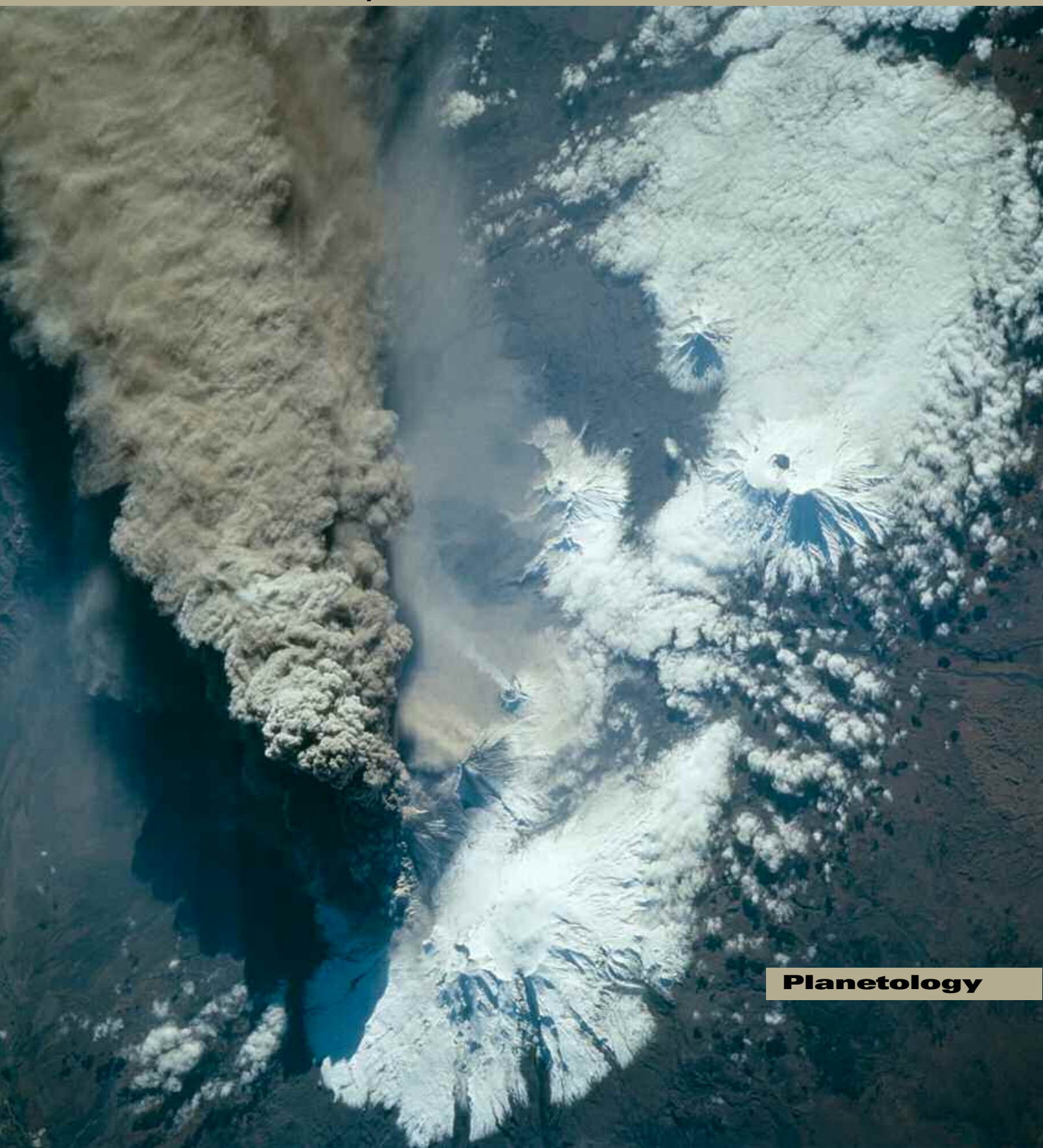
The PLANETARY REPORT

Volume XXIX Number 5 September/October 2009



Planetology

From The Editor

I can never predict at what moments I'll miss Carl Sagan. It might be when I hear a new result from the exploration of Titan, a world whose organic chemistry was one of Carl's research specialties. Or maybe when I try to end a dispute with another Planetary Society staffer by asking, "What would Carl say?" He was my boss for 16 years, and I relied on him for insight, support, and inspiration. No one can replace him.

Carl would have celebrated his 75th birthday this November 9, and with that date looming, I—along with all the staff at The Planetary Society—have been thinking a lot about how to remember him.

Traditional memorials are static things, whether stones planted in the ground or elegies that fade away to silence. How much better it would be to create something that grows, builds, and plants the seeds for the future that Carl helped us imagine. This is what we are trying to do with the Carl Sagan Fund for the Future.

You'll read about the fund in this issue of *The Planetary Report*; you'll soon be receiving a letter detailing how it will work. As you read, I hope you'll consider how you can help us create a living and growing memorial to Carl, one that will seed the exploration of the solar system that was, after all, the reason he helped found our Society all those years ago.

So now, when I miss Carl, I feel like we're pushing open a door to let in the future he envisioned. There is no better way to honor him.
—*Charlene M. Anderson*

On the Cover:

Space shuttle astronauts took this optical photo of Russia's Kliuchevskoi volcano in the early hours of its eruption on September 30, 1994. The ash plume, which reached a height of more than 18 kilometers (about 11 miles), is emerging from a vent on the north flank of Kliuchevshoi, which is partially hidden in this view by the plume and its shadow. The small, whitish steam plume near the photo's center is emanating from the dome of a companion volcano, Bezymianny. This is part of a sequence of photos that first allowed scientists to image through ash and cloud. To see a radar version of this photo, go to *jpl.nasa.gov/radar/sircxsar/kliucomp.html.*

Image: NASA

Background:

On September 6, 2009, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on NASA's Terra satellite captured this simulated natural-color image of the Station fire, burning in the San Gabriel Mountains north of Los Angeles. Smoke from the actively burning area is visible on the right side of the image. The large purple-gray area dominating the picture shows the destruction of forest and chaparral in what would grow to become the largest fire in the history of Los Angeles County.

Image: NASA/GSFC/METI/ERSDAC/JAROS and United States/Japan ASTER Science Team

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A PUBLICATION OF THE PLANETARY SOCIETY

We Make It Happen!

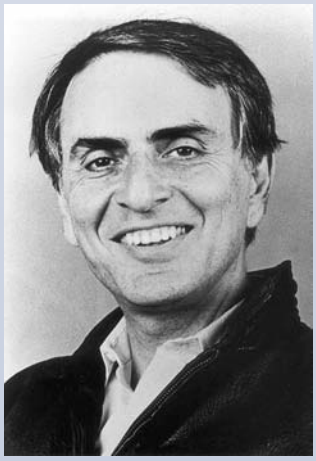
Project Roundup

by Bruce Betts

Above: This aerial photo of the Bajada del Diablo crater field in Argentina shows many circular impact craters. Maximiliano Rocca used images like this to identify the area as a crater field. Photo: Instituto Geografico Militar

We always have a lot going on at The Planetary Society, so for this project report, I decided I'd bring you up to speed on a few recent developments.

Announcing the Carl Sagan Fund for the Future



Planetary Society cofounder Carl Sagan. Photo: The Planetary Society

The Planetary Society is proud to unveil the Carl Sagan Fund for the Future in connection with the 75th anniversary of Carl Sagan's birth, which will be on November 9, 2009. The Sagan Fund will provide seed money for excellent high-risk/high-reward ideas, critical in an era when NASA has been forced to kill some of its programs. The Sagan Fund honors the enduring inspiration of The Planetary Society's cofounder by helping to keep alive our shared dream of a spacefaring future.

The Sagan Fund will allow us to pursue innovative ideas to advance us farther, faster, and more creatively into space. New propulsion systems, more sensitive detectors, elegant experiments—we expect all this and more to result from our new fund.

Thanks to support from our Members, imaginative researchers with great ideas won't run into a brick wall; they'll move forward with the backing they need, at the moment they need it.

To help our staff and our Board of Directors guide the fund, we have engaged an esteemed New Ventures Committee made up of space experts from a variety of disciplines. With their assistance, we plan to seed fund new work in areas from propulsion to scientific mysteries, to better ways to gather Earth climate data, to new planetary exploration techniques. To find the best ideas, we will solicit proposals from researchers. The best of the proposed projects will be included in the fund based upon the quality of the proposals and funding available.

The Carl Sagan Fund for the Future builds upon our

This 350-meter-wide crater is one of more than 100 in the Bajada del Diablo crater field. The picture was taken during a scientific trip to Patagonia in 2007.
Photo: Daniel Acevezo

past abilities to move quickly and fund outstanding projects, such as SETI@Home, near-Earth object projects, research on the *Pioneer* anomaly, and flying the Mars Microphone. The Sagan Fund will use our strengths while providing greater flexibility and reach.

Sagan's work was one of the reasons I went into planetary science, and his legacy is of great interest to me both personally and because he was one of The Planetary Society's cofounders. Once we begin funding new projects from the Sagan Fund, I look forward to sharing their progress with you here in "We Make It Happen!" and on our website at *planetary.org*.

Near-Earth Objects: A Really, Really Big Crater Field

Congratulations are due to Maximiliano Rocca for his studies of impact craters on Earth. In particular, Max focuses on uncovering potential new impact structures using aerial and satellite photographs. Max recently co-authored a paper in the scientific journal *Geomorphology*

The Milky Way from Glacier Point in Yosemite National Park. Moonlight still illuminates Half Dome and the high Sierras beyond. While the colors of the Milky Way are visible only in long-exposure photographs, most of the detail is visible to the naked eye if you take the time to look.
Photo: Tyler Nordgren

What's **Up?**

In the Sky—October and November

In the early evening, Jupiter is the brightest star-like object in the sky, appearing high in the south in October and moving toward the lower west in November and December. It will appear near the Moon on October 26 and November 23. Before dawn, extremely bright Venus is low in the east. Saturn appears above it, gets higher as the weeks pass, and appears close to the crescent Moon on November 12. Reddish Mars is high in the predawn sky, brightening as the weeks pass. The Geminids meteor shower peaks on December 14. Traditionally the best of the year, the Geminids shower averages more than 60 meteors per hour from a dark site—and this year, it occurs around the time of the new Moon, when the skies are particularly dark.

Random Space Fact

Io has the highest surface gravity of the Galilean satellites; it's about 10 percent higher than the surface gravity on the Earth's Moon.

Trivia Contest

Our March/April contest winner is Denise R. Price of Renton, Washington. Congratulations!

The Question was: Since what date has the International Space Station been continuously staffed (had people on board constantly)? *The Answer is*: November 2, 2000.

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

Who was the first person to spend more than one day in space?

E-mail your answer to *planetaryreport@planetary.org* or mail your answer to *The Planetary Report*, 65 North Catalina Avenue, Pasadena, CA 91106. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one).

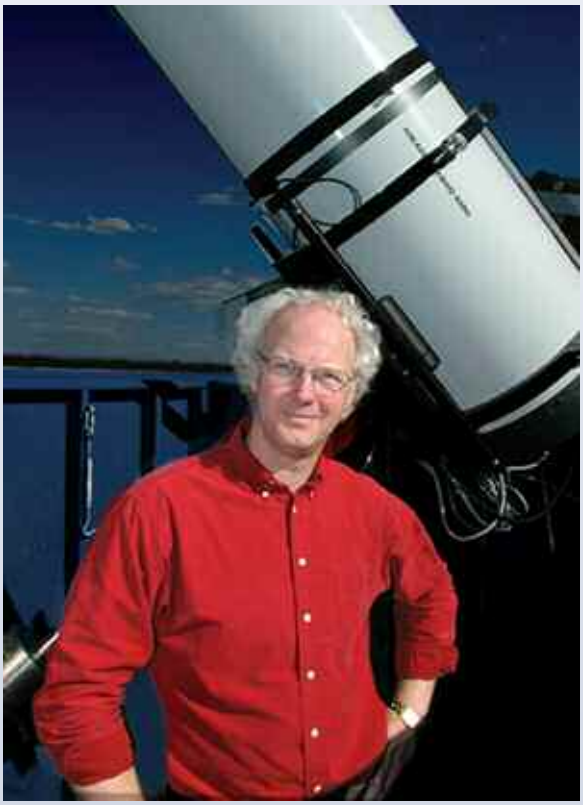
Submissions must be received by December 1, 2009. The winner will be chosen by a random drawing from among all the correct entries received.

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.*

(lead author R. D. Acevedo) identifying the largest impact crater field in the Southern Hemisphere—the Bajada del Diablo crater field in Argentina. Max's studies helped lead to his coauthors' investigation of the craters, including doing field geology in remote Patagonia. Amazingly, there are more than 100 craters from 100 meters to 500 meters in diameter. The craters in the field formed at the same time, either from the breakup of one object or from a swarm of objects entering the atmosphere together.

Near-Earth Objects: Award

Congratulations to two-time Planetary Society Shoemaker Near Earth Objects Grant recipient Robert E. Holmes, who received a 2009 Edgar Wilson Award for his discovery of comet C/2008 N1. The Wilson Award is given every year by the Central Bureau for Astronomical Telegrams (CBAT) for discoveries of comets by amateur astronomers. Holmes' Astronomical Research Institute has discovered various asteroids and has provided tens of thousands of accurate measurements of the orbits of potentially dangerous near-Earth objects. The institute also actively involves classrooms around the world in the hunt.



Robert Holmes of the Astronomical Research Institute in Illinois is The Planetary Society's first repeat Shoemaker NEO grant recipient, having won awards in 2007 and 2009. Robert recently received an Edgar Wilson Award for his discovery of comet C/2008 N1. *Photo courtesy Robert Holmes*

National Parks and Space

Astronomer and physics professor Tyler Nordgren has returned to teaching after a one-year journey across the American landscape partially funded by The Planetary Society. During this journey, Tyler visited twelve parks in twelve months, from the icy grandeur of Denali National Park in Alaska to the red rocks and steep-walled canyons of Bryce Canyon National Park in Utah. As he met with park experts and visitors, he examined the themes that link the parks to other landscapes in the solar system. Tyler's reports from each park and amazing images of the night sky with park landscapes in the foreground are on our website (check them out at *planetary.org/parks*).

Nordgren has recently posted an epilogue on our website about his follow-on visit to Yosemite and presentations. He is working with the National Park Service on utilizing the dark skies of the parks to inspire and educate visitors about space, and next spring he will have his book about his journey published.

More Cool Exoplanets

Lots of newly discovered exoplanets have been added to our Catalog of Exoplanets in the last few months. The current total is more than 360 planets discovered around other stars. Check them out, including our unique orbital simulation diagrams for each, online at *planetary.org/exoplanets*. We've also added more planets to our Notable Exoplanets page, which highlights some of the exoplanets that stand out from the crowd.

You can also find recent articles on our website about some exotic new discoveries, including a planet orbiting retrograde (opposite the direction of its parent star's rotation) and information on early science results from NASA's *Kepler* mission.

Phobos LIFE Ready for Launch

After three years of hard work, our Phobos LIFE (Living Interplanetary Flight Experiment) biomodule is ready for launch on board the Russian *Phobos-Grunt* space mission. LIFE will break new ground in testing the survivability of life traveling through deep space (see the July/August 2009 issue of *The Planetary Report*).

Our Phobos LIFE biomodule—about half the size of a hockey puck—has been integrated into the* Phobos-Grunt *spacecraft and is awaiting launch. *Photo: Bruce Betts, The Planetary Society*

Our titanium biomodule contains 10 well-studied organisms representing the three domains of life—eukaryotea, bacteria, and archaea. If any of these organisms survive the three-year trip to Phobos and back, that will provide evidence supporting the transpermia hypothesis—the possibility that life can travel from planet to planet inside rocks blasted off one planetary surface by impact.

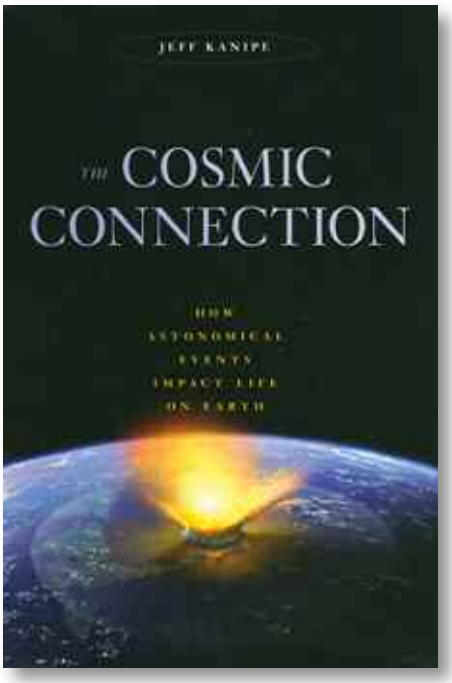
At the time of this writing, the *Phobos-Grunt* launch was still on schedule for mid-October 2009 from Kazakhstan. Final reviews of the spacecraft remain to be done, so the possibility exists that the launch will be delayed two years, to the next Mars/Phobos launch opportunity in 2011. Stay tuned to *planetary.org* and to this column for updates on the status of the mission and The Planetary Society's Phobos LIFE project.

Bruce Betts is director of projects for The Planetary Society.

OUT OF THIS WORLD BOOKS

The Cosmic Connection: How Astronomical Events Impact Life on Earth

by Jeff Kanipe
Prometheus Books, 263 pp.
$27.95, hardcover



Although astronomical events are not something most people think about, life on Earth has been profoundly affected by them and will continue to be. This is the theme of *The Cosmic Connection: How Astronomical Events Impact Life on Earth*. The author takes readers on a fascinating journey through a variety of cosmic phenomena that either have affected life on Earth or could do so in the future.

The author often leads into an astronomical topic with an example of something on Earth—for example, the expansion and recession of a French glacier, as historically documented and captured in paintings, leading to discussion of possible solar flux and climate changes. From this "Little Ice Age" to a meteorite hitting a car, he gives real-world examples of things affected by astronomical phenomena.

The wide range of topics includes climate variability, solar flux variations, solar storms, asteroid impacts, and supernovae. All have had profound impacts on life on Earth, strongly affecting the course of evolution leading to humans, and all have potential impacts, so to speak, on our future.

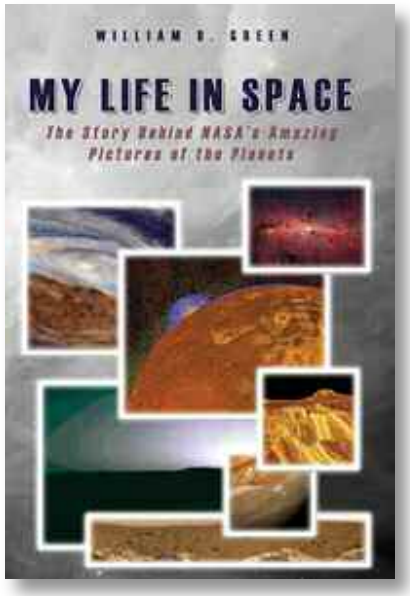
The book contains a section of images to support its discussions. It also contains a thorough set of footnoted references.

Another related theme in the book is how a fortuitous set of "coincidences" led to life on Earth even being possible. These range from the well-known example of the position of Earth in the habitable zone of our solar system (not too hot, not too cold) to lesser-known facts, such as the relatively calm place we currently occupy in our galaxy and in space in general. As author Jeff Kanipe says in the book, "Hey, it's amazing we're here."

He also discusses the future. At some point, bad things may happen. Some, such as an asteroid impact, could happen soon. Others, such as galactic "collisions," are billions of years off. This book does a nice job of giving an appreciation for how lucky we are to be here, as well as a note of caution for our future.
—Bruce Betts, Planetary Society Director of Projects

My Life in Space: The Story Behind NASA's Amazing Pictures of the Planets

by William B. Green
BookSurge Publishing, 248 pp.
$47.99, softcover



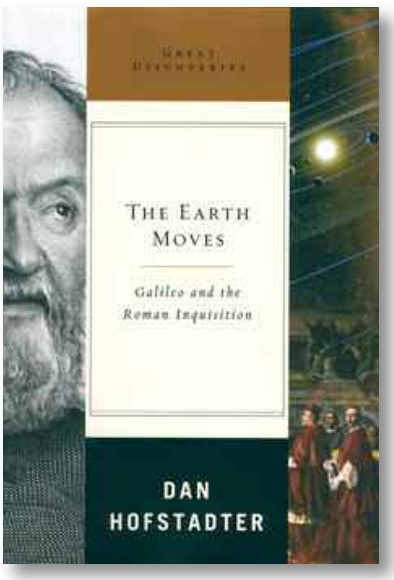
My Life in Space is the self-published memoir of a man who played a central role in the production of the awe-inspiring images from the Jet Propulsion Laboratory's robotic missions. William Green began his professional career in 1960, at the dawn of computing. He started work at JPL's Image Processing Laboratory in 1969, where he led the team responsible for processing images from *Mariner 9*. His career at JPL spanned three decades and saw the successes of the *Mariner 9* and *10*, *Viking*, *Voyager*, *Galileo*, and *Mars Pathfinder* missions. Since then, he's gone on to consult on Spitzer Space Telescope, *Phoenix*, *Kepler*, WISE, and James Webb Space Telescope missions.

The book is an enthralling account of the hard work,

struggles, conflicts, and triumphs that happen behind the scenes of every space mission. It's also a chronicle of the development of imaging technology on interplanetary spacecraft, written in a conversational tone that is easy for the layperson to understand. As Green tells the stories of what it took to develop cameras and produce beautiful and scientifically valuable images, he also debunks some myths (such as those surrounding the infamous "blue sky" image from the first *Viking* lander), clearly explains some befuddling NASA-speak, and shines light on the internal organization of NASA missions and the tensions that exist among engineers, science teams, mission managers, press officers, and NASA higher-ups.

Green published *My Life in Space* himself through a company owned by Amazon.com; because of this, it was not professionally edited and so is a bit rough around the edges. In a way, though, that adds to the book's verisimilitude: it contains the war stories of a retired soldier whose campaigns have taken him to destinations across the solar system. Green's memoir captures nearly all of the history of interplanetary exploration and exposes the foundations on which current missions stand.
—Emily Stewart Lakdawalla, Planetary Society Science and Technology Coordinator

The Earth Moves: Galileo and the Roman Inquisition
by Dan Hofstadter
W. W. Norton, 240 pp.
$23.95, hardcover



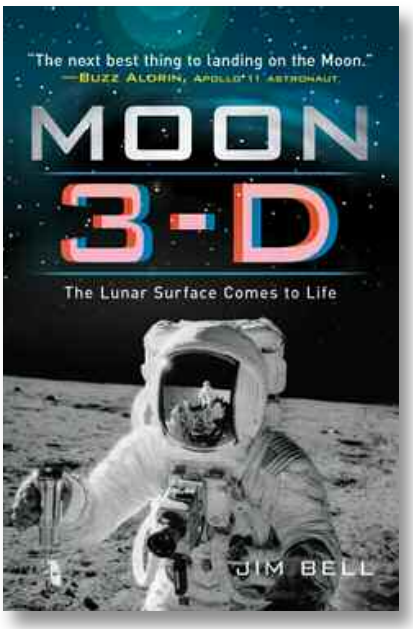
Almost exactly 400 years ago, in the fall of 1609, a professor at the University of Padua named Galileo Galilei built a telescope and pointed it toward the heavens. What he saw there changed humans' view of the world forever.

The story of Galileo has been told many times, but rarely with such clarity and verve as in Dan Hofstadter's *The Earth Moves*. Galileo, brilliant and stubborn but also insensitive to the feelings and motives of others, comes to life in Hofstadter's depiction. The same is true of Pope Urban VIII, torn between his love of art and learning and his commitment to the doctrinal authority of the Church; of Francesco Niccolini, consummate diplomat and the Grand Duke's legate to Rome; and of numerous others. When, in the book's final chapters, these colorful personages clash in Galileo's trial, readers witness not only an ideological contest between science and religion but also a gripping human drama.

Hofstadter does not limit himself to the traditional issues of the Galileo Affair but places it in the broader culture of the period. In some of the most original parts of the book, he relates the hypothesis of the moving Earth to swirling Baroque aesthetics championed by the pope's favorite, Bernini. Elsewhere he shows how the struggle between notions of a moving and stable Earth was played out in frescoes of the heavens that adorned the domes of many Baroque churches. The commitment to a stationary Earth, he argues convincingly, was not only doctrinal but also deeply cultural, rooted in the powerful imagery of Dante's cosmos.

The Earth Moves is a readable and entertaining account of Galileo's rise and fall, but it is much more than that. It probes deep into the different layers of the Galileo Affair—the doctrinal issues, the philosophical stakes, the personal dynamics, and the cultural context. Hofstadter weaves all these strands together seamlessly to produce a complex yet gripping narrative. I highly recommend it.
—Amir Alexander, Planetary Society Writer/Editor

Moon 3-D: The Lunar Surface Comes to Life
by Jim Bell
Sterling, 160 pp.
$19.95, hardcover (with red/green glasses)



Jim Bell follows his successful book about Mars in 3-D with this one about the Moon. Again, the device is innovative: the book is bound in such a way that the reader, poking his or her nose through a hole in the front cover and viewing a right-side page through red and green stereo filters, sees an image in depth.

At first, the effect is remarkable. Just as viewers used to be astonished by 3-D in a Victorian stereopticon, the initial experience here is exciting. After a while, you get used to it, and after

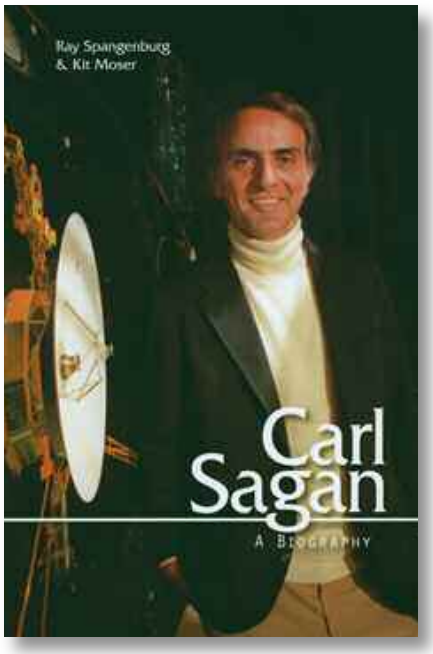
some more looking, you—like me—may have had enough. The pictures are the wonderful result of an elaborate process patiently executed by the author and publisher, leading to perhaps too much of a good thing.

Bell's text, on the other hand, is a treasure, as are the two-dimensional images displayed on left-side pages. It is hugely enjoyable to one who lived through *Apollo* and its robotic precursors and followers to see—through the eyes of someone who was just a kid during the heroic age—the great Moon Race, its sudden collapse, the wasted decades that followed, and, finally, today's modest recovery. Bell eloquently describes the magic of those audacious lunar missions and of the ancient Moon itself, giving readers a renewed and thrilling sense of what humans can do when driven to rise to greatness.

—James D. Burke, Planetary Report *Technical Editor*

Carl Sagan: A Biography

by Ray Spangenburg and Kit Moser
Prometheus, 167 pp.
$16.95, softcover



This biography is an excellent introduction to Carl Sagan and his scientific interests. It is also very readable, and it somehow manages to fit within its 167 pages a wide-ranging look at Sagan's career, the colleagues who influenced him, and the scientific topics that he pursued. It also captures, albeit briefly, some of the controversies that dogged him and, at the same time, made him so interesting and so influential with the public.

Sagan's attitudes about way-out ideas often confused people and sometimes caused him to be misunderstood. For instance, he advanced the search for extraterrestrial life while he also debunked the search for ancient astronauts and purported evidence of UFOs. Spangenburg and Moser deal well with Sagan's rigor and scientific discipline, which demanded extraordinary evidence for extraordinary claims. They take readers on a tour through Sagan's entire life, from his boyhood in Brooklyn and New Jersey, through his broad and multifaceted academic training, to the joyous discoveries about the other worlds in our solar system made possible by space exploration, and then to his leadership in astrobiology, a whole new field of science whose discoveries may someday turn out to rival those of Copernicus or Einstein. The biographers also introduce readers to Sagan's personal life and some of the many people he touched so deeply. The founding of The Planetary Society is covered in a section titled "Promoting Planetary Science and SETI."

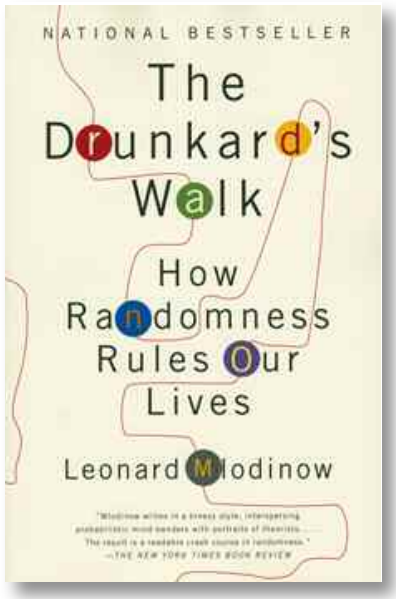
Although this is a good book for readers of all ages, I'd especially recommend it to young people—say, those born after the *Cosmos* TV series was shown on PBS. There is now a generation growing up who were born after Sagan died. Sadly, many of them have been in school during a time of widespread denigration of science, at least in the United States. Sagan provided a powerful antidote to anti-intellectual, anti-science attitudes. One wonders if his untimely death (and the similarly untimely death of Stephen Jay Gould in 2002) wasn't in some way a part of the shift away from science.

The oldest in this generation are just becoming teenagers, about to put their mark and their attitudes into the mainstream of human life. Republishing this very readable biography is very timely, and I hope it introduces Sagan to a whole new generation.

—Louis D. Friedman, Planetary Society Executive Director

The Drunkard's Walk: How Randomness Rules Our Lives

by Leonard Mlodinow
Vintage Reprint edition, 272 pp.
$15.00, softcover



Mlodinow takes a difficult and counterintuitive subject—randomness and statistics—and explains quite a bit about it in a very entertaining and informative book. By using examples "ripped from today's headlines"—such as assigning individual blame or credit to company executives, the making and losing of fortunes, the statistics of sports stars, and the making of a successful career in Hollywood—he shows how randomness rules our lives in ways we may not suspect.

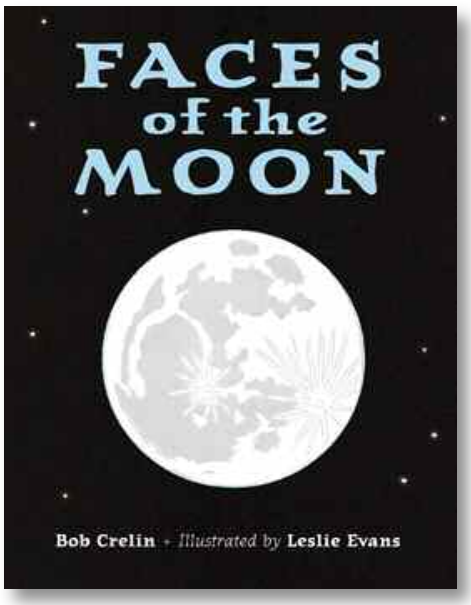
He also provides the reader with lots of party icebreakers, with questions that sound like they have obvious answers but turn out to be much trickier. For

example, if a woman has two children, one of whom is a girl, what is the probability that the second one is a girl? Hint: it is not 50 percent.

The value of this book is more than good party conversation—the description of Mlodinow's having received a misdiagnosis of HIV is not to be missed by anyone who wants to know how data can be misused, even by professionals. The doctor involved simply didn't understand statistics. What happened to those who were similarly misdiagnosed but were not Caltech professors of mathematics?

Although this book is not about space science, it is about science, and its relevance to all of us makes it worth reading.
—LDF

Faces of the Moon
(ages 4–8) by Bob Crelin and Leslie Evans
Charlesbridge Publishing, 36 pp.
$16.95, hardcover



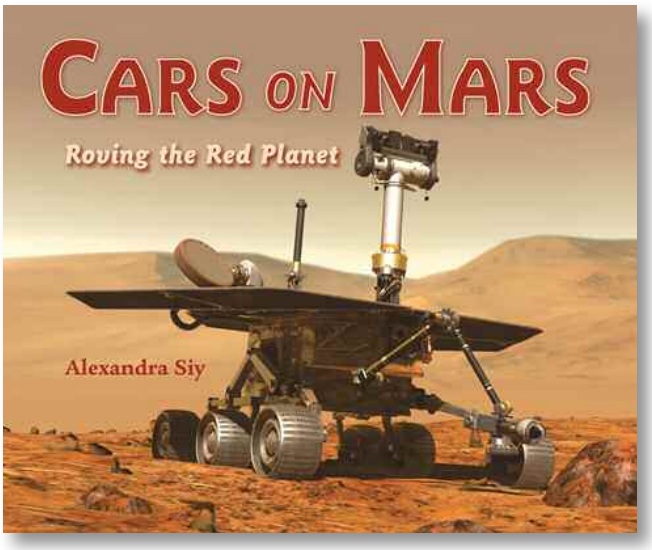
Among my daughter Anahita's earliest words was "Moon." She'd point it out in the sky whenever she saw it, which wasn't usually at night; it was usually in the morning or evening when we were out and about. But sometime during the last year, popular culture (or toddler culture, anyway) has "taught" her that the Moon is out only at night. Failing to find a book appropriate for preschoolers that discussed the Moon's phases and the fact that it can be seen in the daytime too, I even considered writing one myself. Now I don't have to, because Bob Crelin has done it, and done it admirably, in *Faces of the Moon*.

The book is written in verse and has beautiful, bold, block-printed illustrations by Leslie Evans that will appeal to young children, but the concepts it teaches work well for older children (and even adults). As the verse defines "new," "crescent," "quarter," "gibbous," "wax," and "wane," cutouts in the pages cleverly show only as much of the Moon as is visible during each phase; along with tabbed page edges, the book's design helps to hold the attention of younger kids.

The quality of the verse is way above the average for educational kids' books. For example: "A few days pass, and Moon's less shy;/ her smile lights the twilight sky./ The more her sunlit surface shows,/ the more Moon's WAXING CRESCENT grows."

A final two-page spread provides more detailed information for older children, parents, or teachers; a teachers' guide is available from the author's website. I'm sure there are plenty of adults who will learn a thing or two about lunar phases from this book!
—ESL

Cars on Mars: Roving the Red Planet
(ages 8 and up) by Alexandra Siy
Charlesbridge Publishing, 64 pp.
$18.95, hardcover



Cars on Mars is a detailed travelogue for kids of all ages of the amazing journey of the Mars Exploration Rovers. It covers *Spirit*'s and *Opportunity*'s voyages, from their launches in June 2003 up to late 2008, toward the end of their third Martian winter, as *Spirit* was parked on the north edge of Home Plate and *Opportunity* had departed Victoria crater to embark on the long journey to Endeavour. Along the way, Siy's energetic narrative captures the excitement and challenges of the twin rovers' different journeys at the same time that it explains the capabilities of the rovers and their instruments. (It helps that Siy quotes Rover Principal Investigator Steve Squyres extensively, calling him "Steve" throughout.)

The book is absolutely crammed with pictures, most of them full-color Pancam shots of the Martian landscape, including many panoramas. Each picture is accompanied by a detailed caption. Although the publisher identifies the age range of the target audience as ages 8 and up, I'd emphasize the "and up" part. There is plenty of detail here to delight both kids and adults, even adults who have been following the missions closely.
—ESL

Planetology: Viewing Earth in Context

by Tom Jones and Ellen Stofan

Coastal Brazil, the Atlantic Ocean, West Africa, and Antarctica are visible in this Apollo 4 *image taken on November 9, 1967.*
Image: NASA

July marked the 40th anniversary of the first visit by human explorers to another world, the Moon. One of the unexpected but long-remembered results of the *Apollo* program for humanity was the startlingly beautiful first sight of Earthrise above the lunar horizon. We saw Earth for the first time as a unique oasis in space, home to our curiosity-laden species and the only known harbor of life anywhere in the solar system. By breaking the bonds of Earth, we changed our view of ourselves from a local or regional perspective to a global one. That serene image of Earth, first seen from *Apollo 8*, helped us understand in a visceral way that ours is just one of many planets in our solar system, one of many planetary systems in our galaxy, and one of many galaxies in the universe. That discovery humbles us still.

Following on *Apollo*'s success, our robot explorers have reconnoitered the faces of all but one of the Sun's family of planets ("minor planet" Pluto gets its turn in 2015). We've also had a good look at dozens of satellites, many of them varied and interesting worlds in their own right. Expeditions to neighboring planets have delivered astounding scientific insights and, equally profoundly, a new appreciation of our home world.

A doctor with only a single patient might become quite familiar with that individual's condition, but without examining others, she would learn little about the normal state of health or about the nature, variety, and progression of human diseases. Similarly, planetary scientists need a suite of worlds to examine if they are to develop a general understanding of how a planet works. Planetologists currently are blessed, for example, with opportunities to compare crustal faults on the icy moons of Saturn with rifts on Mars and tectonic faults on Earth. We compare volcanic eruptions on Jupiter's moon Io with ongoing lava activity on Hawaii's Kilauea. We are even able to compare the way prevailing winds build sand dunes on four different planets and moons. These field observations in planetology constantly refine and deepen our understanding of how our own world ticks.

We often hear investigators say "I study Mars" or "I study icy satellites," but planetary science really is a discipline that rests on comparisons. A planet is a complex system: its interior state affects the geology visible on the surface and the evolution of its atmosphere. Cosmic forces also matter: bombardment by small bodies, as recorded on the heavily cratered surfaces of the Moon and Mercury, for example, informs our knowledge of Earth's early history. To truly understand how any planet works, especially one as complex as Earth, we go out to neighboring worlds to study the processes, such as volcanism and tectonics, that shape all of their surfaces. Understanding how all these processes work over time to shape Earth and its solar system neighbors is the underlying premise behind comparative planetology.

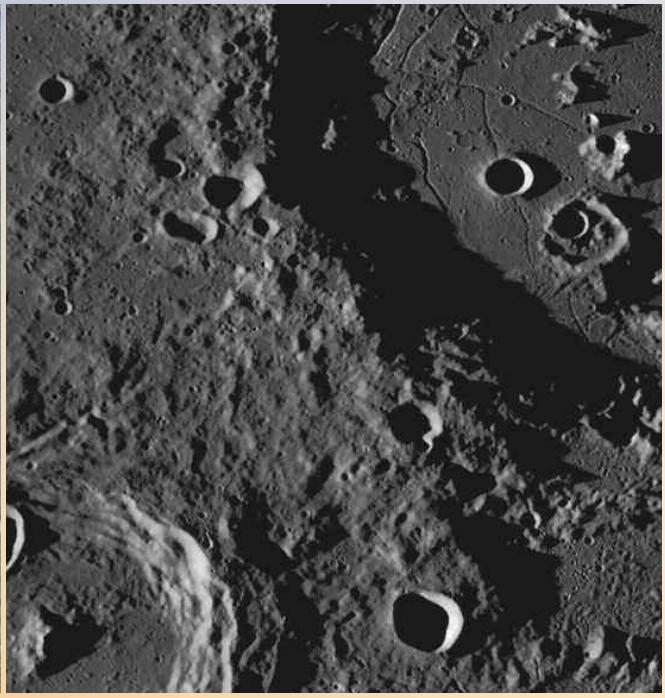
Small Bodies and Catastrophes

When the two of us studied Earth from space using NASA's Space Radar Laboratory (an advanced imag-

Right: Sand dunes are visible on many bodies of the solar system. This composite view of the Bodele sand dunes in Chad, taken by NASA's Terra satellite, allows scientists to monitor how dunes advance and retreat as Earth's climate changes.
Image: NASA/GSFC/METI/ERSDAC/JAROS and the United States/Japan ASTER Science Team

Above: Cosmic bombardment is an ongoing process in our planetary neighborhood. Although some terrestrial impact craters are billions of years old, Arizona's Meteor crater (created by the impact of a nickel-iron asteroid 30 to 50 meters in diameter) is a relatively young 50,000 years of age. Tom Jones and fellow STS-59 crew members took this picture of Meteor crater from a NASA training jet in 1993.
Photo: NASA

This terrain, southwest of Mars' Schiaparelli crater, is surrounded by a field of traverse aeolian ridges (TARs) and star ripple dunes. TARs are linear ripples that can vary in shape. The High Resolution Imaging Science Experiment (HiRISE) on Mars Reconnaissance Orbiter (MRO) *captured this image on May 6, 2008.*
Image: NASA/JPL/University of Arizona



On July 8, 2009, Lunar Reconnaissance Orbiter (LRO) *imaged a portion of the impact crater Gauss (upper right). The large crater is 170 kilometers (106 miles) in diameter, and its floor appears to have been flooded with lava that solidified and later fractured.* LRO *will search the floors of shadowed polar craters for evidence of water ice deposits, a key to future exploration of the Moon.*
Image: NASA/GSFC/Arizona State University

ing radar flown twice on the space shuttle in 1994), one set of geologic targets was terrestrial impact structures. Some of these craters, evidence of cosmic bombardment, such as the Vredefort structure in South Africa, were billions of years old, whereas others, such as the famous Meteor crater in northern Arizona, were formed less than 50,000 years ago. These impact scars link Earth's geologic history to the battered surfaces of neighboring worlds, and they also remind us that cosmic bombardment continues today.

For 4.5 billion years, planets and moons have swept up the small bodies and shards of debris left over from their formation in the solar nebula. Today, our world circles the Sun in a cosmic shooting gallery, the target of near-Earth objects (NEOs) that approach or cross Earth's orbit. Comprising mainly asteroids and a few comets, the NEO population continues to strike Earth. Major impacts from comets or asteroids not only have pocked the face of Earth and Moon but also, through their catastrophic effects, have fundamentally altered the course of life on this planet.

Impacts on the Moon's battered surface may furnish an opportunity for future explorers. Craters at the lunar poles, largely shadowed from direct sunlight, may harbor ice—water vapor delivered by aeons of cometary impacts, then trapped in regolith on crater floors chilled to about 100 degrees Kelvin (–175 degrees Celsius, –280 degrees Fahrenheit). If *Lunar Reconnaissance Orbiter* (launched June 18, 2009) can confirm the presence of this ice, it will become an obvious target for robotic prospectors and a major argument for further lunar exploration by astronauts.

Layered deposits in a cliff near Mars' Capri Mensa give us a glimpse of the rich geologic history accessible to us on the Red Planet. Each layer of beds like these tells its own story of wind, weathering, the flow of water, or volcanism. HiRISE snapped this picture on November 11, 2006.
Image: NASA/JPL/University of Arizona

Far left: **Rupes** *are cliffs or ridges that cut across the surface of Mercury. Scientists believe they formed when the planet contracted slightly as its interior cooled. This* **MESSENGER** *image, acquired on January 14, 2008, is bisected vertically by Beagle rupes, which cuts through the middle of Sveinsdóttir crater.*
Image: NASA/JHUAPL/Carnegie Institution of Washington

Left: On Earth, faults such as California's famous San Andreas are generated when two blocks of our planet's crust slip in relation to each other. Although no evidence of active plate tectonics has been detected on any planetary body other than our own, volcanoes and faults are common on Venus and Mars.
Photo: USGS

Small asteroid impacts such as that of 2008 TC3 over Africa and the recent detection of another planetary impact remind us that cosmic bombardment is an ongoing process. On July 19, 2009, while Australian amateur astronomer Anthony Wesley observed Jupiter, he noticed a dark blemish near the gas giant's south pole. The tantalizing images he sent other observers resembled the impact scars left on Jupiter by 1994's Shoemaker-Levy 9 comet impact. Other observers soon confirmed the impact using NASA's Infrared Telescope Facility, the Keck and Gemini telescopes on Mauna Kea, and the newly refurbished Hubble Space Telescope. The responsible comet or asteroid likely was no more than a kilometer or so across, but the dark smear of aerosols left behind by the impact fireball soon widened to nearly the diameter of Earth, some 12,700 kilometers (7,900 miles).

Research into the 1908 Tunguska impact in Siberia suggests that objects as small as 30–40 meters across can strike Earth's surface and threaten populations through either blast or tsunami effects. We have the necessary detection capability to find most NEOs capable of hitting us, as well as the spaceflight technology enabling us to nudge a future impactor from a collision course. What we lack is an international strategy for deciding when to actually take action against a threatening NEO.

The Association of Space Explorers (ASE) last year delivered to the United Nations a draft framework for NEO decision making. Years of negotiations lie ahead,

By studying features—such as volcanoes—that formed on worlds different from our own, scientists acquire understanding of processes such as the flow of lava during an eruption or of the effects that internal geologic forces have on a body's crust. Perhaps this kind of information can one day help us better predict events such as earthquakes and volcanic eruptions here on Earth. Water vapor and gases are currently erupting from Alaska's Mount Redoubt volcano. This photo was taken on July 2, 2009. Photo: Cyrus Read, Alaska Volcano Observatory/USGS

but developing an international set of "mission rules" for reacting to a possible NEO impact is vital to the long-term survival of our species. Our studies of other planets tell us that this hazard is real. To paraphrase Carl Sagan, we will either learn to move small celestial bodies around or eventually go the way of the dinosaurs.

Forces from Within

On Space Radar Lab, we watched in fascinated awe as the tallest volcano in Asia, Russia's Kliuchevskoi, blew its top in a week-long eruption that our space-borne instruments examined minutely. In 2009, a new eruption of Mt. Redoubt in Alaska diverted airliners from their usual routes to avoid the ash-filled volcanic plume, and a major earthquake in Italy killed more than 250 people and damaged more than 10,000 buildings. On our active Earth, geologic events like these are driven by forces acting from deep within the planet. Humans can't control such events, but we hope someday to make them more predictable.

Earth's surface is broken into numerous, thin crustal plates that are constantly in motion. As the plates interact, along faults like the San Andreas (marking the boundary between the North American and Pacific plates), they generate geologic events such as earthquakes or create chains of volcanoes, such as the Pacific Ocean's "ring of fire." Although we have not found active plate tectonics on any other planet in the solar system, volcanoes and faults are common on Venus and Mars. Studying such features, formed under different conditions from those prevailing on Earth, can help refine our models of how far lava can flow in an eruption, or of how a planet's crust fractures as geologic forces extend or compress its surface.

For example, recent data from the *MESSENGER* spacecraft have shown us that even on a one-plate planet such as Mercury, volcanic flows cover large areas of the crust, and horizontal movement has buckled it into large faults. Steep cliffs, called *rupes*, more than 250 kilometers (150 miles) long cut across Mercury's surface, the result of crustal cooling and contraction very early in the planet's history. *MESSENGER*'s detailed images of these scarps will help us better understand the timing and extent of this important phase in the innermost planet's geologic record.

The *Cassini* spacecraft, orbiting Saturn in the frigid outer reaches of the solar system, has returned images of the moon Enceladus, showing elaborate patterns of fractures on its icy surface. Some of these fractures may be spreading centers, where the crust of Enceladus has split apart and

On February 22, 2000, Galileo *captured this image of an active volcanic eruption on Jupiter's moon Io. The bright areas at left show newly erupted hot lava. Dark, diffuse deposits surrounding the active lava flows were not there during* Galileo*'s November 1999 Io flyby.* Image: NASA/JPL

formed new crust. The new ice may originate far below Enceladus' crust in a subsurface liquid water ocean thought to also feed the geysers of ice crystals and water vapor escaping through the fractures.

Leaving Enceladus' frigid geysers to study Venus' hellish surface, we find Earth's near-twin (in size) to be the place to go to study volcanoes, with thousands of examples ranging in size from less than a mile to more than 550 kilometers (350 miles) across. The extreme surface heat and the resulting dearth of water in crustal rocks are thought to prevent subduction from occurring on Venus today (though we think an earlier, wetter era may have enabled plate tectonics). On today's Venus, therefore, we see (through radar eyes) volcanoes scattered across the surface rather than strung along plate boundaries. Some Venusian volcanoes should still be active, although spacecraft have not been able to detect an eruption directly. The European Space Agency's (ESA) *Venus Express* spacecraft, currently in orbit around Venus, is searching the atmosphere for chemical traces of an eruption, and the Japanese *Venus Climate Orbiter* should assist in that monitoring role after it launches in 2010.

With more than 400 active volcanoes, Jupiter's moon Io is the most volcanically active body in the solar system. Heat in the interior of the terrestrial planets is supplied primarily by the decay of the radioactive elements potassium, thorium, and uranium. Io's inner fires, by contrast, stem from tidal stretching and friction caused by Jupiter's massive gravitational pull.

Weather, Wind, and Water

Comparative planetology plays an important role in providing an understanding of Earth's changing climate. Venus, with its extreme runaway greenhouse effect, illustrates the importance of carbon dioxide in planetary atmospheres. The ancient surface of cold, desiccated Mars is cut by valley networks and now-dry flood channels, evidence of a warmer, wetter past. Recent discoveries that glaciers were once present (or lie buried still) at low latitudes on Mars also suggest a dramatic climate change. The atmospheric conditions and compositions prevalent on Venus and Mars differ from those of today's Earth, but these two worlds exhibit many similar geologic and atmospheric processes that undoubtedly influence climatic evolution. We have much to learn from such planetary "experiments."

Saturn's largest moon, Titan, seems like one of the less likely places to find an Earth-like hydrologic cycle. Here on Earth, water evaporates from lakes and oceans, cools and condenses in the atmosphere, falls as rain or snow, and then evaporates again in a continuous cycle. *Cassini*'s examination of Titan has given us evidence of a surprisingly similar cycle occurring there: liquid rains down onto the surface to fill lakes and rivers, then evaporates again into the atmosphere. At surface temperatures below 100 degrees Kelvin,

The sheer tenacity of life on Earth, which exists in the most unforgiving conditions, provides tantalizing incentives to search our neighboring worlds for evidence of living things. Yellowstone National Park's Grand Prismatic Spring is surrounded by huge orange mats of heat-loving bacteria and algae. Although the blue water at the center of the spring is extremely hot, it may support chemotrophs—organisms that use chemicals as a source of energy.
Photo: Jim Peaco, National Park Service

however, the liquid cannot be water but is instead methane (CH_4, commonly called *natural gas*). Methane/ethane lakes seem most common in Titan's polar regions, whereas the equatorial belt is covered with seas of "sand" dunes. Dry riverbeds cutting through these dune fields suggest that heavy rains occasionally fall, similar to Earth's infrequent but violent desert thunderstorms.

Life in the Solar System

As we compare the worlds of the solar system, we naturally wonder whether life might exist beyond our own biologically rich home planet. On Earth, life exists even in the harshest of environments: at high and low temperatures, in high acidity, under high pressures (in the deep oceans and buried within crustal rocks)—even in nuclear waste. We believe that the formation of life on Earth required liquid water, organic compounds, and a source of energy. From comparative planetology, we know these conditions existed in the past on Mars' surface, and they may still persist below the surface today. Jupiter's moon Europa probably meets these same conditions beneath its icy crust. Prospecting these exotic environments for life, however, is a daunting (and expensive) technical challenge.

Some scientists speculate that life could have formed in even more exotic environments: in the clouds of Venus, or beneath the ultra-cold surfaces of Enceladus or Titan. All three worlds are candidates for a future NASA mission. The space agency's recently announced robotic mission to Europa will expand knowledge of the thickness of its icy crust and its surface composition, first steps to someday trying to plumb the depths of the ocean thought to surge beneath.

Spacecraft like the Mars Exploration Rovers, *Mars Odyssey*, ESA's *Mars Express*, the *Phoenix* lander, and *Mars Reconnaissance Orbiter* have been examining the geology and chemistry of the Red Planet's surface, looking for clues that environmental conditions there might have enabled life to evolve, thrive, and perhaps persist today. The 2011 *Curiosity* rover (formerly the Mars Science Laboratory) will explore one possible region with a capable suite of scoops, drills, and life-detection instruments.

July's 40th anniversary celebration of *Apollo 11*'s historic mission focused attention on Mars as the next destination for human exploration. Coupled with the work of the Augustine Committee's review of U.S. human spaceflight plans, the *Apollo* commemorations heightened debate over whether Mars ought to be the declared destination of future human exploration efforts. In our view, it is unlikely that robots will be capable of discovering biological proof of past or present Martian life. To get access to subsurface sites still harboring life, or to find subtle fossil traces of its past existence, we'll need the skills of human explorers following up promising results from robotic reconnaissance. Comparing Mars' biological past (or its apparent sterility) with the explosion of life on Earth more than 3.5 billion years ago promises to be one of the most challenging and invigorating detective stories in all of comparative planetology.

The Space Radar Lab (SRL) rests in* Endeavour*'s payload bay as the shuttle soars 224 kilometers (about 139 miles) above Earth's surface. Tom Jones and his fellow astronauts took this picture of Sri Lanka and India's southern tip during their 11-day mission in April 1994. The crew used the American-, German-, and Italian-built SRL to image 66 million square kilometers (26 million square miles) of our home planet. *Image: NASA*

Understanding the Third Planet

One of the principal benefits of planetary exploration has been the unexpected increase in knowledge of our home planet. We go to Venus, Mars, and Titan to explore basic questions we have about our own world: where did we come from, and what is the fate of our world? Comparative planetology seeks answers to what seem like philosophical questions, but the fascinating details, as well as the accompanying larger picture of how worlds function, are increasingly within our reach as we expand our robotic and human presence beyond Earth.

As scientists, our most rewarding experiences have come from personally exploring our own Earth, from the slopes of a lava-spouting Mt. Etna to the stunning vistas seen from a shuttle flight deck. Earth is both our starting point and the key to understanding distant worlds. Ever curious, we humans will always long to travel the solar system, but our voyages of exploration will always bring us back to the third planet, this island—Earth.

Ellen Stofan, planetary geologist, and Tom Jones, former astronaut and planetary scientist, are coauthors of Planetology: Unlocking the Secrets of the Solar System *(National Geographic, 2008). See* www.nationalgeographic.com/books *and* www.AstronautTomJones.com.

World Watch

Washington, D.C.—The Review of U.S. Human Space Flight Plans Committee, chaired by Norman Augustine, former CEO of Lockheed Martin Corporation (and former Planetary Society Board Member), has delivered its message to the president: "The U.S. human spaceflight program appears to be on an unsustainable trajectory. It is perpetuating the perilous practice of pursuing goals that do not match allocated resources." The ball is now in the Obama administration's court.

The committee examined many rocket options and various destinations for human spaceflight and found that no exploration program, including the current one, could send human explorers beyond low Earth orbit and stay within the current budget plan. The committee did offer several options that it said could advance human space exploration beyond Earth orbit if the budget were less constrained—for example, gradually being increased to a level of $3 billion more per year by fiscal year (FY) 2014.

The committee is presenting options to the administration, which will then decide which path to take. We will see the administration's choices reflected in the FY 2011 budget proposal that will be sent to Congress next February. There is also a small chance that the administration will request a supplement before that—for the FY 2010 budget, which goes into effect on October 1, 2009.

The committee proposed three paths that humans could take as we explore the inner solar system:

• Mars first, with a Mars landing, perhaps after a brief test of equipment and procedures on the Moon.

• Moon first, with lunar surface exploration focused on developing the capability to explore Mars.

• Flexible path to inner solar system locations, such as lunar orbit, Lagrangian points, near-Earth objects, and the moons of Mars, followed by exploration of the lunar surface and/or Martian surface.

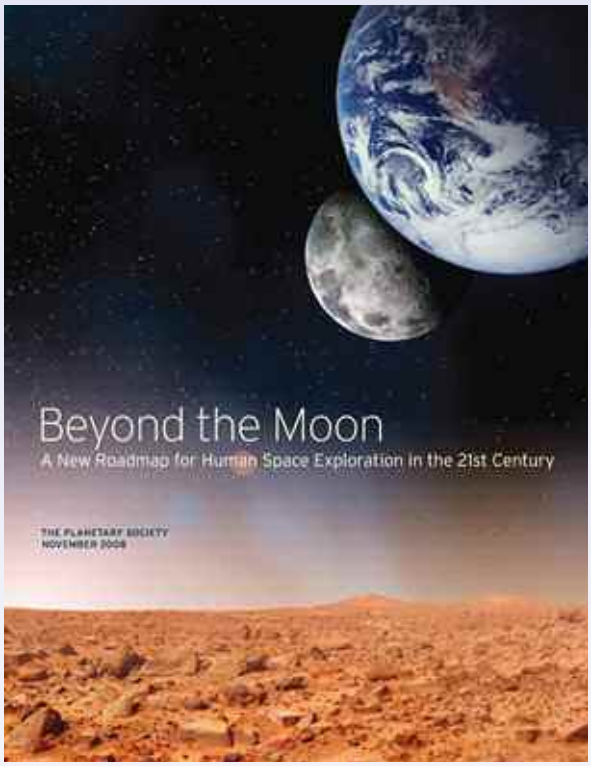
The committee rejected "Mars first." Although it affirmed that Mars is the ultimate goal for human explorers, members felt we are just not ready technologically to launch a mission directly to the Red Planet.

"Moon first" could follow either of two strategies: the current plan of the Constellation program, building a lunar base, or a series of sorties to explore diverse sites in greater detail. The ultimate point, NASA says, would be to acquire the skills and knowledge necessary eventually to explore Mars.

The "flexible path" echoes the recommendations made by The Planetary Society in our report *Beyond the Moon: A New Roadmap for Human Space Exploration in the 21st Century*. In the Roadmap to Space, we presented a plan to move astronauts ever deeper into space, achieving milestones and exploration objectives on a road to Mars. Our Members can take pride in knowing that our voices were heard.

But then there's that bottom line: the committee concluded that none of these options, nor any human exploration beyond Earth orbit, was feasible within the current NASA budget. Although the original charge to the committee specified that suggestions had to stay within current budget guidelines, the committee said that if forced to do so, NASA would have to de-orbit the International Space Station (ISS) in 2016 (and that would require extra money), and the agency would not be able to produce a program that could take humans beyond Earth orbit.

If NASA's budget were to be increased gradually to a level $3 billion per year over current guidelines, however, then the Moon first or flexible path options would be possible, albeit over longer time scales than originally envisioned. The committee found that the two paths "are not necessarily mutually exclusive; before traveling to Mars, we might be well served to both extend our presence in free space and gain experience working on the lunar surface." Of course, that would delay sending humans to Mars even more. The committee's sugges-



Cover of The Planetary Society's* Beyond the Moon: A New Roadmap for Human Space Exploration in the 21st Century, *published in November 2008.
Image: The Planetary Society

tions of a budget increase was similar to that which the Society made in its Roadmap to Space.

Although it was only presenting options to the administration, the committee made some important suggestions and conclusions:

• Extend U.S. use of the space station beyond 2015 and build on the existing successful international partnership to prepare for human exploration beyond Earth orbit. The committee pointed out that abandoning the ISS would be extremely detrimental to building international cooperation.

• Retire the shuttle but plan on extra funding to fly it until March 2011 (instead of October 2010) to complete the current manifest. Concern about astronaut safety, as well as cost, should ensure that the shuttle program will not be extended more than a few months into 2011.

• Develop an Ares V "light" and use it instead of the two different vehicles, Ares I and Ares V, now planned. The committee suggested that an Ares V "light" be developed that could launch both humans and cargo (still separately) and provide more performance than the current plan, both to Earth orbit and for heavy lift beyond it.

• Expect the gap between the end of the shuttle and a new U.S. rocket that can deliver astronauts to Earth orbit to be no less than seven years, instead of the currently projected five years. The committee found "the interim reliance on international crew services"—that is, Russian Soyuz launches—acceptable.

• The committee strongly encouraged the administration to support both commercial launch alternatives and the role of the private sector in developing transport vehicles to Earth orbit. This includes using private rockets to take astronauts to the ISS.

• Invest in new U.S. technology. The committee strongly supported new technology investment, stating that "a technology development program would re-engage the minds at American universities, in industry, and within NASA."

The Augustine Committee has made it clear that the 2020 goal for returning astronauts to the Moon is unreachable. In some ironic way, the spate of attention to the 40th anniversary of the first lunar landing this past July may have added to the characterization of the lunar goal as a past achievement, not a future one. The Constellation program that grew out of President George W. Bush's Vision for Space Exploration has not garnered the public or political support—or the budget—needed to turn it from plan into reality.

Although I am impressed by the realism of the report and agree with the flexible path option and the conclusions listed above, I would have liked to see the report focus more on the rationale for human spaceflight. To make the case for an increased budget, we have to address the exploration goals and the public interests—and this includes the importance of international cooperation and engagement that is crucial for large-scale space exploration. The significance of humans reaching Mars and exploring life in the universe was recognized by the committee but not integrated into its suggestions. In addition to addressing how we can advance the human space program, we need more emphasis on why we need to advance it.

The devil will be in the details, and until the administration makes its decisions about the Augustine Committee's options and conclusions, we won't know about the fate of Ares rocket development and the commitment to a heavy-lift launch vehicle or which path the administration will choose to take. Meanwhile, we will continue our advocacy with the key decision makers.

Let me close here with a final quotation from the committee, which sets the stage for making the case for not only an increased budget but also an increased purpose for human spaceflight: "Exploration provides an opportunity to demonstrate space leadership while deeply engaging international partners; to inspire the next generation of scientists and engineers; and to shape human perceptions of our place in the universe. The committee concluded that the ultimate goal of human exploration is to chart a path for human expansion into the solar system."

Louis D. Friedman is executive director of The Planetary Society.

In this artist's concept of the future, an astronaut gathers samples on the surface of Mars while a robotic explorer stands by to help. The U.S. is determining when and how it will return astronauts to the Moon and eventually send humans to explore Mars and beyond. *Painting: NASA*

Questions and Answers

How would scientists identify an extraterrestrial signal as intelligent and not a natural phenomenon? I've heard that nature does not make signals restricted to one spot on the dial.
—Peter Burger

This is a good question—and one that has long been debated in the SETI community. Sometimes it's hard to tell: the rapid and stable periodicity of pulsars was baffling to the discoverers, who initially dubbed them "LGMs," for Little Green Men. (We now understand them to be neutron stars, dense collapsed remnants of stars that are well past their prime.) A signal that's really at "one point on the dial" is pretty much guaranteed not to be cosmic static. The *theoretical* reason for this is that any motions within the gas blob, or whatever was emitting, would cause little Doppler shifts of wavelength, so that overall, you'd get a signal that was spread out on the radio dial. Motions of just an inch per second (tiny by astronomical standards) cause detectable spreading of a tenth of a hertz at SETI's favorite frequency (1.4–1.7 gigahertz, also known as the "waterhole").

The *experimental* confirmation is that we have never seen a sub-hertz radio signal of natural origin. The narrowest natural radio signals ever observed come from interstellar masers (radio lasers), and they are spread over thousands of hertz. When narrow signals of extraterrestrial origin have been detected, they have come from our own satellites. Definitely nonnatural, though perhaps of dubious intelligence.

So, a narrow radio signal therefore is a plausible guess for apparent intelligence. But let's face it, we do not really know what The Signal will look like. Here's what Ed Purcell (who shared the Nobel Prize for the invention of nuclear magnetic resonance, the basis of medical MRI) had to say about it, in a 1960 lecture: "When we get a signal, how do we know it is real and not just some accident of cosmic static? . . . The neatest suggestion I know of originated with Cocconi and Morrison, who have published a discussion of this whole subject. [Guiseppi Cocconi and Philip Morrison's famous paper, "Searching for Interstellar Communication," appeared in *Nature* in September 1959.] Morrison would have the sender transmit a few prime numbers. That's all you need: 1, 3, 5, 7, 11, 13, 17—by then you *know*. There are no magnetic storms or anything on Venus making prime numbers."

There are plenty of other possibilities, and it's fun to try to invent better candidates. For example, why should the senders bother generating and transmitting the enormous power needed to reach us when they might instead simply modify an existing (and visible) natural source? You might imagine a giant Venetian blind used to blink the light from a star. An example of this sort of "astroengineering" was recently proposed by astronomers at the Universities of Hawaii and of California at Santa

Are we alone? For those in search of the answer, the night sky twinkles with possibilities. In this view, Jupiter shines brightly just beneath the center of the Milky Way in Sagittarius. Tyler Nordgren's flashlight illuminated his path as he hiked down the Navajo Trail in Utah's Bryce Canyon National Park in June 2008.
Photo: Tyler Nordgren

Barbara—namely, to use neutrinos to periodically "tickle" the cycles of a variable star into a meaningful pattern. Forty years earlier, the ever-creative Philip Morrison tossed off the suggestion of dumping some unusual material onto a civilization's host star: "The resultant strange but characteristic optical emission line might prompt someone to say, 'A star that emits a narrow line of gadolinium, what can that be?'"

These are all plausible suggestions, but we probably won't guess it right ahead of time. Our best approach is always to be curious about astrophysical anomalies and to keep an open mind. A sending civilization knows what it is doing, and we should trust it to make its heralding signal distinctive. To paraphrase Supreme Court Justice Stewart's memorable phrase, "We'll know it when we see it."

—PAUL HOROWITZ,
Harvard University

Factinos

For the first time, scientists have discovered a planet that orbits in the direction opposite that of its parent star's spin. They believe the planet was flung into its retrograde orbit by a close encounter, either with another planet or with a passing star. The new object, named WASP-17b, is the 17th exoplanet to have been discovered by the United Kingdom's Wide Area Search for Planets (WASP) consortium of universities. WASP-17b was detected using an array of cameras set up to monitor hundreds of thousands of stars. The gas giant is about twice the size of Jupiter but about half its mass. This bloatedness might be rooted in the close encounter that changed the "backward" planet's direction.

A report on the team's findings has been accepted for publication in an upcoming issue of *Astrophysical Journal*. One of the paper's coauthors, Coel Hellier of Keele University in Staffordshire, England, said planets with retrograde orbits are thought to be rare. "If you have a near-collision, then you'll have a large gravitational slingshot from that interaction," he explained. "This is the likeliest explanation. But it might be possible [that] you can do it by gradually perturbing the orbit through the influence of a second planet. So far, we haven't found any evidence of a second planet there."

—from BBC News

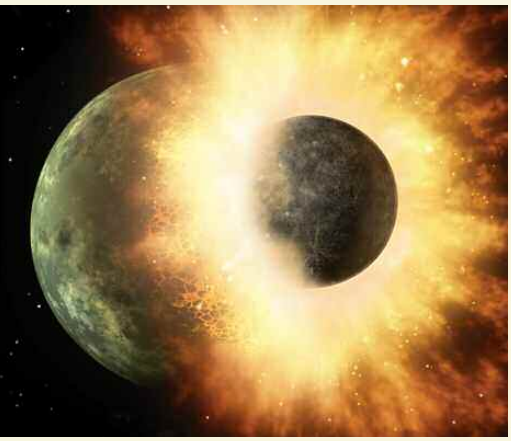
A team of American and British researchers using the Spitzer Space Telescope has detected evidence of a high-speed collision between two nascent planets around a young star called HD 172555.

The group reports that two rocky bodies, one at least as large as the Moon and the other at least the size of Mercury, slammed into each other within the last few thousand years or so. The impact destroyed the smaller body, vaporizing huge amounts of rock and flinging massive plumes of hot lava into space. Spitzer's infrared detectors were able to pick up the signatures of the vaporized rock, along with glassy pieces of refrozen lava, called *tektites*.

"This collision had to be huge and incredibly high-speed for rock to have been vaporized and melted," said Carey M. Lisse of Johns Hopkins University's Applied Physics Laboratory. "This is a really rare and short-lived event, critical in the formation of Earth-like planets and moons. We're lucky to have witnessed one not long after it happened."

Lisse and his colleagues say the collision is similar to the one that formed our Moon more than 4 billion years ago, when a body the size of Mars smashed into Earth. "The collision that formed our Moon would have been tremendous, enough to melt the surface of Earth," said Geoff Bryden of the Jet Propulsion Laboratory. "Debris from the collision most likely settled into a disk around Earth that eventually coalesced to make the Moon. This is about the same scale of impact we're seeing with Spitzer—we don't know if a moon will form or not, but we know a large rocky body's surface was red hot, warped and melted."

—from NASA/JPL-Caltech



Spitzer's recent detection of a cosmic collision around HD 172555 probably looked like this. Shock waves from the collision would have traveled through the larger planet, throwing rocky rubble into space. The infrared telescope also identified the signatures of this rubble.
Illustration: NASA/JPL

Stardust scientists have discovered glycine, an essential building block of life, in samples of comet Wild 2 that were captured by the spacecraft in January 2004. "Glycine is an amino acid used by living organisms to make proteins, and this is the first time an amino acid has been found in a comet," said Jamie Elsila of Goddard Space Flight Center. Protein molecules, the workhorses of life, are used in everything from hair to enzymes, the catalysts that speed up or regulate chemical reactions.

"The discovery of glycine in a comet supports the idea that the fundamental building blocks of life are prevalent in space and strengthens the argument that life in the universe may be common rather than rare," said Carl Pilcher, director of NASA's Astrobiology Institute.

—from NASA/JPL

For information on this discovery, visit *planetary.org/news/2009/0825_Stardust_Retrieves_Life_BuildingBlock.html*.

Society News

Welcome! New Society Leaders

The Planetary Society welcomes two new members to our Board of Directors, as well as four additions to the Advisory Council. Alexis C. Livanos and Bijal (Bee) Thakore are our newest board members. Livanos is corporate vice president and chief technology officer of the Northrop Grumman Corporation. Thakore, our youngest board member, is regional coordinator for Asia Pacific, Space Generation Advisory Council.

Our new advisers are Robert D. Braun, David and Andrew Lewis Professor of Space Technology in the School of Aerospace Engineering at the Georgia Institute of Technology; James Cantrell, founder of Strategic Space Development; Rosaly Lopes, a principal scientist at the Jet Propulsion Laboratory; and Kevin Stube of the Space Generation Advisory Council.

—Susan Lendroth, Manager of Events and Communications

Jump In with Both Feet! Take Your Place on the New Millennium Committee

Planetary Society Chairman of the Board Dan Geraci always makes me smile when he urges our members to "jump in with both feet!"

He's talking about joining The Planetary Society's New Millennium Committee, our program for donors who pledge an annual unrestricted contribution of at least $500 a year.

Like many of you, Dan is a longtime member of the New Millennium Committee, as well as a Charter Member of the Society. Also like you, he has a lifelong passion for space exploration and a deep commitment to The Planetary Society.

Membership in the New Millennium Committee is one way that you can make a lasting impact on the future of space exploration. Your commitment to annually providing funds is crucial to our success. Your gift enables us to move quickly and to take on challenges and projects knowing that we have the funds to do the work.

As Dan would say, jump in with both feet! Take your place on the New Millennium Committee.

You can find out more, or join online, at our website at *planetary.org/join/programs/new_millennium_committee.html.*

If you have any questions, please give me a call at (626) 793-5100, extension 214, or drop me a note at *andrea.carroll@planetary.org* or to my attention at The Planetary Society, 65 N. Catalina Ave., Pasadena, CA 91106-2301 USA. Thank you!

—Andrea Carroll, Director of Development

Want to Go Paperless?

In the last issue, we let you know that, if you wished, we would stop sending you paper copies of *The Planetary Report*. If going paperless interests you, go to our website at *planetary.org/emailupdate* and complete the form there.

We'll send you an e-mail letting you know when each issue of the magazine is available online in the For Members section of our website.

—AC

Have You Thought About Volunteering for The Planetary Society?

The Planetary Society needs you! In addition to seeking assistants at public events, we have many ways in which you can become more closely involved with *your* Planetary Society.

To give a few examples, we are looking for Web-savvy volunteers to help us with our own website, as well as to better disseminate information about our programs to other websites. Another task that needs extra hands is transferring videotapes from several decades to DVD or other storage formats. If you have the right equipment to help, we'd love to hear from you.

Whatever your skills or background, let us know how you would like to become more closely involved with the Society in the future. Contact me at *tps.lb@planetarysociety.org*.

—Lonny Baker, Global Volunteer Coordinator

Thank You for Your Dedication!

Sometimes you, our Members, awe the staff with your dedication and support. We recently had to raise our dues. We notified the entire membership and offered you the chance to renew at the old rate for as many years as you wanted. Not only did many of you renew for 2, 3, or 4 years, but many of you renewed for 10, 20, and 30 years!

We will not be celebrating our 30th anniversary until next year, yet you displayed confidence that we will be around for 30 more years. The staff works hard to earn that confidence, and your show of approval not only validates what we are doing but also makes us want to do more. Thank you!

—Planetary Society Staff

Members' Dialogue

Ongoing Debate

I was upset and angered by Hans K. Buhrer's letter [see the May/June 2009 issue]. As a 20-plus-year member and strong supporter of The Planetary Society (through many donations), I believe that its most important mission is to keep space exploration, in *all* its forms, before the minds of the public and the world's governments.

One of the distinguishing features of humanity is its urge to explore and venture "beyond the hill." This urge separates us from almost all other species. The prospect of the entire future of the human race being limited to this small sphere approaches the nightmarish.

It is utterly wrong to say that adventure and excitement have no place in today's space exploration programs. If space exploration did not inspire enthusiasm, curiosity, and the urge for discovery and adventure, the effort would never have started, and would certainly have died long since if confined to dry academic study, as Buhrer suggests.

On the page opposite Buhrer's letter is a quotation from The Planetary Society's cofounder Carl Sagan: "If we crave some cosmic purpose, then let us find ourselves a worthy goal." This can only mean the exploration and colonization of the universe by humankind. Scientific study by unmanned probes is fundamental to this but makes sense only as a precursor to human expansion.

If The Planetary Society were to go down Mr. Buhrer's road, I would resign immediately.

—RICHARD McCONNELL,
Hessle, East Yorkshire, United Kingdom

Like so many space enthusiasts, I witnessed the *Apollo* landings as an adolescent, and I'm still moved by the memory of seeing that giant leap take place—that first step into a space-age future that my generation looked upon as our birthright.

I also agree with Hans Buhrer's recent letter. Human exploration of the solar system is expensive, impractical, and dangerous. And for what? As thrilling and inspirational as the Moon landings were, as much pride as they gave me (and still do) to see what human beings can accomplish, let's not forget that a major catalyst for the success of the *Apollo* program was anything but high-minded. It was simple one-upmanship. We just *had* to get there before the other guys did. That may partially explain why human exploration beyond Earth orbit never progressed. Instant gratification is often its own reward.

People's reasons for supporting human exploration and colonization often sound less like rational arguments than defense of religious beliefs—idealized and without supporting evidence; for example, "we have to colonize space to ensure the long-term survival of our species." Yes, our planet's health has been seriously compromised, and it will take great effort to reverse this damage. But hasn't anyone stopped to think that no matter how bad things were to get on Earth, it would still be far easier to survive here and to turn things around than to terraform and colonize another planet? Let's suppose a base was built on Mars. How many people would get to "enjoy" their new world? Would there be no dissent, pettiness, greed, and so on, in this small, enclosed habitat? When these future astronauts depart Earth, will they leave their human natures behind?

Many folks believe that "manned missions will energize interest in space exploration, resulting in more financial backing." Those people are just preaching to the choir. I can't remember the last time I met someone in their twenties who was for human exploration in the near future. These younger people are the ones who will inherit the space program, and they will do things their way. Technology—from iPods to spacecraft— is continuously becoming smaller and more efficient. By comparison, a human mission would be a lumbering, money-gobbling behemoth.

Someday, humans may dwell in space or on other worlds. But that can wait until we've truly developed the infrastructure and come up with a reason to do so other than just "because it would be fun" or "because we've messed up this planet and we need a new one." Let's learn to clean up our room—beginning with that hazardous space junk in Earth orbit—and to balance a checkbook before we go out looking for adventure and excitement.

—TERRENCE CHURCHMAN,
Altadena, California

Please send your letters to
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Mars' Valles Marineris is most likely a rift valley—its origins are closely tied with the volcanoes of the Tharis bulge to its west. Some channels near the canyon's eastern flanks appear to have been formed by erosion from carbon dioxide or liquid water. In *Sunrise Over Valles Marineris*, based on imagery from *Mars Express*, parts of the canyon are filled with an early morning fog that will burn off quickly as the day warms up.

Steven Hobbs is a professional photographer and graphic designer from Queanbeyan, New South Wales, Australia. He is a member of the International Association of Astronomical Artists, and his work has been used by NASA, the new *Sky & Space* magazine, Design Graphics, and Weldon Owen Incorporated.