THE PLANETARY SOCIETY

THE PLANETARY REPORT

SEPTEMBER EQUINOX 2015

VOLUME 35, NUMBER 3

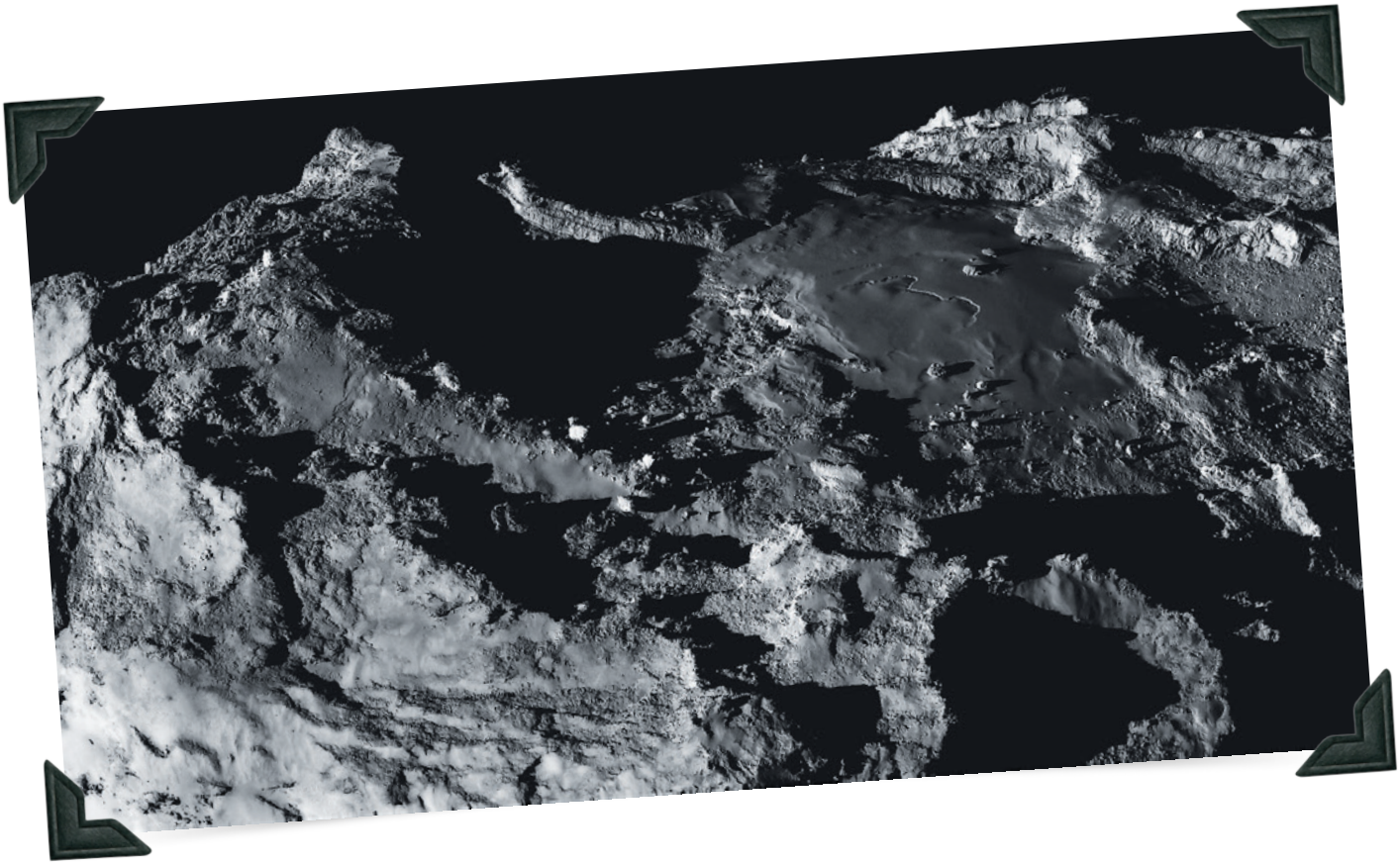
planetary.org

MORE TO EXPLORE

WE'VE ONLY JUST BEGUN!

THIRTY-FIVE YEARS OF PROGRESS ✻ MASTCAM-Z ✻ MEMBERS' VIEWPOINTS

EMILY STEWART LAKDAWALLA
blogs at planetary.org/blog.



Comet Landscape

NOTHING QUITE AS WEIRD and wonderful as comet Churyumov-Gerasimenko has been seen by spacecraft before. ESA's *Rosetta* mission has accompanied the comet in its orbit around the Sun since August 2014. The craft carries a navigational camera to help steer its course. ESA has begun to release NavCam data to the public, and astronomy outreach educator Stuart Atkinson has sifted through the archives to find evocative views of the comet's strange and varied landscapes. This photo of blocky ridges rising above smooth, perhaps dusty, lowlands was taken as *Rosetta* approached for a close flyby of the comet on March 28, 2015.

–Emily Stewart Lakdawalla

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SEE MORE EVERY DAY! PLANETARY.ORG/BLOGS

Credit: ESA/Rosetta/NavCam/Stuart Atkinson

Dear readers:

I want to offer my sincere apologies for the fact that you are receiving this "September Equinox" issue of The Planetary Report *so very late. As you know, 2015 has been an incredible year for The Planetary Society. We launched a spacecraft, we celebrated the payoff of our years of Pluto advocacy, ran a wildly successful Kickstarter campaign, we moved to—and continued work on—our new headquarters, and topped it all off with a very ambitious 35th anniversary celebration weekend.*

Although the staff of The Planetary Society is growing, it's still not very big and we can't believe we pulled it all off. Unfortunately, the trickle-down effects of so much extra activity affected some areas of our work, one of them being the magazine schedule. But we love producing The Planetary Report *for you, and we will be working hard to catch up over the next couple of issues.*

Thank you for your patience and understanding.

–Donna Stevens

ON THE COVER: In the realm of space exploration, we citizens of Earth have made an astonishing amount of progress in the last 35 years. Our visit to Pluto and Charon is a testament to the power of vision and focused, hard work in reaching ambitious goals. Our cover image is a colorized, infrared layer from the now famous, enhanced-color, high-resolution global view of Pluto captured by New Horizons on July 14, 2015. To read more about how the image was created, go to planet.ly/colorpluto. *Image: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Zac L. Doyle*

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

So Much to Explore

Looking Back at 35 Years, and Forward to Many More

EVERY TIME I LOOK at the recent pictures of Pluto sent by *New Horizons*, I think about what's next in space exploration. I was at the launch of the spacecraft in 2006. It was picture perfect. For the last nine and a half years, the spacecraft sent reassuring signals and images back to us here on Earth. There was a significant, potentially catastrophic software problem just a few days before the mission's main moment, but that was overcome. When the time came for *New Horizons*' amazing flyby of distant Pluto, all systems functioned flawlessly, exactly as planned. Somehow, I wasn't surprised. It all worked, and we can expect many more astonishing images and insights about the nature of worlds beyond the orbit of Neptune in the coming months. But as I reflect on this amazing mission, I think, "That was great." And then immediately my mind follows up with: "Wow, there is so much more to explore."

Planetary exploration carries with it optimism, a belief in the future. Mission planners, designers, and engineers all accept that their missions will be decades-long undertakings. They are confident that, no matter what happens on the world stage, no matter who comes and goes in politics, no matter what happens in their personal lives, the mission will go on, and discoveries will be made—discoveries to be shared by all humankind. It's this optimism that makes missions like *New Horizons*, *Cassini*, *Chang'e*, *Rosetta*, *Hayabusa*, *Mangalyaan*, and *Curiosity* worthy of our intellect and treasure.

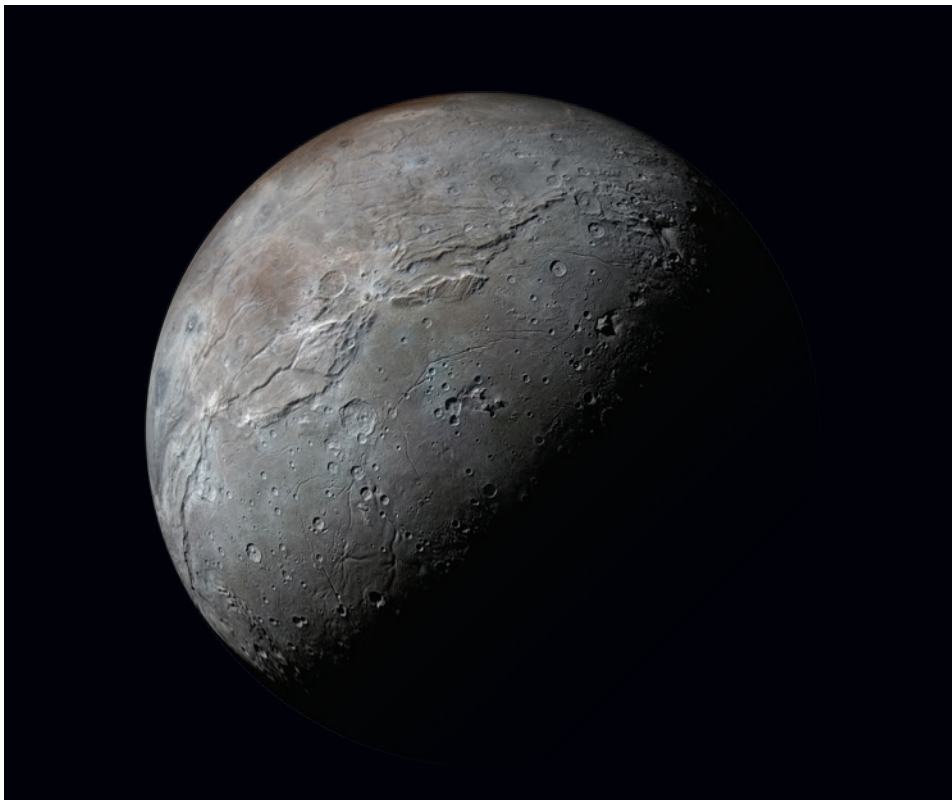
The Planetary Society has been at this business now for 35 years, and I am more aware than ever that the cosmos is vast, replete with planets that hold countless secrets worthy of our investigation. Since our beginning, we have embraced the not-always-obvious idea that a discovery of life elsewhere in the cosmos would change the course of human history. Members like you have shared the understanding that a signal from out there in space would mean that you and I, along with sea jellies, sycamore trees, and cold viruses are not alone in the universe. Carl Sagan wrote and spoke eloquently about how we might go about listening for evidence of an extraterrestrial intelligence. We might not know the intrinsic meaning of a signal from deep space, but its very existence would be profound.

WE CONTINUE THE SEARCH

Part of The Society's purpose is to remind the world how important is the search for life, both from a scientific point of view and a philosophical one. Since our founding, The Planetary Society has supported SETI: the Search for Extraterrestrial Life. Over the last decade, we've focused our efforts on our dedicated telescope searching for an optical signal produced by an intelligence somewhere up and out there. Night after night, year after year, we continue the search, knowing there is only one way to detect an electromagnetic signal from another civilization—by listening and looking.

In the coming years, I very much want for us to focus on the search for life. We have studied our neighboring worlds in great detail, especially their composition, their rocks, cores, and atmospheres. But after these few decades of investigation, it is time, I believe, for us to get specific. In the same way in which we target specific regions around specific stars in specific galaxies in the search for a planet as habitable as our Earth, I want us to look specifically for signs of life right here in our own solar system.

We support the Planetary Deep Drill, an innovative way to look at the soils a few meters below the Martian surface, where microbial life may thrive. We continue our work on the zooming camera that will be mounted on the mast of the 2020 Mars rover. Bruce Betts has a good deal more to say about these innovations on page 20. In the coming months, we will maintain our steady work to keep the Europa mission on track, to make sure Congress and NASA stay the course. This mission will be the important first step to exploring that world, which has twice as much seawater as Earth. Who knows what might swim beneath the ice there?



ABOVE *This simulated view of a half-phase Charon was generated from images captured by New Horizons' Multispectral Visible Imaging Camera.*

Image: NASA/JHUAPL/SwRI/Roman Tkachenko

A PATH TO MARS

I am especially pleased and excited to release our "Humans Orbiting Mars" workshop report. Based on measured, careful analysis, we are confident that we could create a Mars exploration program that would put astronauts in orbit around Mars in 2033, an especially well-suited orbital opportunity. Casey Dreier has more about this on page 18.

THE NEXT DECADE

The recent success of the *New Horizons* mission to Pluto serves as a reminder that we can do great things. We can work together to make discoveries out there. Everyone reading this has wondered at one time or another, what is Pluto really like? Well today, we have a much better understanding of the Pluto system than we have ever had, because we committed time, effort, money, and energy to producing a spacecraft that could give us a good look up close.

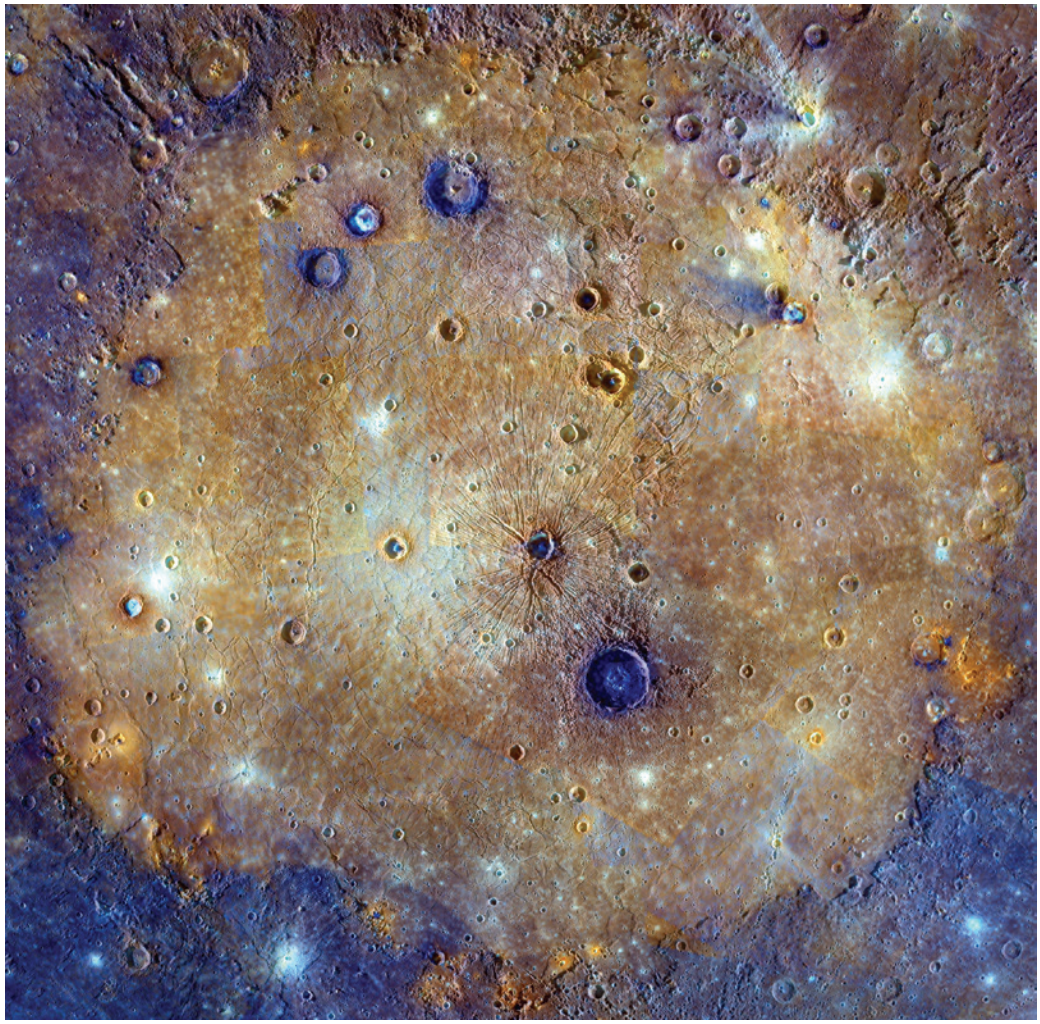
As we celebrate our first 35 years, I once again reflect on what seem to be obvious eventualities. One hundred years from now, humankind will probably know whether or not there is or was life on Mars. One hundred years from now, we will probably know whether or not there is life on Jupiter's moon Europa.

But as a person who came of age during the space age, and who became your CEO during our transition to the digital age, I want us to look for life beyond Earth now, in the next decade. I want my contemporaries and their kids to know whether or not we are alone in the solar system. I strongly believe that this discovery would affect all of us everywhere. Everyone would feel differently about what it means to be a living thing in the cosmos. Everyone would have a different perspective of our time here on Earth.

So, happy anniversary! We have much to celebrate and even more to look forward to. As more of us get involved in our mission to advance space science and exploration, more of us will be able to influence the future and change our understanding of worlds beyond our own. I want us to look for signs of life in the universe—and change the world.

Bill Nye

JENNIFER VAUGHN *is The Planetary Society's chief operating officer.*
BRUCE BETTS *is director of science and technology for The Planetary Society.*



RIGHT *Before* MESSENGER, *we had images (taken in 1974 and 1975 by* Mariner 10*) of only 45 percent of Mercury.* MESSENGER *mapped Mercury's entire surface and demystified much about our solar system's innermost planet. This enhanced-color composite image shows that Mercury's iconic Caloris basin has been flooded by lavas (shown in orange). Post-flooding craters have revealed low-reflectance material from beneath the surface.*

The Extraordinary Pace of Progress

35 Years of Exploration

WHEN CARL SAGAN, *Bruce Murray, and Louis Friedman created The Planetary Society 35 years ago, the future of space exploration looked bleak. Although there was a trove of* Viking *Mars data to sort through and the* Voyagers *were still heading toward the outer planets, the pace of space exploration was about to slow down significantly. Some feared the end of the so-called Space Race meant the end of space exploration.*

The birth and rapid growth of The Planetary Society showed that many people shared a deep commitment to advancing future exploration. Fueled by passion and dedication, the members, staff, and leaders of the Society worked tirelessly to keep this organization moving forward as we fought for new missions, seeded innovative technology, forged international relationships, and engaged the world's citizens. You, our members, have much to be

Image: NASA/JHUAPL/Carnegie Institution of Washington

proud of. Space exploration would not end; in fact, planetary exploration has thrived.

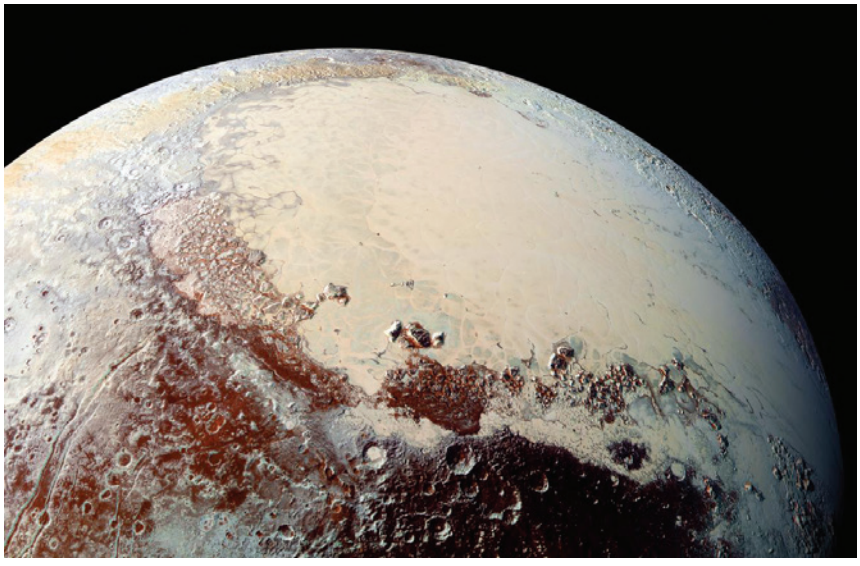
Director of Science and Technology Bruce Betts and I put our heads together to take a brief look at how much has happened in 35 years, a relatively short period of time. We sought to answer a few key questions: What do we know now about our place in space that we didn't know when The Planetary Society was founded in 1980? How have our perspectives and priorities changed over the last 35 years of exploration? What exploration milestones have we experienced together as members of The Planetary Society? It was gratifying to find the answers far too numerous to chronicle in these pages, but we pulled out some of the highlights for you. Enjoy! –JV

EXPLORING THE NEIGHBORHOOD

Getting to know even our nearest neighbors takes time. While *Mariner 10* gets the credit for being the first spacecraft to visit Mercury (in 1974), half the planet remained unseen by spacecraft for more than 30 years. In 2008, NASA's *MESSENGER* finally illuminated Mercury as a whole world, showing us what we had not seen, first with flybys, then in 2011 from orbit. The bonanza of science from *MESSENGER* was huge and included confirmation of water ice in permanently shadowed craters at the poles, evidence of a complex magnetosphere, discovery of a unique set of geologic features called hollows, and greater understanding of Mercury's origin and evolution.

Our views of Venus also took shape in this era. The Soviet *Venera 13* and the follow-on *Venera 14* gave us our first color images of the Venusian surface. NASA's *Magellan* orbiter used radar to lift the veil of Venus' thick atmosphere at unprecedented resolutions, revealing volcanic domes, lava channels, and very few impact craters—suggesting that Venus' surface underwent global upheaval about half a billion years ago. The European Space Agency's *Venus Express* orbiter enhanced our knowledge further with insights into Venus' thick and bizarre atmosphere.

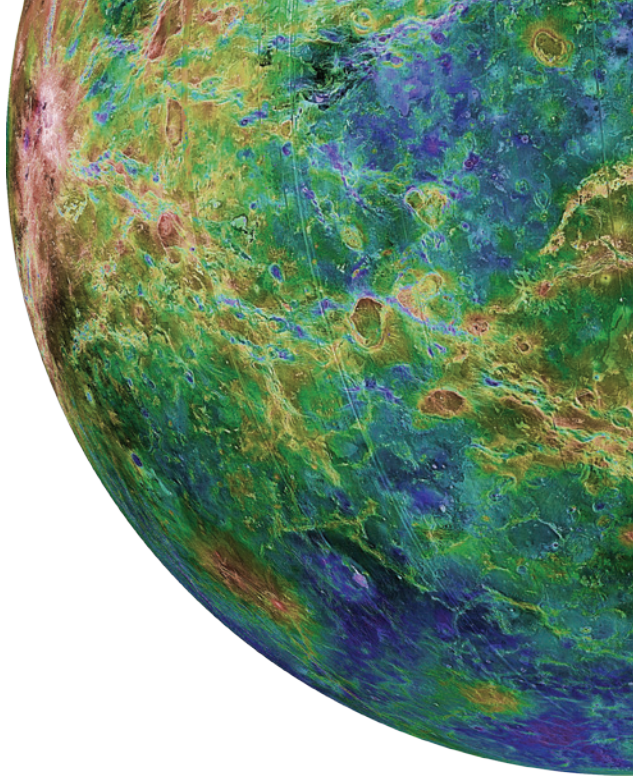
In the 1990s, NASA delivered our first orbiters to Jupiter (*Galileo*) and to Saturn (*Cassini*). These orbiters carried, respectively, the first giant-planet atmospheric probe, and the first moon lander (ESA's *Huygens*) outside the Earth-Moon system. *Galileo* and *Cassini* taught us not only about the spectacular gas giants, but also the intriguing moons, rings, and magnetospheres in their complex systems.



ABOVE *Now that we've seen it up close, Pluto's surface shows a remarkable range of subtle colors, enhanced in this view to a rainbow of pale blues, yellows, oranges, and deep reds. This high-resolution image, captured by* New Horizons, *combines blue, red, and infrared images taken by the spacecraft's Ralph/Multispectral Visual Imaging Camera.*

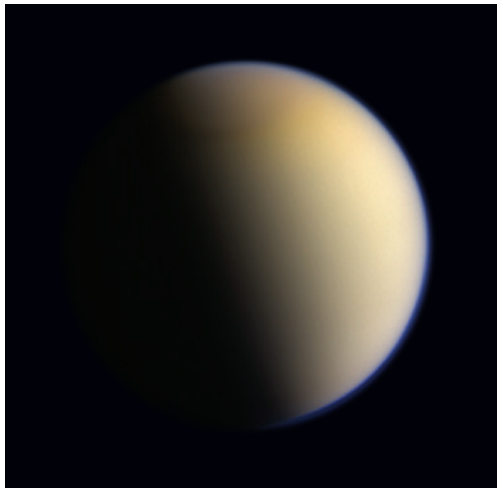
Jupiter's moon Europa emerged as a captivating ocean world with a potential subsurface habitat for life. *Galileo* also discovered that Ganymede has its own magnetic field, Io has varied volcanism, Jupiter has water cloud thunderstorms much larger than Earth's, and Jupiter's rings contain material that was blasted off its moons by impacts. In Saturn's system, *Cassini* peered through Titan's thick atmosphere and discovered a landscape of methane lakes, and ESA's *Huygens* probe gave us our first views from that fascinating moon's surface. *Cassini* surprised us further by detecting active water geysers at Encela-

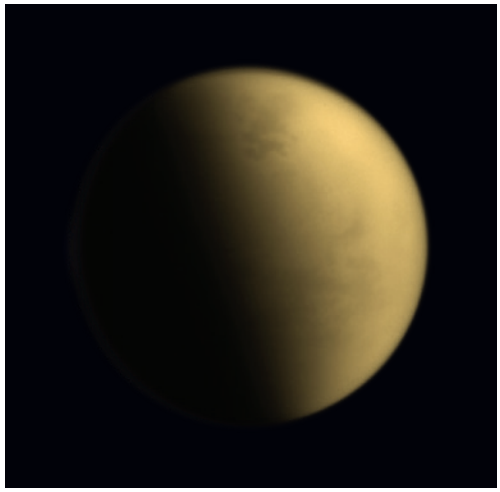
Image: NASA/JHUAPL/SwRI

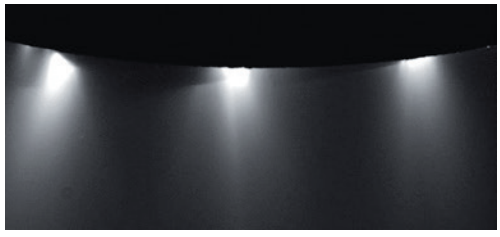


dus. Our long-term presence at Jupiter and Saturn showed us that the moons of our solar system are often as complex and dynamic as planets, and many of these worlds call for in-depth exploration.

During the Society's history, we have also enjoyed some first-flyby glimpses of outer solar system worlds. NASA's *Voyager 2* flew by Uranus in 1986 and Neptune in 1989, delivering our first and only close-up views of these planets and some of their moons. Most recently, NASA's *New Horizons* arrived at Pluto this past summer. We're still downloading the data from our first close pass of this beloved world and its largest moon, Charon. This single encounter will literally rewrite textbooks, kick-start careers, and redefine our perspective on our solar system. As with past initial flybys, Uranus and Neptune, Pluto, and Charon all beckon for more exploration.







Pluto and Charon also play a part in another revolution in our understanding of our neighborhood. We now know that Pluto is one of a swarm of bodies orbiting beyond Neptune. These bodies are known as Trans Neptunian Objects (TNOs), and are currently split into the Kuiper Belt and Scattered Disk Objects. Since the discovery of the second TNO in 1992, we've discovered more than 1,500 TNOs, including Eris, which is more massive than Pluto. These discoveries shed light on a new region of our solar system and contributed to the reclassification of Pluto as a dwarf-planet, reducing the number of "classic" planets orbiting our Sun to eight.

MARS, IN DEPTH

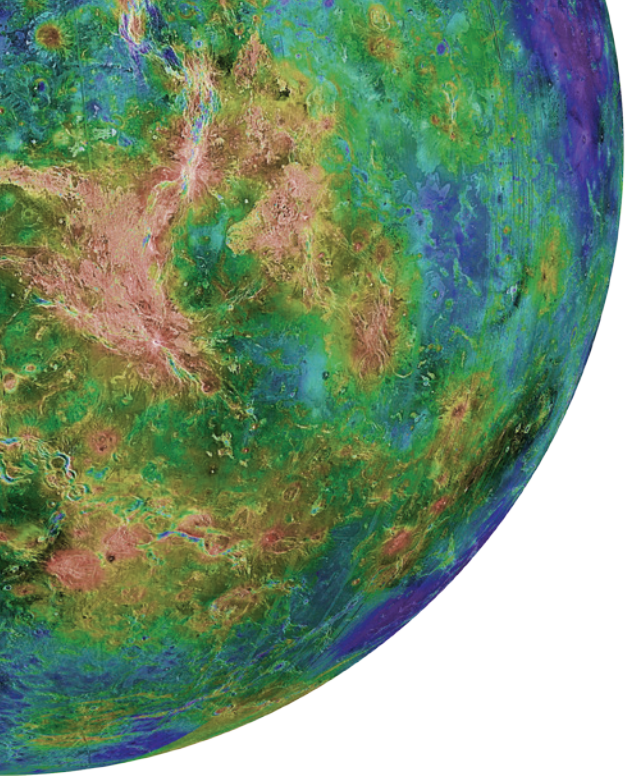
We have witnessed a flourishing of exploration at Mars that has moved us beyond pure reconnaissance to in-depth study of the Red Planet. The more we have learned, the more complex and intriguing the story has become.

TOP CENTER *The Soviet* Veneras *and NASA's* Magellan *spacecraft have shown us the surface of hot, noxious atmosphere-shrouded Venus. To read about the creation of this image, go to* planet.ly/magellanvenus. *To watch a brief animated tour of Venus' global terrain as revealed by radar onboard* Magellan, *go to* planet.ly/rotatingvenus.

RIGHT *An image of Titan in natural color. Below it is a view of Titan as it would look if you could see past its atmosphere and down to its surface. Using a special spectral filter,* Cassini's *high-resolution camera was able to peer through the moon's atmosphere. The darker areas are vast hydrocarbon sand dunes and seas.* Cassini *took both images on June 26, 2013 from a distance of about 1.4 million kilometers (870,000 miles).*

BOTTOM *On May 18, 2010, as* Cassini *approached for its 11th targeted flyby of Enceladus, it looked directly at the little Saturnian moon's active south polar geysers. The pictures in the four-frame animation from which this still is taken were imaged from a distance of about 15,000 kilometers (9,300 miles). See the full animation at* planet.ly/enceladusplumes.

Venus image: NASA/GSFC Scientific Visualization Studio; Titan images: NASA/JPL/SSI/composite by Val Klavans; Enceladus : NASA/JPL-Caltech/SSI/animation by Emily Lakdawalla



In 1980, Mars seemed dead, dry, and unchanging–not a priority for exploration. In the mid-1990s that impression changed with *Pathfinder* and *Mars Global Surveyor*.

Since then, our study of the planet has focused on understanding liquid water, something that is not stable on its surface now, but has existed in a variety of environments in the past–from giant floods, to standing water, to shallow flowing water, to subsurface flows, and maybe even to oceans. There is even tantalizing evidence that water may flow out of the surface to this day (see page 19). Liquid water is required for life on Earth, and its prevalence in Mars' past has brought astrobiology to the forefront in Mars studies.

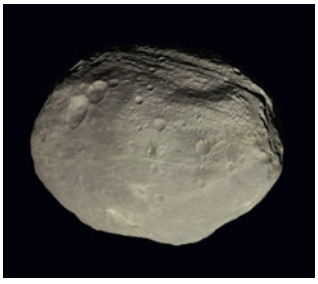
Our robotic emissaries at Mars have become much more capable, providing us with mineral maps, spy satellite-quality images from orbit, and topographic knowledge that rivals our understanding of parts of Earth. We have become more adept at landing objects on Mars, a challenging feat in itself.

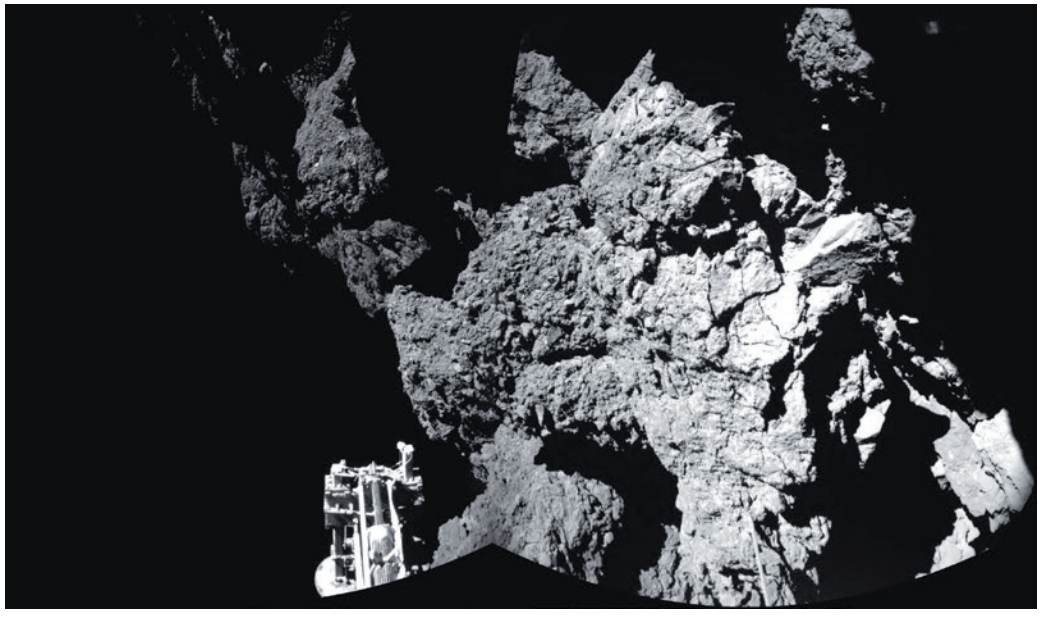
From *Sojourner* to *Spirit* and *Opportunity* to *Curiosity*, we have benefited from the science–and inspirational power–of mobility on another planet. There are seven spacecraft working at Mars now, and more are in preparation, including the Mars 2020 rover, which will cache samples for a hoped-for future return to Earth.

NASA/JPL/MSSS/Emily Lakdawalla

LEFT *As of November 2015,* Curiosity *has drilled and sampled nine locations on Mars. They are (left to right and top to bottom): John Klein, drilled on sol 182; Cumberland, on sol 279; Windjana, on sol 621; Confidence Hills, on sol 759; Mojave, on sol 882; Telegraph Peak, on sol 908; Buckskin, on sol 1060; Big Sky, on sol 1119; and Greenhorn, on sol 1137. All of these images were taken with* Curiosity*'s MAHLI camera from a distance of about 5 centimeters (2 inches). The drill holes are 1.6 centimeters (0.6 inches) wide.*

BELOW *Vesta is one of the more colorful asteroids in our solar system. This view is composed of 17* Dawn *images, individual color frames that have been draped over a digital model of Vesta's shape. The color has been corrected to match Vesta's visible spectrum.*





ABOVE *This nearly true-color image of Ceres was taken on May 4, 2015, as* Dawn *was surveying the large asteroid. Oxo crater makes a small bright splash near the center; Haulani is the larger one to its right.*

ABOVE RIGHT *This view of comet Churyumov-Gerasimenko, taken by* Rosetta*'s* Philae *lander, is composed of two CIVA (Comet Nucleus Infrared and Visual Analyser) images, representing just a part of the full panorama.*

Vesta: NASA/JPL/MPS/DLR/IDA/Björn Jónsson; Ceres: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA/Justin Cowart Philae: ESA/Rosetta/Philae

SMALL, INTERESTING, AND SOMETIMES DANGEROUS

We have discovered thousands of comets and hundreds of thousands of asteroids in the last 35 years. All asteroid and comet exploration by spacecraft has occurred during The Planetary Society's history, beginning with the 1986 flybys of comet Halley and a series of asteroid flybys starting in the 1990s with *Galileo*'s flyby of Gaspra.

We moved to more in-depth exploration with NASA's *Shoemaker NEAR* at Eros, and now with ESA's *Rosetta*, flying alongside comet 67/P Churyumov-Gerasimenko. NASA's *Dawn* became the first spacecraft to orbit two separate deep-space bodies, Vesta and Ceres, complex worlds in their own right. Other milestones include a comet lander with *Rosetta*'s *Philae*, an asteroid sample return from Japan's *Hayabusa*, and the conversion of an orbiter to a lander with *Shoemaker NEAR*.

Thanks to these spacecraft, we have learned about the present state and evolution of comets and asteroids and, because they are windows into the early solar system's formation, also learned about the history of our planetary neighborhood. We have found that some 15 percent of asteroids have "moons" or exist in binary systems. We have also seen, as is so often the case with true exploration, that asteroids and comets are more complex and far more diverse than expected.

During the last 35 years, we have made strides in assessing the threat from asteroid and comet impacts to life on Earth, both in the past and the future. These strides include most of our understanding of the Chicxulub crater, formed by an impact off the modern-day Yucatan Peninsula of Mexico that led to the extinction of the dinosaurs and 70 percent of all species on Earth.

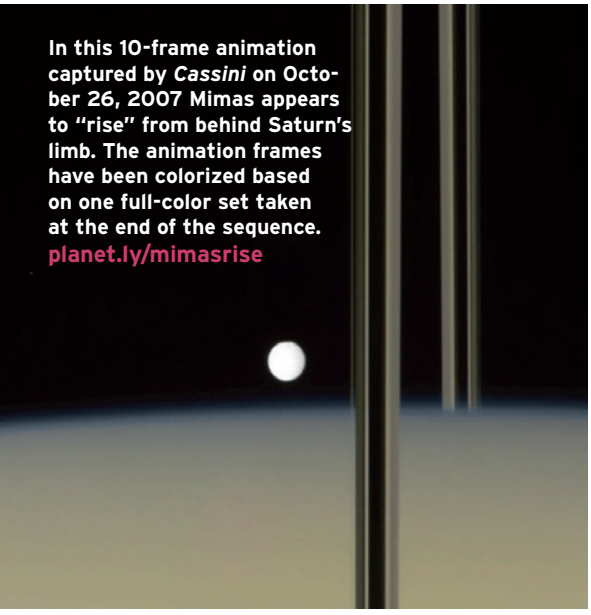
Over the decades, we have discovered hundreds of other impact craters and their remnants on Earth. In 2013, the shockwave from an airburst explosion of an 18-meter object over Chelyabinsk, Russia caused damage and injuries, and served as a vivid reminder that the threat from near-Earth objects is real and we do not yet have a plan of action.

The good news is that we have made progress toward finding, tracking, characterizing, and conceptualizing how to deflect dangerous asteroids. In 1980, we knew of fewer than 100 near-Earth asteroids. Now,

thanks to professional and amateur surveys and tracking, we've found more than 13,000, and the numbers continue to rise.

PLANETS, PLANETS, EVERYWHERE

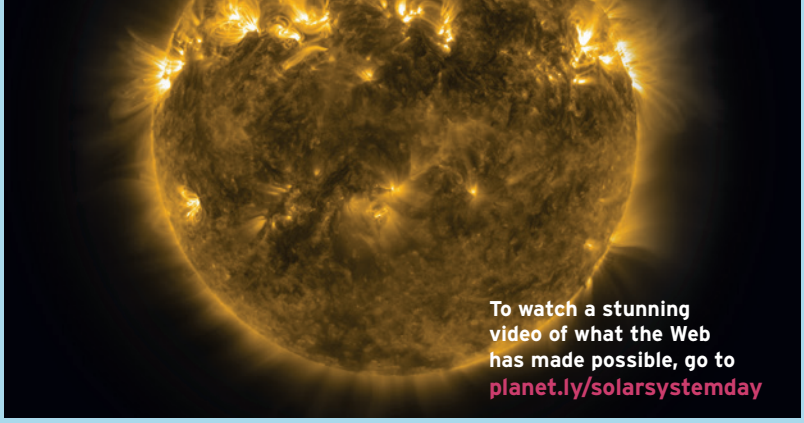
The Planetary Society operated for 15 years before astronomers detected their first planet orbiting another star. Now we have confirmed evidence of nearly 2,000 exoplanets, while another 4,000 candidates await confirmation. These planets are diverse, altering our thoughts on solar



In this 10-frame animation captured by *Cassini* on October 26, 2007 Mimas appears to "rise" from behind Saturn's limb. The animation frames have been colorized based on one full-color set taken at the end of the sequence. planet.ly/mimasrise

system formation. Gone are the days when we had only one solar system as our laboratory. We have found Jupiter-size planets orbiting close to their parent stars in periods of only a few days. Among these new worlds, we have found a surprising range of sizes and characteristics, from planets many times the mass of Jupiter, to Earth-sized planets, and everything in between. And, we are getting closer to finding an Earth-like planet orbiting a Sun-like star in a region (the habitable zone) where liquid water could exist on the surface. We have already found more than a dozen roughly Earth-sized planets in the habitable zones of their parent stars, and, in many ways, the hunt has just begun.

Mimas NASA/JPL/SSI/Gordan Ugarkovic; Sun image NASA/SDO



To watch a stunning video of what the Web has made possible, go to planet.ly/solarsystemday

How the Web Changed Things

When *Voyager 2* flew past Uranus and Neptune in the 1980s, a lucky few people could watch images build up, line by line, on television screens. The rest of us could only wait for newsletters, magazines, and television specials to show us a few of the best images, selected and explained by mission scientists and NASA public information officers.

By the late 1990s, the way NASA distributed information about active missions was changing. In 1997 the *Mars Pathfinder*, *Mars Global Surveyor*, *Galileo*, and *Near Earth Asteroid Rendezvous* missions shared precious image data with the public through the fledgling medium of the World Wide Web. News was more rapid and immediate, giving viewers a feeling they were looking over the shoulders of the scientists and engineers. But it was still mostly a traditional, one-way flow of information: from on high, NASA experts distributed information downhill to the waiting masses.

But the Web could facilitate more, and NASA's Planetary Data System began to use it to distribute space mission data archives to researchers. No longer confined to a few Planetary Image Facilities, the data were accessible to anyone connected to the Web. Members of the public around the world began to download, process, and share space images, increasing the variety and beauty of our views of distant worlds at little additional cost to NASA. It was the discovery of the riches available at the Brown University Regional Planetary Image Facility, and the desire to help the public take advantage of them, that led me to the work I do now for The Planetary Society.

In 2004, the *Mars Exploration Rover* mission took a bold step: they automated the release of all rover image data, allowing many of the rovers' photos to be seen by members of the public first, often halfway around the world, before NASA personnel saw them. The photos didn't get scooped by unscrupulous scientists, and they helped build a legion of loyal rover fans and armchair scientists who could participate in the joy of discovering new places on Mars along with the science team.

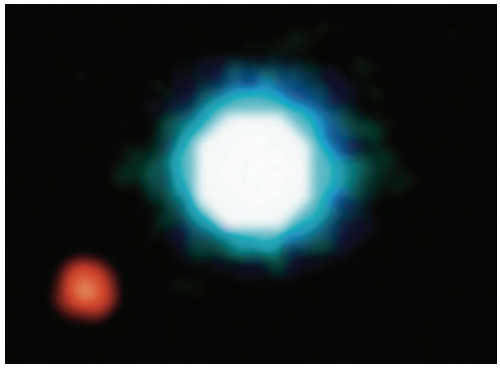
With minute attention to detail and countless hours spent examining and playing with image data, space enthusiasts can now make positive contributions to solar system research. They bring artistic talent and computational skills to space image data, generating new views of distant worlds for the public—and science teams. They answer questions and debunk conspiracy claims, actively educating the public. Through citizen science projects they count craters, map landing-site hazards, and search for future mission targets. Sometimes they even catch oddities that the science team misses. It's no longer a one-way flow of information; the Web-connected space community really is a network, with information flowing in all directions.

Since its founding, The Planetary Society has served as a node in the space information network, facilitating the transfer of information between experts and the public. Through our publications, our website, and now our social media channels, we help space fans—whether they're members of the public or mission personnel—connect with each other and share their excitement about space.

– Emily Lakdawalla

SO MUCH MORE TO EXPLORE

The last 35 years have emphasized that the more we explore, the more we learn, the more we are surprised, and the more we yearn to know. We have completed the initial spacecraft reconnaissance of the eight planets of our solar system, plus Pluto. Part of what our initial planetary reconnaissance has taught us is that every world we visit has a tale to tell, and it is always more complicated than predicted. Some of the giant planets' moons—such as Titan with its methane lakes, Enceladus with its spewing icy geysers, and Europa with a subsurface ocean likely twice the volume of Earth's oceans—are truly fascinating worlds in their own right. There is so much more to see for the first time, and so much more to learn about a host of complex worlds we have already glimpsed.



RIGHT *This is the first directly imaged picture of an exoplanet (the red spot at lower left). It is also the first to be found orbiting a brown dwarf star, in this case 2M1207. The planet was imaged the first time by the VLT in 2004. The planet was imaged for the first time in 2004 by the European Southern Observatories Very Large Telescope, located in Chile. The identification of 2M1207b as a planet was confirmed in 2005. This distant world is a Jupiter-like planet, but five times more massive than Jupiter. It orbits its star at a distance 55 times that between Earth and the Sun, or nearly twice as far as Neptune is from the Sun. The 2M1207 system is 230 light-years away in the constellation of Hydra.*

Human exploration must also advance. Since 1980, our human exploration programs have been busy in low-Earth orbit, and we've gone no farther. All Space Shuttle flights took place during the last 35 years. Mir, the International Space Station, and Tiangong-1 are all space stations whose entire histories fall within this time period. Records were set and broken for human spaceflight, from most days spent in space at one time (438) to most people in space at once (13). It is time now to focus on taking steps toward human exploration of Mars.

We have much to look forward to, from a series of upcoming planetary missions, to finding and studying Earth-like exoplanets, to humans again moving beyond low-Earth orbit, to sample return missions from Mars, to more in-depth studies of ocean worlds in our solar system, and—as always—to the search for life.

So here we are, looking back at 35 years of exploration, feeling awed by the accomplishments and inspired by the growth in knowledge. As we look forward, we feel the welcome burden of the challenge ahead of us. Within the next few years, we will no longer have spacecraft at Mercury, Venus, or any of the outer planets. Just as when The Planetary Society started, we still believe in working tirelessly toward continuous exploration. We seek to know the cosmos and our place within it, and we know our quest has just begun.

Imagine what will happen in the next 35 years.

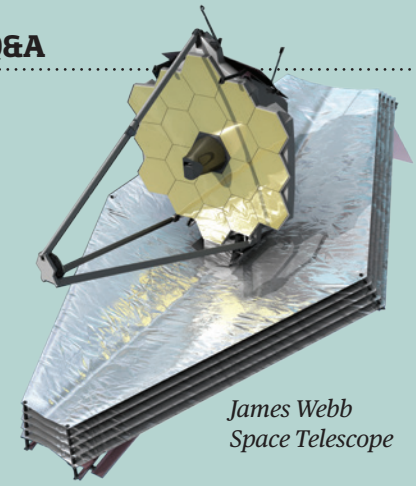
On behalf of all of us at Planetary Society headquarters, thank you for your role in advancing space exploration over the last 35 years. Working together, we will continue to push for more exploration, more discovery, and more understanding of our place in space.

JENNIFER VAUGHN *Jennifer Vaughn started her career with The Planetary Society in 1997, working on* The Planetary Report *and an early version of the Society's website,* planetary.org. *In time, her passion for The Planetary Society and her aptitude for management led her to the Chief Operating Officer position shortly after Bill Nye took the helm as Chief Executive Officer. Outside of The Planetary Society, Jennifer co-owns a dance studio and performance space in Los Angeles, California.*

BRUCE BETTS *got his Ph.D. from Caltech with Planetary Society founder Bruce Murray. He served as a Discipline Scienstist at NASA Headquarters before coming in 2001 to The Planetary Society where he manages science and technology projects. Bruce is passionate about communicating the wonder and fun of space exploration, including through social media (@RandomSpaceFact), video, online teaching, and on* Planetary Radio.

Image: European Southern Observatory

Q&A



James Webb Space Telescope

Q **Given that amazing space telescopes like the Hubble and James Webb can, and will, observe extremely distant objects, why do we not have a class of telescopes capable of seeing fine detail on the surfaces of much closer objects such as Pluto and Europa? From an engineering perspective, is it impractical? Are there technological or budgetary reasons?** *–Tony Mountjoy, Regina, Saskatchewan, Canada*

A Before *New Horizons* gave us close-up pictures of Pluto earlier this year, some of the best images we had of Pluto were from the Hubble Space Telescope (HST). Likewise, we have used HST to look at Europa, which is the target of a planned NASA probe in the 2020s. The James Webb Space Telescope (JWST) will do even better than HST, due its larger mirror. However, no telescope near Earth will be able to rival a probe that visits these objects up close in terms of instrument resolution and detailed images. Physics dictates that the resolution of a telescope is proportional to its mirror size and inversely proportional to the distance to the object being observed. While we continue to create larger telescope mirrors, both on the ground and in space, we cannot reduce the immense distances to objects in the solar system. A closer view always enables a better view.

–Jason Rhodes, JPL

Photos: The Planetary Society and Patrick Morton; JWST image: ESA (C. Carreau)

VOLUNTEER SPOTLIGHT

Get Your Scopes Out!

THE FIRST STEP to engaging the public is to get their attention, and there's no better way to do this than with a telescope. Kids and adults alike jump at the chance to peer through that lens and get an awesome view of a distant planet or even our own Moon.

LEFT *In Venezuela, schoolchildren got excited about astronomy during the Asteroid Day event organized by outreach coordinator Patrick Morton.*

RIGHT *Outreach coordinator Chris Streeter set up a telescope and materials to teach people about space at the 65th Annual Los Angeles Science Fair.*

A cool view can open up a person's mind and get them curious to learn more. Seeing the red glow of Mars for the first time at a local star party could be what sparks an interest in space for the child who will grow up to be among the first humans to walk on Mars. And any citizen's support for space exploration could be won by showing them the beauty of what we seek to understand.

The Planetary Society's volunteers know this well, and they take to schools, parks, and even city sidewalks to share the cosmic perspective and get their communities excited about the universe that surrounds them. By showing people around the world the stunning beauty of what's out there, we advance our mission to engage them in exploring those alluring destinations.

To learn more about what our volunteers do, check out **planetary.org/blogs/volunteers**. Help us spread the wonder in your community by joining us at **planetary.org/volunteer**. Future astronauts and space scientists are waiting to be inspired!

DONNA STEVENS *is editor of* The Planetary Report.

AS WE CELEBRATE 35 years–and settle into our new offices–we are thinking about the history of our organization. In fact, we're beginning to archive it for future generations (more about that in an upcoming issue). For now, we're sorting through piles of files and stacks of boxes.

Amidst our collection of papers and books, we have photos–prints and slides in manila folders and old albums. You've seen a lot of them, but many you haven't. We thought it would be nice to share some old pictures now and then. The most logical place to start is with our founders. Here's a look back at Carl Sagan, Bruce Murray, and Louis Friedman, along with a few key colleagues and friends, in the early days of The Planetary Society.

RIGHT *Carl guides some of the many notable participants in The Planetary Society's Together to Mars Space Bridge conference, an unprecedented four-hour video conversation between American scientists and engineers in Boulder, Colorado and their counterparts in Moscow. Held on July 18, 1987, Space Bridge was aimed at stimulating interest in human and robotic missions to Mars, and in cooperation between the United States and Soviet Union in working on peaceful missions of exploration. Shown from left are: Carol Stoker, Chris McKay, Carl, and Harold Klein.*

Death Valley, California: Louis Friedman celebrates successful Marsokhod rover tests with Russian colleagues Gary Rogosky and Slava Linkin. Marsokhod, a product of U.S./Soviet cooperation, was a precursor to the rover missions that explore Mars today.

The Planetary Society's Board of Directors in 1989: Carl Sagan, Joseph Ryan, Bruce Murray, Henry Tanner, Louis Friedman, Thomas O. Paine.

RIGHT *Filmmaker Steven Spielberg and then-wife Amy Irving (holding son Max) listen as Harvard Professor Paul Horowitz (center) explains the eight-million channel Megachannel ExtraterresTrial Assay (META), a dedicated all-northern-sky search for extraterrestrial intelligence. The project was funded by The Planetary Society through a gift from Spielberg and ran from 1985 to 1994.*

BELOW *Bruce Murray and California Governor Jerry Brown discuss* Voyager 1*'s Saturn encounter at the gala dinner that was part of Planetfest '81.*

ABOVE *August 1989: The Planetary Society threw a huge wrap-party at the Jet Propulsion Laboratory to celebrate the success of* Voyager 2*'s Uranus encounter and the culmination of Planetfest '89. Chuck Berry, whose song "Johnny B. Goode" is etched into the* Voyager *Interstellar Record, performed his song for the crowd. Here, Carl awards Berry with a bronze* Voyager *Medallion.*

LEFT *Lou and Planetary Society Adviser Hans Mark at Planetfest '89.*

ABOVE LEFT *In the background, Bruce keeps an eye on the time as Carl addresses Planetfest attendees in August 1981.*

LEFT *Lou, Bruce, and Ray Bradbury meet over lunch to plan "An Evening on Mars." This Planetary Society-produced event, which took place in 1998, was a theatrical reading from Bradbury's Mars-related works.*

To download the Society's "Humans Orbiting Mars" report go to hom.planetary.org. See Casey Dreier's commentary on the conference and report on page 18.

In our June 2015 issue, Director of Advocacy Casey Dreier introduced The Planetary Society's Humans Orbiting Mars *concept and requested feedback from our members. We were delighted to receive many thoughtful responses. Below is a sampling of the letters you wrote. Member views and suggestions informed our "*Humans Orbiting Mars*" workshop report and will continue to guide our next steps as we move forward.*

In the same issue, we also asked you to tell us what you think about the Society's mission and vision, and how you feel about being a member. We share a couple of letters here about the value of Society membership as well.

–Donna Stevens

HUMANS ORBITING MARS

To the extent that independent, third- and fourth-party, centimeter-by-centimeter reviews of all data, experimentation, and projections support humans orbiting Mars first, this is what I favor. I find Mr. Nye's contention, however, that what "our very best robots do in a week a human geologist ... could accomplish in less than 15 minutes" a weak argument. What robots currently accomplish in seven days will pale by comparison with what they–and humans–will surely be able to do 20 years from now.

–Hal Rothberg, Calabasas, California

I would like to see us hold off on sending humans to Mars. Life-support technology and robotics will only improve over coming years. The money saved on not having to include life support and crew-safety hardware could fund several robotic missions. I believe several robotic missions to sample and return Martian material to Earth would give us a great deal of knowledge about Mars. It would also help us to prepare for a smarter mission when humans do go. We would have a better knowledge of available resources, which might make a human trip easier.

–John Monzyk, Louisville, Kentucky

I just read, with growing excitement, Casey Dreier's article in the June Solstice issue of *The Planetary Report*. Sending a crewed vessel to Mars to orbit the planet first is an excellent idea. It is, after all, what NASA did with the Apollo missions and is a logical step for missions to Mars as well. Spending a year on Phobos will very likely provide a lot of information on how that body became a moon of Mars and perhaps other knowledge as well. But do we really need a full year there? Could not some of that time be spent also looking at Deimos? Could there also be some means that the return flight might happen sooner, say eight to nine months? This might help lower the cost as reduced infrastructure may be required for the shorter trip.

–Rick Curry, Thornville, Ohio

I've been an international member of The Planetary Society for some years, and I love your work! I can hardly think of anything more important, long term, than putting humanity into space.

People who argue against this–solely based on cost-efficiency concerns–fail to see the enormous, long-term inspirational value of such missions, which [would] influence generations to come. Missions like these turn men and women into heroes and can change entire paradigms of society. What could be more powerful?

Keep pushing for the Mars mission.

–Alexander Hahn, Heidelberg, Germany

The *Cassini-Huygens* mission produced more than 11 years of amazing science at a cost of $3.26 billion. A human mission to Mars could cost 100 times more. If we chose to fund a human Mars mission, it means that we would not have money to fund 100 unmanned missions similar to *Cassini-Huygens*.

I am thrilled with most of the efforts of The Planetary Society, but I am opposed to your intent to push for a human mission to

Mars. It seems the best way to get crewed missions beyond the International Space Station would be to establish a base on the Moon. The advantages would be: it's just a three-day trip, the cost would be a fraction of a Mars mission, and there are no lunar dust storms. Once we have taken a few dozen trips and have improved our understanding of space travel–if we have ample money–we could consider a human mission to Mars. I think a realistic target date for such a Mars mission is a century away.

–Tom Kellogg, San Francisco, California

WHY I'M A MEMBER OF THE SOCIETY

I have been a member for almost a year now. Personally, I am not a scientist, but that does not stop me from appreciating science, as well as the organization's entire cause (that being, as Bill Nye often says, that "together we can change the world"). To me, changing the world really means raising the level of science literacy among people of the entire planet, which will inevitably lead to leaders who will understand and, therefore, appreciate the importance of space exploration and will be willing to spend money on it, rather than on wars, weapons, etc.

My admiration for you is even greater after reading in the last edition of *The Planetary Report* about how hard you have to fight to make some planetary missions possible, and how you stand up for those people who really understand how important those missions are.

Thanks for everything,

–Ljupka Jovanovska, Bitola, Macedonia

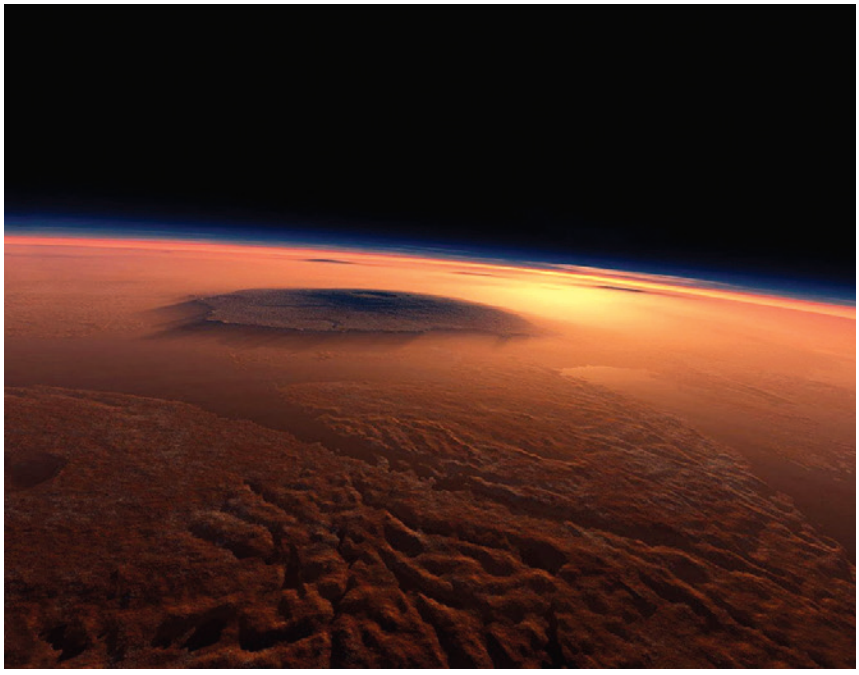
Let me start by commending the work the Society has done. I have always been proud to be a member. I recently retired from my job as a high school science teacher. I taught astronomy for several of the 33 years I spent in the classroom. I used to post the Trivia question and its answer to encourage my students to get involved. I think I have been successful in instilling the importance of space exploration to many generations of voters.

If the Society knows of someone running for office who supports spending money on space exploration, is it possible to make that person known to our members? I don't begin to understand the "cans" and "cannots" with regard to maintaining a charity status, but that's my idea.

Keep up the good work. It makes my day when I check the mail and find a *Planetary Report*.

–Steve Solak, Fort Myers, Florida

Thank you for your question regarding political candidates who support space exploration. As a 501(c)(3) nonprofit organization, The Planetary Society must avoid any direct, indirect, or implied involvement in, endorsement of, or intervention in political candidates' campaigns. We encourage our members to look into candidates' history of support for, and current positions on, space science and exploration.



BELOW *Olympus Mons dominates the landscape in this artist's view of Mars from orbit.*

Illustration: NASA

CASEY DREIER *is director of advocacy for The Planetary Society.*

Humans Orbiting Mars

Looking at a Realistic Plan

CAN I DECLARE IT officially? Mars is hot.

The Martian, a movie about as major as a major motion picture gets, is raking in the dollars. NASA held its first workshop on Mars landing sites for astronauts in October. And NASA's next robotic lander, *InSight*, is undergoing final testing before its launch to the Red Planet in March of next year.

Meanwhile, The Planetary Society released the report from our Humans Orbiting Mars workshop, which I discussed in the June Solstice 2015 issue of this magazine. The report synthesizes the discussion and presentations regarding the budgetary benefits, coalition-building opportunity, and scientific potential of taking a step-wise approach to getting humans to the surface of Mars, including the critical step of an orbital mission in 2033.

The entire report and additional background material are available at our new website, hom.planetary.org. I encourage every Society member to read it and start thinking about how we can get humans to Mars in a sustainable and affordable way.

To download the Society's "Humans Orbiting Mars" report go to hom.planetary.org

A RARE STATE OF TRANSITION

NASA's human spaceflight program is in a rare state of transition. For the first time since the 1970s, NASA is building new human-rated space hardware. The space agency is spending considerable sums of money creating a new heavy-lift rocket, the Space Launch System (SLS), and a new deep space crew vehicle, Orion. When these vehicles are complete the U.S. will have the capability to send humans beyond Earth orbit for the first time since 1972. This is a big deal.

At the same time, NASA is funding SpaceX and Boeing to develop new human-rated hardware to take astronauts to low-Earth orbit. NASA will purchase flight services from commercial companies to send humans into space. This is also a big deal.

THE BUDGET CHALLENGE

As usual, the challenge is budget, or lack thereof. NASA's funding has fallen while its overall programmatic responsibilities have grown. Nearly half the human spaceflight budget—over $3 billion per year—is needed to operate and supply the International Space Station. An equivalent amount is spent on the development costs of SLS and Orion. The rest of the budget goes mainly toward commercial crew support, overhead, and research. Deep space human habitats, landing vehicles, or other required hardware for human exploration are not funded at any significant level.

A report on the future of human spaceflight released in 2014 by the National Academies, *Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration*, analyzed a variety of possible NASA exploration programs and found that a budget that grows at the rate of inflation (about 2 percent per year) would not support a human Mars landing before the middle of next century.

A WAY FORWARD

That's why the orbit-first concept study we discussed at our workshop is so important. The independent Aerospace Corporation—using the same methodology it used in the *Pathways* report—found that the orbit-first architecture is plausible within a human spaceflight

budget that grows only with inflation. Orbit-first provides a strong proof-of-concept framework for how NASA could get astronauts to the Red Planet. Show-stopping budget increases are not required.

I believe JPL's concept team has provided a strong proof-of-concept framework for how NASA could get astronauts to the Red Planet. Obviously, the actual path to Mars will look different–it's impossible to predict all the engineering challenges–but the core ideas are strong. To sustain a long-term commitment to Mars, NASA should build a coalition of partners in industry, government, science, and the public. This means embracing the building blocks we have (SLS, Orion, and the commercial sector), planning for a tight budget, and defining a clear path that gradually increases in complexity (like the robotic Mars exploration program).

Even though Mars is hot right now, we need to plan for the tough times. When the going gets hard–and it will–a clear path and strong coalition will be there to see us to the goal.

Evidence of Water

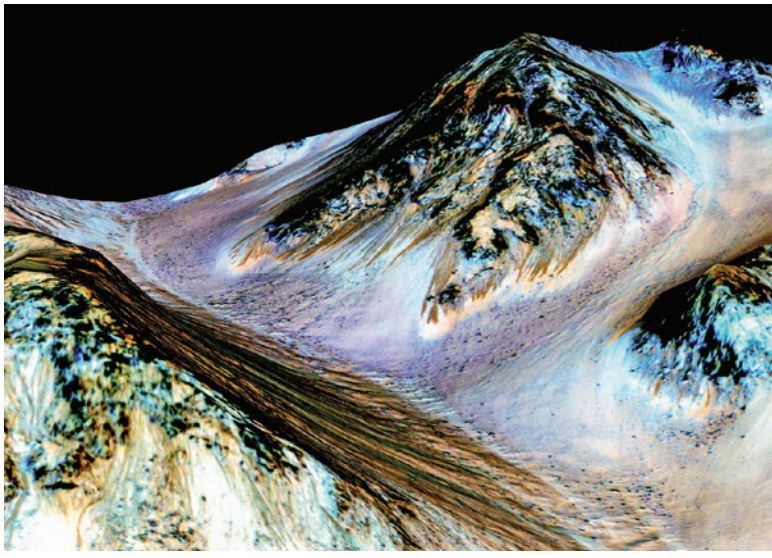
Dark Streaks Are Providing Exciting Clues

RECENT FINDINGS from NASA's *Mars Reconnaissance Orbiter (MRO)* provide the strongest evidence yet that liquid water flows on present-day Mars. "When people talk about water on Mars, they're usually talking about ancient water or frozen water," says Lujendra Ojha, lead author of a September 28, 2015 report in *Nature Geoscience*. Now, mineral mapping by *MRO* shows chemical signatures of hydrated salts that appear to come and go with seasonal features known as recurring slope lineae (RSL).

RSL are dark streaks, detected at dozens of sites by *MRO*'s High Resolution Imaging Science Experiment (HiRISE), which appear to flow down steep slopes during warm seasons and then fade in cooler seasons, when temperatures fall below -23 Celsius (-10 degrees Fahrenheit). According to the new study, spectrometer observations reveal hydrated salts at multiple RSL locations but only when the dark features are relatively wide. Looking at the same locations when the RSL were less extensive, researchers detected no hydrated salts.

Interpreting data from *MRO*'s Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), Ojha and coauthors believe the hydrated salts are likely a mixture of magnesium perchlorate, magnesium chlorate, and sodium perchlorate. Some perchlorates can keep liquids from freezing even in conditions as cold as -70 Celsius (-94 degrees Fahrenheit). On Earth, naturally produced perchlorates are concentrated in deserts. Some types of perchlorates can be used as rocket propellant.

–NASA/JPL



ABOVE *Roughly the length of a football field, these dark streaks at Hale Crater are examples of recurring slope lineae (RSL), which are thought to form with seasonal flows of water on Mars. In this false-color image, overhead observations by the HiRISE instrument aboard* MRO *were used to create a 3-D computer model of the terrain. The vertical dimension is exaggerated by a factor of 1.5.*

Image: NASA/JPL-Caltech/University of Arizona

BRUCE BETTS *is director of science and technology for The Planetary Society.*

Drilling and Imaging Updates

Member Dollars Enable Real Projects

GET READY TO PLANETARY DEEP DRILL

THIS FALL, the Planetary Deep Drill will get its first taste of drilling into a planetary surface, albeit on Earth.

BELOW *The 4-meter-long Planetary Deep Drill in the lab at Honeybee Robotics.*

Honeybee Robotics, developers of the drill, will be taking it to a gypsum mine near the Salton Sea in southeastern California. The field test is supported by The Planetary Society, and we'll be there to document at least part of the three-plus week exercise.

Planetary Deep Drill is a futuristic project to develop a prototype of an autonomous drill that could drill much deeper than before—hundreds of meters to even kilometers—through planetary ices. This capability could allow us to look back in time by drilling through layers of the Martian polar caps, or learn more about the possible subsurface oceans on Europa and Enceladus.

The first steps, now completed, were to design, build, and test the drill system in the lab. Now it is time to head to the field. The Planetary Society is supporting the field tests at the USG Corporation's gypsum mine. Why a gypsum mine? Gypsum has strength properties that are similar to extremely cold water ice found on other planetary bodies, making it a good first-step test for the prototype.

The goal of the field test is to drill to a depth of about 30 meters (about 100 feet), focusing on autonomous operation of the subsurface drilling. This version of the drill includes a microscope with visible and UV lights, and future versions can contain more advanced science instrumentation. The 4-meter-long wire-line drill also returns drill cores to the surface, a capability that in the future could be used to do more detailed analyses or gather materials for sample return.

Learn more about Planetary Deep Drill on its project page on our website at **planet.ly/deepdrill**, and in the December 2014 issue of *The Planetary Report*. Lots more to come!

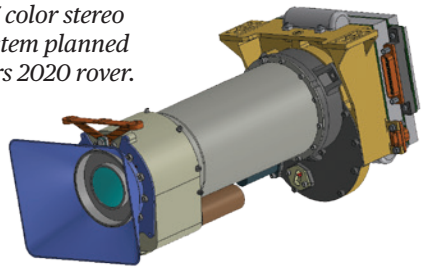
MASTCAM-Z: THE FUTURE OF STERO IMAGING ON MARS

Mastcam-Z is the color stereo mast imager selected by NASA for the Mars 2020 rover, a structural copy of the *Curiosity* rover that will

Photo: Honeybee Robotics; Mastcam-Z illustration: Malin Space Science Systems/Arizona State University

Thanks! Planetary Society members have helped make these grants—and many other projects—possible! Thank you.

BELOW *A CAD model of one camera in the Mastcam-Z color stereo camera system planned for the Mars 2020 rover.*



be launched with a new suite of instruments in 2020. The Planetary Society is ramping up its involvement in this project as an education and outreach partner.

Mastcam-Z has a zoom capability, something we have never had on a Mars rover. It will produce stunning images from the surface of Mars, including 3-D images. It also has a range of filters carefully selected for geologic studies. And, the zoom capability will help in the planning of drives for the rover. Mastcam-Z derives from *Curiosity*'s Mastcam instrument, and will be built by the same company, Malin Space Science Systems. Imagine the amazing *Curiosity* images, but now with zoom and more science capability.

Planetary Society President Jim Bell, in his other life as a professor at Arizona State University, is the principal investigator for Mastcam-Z and began talking with us about it very early in the proposal development process. Jim said, "I am excited to help bring Planetary Society members along for our next ride to Mars!"

I and other Planetary Society staff attended the first two Mastcam-Z meetings. I was reminded of the tremendous amount of expertise, time, and energy that goes into the development of a space flight instrument. Tens of smart, highly educated people spend years developing, designing, testing, and calibrating the instrument before it is ever launched into space. Tremendous work goes into making the best, most reliable instrument that can do amazing science. This is far from just slapping a camera onto a rover.

Join us on our journey as we work with Jim, the instrument team, NASA, and the many organizations involved, to tell the story of how this all comes together and delivers the payoff: beautiful science-rich images from the surface of the Red Planet. Zoom, zoom, zoom.

Go online to learn more at **planet.ly/mastcamz** and in the Planetary Radio episode about Mastcam-Z at **planet.ly/prmastcamz**.

WHAT'S UP? *by Bruce Betts*

IN THE SKY

The predawn East is rich with planets: super bright Venus, bright Jupiter, and dimmer, reddish Mars. Saturn joins the predawn East in December and grows closer to Venus until they are at their closest on January 9. The Geminid meteor shower, often the best meteor shower of the year, peaks December 13-14. The Moon will not interfere with shower viewing after setting in the early evening. One hundred meteors per hour may be seen from a dark site.

RANDOM SPACE FACT

The distance to our closest star system, Alpha Centauri, is about 270,000 times the distance from Earth to the Sun.

TRIVIA CONTEST

Our March Equinox contest winner is Thomas McGill of Bradenton, Florida. Congratulations! **THE QUESTION WAS:** What type of propulsion does the *Dawn* spacecraft use?? **THE ANSWER:** Ion propulsion, also called (solar) electric propulsion, or ion drive.

Try to win a free year's Planetary Society membership and a Planetary Radio T-shirt by answering this question:

What is the ninth-largest object (diameter) in our solar system?

E-mail 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 e-mail 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 January 1, 2016. The winner will be chosen by 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*.

Join Us on an Eclipse Adventure!

Wonderful eclipse viewing opportunities await you in 2016 and 2017, so take your pick! Hundreds of Society members have enjoyed our exciting—and information-packed—travel adventures, and we invite you to join them!

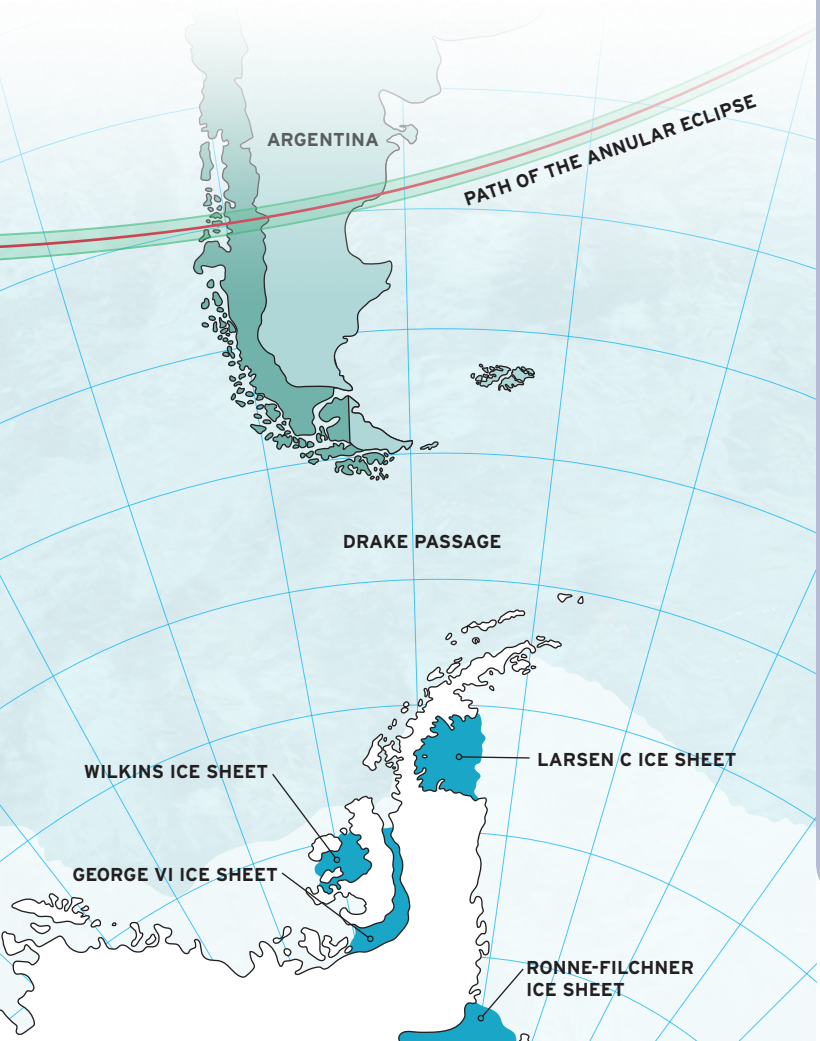
BALI & SULAWESI (INDONESIA) TOTAL SOLAR ECLIPSE
FEBRUARY 25 - MARCH 10, 2016

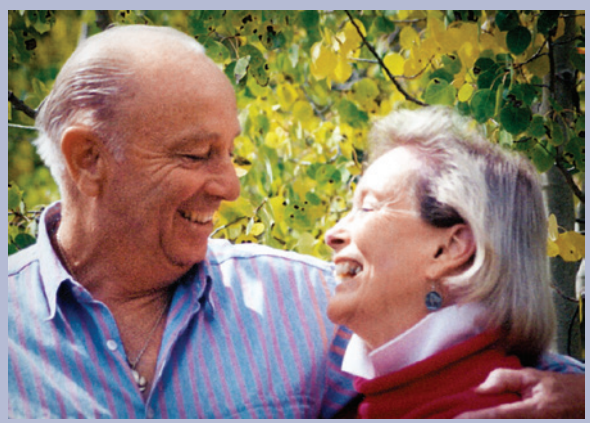
TANZANIA ANNULAR ECLIPSE
AUGUST 23 - SEPTEMBER 3, 2016

MADAGASCAR ANNULAR ECLIPSE
AUGUST 20 - SEPTEMBER 4, 2016

ANTARCTICA ANNULAR ECLIPSE
FEBRUARY 23 - MARCH 9, 2017

For reservations or information, contact our travel partner, Betchart Expeditions Inc.: (800) 252-4910 or *info@betchartexpeditions.com*





Remembering Bud Vance

FOR ALL BUT FOUR of The Planetary Society's 35 years, Donald Edward Vance (always "Bud" to us) was our printer. As a representative first of Welch Graphics and then, for 29 years, The Dot Printer, it was Bud's job to oversee the print production of *The Planetary Report*.

While we will always be grateful for his professionalism and dependability—his attention to detail and unwavering commitment to getting our job done right—it is simply Bud himself that we will miss the most: his droll sense of humor and his solidness.

It was obvious how devoted he was to his work, driving many miles from home to be at the plant for every *Planetary Report* press check with art director Loren Roberts. But it was his love for his family that truly characterized Bud. This last spring, as we worked on what I didn't realize would be our final issue together, he told me with great pride that he and his wife Marge had just celebrated their 64th wedding anniversary.

On June 20, 2015 Bud left Earth for the big print shop (with tennis court!) in the sky. Thanks for everything, Bud. We miss you.

–Donna Stevens

Photos courtesy of the Vance family

HAPPENING ON
PLANETARY RADIO
planetary.org/radio

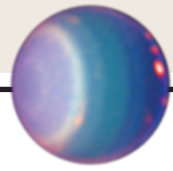
FROM MARS TO THE STARS
The founding Executive Director of the Planetary Society has just written *Human Spaceflight: From Mars to the Stars*, an optimistic view of humanity's future in the solar system and beyond. **planet.ly/marstothestars**

A CONVERSATION WITH ANDY WEIR
The Martian has won universal acclaim from scientists, astronauts, NASA, science fiction fans, and people who thought they weren't science fiction fans. Mat Kaplan talks with the author about his harrowing, uplifting, amazingly detailed, and realistic tale. **planet.ly/andyweir**

PLUTO AMAZES
Project Scientist Hal Weaver's *New Horizons* spacecraft has shocked his fellow researchers with magnificent images and data. He shares his excitement with Mat. **planet.ly/amazingpluto**

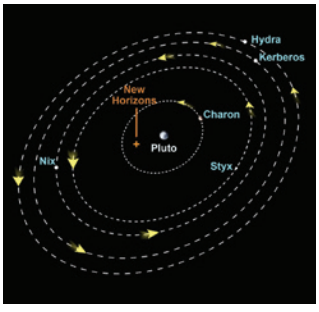
IMAGING HOT YOUNG JUPITERS
Franck Marchis is on the team that has delivered an actual image of a young, hot world about 100 light-years from Earth. We talk with him on the 20th anniversary of the first exoplanet discovery. **planet.ly/youngjupiters**

A MISSION TO THE ICE GIANTS
They are the most neglected planets in our solar system, but that status may be changing. Planetary scientist Elizabeth "Zibi" Turtle celebrates NASA's announcement that it will study a mission to Uranus or Neptune. **planet.ly/icegiants**



Find these shows and our entire archive of *Planetary Radio* at planetary.org/radio!

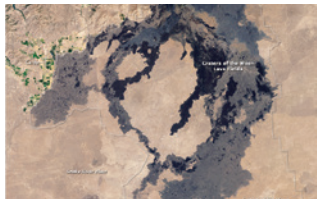
ON *PLANETARY.ORG*



SCIENCE SURPRISES
PLUTO'S MOONS SPIN Emily Lakdawalla shares some surprising data on the rotation of Pluto's moons at this year's Division of Planetary Sciences Conference.
planet.ly/moonsofpluto

STATION ANNIVERSARY
ASTRONAUT UTILIZATION Jason Davis shows us who has been living and working at the International Space Station over the years.
planet.ly/ISS15

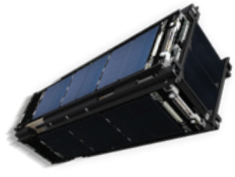
MARS AND EARTH
DUST DEVIL RESEARCH Ralph Lorenz studies dust devils on Earth and Mars, and hypothesizes similarities and differences.
planet.ly/dustdevils



PLANETARY ANALOGUES
MARS ON EARTH Deepak Dhingra reports on a field trip to the Idaho desert to prepare for human trips to the Moon and Mars.
planet.ly/beyondmars

AFFORDABLE MISSIONS
EUROPA Van Kane looks at JPL's newest plans for getting to Europa.
planet.ly/joviansystem

TELEROBOTICS
UNIFYING HUMANS AND ROBOTS Deploying robots with human operators close by could solve problems with planetary robotics.
planet.ly/humansandrobots



LIGHTSAIL NEWS
A BACKUP BURN WIRE is installed on a separate circuit that will activate right after the first, providing redundancy.
planet.ly/burnwire

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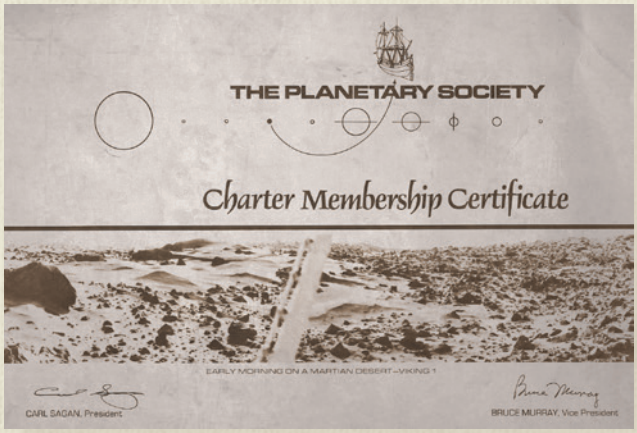

An original "Charter Membership Certificate" from our archives, with Carl Sagan's and Bruce Murray's signatures underneath a then-new *Viking 1* image of Mars.

The Society Salutes Its Charter Members

One of the first things I learned when I joined the staff about a year ago was the esteemed position held by our Charter Members: those who joined the Society in its first years, 1980–81, and are still members today.

Over and over again these Charter Members tell stories about how they heard Carl Sagan speak about the Society on a television talk show or how they read an article in which Carl mentioned the Society, and they decided to just send in their membership gift. They didn't wait for an invitation; they took the initiative to connect with us and become our partners.

Now, in the Internet Age, we might call such members "early adopters." I have a better, more old-fashioned word: visionary. Like our three founders—Carl Sagan, Bruce Murray, and Louis Friedman—these members believed so strongly in the Society's mission to promote space exploration that they took a risk and helped create a private, nonprofit organization that today—with more than 50,000 members—has few peers. Like Bill Nye, our CEO and a Charter Member himself, these pioneers were ready "to change the world"!

But they were more than risk-takers. They have remained doggedly consistent and stayed the course for over three decades. And many Charter Members seem to have sensed they were embarking on a journey that was both enduring and special, because they kept their original membership certificate, carefully safeguarding it among their possessions.

So, upon our celebration of our 35th anniversary, it is with great pride that we salute our Charter Members. We thank them for their remarkable vision, deep commitment, and steadfast support of our mission to empower the world's citizens to advance space science and exploration.

Regards,

Richard

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Image: NASA, ESA, the Hubble Heritage Team (STScI/AURA), A. Nota (ESA/STScI), and the Westerlund 2 Science Team