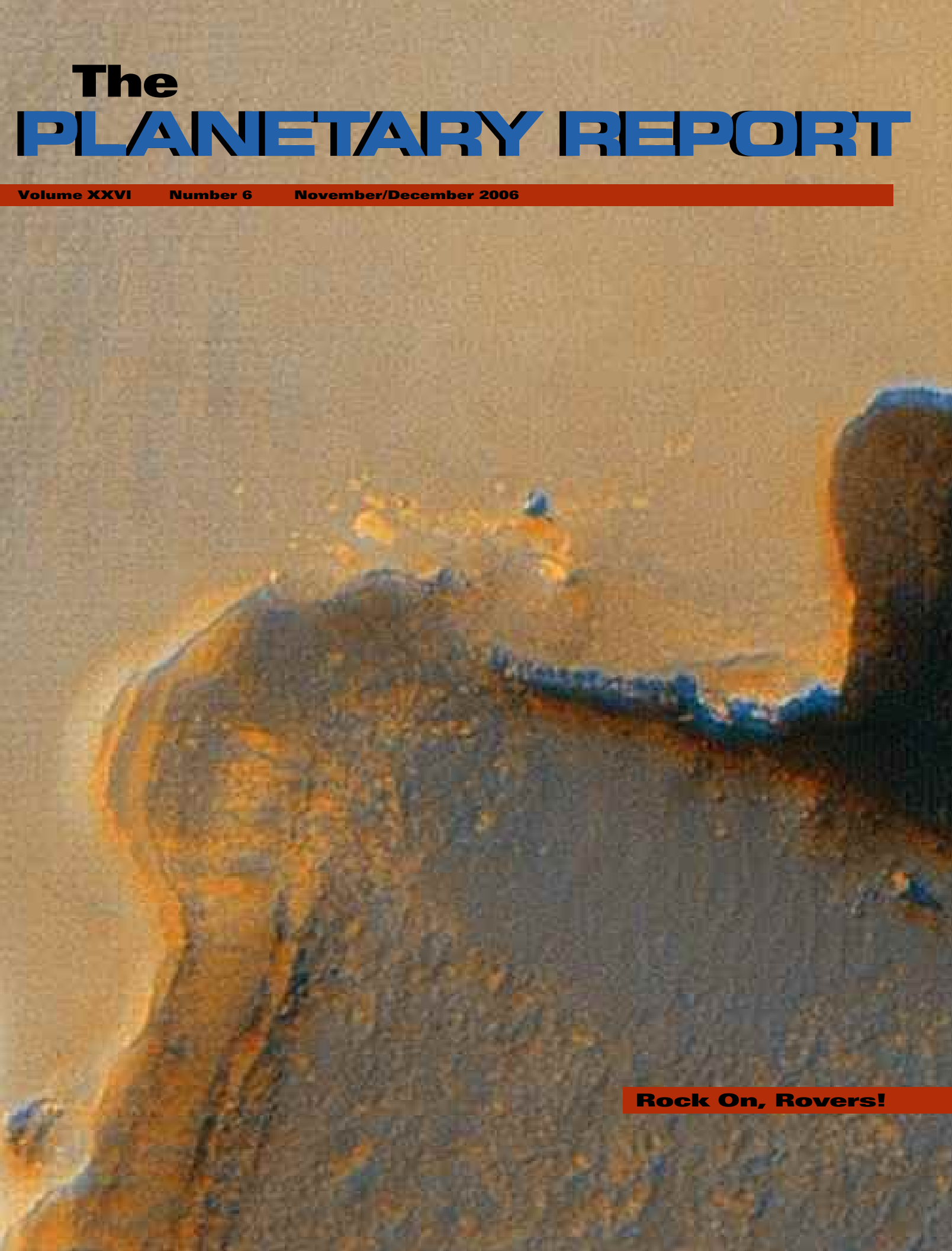
The PLANETARY REPORT

Volume XXVI Number 6 November/December 2006



Rock On, Rovers!

A PUBLICATION OF THE PLANETARY SOCIETY

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From The Editor

A few days ago, I took from the shelf a book I hadn't read in 10 years. Glancing though its pages, I was startled again by the power of its words to move me, emotionally and intellectually. I also was saddened that the man who presented this Cosmos to the world, who profoundly shared his spiritual and scientific wonder of the universe, has been gone for so long.

This December marks the 10th year since Carl Sagan's death. With his passing, science—particularly its planetary and astronomic branches—lost its most effective spokesman and defender. The Planetary Society lost not only a founder and figurehead but, more vitally, an involved and energetic leader. His fingerprints are on every aspect of our program, from our research projects to our political advocacy.

Most of all, his influence is felt in the pages of this magazine. *The Planetary Report* is, in many ways, his creation. Carl took special responsibility for it, and, until a few weeks before his death, he read every word before we published it.

We continue The Planetary Society's work in his long shadow. When we hear of discoveries on other worlds, encounter new policies that advance or impede our explorations, struggle with disappointments, or celebrate our successes, we often ask, "What would Carl have said?" There is no answer to that question.

—*Charlene M. Anderson*

On the Cover:

We had to do it. When this amazing orbital view of Mars' Victoria crater and the *Opportunity* rover appeared on our computer screens, we knew it was so cool that we simply had to swap it for the cover image we'd planned. We wanted to run it as large as possible, so we spread it out over both the front and back covers. This view is cropped and enlarged from a larger image showing the entire crater. For more details, see the back cover caption, and for an annotated version of this picture, see page 15.

Image: NASA/JPL/University of Arizona

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The Planetary Report (ISSN 0736-3680) is published bimonthly at the editorial offices of The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106-2301, 626-793-5100. It is available to members of The Planetary Society. Annual dues in the United States are $30 (U.S. dollars); in Canada, $40 (Canadian dollars). Dues in other countries are $45 (U.S. dollars). Printed in USA. Third-class postage at Pasadena, California, and at an additional mailing office. Canada Post Agreement Number 87424.

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Members' Dialogue

Our Weblog:
From July 31 to October 22, while our regular blogger Emily Lakdawalla was on maternity leave, The Planetary Society's Weblog at planetary.org/ blog *featured a variety of guest bloggers from around the world of space exploration.*

Our special guests were Planetary Society Chairman of the Board Neil deGrasse Tyson; Star Trek: Enterprise *writer and producer Andre Bormanis; Stardust@home Project Director Andrew Westphal; Mars Exploration Rovers Pancam leader Jim Bell; Planetary Society Executive Director Louis Friedman; extraterrestrial volcanologist Rosaly Lopes; New Horizons team member John Spencer; the Jet Propulsion Laboratory's Chief Mission Concept Architect Mark Adler;* Cassini *Mission Planner David Seal; founder of* unmannedspaceflight.com *Doug Ellison; planetary scientist Brad Thomson; and Bill Nye the Science Guy.*

Here we share a sampling of readers' comments we received.
—Jennifer Vaughn,
Director of Publications

To Mark Adler:
This week's blog by Mark Adler is very good and puts the issue of the Moon versus Mars in the spotlight. I want space travel and exploration to succeed, and I feel it is time for The Planetary Society to think long and hard about keeping it practical and within a budget that can be defended.
—Frank Wilson

I just wanted to let you know that I really enjoyed your guest blogging this last week. I think your style was what a blog should be: informal, informative, current and relevant, and peppered with humor and a bit of cynicism.
—Eric Fulmer

To Rosaly Lopes:
I enjoyed your blog and I have often wondered why there is not more humor injected into the names for objects. The world of science is occasionally a little too serious. Thank you for the good work that you do every day. We need more scientists.
—Stephen Hawkins

To Neil Tyson:
I'm a proud Planetary Society member since 1991! Reading the blog is always a pleasure—it's full of insight on our greatest adventure—knowing the cosmos.

I'm very happy for Ms. Lakdawalla and hope everything goes well. Then I'm back to the blog again, just to find Neil deGrasse Tyson! What a guest! His series of testimonies on the fire within every one of us is just awesome and inspiring to read. His last one, "The Cabbie," reminds me of the late Carl Sagan (in *The Demon Haunted World*), but [Tyson] takes a more optimistic turn.

Dr. Tyson, bring the flame and keep it shining in the dark to inspire us!
—Almir Germano

To Andrew Westphal:
Great blog topic, Andrew. I am reminded of my high school physics class, in which our lab assignments generally consisted of a single sentence, such as "Measure gravity." There was no recipe—how we did it was up to us. Of course, the teacher was standing by to help if we needed ideas, but using our own methods was encouraged. In another lab, we were given a target (with Fred Flintstone on it) and some toy dart guns. Our grade was determined by the ring on the target that we managed to hit from about two meters away. Best course I ever took . . .
—Devon Bowen

From the Blogger:
I'm very grateful for the efforts of the guest bloggers who, over the last 12 weeks, donated their time to explore issues they found important while also covering some of the newsworthy events that took place, such as the semantic debate that gives us eight planets, the arrival of Opportunity *at Victoria, and* Cassini*'s smashing portrait of Saturn eclipsing the Sun, among other things.*

Most of the guests seemed to enjoy themselves, and I hope to see them, as well as new contributors, appear again on the site from time to time. Many of the guests told me, though, that blogging turned out to be much harder than they expected. Blogs may be off-the-cuff in style, but that doesn't mean you can get sloppy with the facts, and trying to get the facts right does take work! Thanks to all of you for taking the time and effort out of your busy lives to share your thoughts. The full 12 weeks of guest blogs are archived at planetary.org/blog/specials.html.
—Emily Lakdawalla,
Science and Technology Coordinator

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tps.des@planetary.org

We Make It Happen!

by Bruce Betts

Planetary Society Is Flying to Mars on *Phoenix*!

I'm very excited to announce that, in 2007, we're flying an archival disk with people's names and an amazing collection of Martian literature to Mars on NASA's *Phoenix* mission. We are also participating with a microphone to get sounds from Mars.

Phoenix is an independently selected Mars Scout mission and is led by Principal Investigator Peter Smith of the University of Arizona. It will launch in August 2007 and arrive at the Red Planet in May 2008.

Phoenix will be the first lander to explore the Martian arctic. It will land near 70 degrees north latitude. It is a fixed lander with a suite of advanced instruments and a robotic arm that will dig half a meter to a meter into the subsurface to study the water ice that is expected to be there. In the Martian arctic soils, *Phoenix* will uncover clues about the history of water and potential for habitability.

Fly Your Name to Mars on *Phoenix*

Thanks to a Planetary Society–provided silica mini-DVD, you and many others can fly your names to the surface of Mars. The names of all Planetary Society members and all *Phoenix* project personnel will be included automatically. If you want to add someone else (children, parents, dogs, postal workers, etc.), or if you want to print out a certificate showing your participation, go to *planetary.org/phoenixdvd*. (To get your certificate, make sure you search on your name exactly as it appears in our records—check the label of this magazine.) All names received by February 1, 2007 will be included on the final DVD that goes to Mars.

The Planetary Society sent member names and almost 4 million other names on the Mars Exploration Rovers (MER) on similar silica disks. The *Phoenix* mini-DVD is a derivation of the MER DVD but without the mounting hardware. This time around, the mini-DVD will be attached to the deck of the lander using adhesive and Velcro. Once it's attached, the whole thing will be baked at high temperatures to kill any Earth critters.

The mini-DVD will be visible in all calibration images taken on the surface of Mars by the *Phoenix* camera system, so you'll be able to see yourself on Mars—well, sort of. The disk itself, made of silica glass, should last for at least 500 years on the surface of Mars and will await discovery by a future generation.

Visions of Mars

Your name will join the greats of science fiction and Mars

The* Phoenix *lander sits on the arctic plains of Mars just as it has begun to dig a trench through the upper soil layer. The* Phoenix *mission is led by Principal Investigator Peter H. Smith of the University of Arizona, with project management at NASA's Jet Propulsion Laboratory and development partnership with Lockheed Martin Space Systems. International contributions for* Phoenix *are provided by the Canadian Space Agency, the University of Neuchatel (Switzerland), the University of Copenhagen, and the Max Planck Institute in Germany.
Painting: NASA/JPL/Corby Waste

This close-up of* Spirit*'s Mars DVD was captured on sol 2 of its mission on Mars. With* Phoenix*, we're going back with a little less hardware but a lot more content, from science fiction literature, to art, to a whole new set of names. *Image: NASA/JPL/Cornell/The Planetary Society*

science history on the DVD. *Visions of Mars* is a collection of Mars literature and art. It includes works from Isaac Asimov, Ray Bradbury, Arthur C. Clarke, and many more in fiction, as well as historical works by Schiaparelli and Percival Lowell, among others. Also included are some Mars artworks and greetings to the future finders of the disk from Carl Sagan, Arthur C. Clarke, Judith Merrill, and Louis Friedman. Consider it the first book in the Martian library!

Visions of Mars first flew on the Russian *Mars '96* mission that failed shortly after launch. We are now updating it in terms of both content and data formats and technology. The *Visions of Mars* content will be made available to Planetary Society members in the near future—I'll let you know how and where in a future issue of *The Planetary Report*.

Descent Microphone

As you may be aware, The Planetary Society flew the first privately funded hardware on a NASA mission: the Mars Microphone on *Mars Polar Lander*. With the failure of the lander, Mars has remained silent to us. (We have worked with sounds from Titan from the *Huygens* lander during its descent. The sounds are posted in the Planetary Microphones section of our website.) We are working to get our specialized Mars Microphone and its data-gathering system on a future Mars lander. In the meantime, we are fortunate to be collaborating on *Phoenix* with Malin Space Science Systems, which has included a microphone on its Mars Descent Imager (MARDI). MARDI's first job, during the descent of *Phoenix* to the surface, is to return images of the landing site from above. If all goes well, MARDI will also capture sounds during the descent and maybe even on the surface.

The Planetary Society has already contributed toward characterizing a simulated MARDI microphone system in a Martian environmental chamber at the University of California at Berkeley. We will continue to be involved with understanding what to expect from the microphone on Mars, ponderings of its sensitivity, and outreach to the public with and about the sounds.

Connections to Carl Sagan

As we consider in this issue of *The Planetary Report* the 10th anniversary of Planetary Society co-founder Carl Sagan's death, I want to point out his connection with our activities with regard to *Phoenix*. Listening to sounds on Mars was an idea of Carl's to engage the public with another sense beyond sight. The first incarnation of *Visions of Mars* was created while Carl was alive, and the current version replicates his greeting to future Martian explorers. Carl's ideas and efforts to engage the public in space exploration continue to be realized through projects like these—thanks to members like you.

Bruce Betts is director of projects at The Planetary Society.

What's **Up?**

In the Sky—December and January

The Geminid meteor shower—usually the best show of the year with perhaps 60 meteors per hour from a dark site—peaks on December 13 and 14. In the predawn sky, Saturn moves from high in the sky in December to farther to the west through January. Mercury is up for a few days at the beginning of December in the east, and Jupiter is low in the east but rising higher over time. On December 9, Mercury, Mars, and Jupiter are very close together but also very low in the east. By January, Mars is below Jupiter, Saturn is in the east in the late evening, and Venus is visible again, very bright but low in the west at sunset.

Random Space Fact

Whether you call it a dwarf planet or the largest asteroid, Ceres is an interesting place: round and icy, with light and dark features, it contains more than a quarter of the mass in the asteroid belt.

Trivia Contest

Our May/June contest winner is Norbert Tackman of Ventura, California. Congratulations!

The Question was: What is the name of the lander, scheduled to land on comet Wirtanen in 2012, that is part of the European Space Agency's *Rosetta* mission?

The Answer: Philae.

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

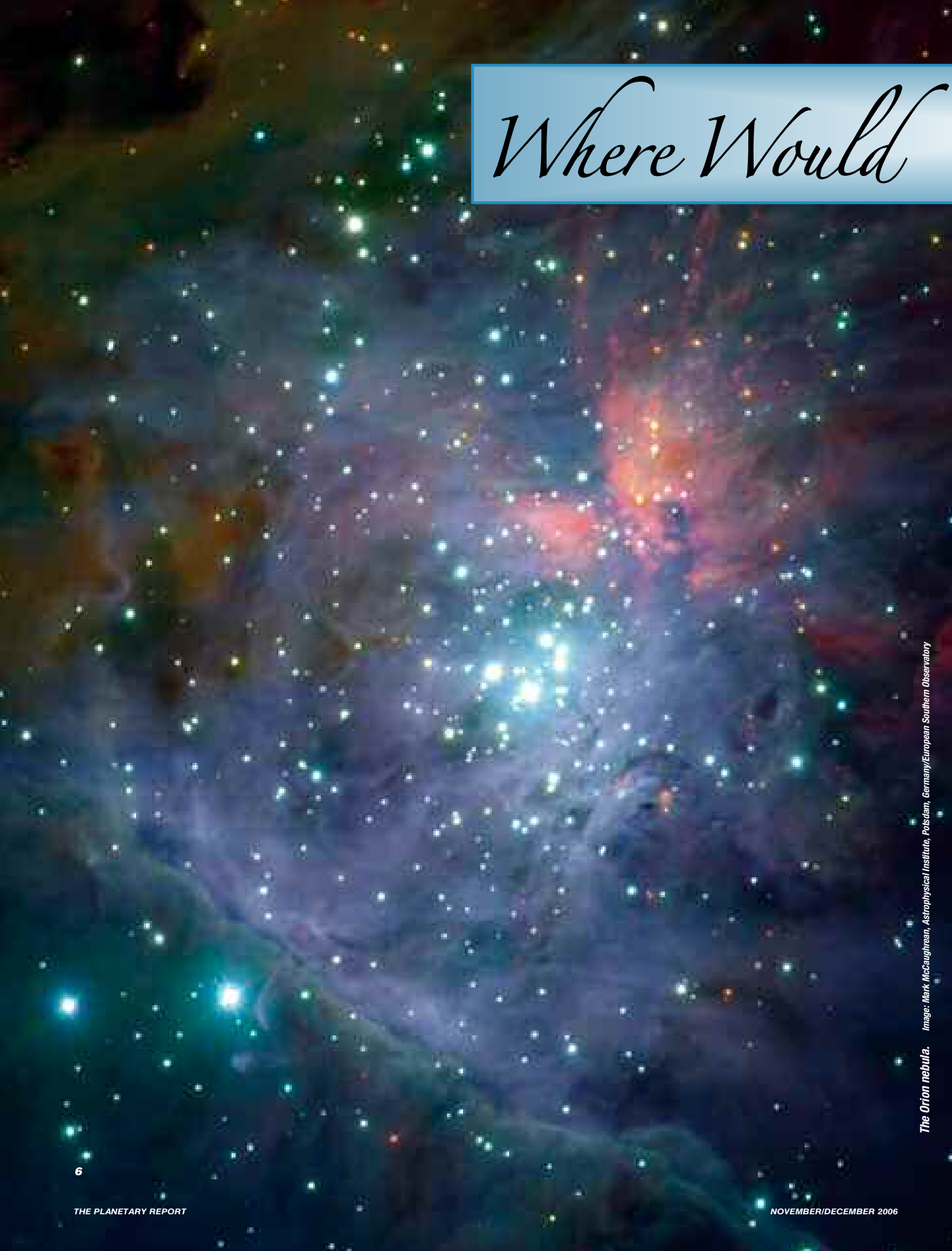
What feline name has been applied to the large "cracks" running along Enceladus' south pole that appear to be sources of water ice and gas coming out of Enceladus?

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 February 1, 2007. 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*.

Where Would



The Orion nebula. *Image: Mark McCaughrean, Astrophysical Institute, Potsdam, Germany/European Southern Observatory*

We Be With Carl?

by Ann Druyan

***Carl Sagan speaking on the future of Mars exploration on The Planetary Society's 1980s television broadcast,* Spacebridge.**
Photo: Courtesy of Ann Druyan

Weather permitting, Carl preferred to think and write outdoors amidst the natural beauty that surrounds our home in Ithaca, New York. As I write this, I look out on the clearing down by the waterfall where he would work, sitting at a table, all but motionless for hours at a time. He said the music of the rushing water provided the perfect background white noise for concentrating. When Carl and I were writing *Shadows of Forgotten Ancestors,* I once looked up from the computer in my office to find him deep in thought, his attention so highly focused on our manuscript that he was completely unaware of the rather large deer peering over his shoulder, as if trying to read what he was writing. The waterfall, the gorge with its record of the aeons inscribed in its strata, and the still-wild animals remain for now. The chair is empty.

We have traveled ten times around the Sun since Carl's death, and our little world is much changed. With his dazzling mind and vast knowledge, what would he have thought of the direction we, as a civilization, have taken in the years since? How might he have campaigned against the forces of darkness and brutality? How many minds might he have opened? During the last ten years, I have longed for the personal Carl of our love, family, and work together, but I have also keenly missed the man who was a global voice for science, exploration, reason, and democracy. Carl's ecological niche has remained tragically untenanted for all this time—and in my opinion, the consequences have been profound. My respect for his greatness keeps me from speaking for him with any degree of certainty. I can only offer my conjectures based on our 20 years of intense communication. Some of my speculations are more confident than others, flowing logically from the deeds and words of his life.

For instance, I feel sure that he would have been gratified by the achievements of The Planetary Society and especially thrilled by our boldness in actually launching our own spacecraft, *Cosmos 1*, the first solar sail. (Only ten years ago, this would have been so prohibitively expensive that even Carl never dared to dream that we could attempt such a feat.) I can see him tipping an imaginary hat in Lou Friedman's direction for his leadership of the mission. I know Carl would now be knocking on every conceivable door to raise the money necessary to see the project through to its fulfillment as a major milestone in the history of exploration. Given his powers of persuasion, I think we would be well into the countdown to our next launch.

Carl would have been inspired by the discoveries of the Mars missions and very proud that they were led by his students. The revelations of *Cassini* and *Huygens* would have taken him to new heights. How I wish he could see the new data from Mars and the outer solar system. If it were possible to share one new image of the planets and moons with him, I would pick a shot of Titan, the object of a lifetime of his scientific imagining. It would be the one taken by the *Huygens* descent probe of the Titan coast, showing icy highlands with dry rivers and what appears to be the shoreline of a vanished sea. Here the Titan coast looks more like Biarritz than any other place that comes to mind.

For we are the local embodiment of a Cosmos grown to self-awareness. We have begun to contemplate our origins: starstuff pondering the stars; organized assemblages of ten billion billion billion atoms considering the evolution of atoms; tracing the long journey by which, here at least consciousness arose.
—Carl Sagan, *Cosmos*, 1980

Globular Cluster 47 Tucanae. Image: European Southern Observatory

The Cosmos is all that is or ever was or ever will be. Our feeblest contemplations of the Cosmos stir us—there is a tingling in the spine, a catch in the voice, a faint sensation, as if a distant memory, of falling from a height. We know we are approaching the greatest of mysteries.
—Carl Sagan, *Cosmos*, 1980

Over the last decade, our spacecraft explorers have returned a multitude of amazing pictures from their interplanetary travels. If the author could share but one of those images with Carl Sagan, it would be this **Huygens** *descent probe picture of a "coastline" on Saturn's moon Titan. Here, on the surface of one of Carl's favorite topics of scientific study, ancient drainage channels appear to run down from icy highlands into what might have once been a sea of liquid hydrocarbons.* *Image: ESA/NASA/University of Arizona*

Carl engrossed in teaching a class of graduate students at Cornell University in the late 1970s. *Photo: Meyerowitz, courtesy of Ann Druyan*

From his boyhood in Brooklyn in the 1930s, he envisioned a time when the planets and their moons would become real places to us. No matter how inhospitable to humans Titan's atmosphere may be, that vision of the Titan coast beckons.

Years before the launch of the first space shuttle, Carl criticized it as an unsafe "capability without a mission," a program that he prophesied would siphon off support from the grudgingly funded space science treasury. I have no doubt that he would have led the fight to protect and enhance federal support for space science. He would have continued to campaign for science and critical thinking against the many different cultural and political assaults of the last several years. It's not that I think he alone could have turned the tide, but he would have provided critically needed leadership for those of us who have felt unrepresented.

To know what Carl would have thought of the current state of our nation, you need only remember that his pride in being an American stemmed from the integrity of our elections, our system of checks and balances, our respect for the rule of law both domestically and internationally, our high standards of evidence and truthfulness, our long historical recognition of the critical importance of the separation of church and state, our ability to take care of each other in times of disaster, what we stand for on the planet, our commitment to science and public education, and, perhaps most of all, the Bill of Rights guaranteed to us in the Constitution.

Carl died five years before the attacks on September 11, 2001, but he saw growing religious fundamentalism—whether it was in Mecca or the Bible Belt—as a looming threat, from without and within, to everything we value. He knew but one antidote for the magical thinking that lies at its root: the ability to weigh contending hypotheses and evaluate them by using the scientific method. So, despite the fact that he was battling a fatal disease and undergoing the "medieval torture" we call bone marrow transplants, he found the strength to write *The Demon-Haunted World: Science as a Candle in the Dark*. It would be one of two books that he would write during his last illness. His doctor told me that he had never had a patient who was able to read two books during the months it takes for a bone marrow transplant, let alone to write them.

I hope that, believing as he did in the profound relationship between science education and effective citizenship in a democratic society based on science and high technology, Carl would have shared my excitement in the current project we at the Carl Sagan Foundation have chosen to support: the Carl Sagan Academy, the nation's first humanist public charter school. CSA serves middle schoolers in the Tampa area of Hillsborough County, Florida who otherwise might never have any experience of the wonders of nature as revealed by science. It is the result of a remarkable collaboration of the American Humanist Association of Florida and the local Baptist churches, the kind of cooperation between people with radically different ideologies that exemplifies the world of which we dream. CSA is now in its second year, with a student body consisting of 78 of some of the most underserved children in America. I hope Planetary Society members who share Carl's dream of a scientifically literate and critically thoughtful public will contact us at the Carl Sagan Foundation.

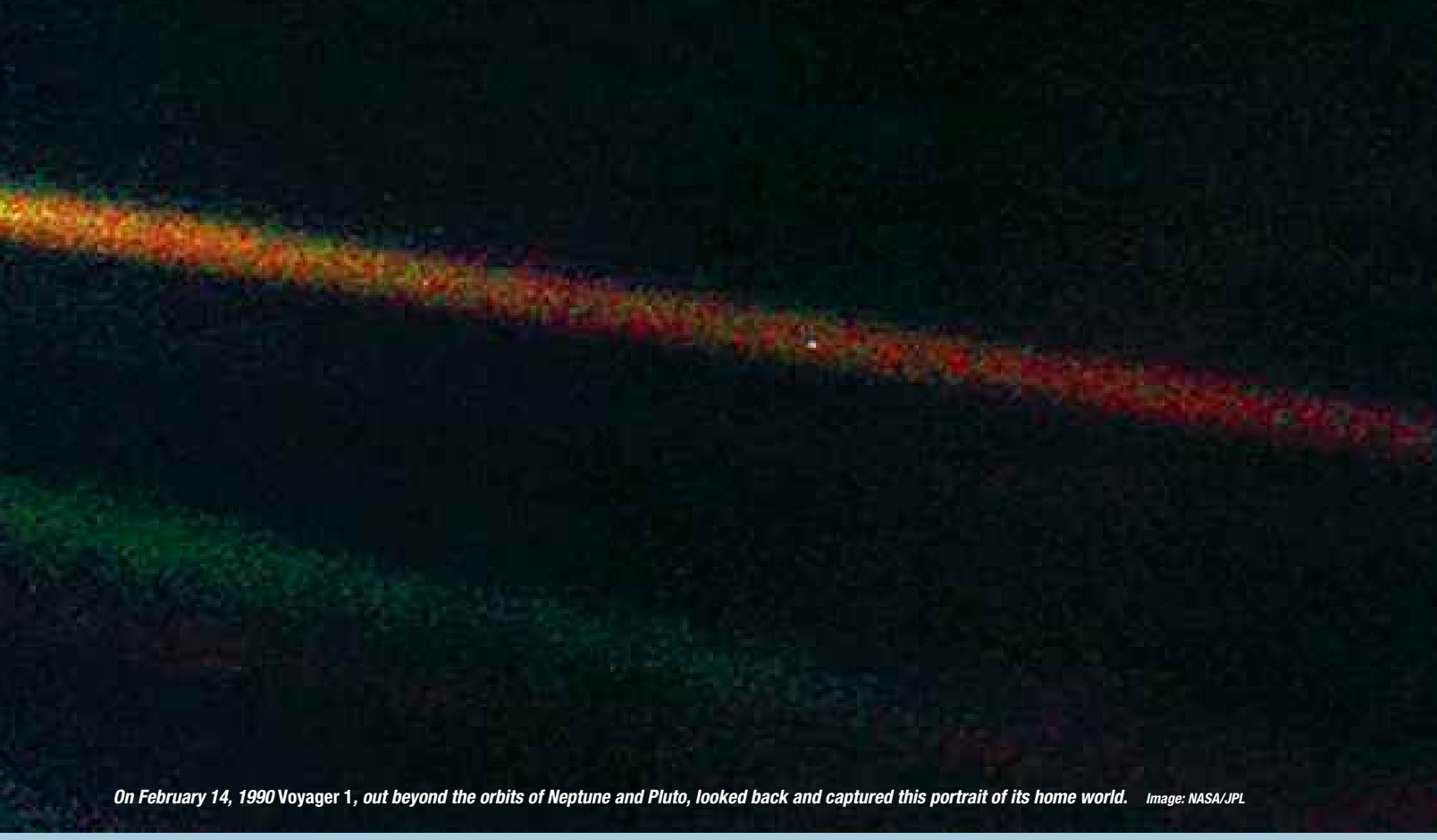
This past summer, as I watched former Vice President Al Gore's film on global warming, *An Inconvenient Truth*, I thought how proud Carl would have been of his former student at Harvard and longtime friend. More than once in the film, Al acknowledges Carl's influence on his thinking, and his evocation of Carl's "Pale Blue Dot" meditation provides the film with its final spiritual impact. I was reminded of how long it has been since we had a tireless, rigorously scientific, eloquent advocate for the planetary perspective to connect with people everywhere and to awaken us from our stupor; to move

Carl would have been thrilled with the parade of fantastic images and other data produced by our exploration of the solar system, such as this magnificent Cassini *portrait of Saturn. On September 15, 2006, the giant planet shielded the spacecraft from the Sun's glare, revealing previously unknown rings and even a glimpse of a very tiny Earth. This view was created by combining 165 images taken by* Cassini*'s wide-angle camera. Color in the picture was created by digitally compositing ultraviolet, infrared, and clear filter images and was then adjusted to resemble natural color. The mosaic images were acquired as the spacecraft drifted in the darkness of Saturn's shadow for about 12 hours, allowing many unique observations of the microscopic particles that compose Saturn's faint rings. During these observations,* Cassini *detected two new faint rings—see page 20 for more on these rings. To see Earth in this image, go to* http://www.planetary.org/news/2006/0920_Cassini_Sees_New_Ring_at_Saturn_and.html. *Image: NASA/JPL/Space Science Institute*

us to act in defense of our life-support system.

The briefcase Carl carried with him on that last trip to the hospital remained locked, exactly as he left it in December of 1996. It's a kind of time capsule of what he was working on and thinking about during those last days of his life. I had carried it home on that last trip from Seattle, but something kept me from exploring its contents. When I sat down to write this article, it occurred to me that it was probably time to open it and look inside. I tried a couple of likely combinations. When I got to my own birthday, bingo, the golden hasps flew open. The case contained photos of our family; a Saturn-shaped birthday card from our then-14-year-old daughter, Sasha; a clutch of NASA security badges; an issue of *Science* with a false-color *Galileo* image of Europa on the cover; slides of various planetary surfaces; a note from Chris Chyba about a visit that was never to be; Carl's reply to Neil Tyson, whom he had known and admired since Neil first wrote to him as a Bronx high school student contemplating a career in science; Charlene Anderson's request that Carl respond to a *Planetary Report* reader's question ("How can simple gases turn to organic residues when exposed to UV rays?"), to which, of course, his answer was "yes"; a message to artist Don Davis regarding the astronomical imaging for the motion picture *Contact*; another from scientist/artist Bill Hartmann about cratering on Mars; and letters of thanks for his agreement to give the keynote addresses to NASA's 1997 Early Mars Workshop and to the December White House Conference on the Future of Space Exploration.

In the last week of his life, Carl wanted desperately to somehow get to that conference. He knew he was about to die, and he wanted to leave us with a vision of how to build on the epochal achievements of the first 40 years of the space age. He was worried that we



On February 14, 1990 Voyager 1*, out beyond the orbits of Neptune and Pluto, looked back and captured this portrait of its home world.* *Image: NASA/JPL*

Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there—on a mote of dust suspended in a sunbeam. —Carl Sagan, *Pale Blue Dot*, 1994

were losing our way and our resolve to continue on the long road to the stars. As he lay dying, he managed, with an effort I found heart-wrenching, to dictate the speech.

A few days later, Vice President Gore opened the meeting by reading Carl's words aloud. It was one of the last things I was able to tell him and be certain that he understood. He smiled at the news. What I saw in those hazel eyes was a mixture of affection for Al Gore, a sense of relief that he had been able to communicate with the space science decision makers, and a flicker of concern about the future, one that proved to be, in the short term at least, all too well-placed.

Well, maybe two steps forward, one step backward is how we as a species wend our way through history. Perhaps these little detours have some selective advantage as a means of processing change along our pathway to the stars. In the meantime, a global community of people coalesces around Carl's legacy. The chair may be empty, but the ideas, the values, and even the dreams of the man are here now.

Ann Druyan's latest collaboration with Carl Sagan is her edit of his 1985 Gifford Lectures into the new book titled The Varieties of Scientific Experience: A Personal View of the Search for God*, published by The Penguin Press. She is working on three feature films. Anyone wishing to contact The Carl Sagan Foundation is urged to write to Cornell Business and Technology Park, 95 Brown Road, Suite #1027, Ithaca, NY 14850.*

Photographing M

All of us on the Mars Exploration Rover (MER) team realize that we're blessed with having some of the coolest jobs in the world. Every morning when I come in to work, I start up my computer and download brand-new pictures from Mars taken by cameras on the *Spirit* and *Opportunity* rovers, which my colleagues and I from Cornell, the Jet Propulsion Laboratory (JPL), and other institutions around the world helped to build and continue to operate. Often these pictures from Mars are only a few hours (or only a few minutes!) old. Incredible. I look at the Sun shining outside my office window, and it reminds me of the motto that we put on each rover's calibration target, or MarsDial: "Two Worlds, One Sun."

I Can't Remember What My Normal Day Job Was Like

More than 60 robotic and human space exploration missions are active right now. This means that some amazing spacecraft operations adventures are happening around the world, or somewhere in the solar system, every day. In my little corner of the world in upstate New York, people in our group are working on data and operations planning for missions such as *Cassini*, the Hubble Space Telescope (HST), *Spitzer*, *MESSENGER*, *Deep Impact*, and, of course, the Mars "armada": *Mars Global Surveyor* (*MGS*), *Mars Odyssey*, the rovers *Spirit* and *Opportunity*, *Mars Reconnaissance Orbiter*, and now the 2009 rover, *Mars Science Laboratory* (*MSL*). My research lately includes working with HST, *Odyssey*, and *MGS* data and helping to plan for *MSL*, but it's the rovers that have taken up almost all of my research time for the past three years. In fact, I was remarking to some friends the other day that I can't remember what my day-to-day research work was like before the rovers. What did I do with all the free time I must have had?

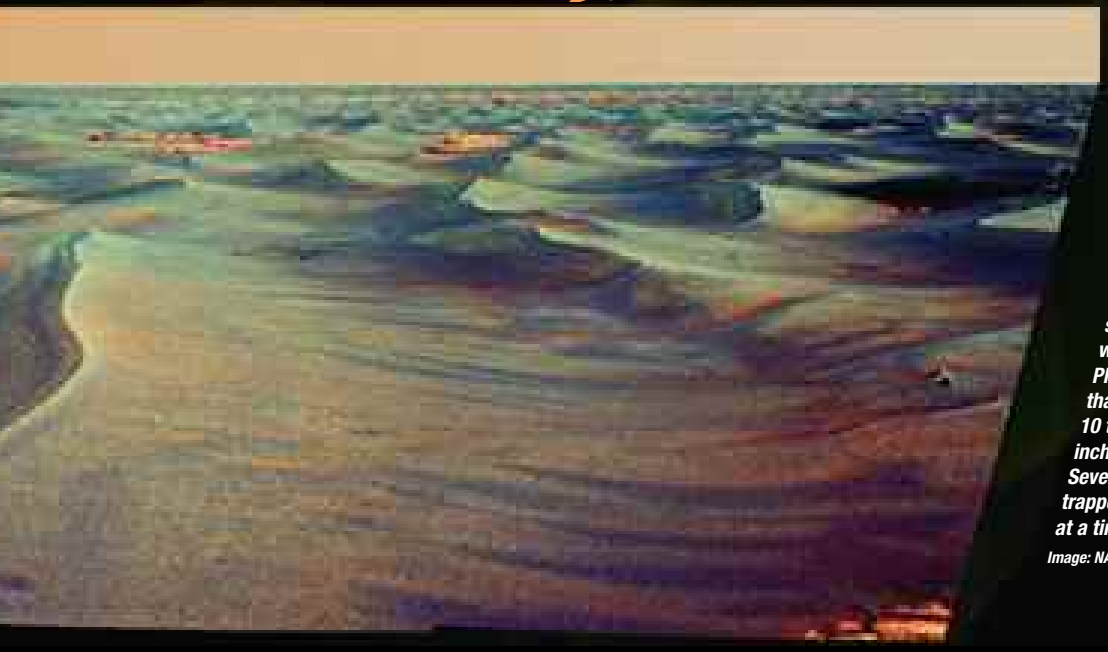
It's remarkable to think about all the complex work and the technology that is required to run a spacecraft mission. A glimpse of that complex, highly specialized world can be provided through our experience with the rovers, helping to operate the Pancam color cameras from the Cornell campus every day (except weekends and holidays, which we get off but the rovers and some JPL and Deep Space Network folks don't).

The rovers are commanded from JPL, so the spacecraft engineering team in Pasadena sets the schedule and pace. The Pancam group's rover planning day typically starts with a kickoff meeting via video- and teleconference around 10:00 or 11:00 a.m. East Coast time. The engineers assess the health of the rovers and estimate how much power and downlink data volume and time for science observations will be available that day, and the scientists make an assessment of how things went "yesterday" on Mars.

We're not on Mars time anymore, as we were early in the mission. The rovers' day is a Martian sol, about 40 minutes longer than an Earth day, so Martian time drifts slowly in correspondence to Earth time. Sometimes the start of a new day's planning session will be many hours after yesterday's data get radioed back from Mars, so everyone has plenty of time to look through

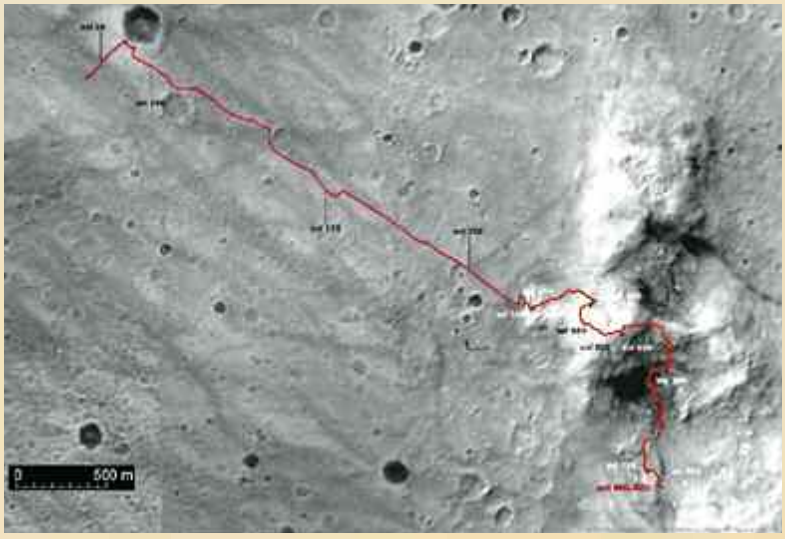
ars

by Jim Bell



Opportunity's Pancam captured this false-color view of a typical landscape in the plains of Meridiani on Martian day (sol) 869. Meridiani is one of the flattest places on Mars, and the beautiful but monotonous landscape is a treasure trove for scientists interested in the ways that wind and sand interact on the Red Planet today. The small sandy ripples that cover the plains are typically only 10 to 30 centimeters (about 4 to 12 inches) high, though some are deeper. Several of these sandy ripples have trapped the rover for days or weeks at a time during its traverse south.
Image: NASA/JPL/Cornell

Left: The area that Opportunity traversed on its way to Victoria crater is shown on this image of the enormous depression taken by the Mars Orbiter Camera (MOC) on Mars Global Surveyor. A blue dot indicates Cape Verde and a red dot, Cabo Frio. These two points mark the extent of the crater visible from the rover's position on September 20, 2006, its 945th sol. The green dot shows Duck Bay, a location that allows a view to the other side of the crater. The yellow lines that surround and cross within Victoria are used to measure the crater and the distance to the far "bays." North is up in this view. Victoria crater is about 800 meters (half a mile) in diameter. *Image: NASA/JPL/MSSS*



Right: This map shows Spirit's path during more than 1,000 sols in Gusev crater. Spirit is currently "parked" for the rest of Mars' winter at the location marked "sol 805-825" on this traverse map. *Image: NASA/JPL/Cornell*

the images and other data before suggesting new activities. Sometimes the data arrive literally at the start of the kickoff meeting, however, and we scramble to react to the latest findings. It can be hectic, but it also can be very valuable to have this kind of flexibility in the mission. It helps keep us all excited about the exploration aspect of these missions: many times, we won't know what we're going to be doing that day with a rover until we see the results from the day before.

After the day's Pancam planning meeting, we convene a virtual gathering of scientists and engineers from around the world to come to a consensus on what specific activities to do with the rover that next sol. This is called the Science Operations Working Group (SOWG)

Looking north from Duck Bay, the promontory Cape Verde is visible. The dramatic cliff of layered rocks is about 50 meters from the rover and about 6 meters tall. This false-color view, enhanced to bring out details within the shadowed regions, is composed of images taken by the Pancam on* Opportunity *on September 28, 2006 (sol 952).

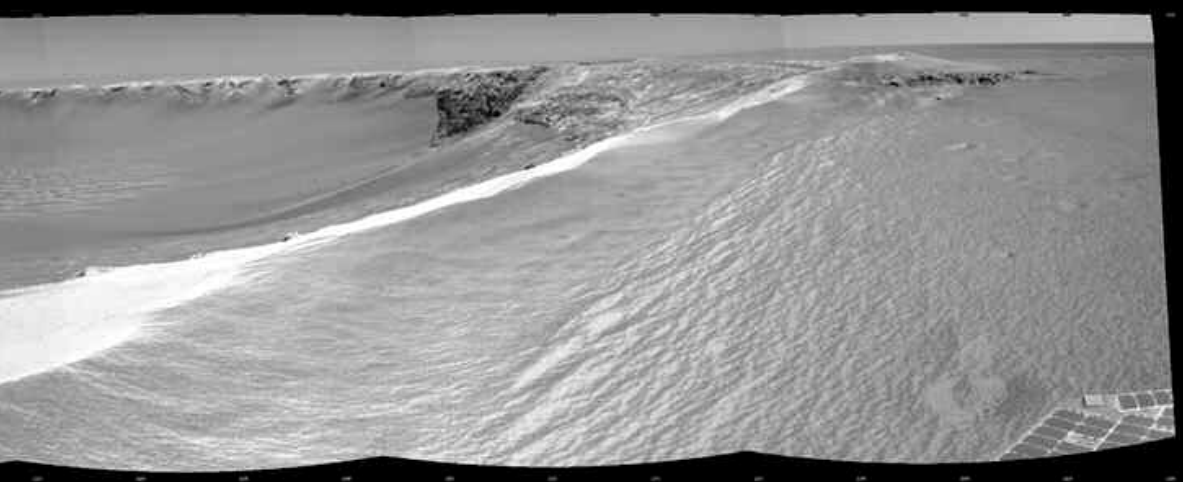
Image: NASA/JPL/Cornell

meeting. It's a give-and-take among scientists and engineers to fill every moment of rover time on Mars with useful science functions or necessary engineering, rover maintenance, or driving activities, and to cram as much information as possible into the available downlink. It's also a give-and-take between different scientists—geologists, mineralogists, atmospheric scientists, and others—lobbying for specific observations or campaigns. Fortunately, we all get along quite well on our team, and these "bit battles" are usually cordial.

The SOWG meeting usually takes about an hour, and when we've outlined a basic plan for that day that fills all the available resources and that the engineers and mission managers agree is doable and does not compromise the health and safety of the rovers (or the team!), then the meeting is adjourned. For much of the rover team, that's the end of the day, and the next step is waiting for the data to come down to start the cycle again the next day.

For those of us responsible for instrument operations, however, that's just the beginning. I like to describe what comes out of the SOWG as sort of an index card version of the rover's next sol, with one pithy line of text describing every activity (e.g., Drive, Deploy Arm, Acquire Panorama). Our job at Cornell is to take every line on the index card that pertains to the Pancam and expand it into the detailed instructions that point the cameras and acquire the images, then to send those instructions to JPL so they can be converted into spacecraft language and transmitted to the rovers by the engineering team. There are similar groups around the world (in the U.S. in Flagstaff, Phoenix, Manhattan, Houston, Pasadena, and in Germany, Canada, and elsewhere) doing the same thing for other instruments and systems on the rover. It's a great example of truly distributed spacecraft operations.

This part of the job for Pancam can take anywhere from one to eight hours, depending on the complexity of the sol being planned (or, on Fridays, the three sols being planned to cover Saturday, Sunday, and Monday on



On September 28, 2006, **Opportunity** *edged closer to the top of Duck Bay at the rim of Victoria crater and got its first full view of the crater. The rover's navigation camera took the seven exposures in this mosaic view of the crater's interior. The rim of Victoria is composed of alternating promontories—rocky points towering approximately 70 meters (230 feet) above the crater floor—and recessed alcoves, such as Duck Bay. The bottom of the crater is covered by sand that has been shaped into ripples by the Martian wind.*
Image: NASA/JPL-Caltech

This annotated portion of our cover image shows Duck Bay, the eroded segment of the crater rim where **Opportunity** *first arrived at Victoria, and Cape Verde, another promontory to the north. This picture shows* **Opportunity** *itself, its wheel tracks in the soil behind it, and the rover's shadow, including the shadow of the Pancam's mast. After this image was taken,* **Opportunity** *moved to the very tip of Cape Verde to perform more imaging of the crater's interior.*
Image: NASA/JPL/University of Arizona

Earth). Most of the Pancam work is done by a dedicated staff of Payload Uplink Leads (PULs), and they are supported by programmers, documentarians, graduate student and staff image analysts, and a gang of Cornell undergraduates who calibrate the Pancam images every day. Sometimes the PULs work until 7:00 or 8:00 p.m. East Coast time to finish the job, delivering the camera instructions to JPL engineers for validation and integration with the activities from other instruments before they send the final commands to the Deep Space Network to be radioed up to the rovers.

It's painstaking work, being done by some of the most intelligent, dedicated, and meticulous people with whom I have ever worked. I know they appreciate the rewards: having the privilege and quiet pride of being the "cameramen" behind the incredible color pictures being shot by *Spirit* and *Opportunity*.

As I've described in a new coffee-table book I've written titled *Postcards from Mars* (Dutton/Penguin 2006), once in a while in this process we have the luxury of thinking like real photographers when designing an imaging sequence or processing the data afterward. That is, sometimes we can think about things like the lighting, framing, depth of field, and color balance—things that landscape photographers think about all the time. The amazing longevity of the rovers, the unexpectedly large amount of downlinked data that we've been able to send back from Mars, and the flexibility of our instruments and mission operations scheme have all combined to allow us to be, in a sense, the first "photographers" on the Red Planet.

I've described how the Mars rovers' distributed operations process works today. For the first few months after we landed on Mars, this whole process was done on "Mars time" at JPL, and it sometimes used to take more than 12 to 15 hours from start to finish. Now that the team has become so adept, after more than 2,000 combined sols on Mars between the two rovers (and no one knows how many more are to come), and the software tools have been refined and optimized, a typical sol's planning cycle might take more like six to nine hours,

This false-color mosaic of Pancam images from **Spirit** *shows sedimentary rock layers at Home Plate, south of Husband Hill. Scientists are trying to figure out if these altered rock layers are the result of volcanic, impact, or other processes. If these are sediments from volcanic ash eruptions, for example, understanding details of their emplacement and modification may demystify the origin of the volcanic rocks and lava flows seen elsewhere in Gusev crater.* Mosaic: NASA/JPL/Cornell

and some days that might include two or three sols of activity rather than just one.

The rover team has made spectacular scientific discoveries during the past two and a half years, and we have settled into a now-familiar routine (as if operating rovers on Mars could ever be routine) of continued exploration and discovery. We have become engrossed with and consumed by Mars. Maybe that's why I can't remember what my normal day job used to be like!

Giving Away the Data

When I was a graduate student studying planetary science in the 1980s, there were very few active space missions to the planets. The *Viking* orbiters and landers had finished their work at Mars. The Soviet Union had sent orbiters and probes/landers to Venus and were turning their sights back to Mars and Phobos. They, and the Europeans and the Japanese, were sending probes to rendezvous with Halley's comet. The U.S. Halley observational space mission, and indeed most of the American space exploration program, was crippled with the loss of the space shuttle *Challenger* and her crew in 1986 (also delaying the shuttle-launched *Galileo* mission to Jupiter, which wasn't launched until three years later). It was a difficult and data-lean time for space exploration. It was no wonder that my graduate thesis research was based on telescopic observations rather than space mission data.

I had been lucky enough as a student to be invited to participate in the *Voyager 2* encounters of Uranus in 1986 and Neptune in 1989 (the former, as an undergrad at Caltech by my research supervisor, the late Ed Danielson, and the latter, as a graduate student at the University of Hawaii by one of my mentors, Fraser Fanale). "Participate" is a generous term. I was really just a gopher—running errands, making copies, going on late-night pizza runs for science team members—but it was still an incredible thrill just being there and watching the images come down, one by one, as each planet got bigger and bigger in the windshield. Of course, there was no Internet or World Wide Web; only a small number of people were privileged to see all the images as they came in, and the media were given hard copies of only a few of the "greatest hits" for the newspapers and the evening news.

Even as an observer, I found the experience amazing and inspiring. I also experienced for the first time, however, some much less inspirational and sometimes downright depressing examples of human behavior and team/media interactions. As a naïve young student, I was not prepared to see the greed, secrecy, anger, and just plain nastiness some scientists exhibited concerning access to, sharing of, and publication of their data.

Many team members had worked for years, or even decades, helping to get the mission approved. Then they had built, tested, and launched the spacecraft, which successfully flew by Jupiter and Saturn, then, two years later, Uranus, and finally Neptune years after that. Long waits occurred between bursts of data acquisition, but the data represented historic discoveries. The images and other data were prime material for *Science* and *Nature* articles, along with Ph.D. theses. Some people felt a sense of personal ownership of the data, which NASA embargoed for public release as proprietary. Using someone else's data for a publication or even showing a certain picture to a member of the media without permission could get a

Beagle crater, just a few hundred meters northeast of Victoria crater, appears to be one of the youngest craters in this region. This is evidenced by the blanket of jumbled, scattered blocks of ejecta; similar blocks have been completely eroded away from most other, older craters in Meridiani. Because we don't have age-dating tools on the rover, we can't tell how long ago an asteroid or comet crashed into Mars to create this big hole, and we don't know how quickly ejected material erodes away. Still, impact craters provide the only way for the rover to access the deep subsurface layers on this part of Mars, which is why studying craters has been a common activity for* Opportunity *since sol 1. *Image: NASA/JPL/Cornell*

person in a lot of trouble.

To be fair, most of the people I met on the *Voyager* team were not like this (quite the contrary, in fact), but the bad apples gave the whole experience a sour aftertaste. I vowed to remember and learn from this experience. There must be a better way.

I graduated and matured, and before I knew it, I found myself in charge of the high-tech Pancam color cameras on the two rovers being sent to Mars. One day I spoke with rover science team leader and Cornell colleague Steve Squyres about the whole issue of sharing data. With my strong opinions about what we should do with the Pancam images, I was braced for a possible fight with Steve about my crazy ideas.

I told him how profoundly my attitudes were influenced by the team interactions that I witnessed on *Voyager* as a youngster. As it turned out, Steve and I were on the same page, as he'd witnessed and also been disturbed by similar experiences earlier in his career. We both wanted to give all the images away, sharing them in as close to real time as possible, with no restrictions, embargoes, or proprietary data periods. Fortunately, most of the rest of the rover science team felt similarly.

We found more challenges working with the JPL team to implement this idea. Many people's first reaction was disbelief, based either on previous mission experience or on the expectation that we would want to hoard the data, slowly leaking out a "greatest hits" image here and there but saving the best for press conferences or splashy science papers. We replied that what we wanted was that when images were decoded at JPL from the radio signals the rovers sent from Mars, a computer program would automatically generate a JPEG version of every one, and that these images would be posted quickly on a publicly accessible website. That's exactly what happened, at the sites *marsrovers.jpl.nasa.gov/gallery/all/spirit.html* and *marsrovers.jpl.nasa.gov/gallery/all/opportunity.html*. The JPL folks tell us that millions of people around the world have been accessing and downloading these and other images that we've posted. We're also posting near-real-time Pancam color images and panoramas on our own Cornell site at *pancam.astro.cornell.edu*.

The Mars rovers aren't the only space missions sharing their images like this. The *Cassini* orbiter imaging team is doing it too, with images of Saturn and its moons at *saturn.jpl.nasa.gov/multimedia/images/raw/*. Both the rovers and *Cassini* have expanded on the data-sharing efforts of previous investigations and teams. For years, the prolific *Mars Global Surveyor* Mars Orbiter Camera team at Malin Space Science Systems has posted a spectacular "Picture of the Day" feature (with a caption!) from Mars at *www.msss.com/mars_images/moc/*. Previously, the *Near Earth Asteroid Rendezvous* Multispectral Imager team posted an asteroid 433 Eros Image of the Day from 2000 to 2002 at *near.jhuapl.edu/iod/v1.html*.

Maybe this is a new trend: share all your pictures. I think it's unfortunate that all space exploration missions don't share all their data as quickly. Heck, it's (partly) my tax dollars at work, too! Maybe other science teams can be talked into joining the fun.

Some of our colleagues think we're fools to be posting all the rover images online in real time ("You're giving your data away!"). It is true that we have been "scooped" a few times on scientific papers or media stories by peo-

This is part of the enormous "McMurdo" panorama that Spirit*'s Pancam acquired between sols 814 and 929. The rover's power has been too low during the winter for* Spirit *to drive (because it is solar powered), so instead the rover team has spent more than six Earth months measuring the chemistry and mineralogy of rocks and soils at Winter Haven, where* Spirit *is parked. The team also has acquired a super-high-fidelity, 360-degree panorama using all of the Pancam's color filters. Once spring returns and* Spirit *can drive again, many on the team want to go back and study some of the bright, enigmatic, sulfur-rich soils exposed by the rover's wheels.*

Image: NASA/JPL/Cornell

ple who use these instant images to get a quick result into the press, sometimes without involving or even crediting anyone on the rover team. Some people get defensive or have their feelings hurt when this happens (it's only human nature), but it's not the worst thing in the world. Worse would be for these fabulous images not to be exposed to a wide audience.

After all, we're collecting the data for everyone, not just ourselves and a small scientific community. Indeed, getting scooped by a colleague now and again is a small price to pay to allow so many others—kids, teachers, bloggers, space enthusiasts, laypeople, even members of Congress—to be able to follow along in near real time and to be a part of this amazing, continuing Martian adventure. I feel that all of us involved in space exploration are privileged to have been entrusted with taxpayer dollars to do the best possible science. We have an obligation to share both our successes and our failures openly and honestly with the general public.

Explore More:

JPL's Mars Rovers Site
http://marsrovers.jpl.nasa.gov

Cornell Pancam Site
http://pancam.astro.cornell.edu

All MER Raw Images
http://marsrovers.jpl.nasa.gov/gallery/all/spirit.html
http://marsrovers.jpl.nasa.gov/gallery/all/opportunity.html

Jim Bell, a member of the Board of Directors of The Planetary Society, is a planetary scientist and professor of astronomy at Cornell University in Ithaca, New York, and is the lead scientist for the Mars Exploration Rover Pancam investigation. This article is based on some of Jim's entries as a guest blogger for the Society's website at planetary.org/blog.

World Watch

by Louis D. Friedman

Washington, D.C.—The trouble with writing for print media is that you have to finish your column weeks before your readers receive it. As I write this, I do not know the results of the midterm congressional elections, but as you read it, you know whether the Democrats or Republicans won control of the U.S. Congress.

If the Democrats won, most of the next few months will be spent planning the reorganization of Congress, setting a new agenda, and changing control and membership of committees, including those that have power over the U.S. space program.

If the Republicans won, then there is a chance—but only a chance—that Congress will act this year on the fiscal year 2007 budget request for NASA. When Congress adjourned before the elections, the House of Representatives had passed a NASA appropriations bill, but the Senate had not. The Senate Appropriations Committee had not even considered the bill passed by its Subcommittee on Commerce, Justice and Science.

The House-passed budget bill contains the same approximate total as the administration requested, but it reallocates funds in favor of science, including the Europa mission new start, which The Planetary Society advocates. The Senate subcommittee, on the other hand, did not address the science issue specifically but passed an amendment increasing NASA's overall funding.

The amendment, introduced by Senators Barbara Mikulski (D-MD) and Kay Bailey Hutchinson (R-TX), provides an emergency supplement to NASA to pay for space shuttle repairs and modifications made after the *Columbia* accident. If those funds are given to NASA, then the agency will not have to raid science programs to pay for the shuttle, as it plans to do over the next four years' budgets. The Planetary Society strongly supports this amendment, although we are not sanguine about its chances for acceptance by the full Congress.

Whatever differences there are between the House and Senate after the Senate passes its appropriations bill, they will be resolved in a House-Senate conference and then will be subjected to another congressional vote before being sent to the president for signature. Most observers do not expect this to occur until early next year—more than three months into the fiscal year. Because of larger national budget issues, there is also some chance that, when the full Congress acts, it could make additional changes—usually this means cuts—to NASA funding.

Before Congress adjourned, it did pass a continuing resolution allowing federal agencies to continue to operate. When Congress reconvenes, it is possible that all remaining federal government appropriations will be rolled into a single omnibus bill. What language will accompany that bill, or the NASA final appropriations, will be the subject of negotiations among all the interested parties in Congress and in the administration.

Meanwhile, Representative Sherwood Boehlert (R-NY), the chair of the House Science Committee, is retiring. In late September, he opened a hearing with the following comment: "Let me start by reiterating my support for the President's Vision for Space Exploration, which I think is an important national undertaking. And let me also reiterate my determination that NASA not become a single-mission agency; human space flight can't succeed at the expense of Earth science, space science, and aeronautics."

We concur.

Venus—Venus is getting some well-deserved attention from robotic explorers. The European Space Agency's (ESA) *Venus Express* is now returning results from an orbit above Earth's "sister" world. Its measurements of the atmosphere could be critical to understanding global climate change on both worlds. The mission is another planetary success for ESA, which conceived, approved, built, and flew the mission in less than three years.

Japan is planning a Venus climate orbiter, targeted to launch in 2010. Called *Planet-C*, this mission will complement the *Venus Express* mission with additional observations of the planet's atmosphere and environment.

One of three missions just selected for concept studies as part of NASA's Discovery program is the *Vesper* mission, a Venus chemistry and dynamics orbiter designed to advance our knowledge of the planet's composition and dynamics. The other new missions selected for concept studies included an asteroid sample return mission and a mission to study the lunar interior.

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

Questions and Answers

Mars' Olympus Mons is reported to be between 22 and 29 kilometers (14 and 18 miles) high. Your November/December 2005 issue states that the tallest mountain on Venus is 11 kilometers (7 miles) high. The highest mountains on Earth are just over 8 kilometers (5 miles) in height. But these comparisons may not be appropriate, as we measure from sea level. On worlds without liquid, how is a comparable "sea level" determined? If Earth were waterless, how tall would Mt. Everest be to an alien explorer?

—Marc S. Williams
Salt Lake City, Utah

Sea level on Earth is one example of an *equipotential surface*, or a surface where the gravitational potential has a constant value. The importance of an equipotential surface is that it requires no energy to move around on it, and a line perpendicular to the surface defines the direction of gravity. Consequently, fluids on the surface of a planet will flow until they become an equipotential surface. In other words, if you are in a rowboat in the ocean on a wind-free day, then you will not feel like you are rowing uphill if you go in one direction and downhill if you go in another.

The shape of an equipotential surface around a planet is determined by its distribution of mass. As one might guess, for the planets this is a predominantly spherical

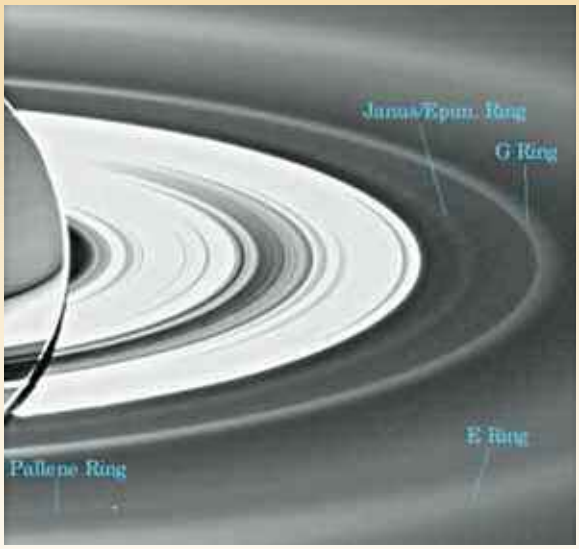
Factinos

Cassini scientists discovered two new rings around Saturn and confirmed the presence of two others during a recent and unprecedented viewing opportunity (see image below). The new rings are associated with one or more small moons and share their orbits with the satellites. Scientists suspect a moon is lurking near a third ring.

"Just like the old maxim that says 'where there's smoke, there's fire,' at Saturn, where there's a new ring, there's bound to be a moon," said *Cassini* team member Jeff Cuzzi, of NASA's Ames Research Center.

Under the cover of Saturn's shadow in mid-September, the entire ring system became visible, and never-before-seen microscopic particles began to appear. The researchers found a single, faint new ring at the orbits of two moonlets, Janus and Epimetheus. They detected a second ring a week later. It is narrow and overlies the orbit of the tiny moon Pallene, which *Cassini* discovered back in 2004. A third and fourth ring are visible in the Cassini division, the big gap in Saturn's main ring system. Curiously, these rings were not seen in images from the *Voyager* spacecraft.

—from the Jet Propulsion Laboratory



This* Cassini *image, acquired while the Sun was almost directly behind Saturn, reveals a previously unknown faint ring of material coincident with the orbit of the small moon Pallene. Another new, diffuse ring is aligned with the orbits of the tiny moons Janus and Epimetheus. The new Pallene ring is a faint narrow band, about 2,500 kilometers (about 1,550 miles) across, between the E ring and the G ring. The Janus/Epimetheus ring is visible between the G ring and the bright main rings, and it is about 5,000 kilometers (3,100 miles) wide. This viewing angle makes microscopic, icy ring particles brighten substantially. *Image: NASA/JPL/Space Science Institute*

A bonanza of 16 extrasolar planet candidates has been discovered orbiting a variety of stars in the central region of the Milky Way galaxy.

Kailash Sahu of the Space Telescope Science Institute in Baltimore and his team hit the planetary jackpot during a Hubble Space Telescope (HST) survey, called the Sagittarius Window Eclipsing Extrasolar Planet Search (SWEEPS). The team looked farther than has ever successfully been searched for extrasolar planets, using HST to look at 180,000 stars in the crowded central bulge of our galaxy 26,000 light-years away. That is one-quarter the diameter of the Milky Way's spiral disk. The team's results appeared in the October 5, 2006 issue of *Nature*.

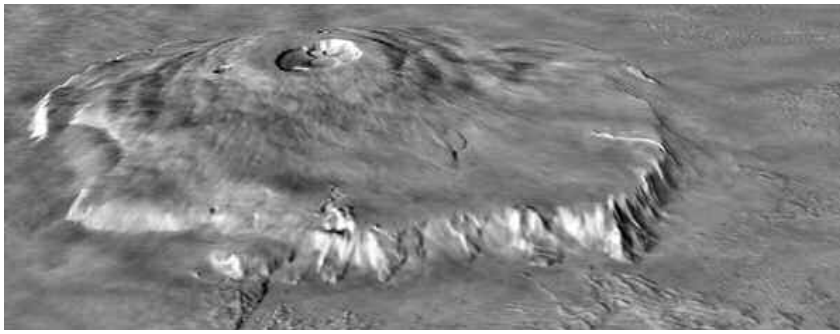
Five of the newly discovered worlds rep-

shape, but there are deviations from a sphere on a variety of scales. For Earth, the major deviations are due to the flattening caused by its rotation, and this results in a difference of 21 kilometers (13 miles) between this planet's radius at the equator and its radius at the poles. On Earth, there are additional deviations of tens of meters that occur at lengths on the scale of hundreds of kilometers. Thus, a person who sails great distances on the oceans actually will move substantially upward or downward relative to Earth's gravitational center.

Elevations on all the planets are defined relative to an equipotential surface that has been described to varying levels of precision. In most cases, elevations are measured relative to an ellipsoid defined by the average radius of the planet's solid surface along with a correction for rotational flattening. On Earth, sea level is a readily identifiable and convenient equipotential surface to use, but sea level is a few kilometers higher than if we picked a surface that evenly divided the solid surface area above and below the planet's ellipsoid.

Relative to an equipotential surface, the high and low points on Venus and Earth each are separated by around 20 kilometers (about 12 miles), but the separation on Mars is about 30 kilometers (about 19 miles) from the top of Olympus Mons to the bottom of Hellas basin. Despite a similar range of elevations, Venus is generally considered flatter than Earth because 80 percent of its surface resides within 500 meters of the planet's mean radius.

—ROBERT HERRICK,
University of Alaska, Fairbanks



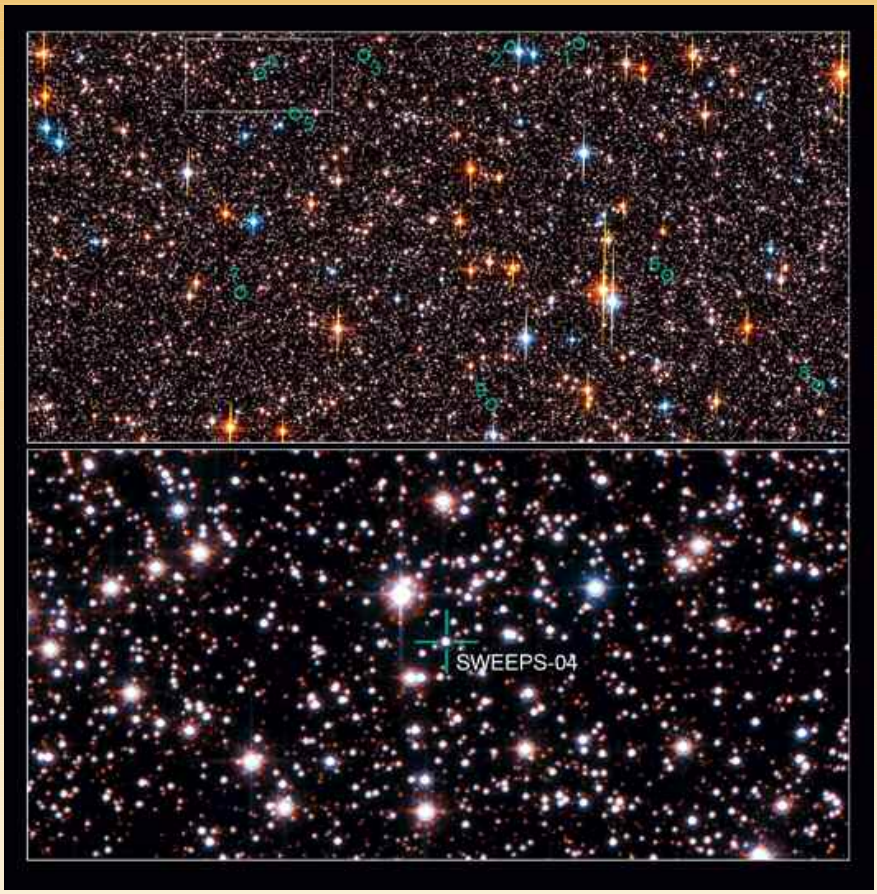
The distance between the top of Olympus Mons, Mars' highest point (seen here), and the bottom of Hellas basin, its lowest point, is about 30 kilometers (19 miles). *Image: NASA/MOLA Science Team*

resent a new extreme type of planet not found in any nearby searches. Dubbed Ultra-Short-Period Planets (USPPs), these bodies whirl around their stars in less than one Earth day.

"Discovering the very short-period planets was a big surprise," said Sahu. "Our discovery also gives very strong evidence that planets are as abundant in other parts of the galaxy as they are in our solar neighborhood."

The team used Hubble's Advanced Camera for Surveys to search for planets by measuring the slight dimming of a star resulting from the passage of a planet in front of it, an event called a *transit*. The planet would have to be about the size of Jupiter to block enough starlight, about 1 to 10 percent, to be measurable by HST.

—from the Space Telescope Science Institute



The image at top shows half of the Hubble Space Telescope's (HST) field of view in the Sagittarius Window Eclipsing Extrasolar Planet Search (SWEEPS). The telescope took approximately 520 pictures of this field, at red and blue wavelengths, between February 22 and 29, 2004. Here HST was looking across 26,000 light-years of space in the direction of the center of our galaxy. Half of these stars are bright enough for HST to monitor for transit events—the small, brief, and periodic dips in brightness caused by the exoplanet passing in front of its star. The green circles identify nine stars that are orbited by planets with periods of a few days. Planets so close to their stars with such short orbital periods are called* hot Jupiters. *The HST observations allow for a robust statistical estimate of the possible false positives, which suggests that at least 45 percent of the candidates must be genuine planets. The bottom frame identifies one of two stars in the field where scientists were able to spectroscopically measure the star's back-and-forth wobble due to the pull of the planet. This planet is less than 3.8 Jupiter masses. *Image: NASA, ESA, K. Sahu (STScI), and the SWEEPS Science Team*

Society News

Special Members-Only Discount!

Autographed copies of Sally Ride's newly revised book, *The Mystery of Mars*

Sally Ride Science is pleased to offer members of The Planetary Society copies of the newly revised *The Mystery of Mars*, signed by Sally Ride, for $18.75, a 25% savings.

In *The Mystery of Mars*, pioneering astronaut Sally Ride and noted science writer Tam O'Shaughnessy draw on results from the most recent missions to Mars to present a comprehensive overview of Earth's nearest planetary neighbor. With its thin atmosphere, rocky canyons, extinct volcanoes, and icy polar regions, Mars has many things in common with Earth. It's possible that water once flowed over its surface and that life may have begun there. Comparing the two planets' evolution, geology, and geography, the authors explain what we know about Mars today—and what we hope to learn about Mars in the future, including whether primitive life does exist somewhere beneath its barren surface. With lavish color photographs, this engaging and accessible introduction to the Red Planet is the ideal guide to a new age of Mars research.

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—Jennifer Vaughn, Director of Publications

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Have a special interest in one of our projects? Your gift—large or small—will make a difference. Again, you can donate online or by mail, and you can designate the project or program that piques your interest.

You might also consider donating your appreciated stock to fuel the Society's work to explore worlds beyond our own.

No matter the size, your gifts make a difference. Together, we are shaping space exploration.

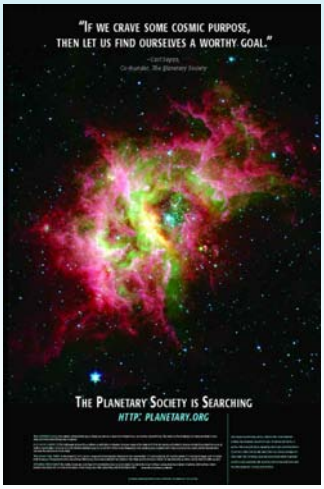
Thank you, and best wishes from all of us for the coming year!

—Andrea Carroll, Director of Development

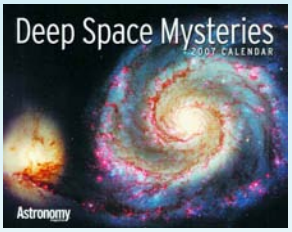
Enjoy the Wonders of the Cosmos!

***Spirit*'s View at Bonneville Crater Poster** On January 3, 2004, *Spirit*, the first of two complex rovers, hurtled toward the Martian atmosphere and bounced down onto the dusty surface. Sixty-seven days after landing, it reached the raised rim of Bonneville and used its panoramic camera to capture this 360-degree view of its new surroundings.
10" x 39" 1 lb. **#350 $13.50**

Pale Blue Dot Poster
In February 1990, *Voyager 1* looked back at its home planet for the first time. The image of Earth as a tiny bluish dot inspired Carl Sagan to write one of his best-known essays, which starts off his book *Pale Blue Dot*. The poster features Carl's timeless words and the full frame of the profound image captured by *Voyager 1*.
12" x 30" **1 lb. #326 $10.00**



Nebula Poster
This awe-inspiring image from NASA's orbital Spitzer Space Telescope shows a false-color infrared view of nebula RCW 49—a birthplace for many hundreds of new stars and likely many thousands of planets. This stunning poster features one of Carl Sagan's poignant statements: "If we crave some cosmic purpose, then let us find ourselves a worthy goal." 22" x 34" 1 lb.
#315 $13.50



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On October 3, 2006, two subjects on another world—nature's awesome beauty and the Mars Exploration Rover Opportunity*—came together for this portrait. Here the power of space exploration to awe and inspire has been captured in a single image.*

The High Resolution Imaging Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter *took this close-up view of* Opportunity *perched on the rim of Mars' Victoria crater from an altitude of 275 kilometers (170 miles). Victoria, the rover's long-term destination for the past 21 Earth months, is an impact crater about 800 meters (half a mile) wide and 60 meters deep in Meridiani Planum, near the Red Planet's equator. Because Victoria is much deeper than any crater explored by* Opportunity *so far, its sedimentary layers will give the rover a chance to see further into Mars' ancient history. This is an enhanced-color view generated from images acquired by the HiRISE camera using its red and blue-green filters.*

Image: NASA/JPL/University of Arizona

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Pasadena, CA 91106-2301

PRINTED ON RECYCLED PAPER
Printed in USA