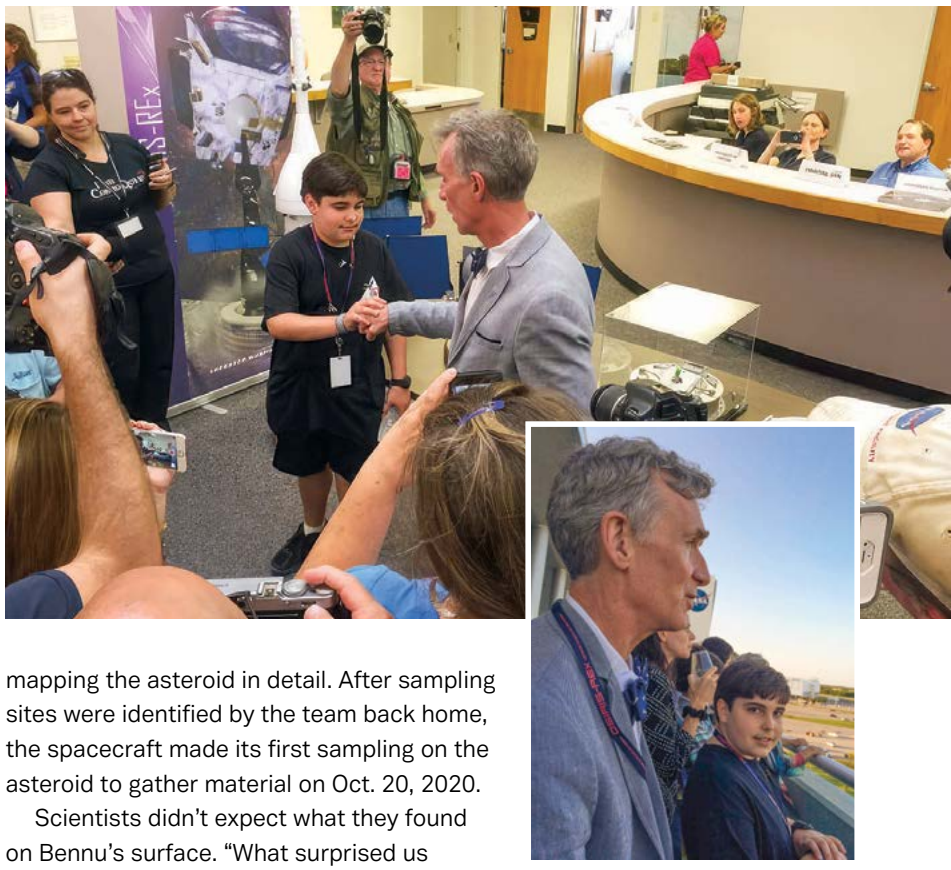
Around 1,000 meters (3,200 feet) above Earth's surface, the main parachute will deploy. And approximately 13 minutes after the reentry process begins, it will be over. The sample container will hit the Utah desert at about 4.6 meters (about 15 feet) per second.

After touchdown is confirmed, it's the ground team's turn to take action.

WHAT IS OSIRIS-REX? AND WHY BENNU?

Before we get into the next phase of the sample container's journey, let's discuss the ins and outs of the mission. At its core, OSIRIS-REx is a mission to a near-Earth asteroid initially called 1999 RQ36. In 2013, 9-year-old Michael Puzio won a competition to name the asteroid. The competition was co-hosted by The Planetary Society along with the University of Arizona and the MIT Lincoln Laboratory. He called it Bennu after a deity from ancient Egyptian mythology.

Bennu orbits the Sun every 1.2 years and is closest to Earth's orbit every six years, around 300,000 kilometers (186,000 miles) away. A little over two years after it launched, OSIRIS-REx entered orbit around Bennu on Dec. 31, 2018, and began the long process of mapping the asteroid in detail. After sampling sites were identified by the team back home, the spacecraft made its first sampling on the asteroid to gather material on Oct. 20, 2020.



ABOVE *Planetary Society CEO Bill Nye and Michael Puzio, who named OSIRIS-REx's target asteroid, Bennu, in a Planetary Society-sponsored naming contest, at the launch of the spacecraft in Cape Canaveral, Florida, in 2016.*
LARRY PUZIO

Scientists didn't expect what they found on Bennu's surface. "What surprised us was how loosely packed and how fragile the surface was," Lauretta says. "When the spacecraft made contact, it sunk in like 2 feet deep. The robotic arm just plowed through with no resistance from the surface whatsoever. And that was shocking to us. And we realized that the material is very weak and breaks apart incredibly easily."

We're about to receive quite a unique sample. Scientists have worked with samples from other worlds before, like the precious lunar samples Apollo astronauts brought back from the Moon. They also routinely seek out and study meteorites. Antarctica in particular is a goldmine for

ABOVE *A photo of the United Launch Alliance Atlas V rocket carrying the OSIRIS-REx spacecraft as it lifted off from Space Launch Complex 41 on Thursday, Sept. 8, 2016, at Cape Canaveral Air Force Station in Florida.*
NASA/JOEL KOWSKY

these otherworldly specimens. "I was able to be a field team member collecting meteorites in Antarctica in 2019," says Nicole Lunning, deputy OSIRIS-REx curator within NASA's Astromaterials Research and Exploration Science Division (she's in charge of preserving the asteroid samples). "Just seeing a meteorite on the ground was an amazing experience. There's nothing like it; even after finding dozens, it doesn't get old."

But any meteorite that falls to Earth is different from what we're getting from OSIRIS-REx because meteorites are what have survived after the traumatic process of reentering Earth's atmosphere. This additional material from Bennu would simply never survive that process. "We're bringing back material that we hope is unlike anything that's available on the surface of Earth from our meteorite collection," explains Lauretta.

This sample is now zipping toward Earth along with 442,803 names collected by The Planetary Society for the mission. These names visited the asteroid Bennu via microchip. One set will continue onward to the asteroid Apophis while a duplicate will land on Earth with the sample return container.

CONTAMINATION, UNBOXING, AND EVERYTHING IN BETWEEN

When the sample container finally lands, the ground team will be very close by to spring into action. Lauretta and his team

members will be waiting in hangars at the Utah Test and Training Range, less than an hour's helicopter ride from the landing site. "There will be four helicopters staged there," Lauretta explains. "In case of inclement weather, we'll have ground track vehicles, so we will drive out, which will take a lot longer. It doesn't matter — rain or shine, whatever happens in Utah, we're coming."

The first helicopter will contain a safety officer, who will make sure the landing site is safe and the capsule is secure. Then, the rest of the team will arrive on-site. Everything will be photographed and documented, and samples will be taken of the soil, air, and everything else possible surrounding the capsule. The canister itself will be taken back to the hangar, where Lunning and the curation team will have set up a portable clean room.

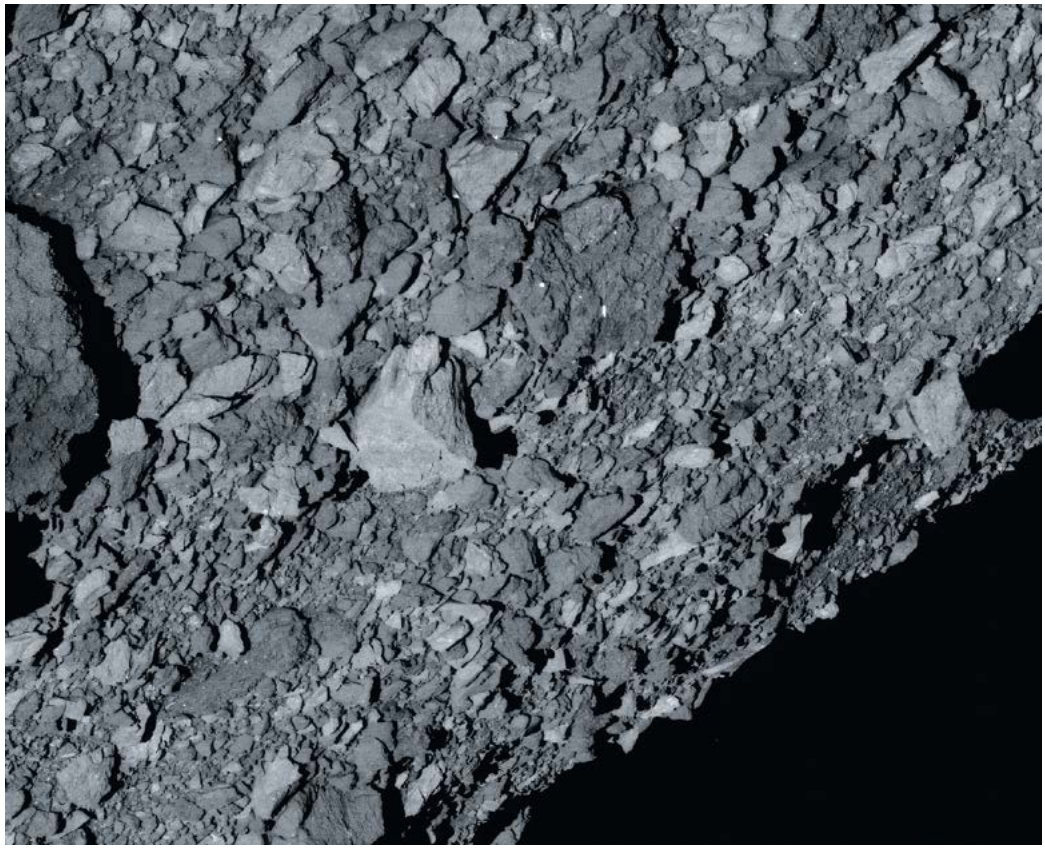
At that point, "the back shell and the heat shield will be taken off as well as other avionics equipment," says Lunning. The aim is to get the sample canister into a nitrogen purge as quickly as possible.

"Nitrogen is an inert gas, and that's why it's beneficial for curation purposes," says Lunning. It's what NASA uses to preserve samples from the Moon as well. "That nitrogen purge then also further prevents the ingress of terrestrial atmosphere and humidity."

The canister will then be put on a plane, still under a nitrogen flow, to Johnson Space

ABOVE *This view of asteroid Bennu ejecting particles from its surface on Jan. 19, 2019, was created by combining two images taken by OSIRIS-REx's NavCam 1 imager: a short exposure image (1.4 millisecond), which shows the asteroid clearly, and a long exposure image (5 seconds), which shows the particles clearly. Other image processing techniques were also applied, such as cropping and adjusting the brightness and contrast of each layer.*

NASA/GODDARD/UNIVERSITY OF ARIZONA/LOCKHEED MARTIN



RIGHT *This image shows a view across asteroid Bennu's Southern Hemisphere and into space, and it demonstrates the number and distribution of boulders across Bennu's surface. The image was obtained on March 7, 2019, by the OSIRIS-REx PolyCam camera from a distance of about 5 kilometers (3.1 miles). The large, light-colored boulder just below the center of the image is about 7.4 meters (24.2 feet).*

NASA/GODDARD/UNIVERSITY OF ARIZONA

OPPOSITE *NASA's OSIRIS-REx spacecraft snapped this image of its sample collection arm, TAGSAM (Touch-And-Go Sample Acquisition Mechanism), hovering over asteroid Bennu during a touchdown rehearsal on April 14, 2020. The spacecraft was just 70 meters (230 feet) over the surface at the time.*

NASA/GODDARD/UNIVERSITY OF ARIZONA

Center in Houston. At this point, it will enter a clean room for further cleaning before finally heading to the curation lab. "The canister does not get opened until they get into the OSIRIS-REx curation lab," explains Lunning. "We actually will open the canister inside of a nitrogen glove box." Because the sample container is quite large, the OSIRIS-REx team worked with Lockheed Martin to design a special glove box specifically for this sample return mission. "We'll basically have a very elaborate unboxing procedure," Lunning jokes, which will take place approximately nine or 10 days after landing.

And then? We'll have the sample.

MATERIAL FROM ANOTHER WORLD

Scientists aren't really sure how much material there is within the sample container, but they think there's quite a bit. Lauretta estimated there would be about 250 grams to work with — about the mass of a baseball — which is far above the mission's goal of 59.5 grams. "Having more sample than we know what to do with is the best-case scenario," says Lunning.

After the canister is fully opened, they'll start taking a closer look at it. "We'll get it all laid out on the trays and do a bunch of photo documentation [and] spectral imaging," says Lauretta. "We'll start to identify the variation that we see in the sample and start to make our selections for science."

Parts of Bennu will stay at Johnson Space Center for study. Smaller samples will get hand-carried to labs around the world for study thanks to NASA's Participating Scientist Program. And many samples will go into the vault at Johnson Space Center, side by side with NASA's lunar samples. One day, future scientists will have the chance to unseal and work with these perfectly preserved pieces of another world.

ABOVE *Participants received this certificate after submitting their name to The Planetary Society's* Messages to Bennu! *campaign on* planetary.org *as part of the Society's collaboration with NASA.*

THE PLANETARY SOCIETY

RIGHT *During Orbital A phase, the OSIRIS-REx spacecraft's NavCam 1 navigation camera regularly captured Bennu's surface, even though its scientific camera suite (OCAMS) was not collecting data. The navigation team uses these "OpNav" (short for optical navigation) images to monitor the spacecraft's close orbit around the asteroid. The photo has an exposure time of 1.4 milliseconds and was captured from a distance of 1.6 kilometers (1 mile). The large boulder at center is about 50 meters (164 feet) across.*

NASA/GSFC/UA/LOCKHEED MARTIN

WHAT'S THE BIG PICTURE?

It's an amazing mission, but why does it matter? There are a few things to think about.

In practical terms, Bennu is a near-Earth object, and it could pose a threat to us one day. That's why studying it is crucial. "We need to understand what this material is — what it's made out of — in the event that a future generation is going to have to come up with an impact mitigation mission," explains Lauretta. "Understanding the asteroid, its orbit, its physical properties, its thermal properties, [and] its chemical properties is going to be essential for all of that information."

But there are bigger implications than just planetary defense. Samples from Bennu could help us understand the beginnings of our Solar System and life within it. "We have no clue how matter goes from an inanimate state to a living state," Lauretta explains. Scientists have been looking for the source of that spark for years. What creates life from nothing? OSIRIS-REx and our samples from the asteroid Bennu might help shed light on the answer.

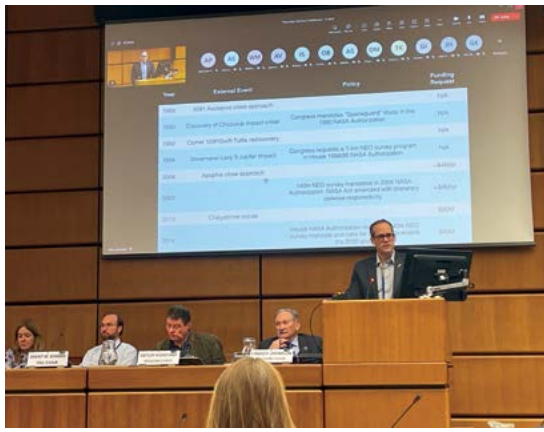
"All life on Earth comes from life," Lauretta says, referring to the very first instance of life sparking from inanimate organic material billions of years ago. "We think that these asteroids record the chemistry and the physics of the processes right before that event took place. It's kind of like the starting inventory." With the samples from Bennu, we can learn about the compounds these asteroids delivered to Earth's surface and possibly understand that singular transition of what sparks life. Lauretta concludes, "We're trying to understand the origin of life, which is the biggest scientific mystery to be solved, in my opinion."

SWAPNA KRISHNA *is a space, tech, and pop culture writer who has written for Engadget, The Verge, SYFY, and more. You can find her on Twitter @skrishna.*

THE PLANETARY DEFENSE CONFERENCE

Every two years, the world's leading experts in planetary defense gather at the Planetary Defense Conference to discuss and advance their work to protect Earth from asteroids and comets. The experts' fields range from science to technology development to policy to public education and more. Thanks to the support of our members, The Planetary Society is a longtime sponsor and participant in the conference.

This year's Planetary Defense Conference took place in Vienna, Austria, in April. Planetary Society Chief of Space Policy Casey Dreier attended to give a presentation about the history of NASA's planetary defense budget. In keeping with past years, The Planetary Society also organized a public event: a special screening of the IMAX original film "Asteroid Hunters" followed by a Q&A with an international group of scientists and planetary defense experts, moderated by Planetary Radio creator Mat Kaplan. This was a valuable opportunity not only for those in attendance but for the Society as a whole as we continue to broaden our international reach and relevance in protecting Earth from asteroids and comets.



ABOVE *Planetary Society Chief of Space Policy Casey Dreier presents his paper, "How NASA's Planetary Defense Budget Grew by More Than 4000% in 15 Years: Lessons in Strategic Alignment," at the 2023 IAA Planetary Defense Conference in Vienna, Austria.*
THE PLANETARY SOCIETY

LEFT *A photo from the public event hosted by The Planetary Society at the 2023 Planetary Defense Conference in Vienna, Austria on April 5, 2023. The event included a screening of the IMAX film "Asteroid Hunters" followed by a Q&A session with planetary defense experts, moderated by the Society's Mat Kaplan. Pictured from left to right: Mat Kaplan, senior communications adviser of The Planetary Society; Nahum Melamed, Aerospace Corporation project manager and co-chair of the Planetary Defense Conference; Marina Brozovic, physicist and orbital dynamicist at NASA's Jet Propulsion Laboratory; Mark Boslough, physicist and airburst specialist, University of New Mexico; Paul Chodas, manager of NASA's Near-Earth Object Program Office at the Jet Propulsion Laboratory; Kelly Fast, NASA program scientist and program manager for the Near-Earth Object Observations Program, Planetary Defense Coordination Office; Bill Ailor, Aerospace Corporation technical fellow and Planetary Defense Conference founder; Ian Carnelli, Project Manager of ESA's Hera mission*
PHILIP GROVES

MEET THE NEWEST STEP GRANT WINNERS

The Planetary Society's Science and Technology Empowered by the Public (STEP) Grants were introduced in 2021 to support projects that advance our core interests of exploring other worlds, finding life, and defending Earth from dangerous asteroids. The first two grants were awarded in 2022, and today, we are proud to announce the second set of winners.

The Planetary Society is thrilled to announce the 2023 awardees of the Science and Technology Empowered by the Public (STEP) grants. Selected through an open international competition, the recipients are Dr. Andrew Palmer, leading a project to evaluate food production systems for deep space exploration, and Dr. Jacob Buffo, who will investigate hypersaline lakes that serve as analogs for various planetary bodies.

Dr. Palmer's team from the Florida Institute of Technology received $50,000 USD to compare the growth of three types of food plants in hydroponics and regolith environments,

BELOW LEFT *Dr. Jacob Buffo collecting ice samples at Last Chance Lake in British Columbia.*
DR. CHRIS CARR/GEORGIA TECH

BELOW *Dr. Andrew Palmer with plants that are being analyzed for growth and sustainability in space.*
FLORIDA INSTITUTE OF TECHNOLOGY

in an effort to understand which method would best support long-term space travel. The project aims to address gaps in knowledge about the most sustainable and productive solutions for deep space agriculture.

Dr. Buffo's team from Dartmouth College has been granted $49,284 USD to carry out a detailed examination of several small, extremely salty lakes in British Columbia, Canada. These hypersaline lakes will provide valuable insights into the existence of liquid water on other planets, and inform our understanding of their habitability.

Both projects will make excellent use of the STEP grant funding, supporting students, purchasing necessary supplies, and covering travel and shipping costs. The teams eagerly look forward to sharing their findings with the Planetary Society members and the public.

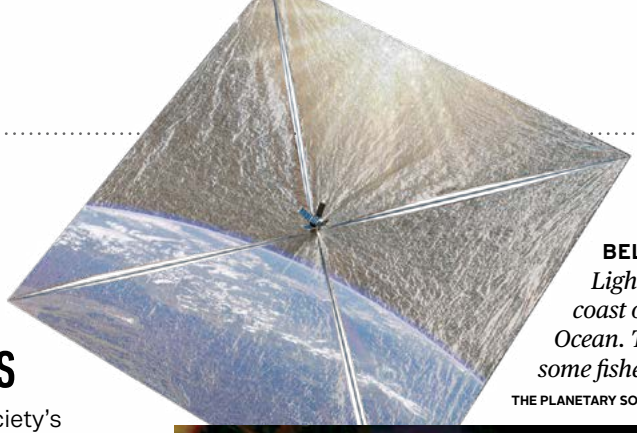
We are grateful to the Halıcıoğlu Family Foundation for its generous support of the development and implementation of the STEP grants program.

BELOW *Gene Shoemaker, seen here in Meteor Crater, Arizona, was a pioneering planetary geologist and is the namesake of The Planetary Society's Shoemaker NEO Grants.*
USGS

A NEW BATCH OF SHOEMAKER GRANT WINNERS

In 1997, our members and supporters helped us launch the Shoemaker Near-Earth Object Grant program to fund amateur and professional asteroid observers. Thanks to the support of members like you, the program has awarded $515,000 to date to 70 winners in 21 countries on six continents. Shoemaker NEO Grant winners do crucial work finding, tracking, and characterizing asteroids and typically have existing telescope facilities and prior observing experience but need additional funding for hardware improvements to take their work to the next level.

By the time this issue of The Planetary Report goes to press, a new set of grant winners will have been selected. Look for our announcement on Asteroid Day, June 30, at **planetary.org** and remember that your membership makes this program possible.

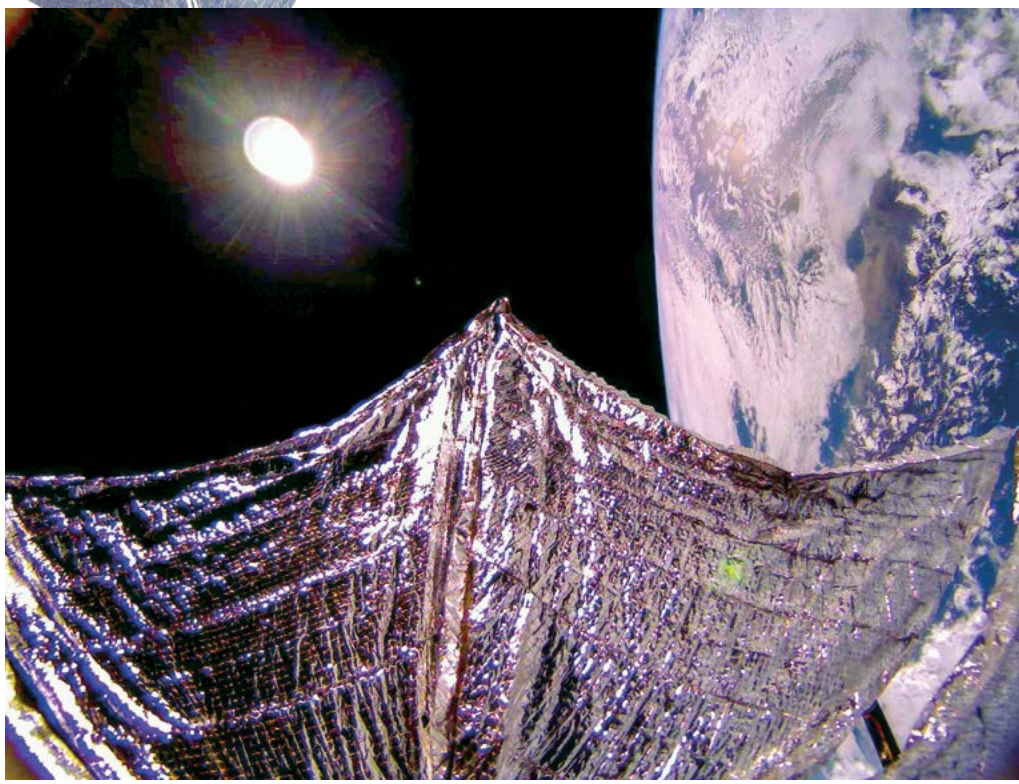


BELOW *This image taken by The Planetary Society's LightSail 2 spacecraft on Oct. 14, 2020, shows the coast of northern Peru and clouds over the Pacific Ocean. The image has been color-adjusted, and some fisheye lens distortion has been removed.*

THE PLANETARY SOCIETY

A SOLAR SAILING LEGACY CONTINUES

Although The Planetary Society's crowdfunded solar sailing spacecraft, LightSail 2, has now completed its mission and burned up in Earth's atmosphere as planned, the work is not yet over. The project lives on after the spacecraft's end thanks to all that we learned from LightSail 2's three years in orbit. The Planetary Society continues to share this hard-earned solar sailing wisdom with others who are pursuing this innovative propulsion technology. This June, Bruce Betts, chief scientist and LightSail program manager, participated in the sixth International Symposium on Space Sailing in New York City, sharing the results of our successful mission and the lessons it taught our mission team about using solar sails to propel CubeSats. Stay tuned for more information later this summer about additional exciting projects to extend LightSail's legacy.



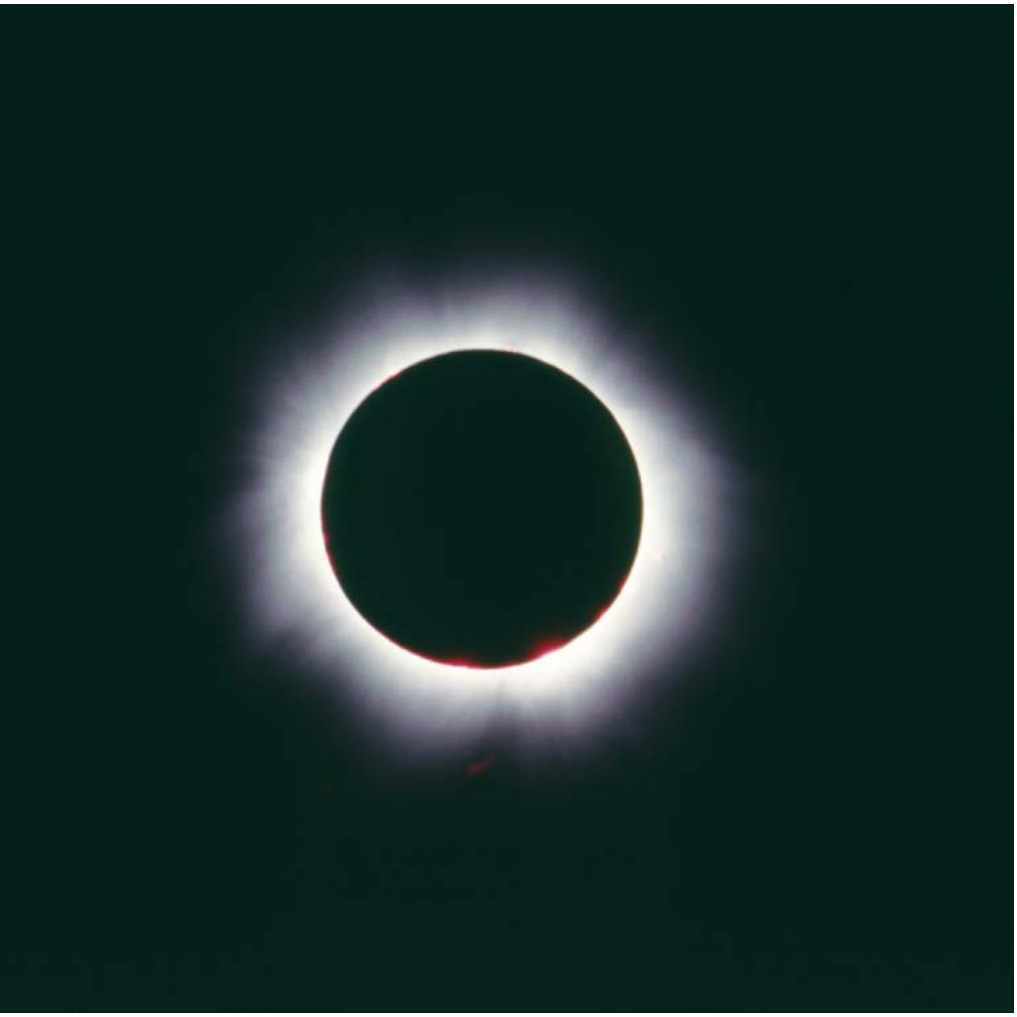
A DIGITAL DAY OF ACTION

Having pivoted away from in-person advocacy events during the COVID-19 pandemic, The Planetary Society found that virtual events made it possible to engage more people than ever before. Even though in-person meetings are possible again, we are committed to continuing to provide our members with meaningful opportunities to advocate for space from home.

On April 18, The Planetary Society hosted an entirely virtual version of our Day of Action, empowering hundreds of advocates in the United States to speak up for space science and exploration. We provided advocacy training, educational resources about the missions we're focusing on this year, talking points to share with leaders in government, letters to send to Congress, and more. Members advocated for NASA's VERITAS mission to Venus, the Mars Sample Return Program, and the NEO Surveyor planetary defense mission.

On Sept. 17-18 of this year, we will also resume our in-person Day of Action, for which space advocates from across the United States travel to Washington, D.C., to meet with their representatives in Congress and speak about the importance of investing in planetary science and exploration. Learn more at **planetary.org/dayofaction**.

PLANETARY SOCIETY MEMBERS GAVE OVER $150,000 THIS SPRING TO SUPPORT OUR SPACE POLICY & ADVOCACY PROGRAM. THANK YOU!



ABOVE *The total eclipse of the sun on 11th August 1999, viewed from Hungary. On April 8, 2024, North America will be dazzled by a total solar eclipse, and The Planetary Society will be there.*
GETTY IMAGES

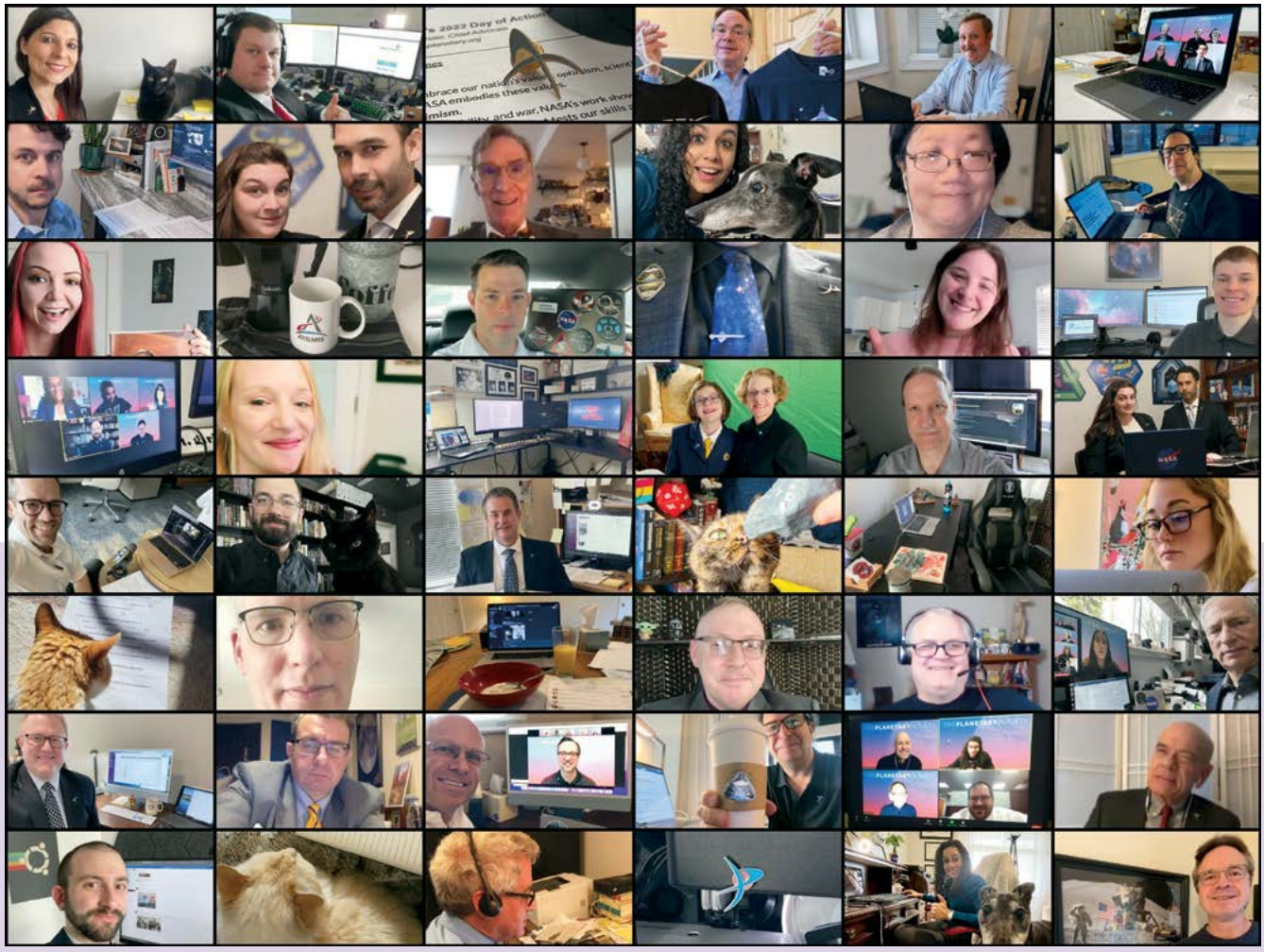
SAVE THE DATE FOR OUR ECLIPSE FESTIVAL

A total solar eclipse will dazzle spectators living in North America on April 8, 2024. The Planetary Society will be offering you an unforgettable viewing experience from the Texas hill country. The next opportunity to see a total solar eclipse in the U.S. won't come again for another 20 years, making this an event not to be missed. Start planning now to ensure you you're able to join us and see this breathtaking cosmic event. For more information, visit **planetary.org/eclipse**.

ABOVE RIGHT *100 Planetary Society members from 25 states came to Washington D.C. to advocate for space science and exploration during the 2019 Day of Action.*
ANTONIO PERONACE FOR THE PLANETARY SOCIETY

SIGN UP FOR THE DAY OF ACTION

The Planetary Society's Day of Action will be coming back to Washington, D.C., this year for the first time in three years. On Sept. 18, advocates from across the United States will come together to meet with their representatives and express their strong support for investments in NASA's planetary science, exploration, and planetary defense missions. This is one of the most impactful ways you can speak up for space, so if you live in the United States and want to do more to support NASA, sign up for the Day of Action today. For members in other countries, stay tuned for email updates about how you can take part in the Day of Action no matter where you live. To learn more, visit **planetary.org/dayofaction**.



Planetary Society members make up the largest community of space enthusiasts in the world.

THE PLANETARY SOCIETY

JOIN YOUR MEMBER COMMUNITY!

The Planetary Society is proud to offer our members a brand-new, exclusive online community. More than 3,500 members have already joined. You should too!

Via web browser or app, Planetary Society members around the world can use this interactive virtual space to connect with each other as well as world-class space experts and Planetary Society staff and spokespeople. Members can read and discuss our latest articles, take free online courses, and share tips and tools for all the things space enthusiasts do, from community outreach to astrophotography to advocacy to artwork and so much more.

This is your place in space. It's where you can collaborate with people who share your interests, passions, and goals. It's where you can deepen your knowledge of the Cosmos and our efforts to explore it. And it's where you can have fun and make friends with like-minded people from around the world.

The Planetary Society is at its core just that: a society. We started as a small group of individuals, but in the decades since our founding, our membership has grown around the planet. We are people of all nationalities, ages, and walks of life, united by a shared belief in the value of space science and exploration. This new platform gives this society a place to meet, to work together, and to accomplish more than we can as individuals. The digital member community is something we've been working toward for a long time, and we're excited to see our members already making the most of it.

Check it out now at **community.planetary.org**.

DO YOUR PART TO FIND E.T.

SETI, the search for extraterrestrial intelligence, encompasses many different techniques to look for life beyond Earth. One is listening for radio transmissions from other star systems. Detecting these signals is challenging because we have to rule out signals from intelligent life right here on Earth. Computer algorithms can sift through large amounts of data and hone in on promising signals, but these programs must be trained to discard false positives.

That's where volunteer scientists come in. Researchers at UCLA in partnership with The Planetary Society and NASA are recruiting volunteers to train computer algorithms that will be used to search for life beyond Earth. Using the Zooniverse citizen science platform, volunteers examine signals captured by the 100-meter (328-foot) Green Bank Telescope that are coming from 100 stars known to have planets. Participants sort signals into categories of known radio interference, which will then help train a machine-learning system for future searches.

The Planetary Society awarded $50,000 to the project through our STEP Grants program in 2022, and we invite all our members to take part. You can sort one signal or a thousand! It's up to you. Sign up today at **arewealone.earth**.

Andy Weir discusses his book "Project Hail Mary," the inaugural selection of The Planetary Society book club, with The Planetary Society's Mat Kaplan.
THE PLANETARY SOCIETY

THE PLANETARY SOCIETY BOOK CLUB

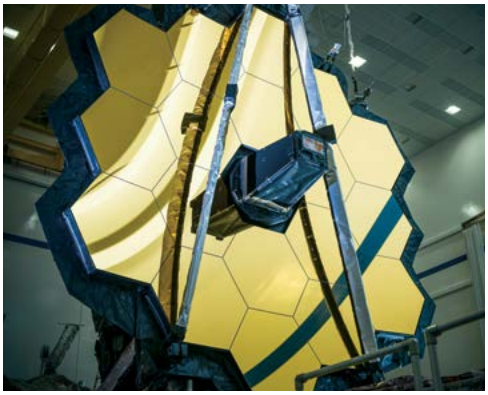
One of the great new activities taking place in the member community is our new monthly space book club. Hosted by Planetary Radio creator Mat Kaplan, this online club will bring you ongoing discussions about each month's book, culminating in a live virtual event featuring a conversation and Q&A with the author or a relevant space expert. Find the book club and more at **community.planetary.org**.

CELEBRATE ASTEROID DAY!

The Planetary Society is proud to partner with Asteroid Day, an international celebration of all things asteroid, from the science of space rocks to the efforts to protect our planet from impacts. Asteroid Day takes place on June 30 every year and involves virtual and in-person events around the world. Go to **asteroidday.org** to learn more and join the party!

VERITAS NEEDS YOUR HELP

NASA'S FIRST VENUS NASA's first Venus orbiter in three decades is facing an indefinite delay. The Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy (VERITAS) mission was selected by NASA in 2021 as the U.S.'s first Venus orbiter since 1989. The project was on time and on budget. However, in the latest President's Budget Request, NASA slashed the mission's funding to nearly zero dollars and indefinitely delayed the launch. NASA admits this decision was due to cost overruns and workforce issues in other programs. We need space advocates like you to voice your support for a renewal of VERITAS funding. If you live in the United States, send a letter to your representatives in Congress urging them to ensure that this important mission gets off the ground. Go to **planetary.org/action-center**.



A GREAT YEAR TO SEE THE PERSEIDS

IN THE SKY

In June and July, super-bright Venus and dimmer reddish Mars are low in the west in the early evening. The crescent Moon joins them in a tight grouping on June 21. Yellowish Saturn is above bright Jupiter in the pre-dawn, starting low to the horizon in June but then getting higher as the weeks pass. By September, Venus has moved to the pre-dawn east. The Perseid meteor shower, usually one of the top meteor showers of the year, peaks Aug. 12/13, with increased activity several days before and after. It is a great year to see the Perseids because there will be little interference from moonlight, as there is only a crescent moon that rises not long before dawn. From a very dark site, there are typically 50 to 75 meteors per hour at the peak.

RANDOM SPACE FACT

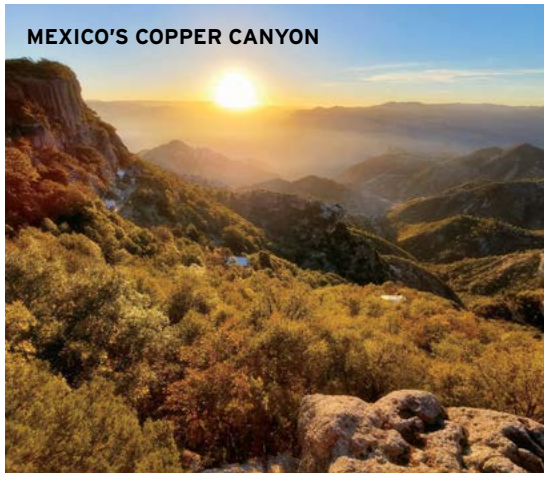
The mass of rocks and dirt brought back from the Moon by astronauts in the Apollo program is equivalent to about 21 granite rocks (stones) used in the sport of curling.

TRIVIA CONTEST

Our December solstice contest winner is Herbert Teitelbaum of Brooklyn, New York, USA. Congratulations! The question was: ***How many hexagonal segments make up the JWST primary mirror?*** The answer: ***18.***

Try to win a copy of the new book "Solar System Reference for Teens" by Bruce Betts and a Planetary Radio T-shirt by answering this question: ***On the asteroid Bennu, what were the names the OSIRIS-REx team assigned to the final four sampling sites they considered before choosing one of them to sample?***

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 Sept. 1, 2023. One entry per person. The winner will be chosen in a random drawing from among all the correct entries received. For a weekly dose of What's Up? complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to Planetary Radio at planetary.org/radio.



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

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

NEW MEXICO ANNULAR ECLIPSE
OCT. 10-17, 2023
See the International Balloon Fiesta, the ancient Indian pueblos at Chaco Canyon and Mesa Verde, and the annular eclipse.

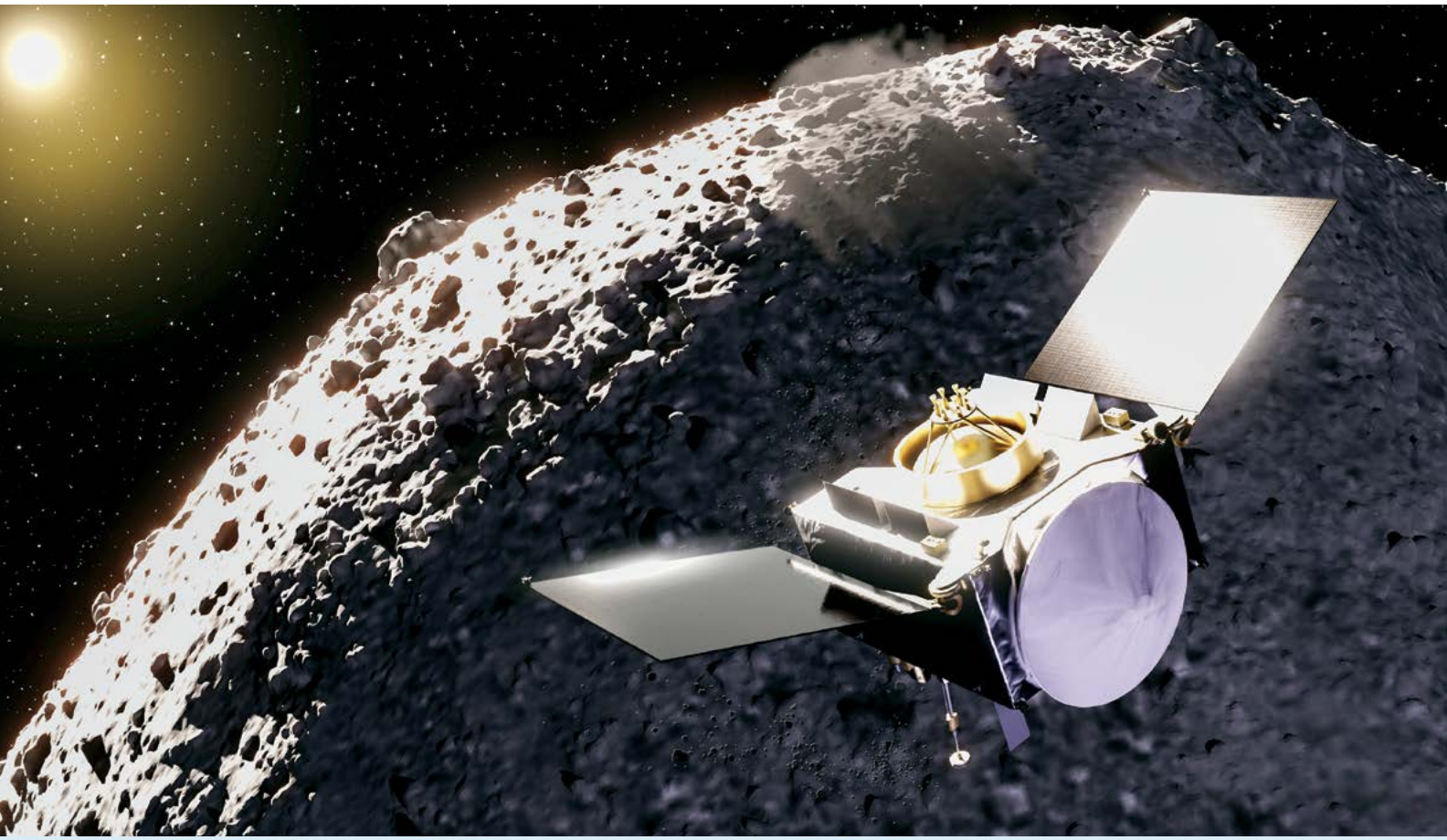
DISCOVER ANTARCTICA
DEC. 5-18, 2023
Encounter this icy paradise of stunning mountains and wildlife!

ALASKA AURORA BOREALIS
MARCH 7-13, 2024
Discover magnificent Denali and the northern lights in the pristine splendor of Alaska in winter.

MEXICO COPPER CANYON AND DURANGO TOTAL SOLAR ECLIPSE
APRIL 1-9, 2024
Discover Copper Canyon and Mazatlan and then see Durango and the eclipse high in the Sierra Madre!

THE PLANETARY SOCIETY

60 SOUTH LOS ROBLES AVENUE
PASADENA CA 91101-2016 USA



Disturbing an asteroid

Chris Doll

This artwork from International Association of Astronomical Artists member Christopher Doll shows OSIRIS-REx approaching the asteroid Bennu with the Sun shining in the background. "I wanted to capture the aftermath of OSIRIS-REx's sample retrieval from asteroid Bennu," said Doll, "with a hint of escaping debris as it sped on its way back to orbit. To the surprise of many, myself included, Bennu's surface wasn't nearly as solid as anticipated. We were left with a new understanding of the composition of asteroids. The image was constructed using available 3D data on the asteroid Bennu and the OSIRIS-REx spacecraft. I used Blender3D to compose the elements in this dramatic scene. Final details and adjustments were added in Photoshop."

CHRIS DOLL

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*.