The PLANETARY REPORT

Volume XXIV Number 5 September/October 2004

A Halo of Moons

A PUBLICATION OF THE PLANETARY SOCIETY

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From The Editor

In this column, it seems like I nearly always write about either grand successes or gut-wrenching failures. Planetary exploration places such great demands on the people who carry it out that either type of outcome arouses great emotion in the people who cheer the missions on. We've been on such an emotional roller coaster the last few months with the spectacular success of *Cassini* at Saturn and the shocking crash of *Genesis* as it returned to Earth with its samples of the solar wind.

We always say that there is value in failure, for it points out mistakes that can be corrected and teaches us to be humble as we try to extend our reach beyond Earth. The people who explore planets are a very clever and resilient lot, and as we are seeing with *Genesis*, they are often able to pull a viable rabbit out of an extremely crumpled hat.

Among our own Planetary Society projects, we've had a disappointment in our search for vulcanoids, as you'll read in an upcoming issue. But we are recovering and moving on, looking forward to the impending launch of *Cosmos 1*, our solar sail, and to celebrating the arrival of the *Huygens* probe at Titan.

If we are serious about exploring the worlds around us, we can't be deterred by failure. And we won't be. Together, we shall push on.

—*Charlene M. Anderson*

On the Cover:

Saturn wears a halo of four moons in this Wide-Angle Camera image taken by *Cassini* on August 18, 2004. The satellites visible in this picture are (clockwise from upper left): Tethys, Dione, Enceladus, and Mimas. This portrait was captured in visible red light at a distance of 8.9 million kilometers (5.5 million miles) from the planet. This black and white image was colored blue and gold. To view the original image, go to *planetary.org/saturn/halo.*

Image: NASA/JPL/Space Science Institute

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Members' Dialogue

Robots or Humans?

I would like to raise the following points in reply to the "Make It Robotic" letters that appeared in the July/August 2004 issue of *The Planetary Report*.

Current robotic missions, as valuable as they are, cannot perform the same level (depth or breadth) of field research that a trained scientist could perform on location. Studies done on Earth comparing robotic field research with human field research (even in simulated space suits) show that the human-driven research is much more effective and complete.

Expansion of the human frontier beyond low-Earth orbit (again) is well overdue. As a child growing up in the 1960s, I was truly inspired to pursue a career in aviation because of the success of the *Apollo* program.

Someone said that human space exploration is "an act of faith and vision." We enjoy the freedom and prosperity we have today because our forefathers had the courage to risk their lives to open up new frontiers. By expanding the human horizon to the Moon and Mars, we are reaffirming our commitment to the pioneer spirit and opening up opportunities for our posterity.
—CARLOS GLENDER,
Cincinnati, Ohio

The three gentlemen writing in July/August's Members' Dialogue are the first evidence I've noticed of a movement away from human beings and towards human-monitored machines in space, as well as a recognition of our vulnerability to an impact from a near-Earth object.

As romantic as it is, human space travel is not the way to go for now. I believe we ought to first develop our nascent artificial intelligence, and then let it take us to the planets. Not until we must migrate our kind into space do we need to be there. And when that time comes, we will be much better equipped to do it—by virtue of what we will have learned, and will have developed—with our thinking machines.

Second, we must stop making planetary exploration our first priority. Its time will come, but to ensure that we are all here to do it we have more urgent business at hand. A devastating space object could impact Earth centuries from now, or next year. Until now we've enjoyed our ability to put our heads in the sand as long as there wasn't a chance we could do anything about it. But now we can consider doing something about it. Since the very survival of the species is at stake, we have no choice.

Some argue that such an approach to space will result in dehumanizing and demystifying the whole thing. Well, we got to the Moon, and it is no less awesome and thrilling a sight today. If machines born of our genius go out and function at our behest, we can be just as proud of our kind as we would be otherwise. The rovers on Mars are clear evidence of that, and that pride is not a bit less for their not having to pee now and then.
—JOHN EASTERLY,
Oklahoma City, Oklahoma

I read the letters in the July/August edition of *The Planetary Report* regarding the debate between crewed and robotic missions to Mars. Certainly both [types of missions] are valuable, but for different reasons. If the goal of the mission is to provide the most cost-effective data gathering ability—while eliminating the risk to human life—the robotic missions clearly have an edge. The recent spectacular successes on Mars show how valuable these efforts can be.

However, if the goal is to support the expansion of our ability to travel and live throughout the solar system, gathering data and skills in the process, then it appears only crewed missions will provide the hands-on experience base to do so.

Space exploration is costly, requiring continued political, and thus public, support. Crewed missions provide visibility for exploration efforts that even the most exceptional robotic missions do not. The need to send robotic probes into new and very hazardous places will continue. But, some of these places may be attractive for human exploration, and if the great explorations of the past are any guide there will be a line of volunteers competing for seats. Both technologies need to be pursued and funded, and I support The Planetary Society's efforts in these areas.
—JAY BRAKENSIEK,
Glendora, California

Please send your letters to
Members' Dialogue
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
or e-mail:
tps.des@planetary.org

We Make It Happen!

by Bruce Betts

The Search for Extraterrestrial Intelligence (SETI) has been actively pursued by the human species for more than 40 years . . . so why have we not found ET? In early August, The Planetary Society gathered major players in SETI, such as Frank Drake, Paul Horowitz, and Dan Werthimer, to address this question. In a scientific workshop titled "The Significance of Negative SETI Results," SETI experts, astrobiologists, and planet hunters discussed what's currently happening in SETI and what the future might hold. Here I review some of the broad conclusions, assumptions, and implications of the meeting.

Where Are We With the Search?

Rarely does the small SETI community get an opportunity to come together as a focused group. The first step of the workshop was to review what everyone there had done, was doing, and planned to do—and the accomplishments were impressive. When SETI started looking at radio wavelengths, people looked in only a few "channels" (think of different radio station channels). Now groups analyze billions of radio channels. Surveys of the whole sky have been completed around a few key wavelengths, and other searches have focused on a smaller number of stars with greater observing frequency or radio channel resolution. In addition, a whole new field of SETI has arisen in recent years: optical SETI. Whereas original searches focused only on radio frequencies, the invention of extremely high power lasers made several of the groups realize that laser communication across the cosmos could be very efficient.

Sam Gulkis leads a session at the Society's SETI workshop, while (left to right) Frank Drake, Kent Cullers, Paul Horowitz, and Andrew Howard look on.

Dan Werthimer, the principal investigator for SETI@home, discusses SETI techniques. Planetary Society SETI Coordinator Tom McDonough is at right. Photos: The Planetary Society

I could spend an entire issue of *The Planetary Report* reviewing even just the Planetary Society–funded searches. Lacking that space right now, we will be putting both summaries of the talks, written by the speakers themselves, and their PowerPoint presentations on our website. I encourage you to keep checking *seti.planetary.org* for updates.

The Cosmic Haystack

The workshop discussed how far we've come in SETI and how much computing power is now being brought to bear on all the SETI searches. But what are we to make of the fact that 40 years have yielded exactly nothing in terms of finding ET?

What became clear was that despite all the advances in SETI, we've only just begun to search. As it turns out, the cosmic haystack in which we are searching for the ET needle is enormous. First, you need to choose a wavelength—even if you concentrate only on looking in the electromagnetic spectrum (all forms of "light" including gamma rays, visible light, and radio waves), you still have to make a choice what you're looking for. Then there's space—you can process and search only so many places in a certain amount of time, and there is a lot of sky up there. Then, there is time—even if you are searching the whole sky, you are searching only a piece at a time, so what if you're not looking when ET is broadcasting? Finally, there have been hypothetical discussions of communication that, instead of using electromagnetic waves, uses something else such as gravity waves or particles or objects.

To be frank, we would have to have been really lucky to have found ET by now, even if there are lots of ETs out there broadcasting. And what if we're missing the boat entirely in the approaches we've taken? If ET is broadcasting at infrared or millimeter wavelengths, we haven't even been looking there, or not much. Why? Because a lot of this part of the electromagnetic spectrum is absorbed by our atmosphere. These wavelengths turn out to be efficient means to communicate across the cosmos, however, so perhaps using these wavelengths is very common for other civilizations. Space-based SETI, looking for signals from above the atmosphere, is an intriguing idea—one The Planetary Society plans to investigate further.

Humanity Is Quieting Down

There are interesting implications of the fact that our species has been quieting down in the electromagnetic spectrum. When SETI was starting out, there was quite a lot of "leakage" from Earth. Our TV and radio transmitters, and even defense radars, were putting out tens of kilowatts each, a good portion of which was spewed into space. But things are quieting down. Cable TV and satellite TV (which uses much less power) are starting to replace on-air broadcasting; defense radars have gone to "digital spread spectrum" technologies that, even if they do leak, are hard to discern from the noise of the universe. Even cell phone and other wireless technologies are focusing more on low power and on digital technology that uses lower power and requires clever work to decode.

If other civilizations follow a similar pattern—quieting down within decades after their invention of electromagnetic communication technologies—then leakage may be utterly impossible to detect as we search for ET. There was more optimism of leakage detection in the past. Now, most researchers think that detectable signals would be intentional beacons: ET sending out signals intentionally to let others know they are there.

Where Are We Going?

Although we've barely picked the surface of the haystack, we've come a long way in our capabilities in the last 40 years, and our capabilities are expected to expand massively in the coming decades, allowing us to churn through the hay faster and faster. Computing power is improving rapidly, telescopes are being built, and strategies are improving: life is good.

There's even more good news—extrasolar planets. The meeting included discussions of planet finding around other stars, led by Geoff Marcy, whose planet-hunting team has discovered the majority of extrasolar planets found so far. Their searches have many interesting implications and have taught us much about how normal or anomalous our solar system may be (see *planetary.org/extrasolar/* for more information). Estimates of the number of planets within our galaxy alone are at least in the tens of billions. That's a lot of places where one might tuck away some advanced ET who wants to broadcast its version of Planetary Radio to the universe.

The searches continue, and they continue to improve. We'll have lots more in *The Planetary Report* and on *planetary.org* about SETI searches and extrasolar planets. In addition to sponsoring SETI research, something that NASA still cannot legally do, The Planetary Society can put together special workshops like this one to facilitate advances in SETI. Searching for ET truly is looking for a needle in a haystack, but if we succeed, it arguably will be the most significant discovery in the history of our species. That's a very big prize. With your help, we'll continue the search. Will we find a signal from ET? I remain patiently but firmly optimistic.

Bruce Betts is director of projects at The Planetary Society

What's **Up?**

In the Sky

Total lunar eclipse: don't miss this event as the Moon passes through Earth's shadow. The center of the eclipse will occur October 27 at 8:04 p.m. PDT.

Partial solar eclipse on October 13/14 visible from Hawaii, Alaska, and many portions of eastern Asia.

Planet viewing is a predawn activity right now. Venus looks like the brightest star in the sky before dawn in the east. Saturn, looking like a bright star but much dimmer than Venus, is to Venus' upper right. Venus will appear very close (0.3 degrees or less) to the star Regulus (less than one hundredth as bright) on the morning of October 3. Jupiter will return to the predawn sky in October, starting very low on the horizon in the east and moving upward relative to Venus as the month progresses. On November 4, these two extremely bright starlike objects will be less than 1 degree apart. By then, the much dimmer Mars will start to poke up just above the horizon in the east.

Random Space Fact

The radio transmitters on the *Voyager* spacecraft use only 23 watts of power, about the same as a refrigerator light bulb, but they are able to communicate from billions of miles away thanks to clever communication schemes and big antennas on Earth.

Trivia Contest

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

What was the first spacecraft to image the far side of the Moon?

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, 2004. The winner will be chosen by a random drawing from among all the correct entries received.

Our March/April contest winner is James Groves of Savoy, Massachusetts.

The Question was: What is the largest moon (natural satellite) in our solar system?

The Answer: Ganymede. Its equatorial diameter of 5,262 kilometers (3,270 miles) is larger than Mercury's (4,880 kilometers or 3,032 miles) and Pluto's. It barely edges out Saturn's moon Titan (5,150 kilometers or 3,200 miles) for the title of largest moon.

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*.

Society News

**International.
Intercultural.
Interdisciplinary.
The International Space University Wants You!**

The Planetary Society is pleased to announce the 2005 Planetary Society Fellowships to the International Space University (ISU). We are proud to again partner with ISU to help shape the future of space exploration.

ISU develops the future leaders of the world space community by providing interdisciplinary educational programs to students and space professionals in an international, intercultural environment. Its programs—a 9-week summer session and two 11-month master's programs—impart critical skills essential to future space initiatives in the public and private sectors.

"I fully understand the responsibilities of participating in a program which might shape the future of humankind, and I will continue my efforts to live up to those goals," declared Eniko Patkos, 2004 Planetary Society ISU Fellow and counselor at the Hungarian Space Agency.

This sentiment is exactly what the Society hoped for when we established the Planetary Society Fellowship to the International Space University. It is a fitting tribute to our members whose support and donations have advanced both the Society and ISU's shared vision for the exploration of space in peace for all humankind.

This year the Society will award two of these competitive fellowships to offset tuition costs for either the 2005 ISU summer session in Vancouver, Canada or the 2005/2006 academic year master's program (in space science or space management) in Strasbourg, France. One fellowship is for $12,000 (US), and the other is for $9,000 (US).

For more information about the Planetary Society Fellowship to the International Space University, visit the Society's website at *planetary.org* or contact Linda Wong at *linda.wong@planetary.org* or 626-793-5100, ext. 236. Visit *www.isunet.edu* for more information about ISU and to download an application.

*—Andrea Carroll,
Director of Development*

**I Want My
Planetary Radio!**

Planetary Radio, our weekly space exploration program, is now available for download across the United States by your local NPR (National Public Radio) affiliate station.

Planetary Radio is the only half-hour public radio program in the United States devoted solely to space exploration. The best way to get Planetary Radio aired in your area is to ask for it. Call your local NPR station . . . and tell them "I want my Planetary Radio!"

The show will be downlinked weekly on the Public Radio Satellite Service satellite Tuesdays at 1:00 p.m. Pacific Time on Channel A67.7.

Of course, if it is not broadcast in your area, you can always listen to it on the Web at *planetary.org/radio*.

Planetary Radio aficionados everywhere, please join us in thanking New Millennium Committee Member Rena Shulsky! Ms. Shulsky generously provided the seed funding to launch our initiative to take Planetary Radio across the United States.

Thank you, Ms. Shulsky, and thank you to all of you listeners who want your Planetary Radio!

*—Mat Kaplan,
Planetary Radio Producer*

**Kudos to Our Dedicated
Volunteers Worldwide!**

Maybe you've seen a Planetary Society volunteer or two at an event in your hometown. Our volunteers around the world are a busy crew, and they are invaluable in sharing their own experience with the Society and encouraging new people to join as Members! In just the past couple of months, our volunteers have represented the Society around the globe:

- At Transit of Venus events in Norway and India
- At the University of Melbourne in Australia, with a lecture by Mikhail Marov, head of the Department of Planetary Physics and Aeronomy at the M.V. Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences
- With observers and explorers in Berkeley, California at AstroCon 2004, where Louis Friedman spoke about our *Cosmos 1* solar sail mission
- In Bagalkot, India with Space Expo celebrating the 35th anniversary of the *Apollo 11* Moon landing
- Again celebrating the 35th anniversary of the *Apollo 11* Moon landing at Splashdown '04 on the USS *Hornet* in Alameda, California
- Alongside Planetary Society staff during Operation: Space Weekend at LEGOland in Carlsbad, California
- At the Goddard Space Flight Center's Open House
- At the Table Mountain star party in Washington state

Thank you to all our hard-working volunteers and regional coordinators. You are a wonderful group of members to work with, and we appreciate the many new members you have helped bring into the Society! If you are interested in joining our growing volunteer network, please e-mail *tps.lb@planetarysociety.org*—we would love to hear from you and get you involved.

You can help us, too, by letting us know about future events in your community. Just e-mail me at *tps.vz@planetary.org*. Thank you for making my job fun!

*—Vilia Zmuidzinas,
Events and Project Coordinator*

Robots, Not Humans, on Mars

BY ANDREW P. INGERSOLL

As a professional planetary scientist and loyal longtime Planetary Society member, I have generally supported the positions taken by The Planetary Society on space exploration. I agree with the statement "The Vision Must Be Global," which is the title of a recent article by Louis Friedman, but I don't agree with the "Vision" as enunciated by President Bush and as reflected by the recent reorganization of NASA.

Sending humans to Mars is like building the Space Station. International or not, there is no clear reason to do it. The time may come, but it's not here now. Rushing into the truly big things tends to jeopardize the small and medium things, which in this case are the near-term high-priority missions, based on their low cost, low risk, and high probability of successful science return.

In 2003 the National Academy of Sciences completed a study titled "New Frontiers in the Solar System: An Integrated Exploration Strategy." NASA had requested the study, which was modeled on the traditional astronomy and astrophysics decadal surveys. The survey recommended a balanced mix of small, medium, and large missions that included targets like the Kuiper belt and Pluto; the Moon's South-Polar Aitken Basin, which is the solar system's deepest crater; the deep atmosphere and interior of Jupiter; the surface of Venus, Earth's hellish sister planet; sampling the surface of a comet and bringing it back to Earth for organic analysis; a Mars science laboratory; and a Mars long-lived lander network. These were the medium-sized missions. The large (flagship) missions include a Europa geophysical explorer to seek the nature and depth of the ocean, and a sample of Mars returned to Earth to search for life and develop chronology. These are exciting missions that promise to answer fundamental questions about the origin of the solar system, the distribution of volatile elements in the solar system, the conditions that led to the origin of life, and the possibility that life might have evolved on more than one planetary body.

My fear is that a gap is opening up that will lead to an unbalanced program and a delay in these wonderful missions. The gap is a cost gap, but it is also a schedule gap and a risk gap. The medium missions are a factor of 2 more costly than the small missions, and they launch half as often. There is another factor of 2 between the Flagship missions, as envisioned in the decadal survey, and the medium missions. That is a healthy mixture. When you know how to do something well, you can usually scale it up by a factor of 2 and do that thing well too. It's much more difficult and risky to scale things up by factors of 10 or 100. Yet that is where NASA will be headed if we try to implement the "Vision" of sending humans to Mars too soon. We won't know enough about the destination to know where to go, we won't know why we're going there, and we won't know how to build a vehicle that will get us there safely.

To guide the decadal survey, The Planetary Society polled those in the general public who have a particular interest in planetary exploration for their opinions about the ultimate purpose of the US space program. The three most frequent responses, with roughly equal numbers, were scientific exploration, determining suitability for human exploration, and looking for dangers to Earth from space. I like those responses, and I think The Planetary Society should flesh them out: hold a debate on why we should explore Mars (science, national pride, international cooperation, or human destiny—whatever that is) and how best to do it (robotic spacecraft or humans). Perhaps rephrase the "how" question into a "when" question: when will it be appropriate to shift from robotic spacecraft to humans? I think it is too early for humans. I also think science has to be the driver for a long time into the future. I wish Lou Friedman had written an article entitled "Science Must Provide the Vision."

Andrew P. Ingersoll is Earle C. Anthony Professor of Planetary Science at the California Institute of Technology.

LINKS TO NASA'S VISION FOR SPACE EXPLORATION AND THE SOCIETY'S AIM FOR MARS! CAMPAIGN

http://planetary.org/aimformars/learnmore.html

"The Vision Must Be Global," by Louis D. Friedman
http://www.planetary.org/aimformars/friedman_oped2.html

"New Frontiers in the Solar System: An Integrated Exploration Strategy"
http://www.nap.edu/catalog/10432.html?onpi_newsdoc071102

Public Survey for Input to the Planetary Decadal Survey
http://www.planetary.org/html/survey/survey_results.htm

We will continue this debate in the pages of The Planetary Report and on our website, *planetary.org.* Let us know what you think! Is it time to take on the challenge of sending humans to Mars, or should we focus our resources on sending robotic explorers to learn more about our solar system? Send e-mail to *planetaryreport@planetary.org* or write to us at The Planetary Report, 65 North Catalina Avenue, Pasadena, CA 91106-2301.

OUT OF THIS WORLD BOOKS

Mars: The NASA Mission Reports, Volumes 1 and 2

Edited by Robert Godwin
Apogee Books: Volume 1, 424 pp.; Volume 2, 415 pp.

These books are for Mars exploration completists. Editor Robert Godwin draws the greatest part of his source material for the two volumes of *Mars: The NASA Mission Reports* from press releases and press kits released to the media by NASA and the European Space Agency. The background information included in the prelaunch and prearrival press kits for each mission represents a series of snapshots in time of our understanding of Mars' present conditions and geologic history.

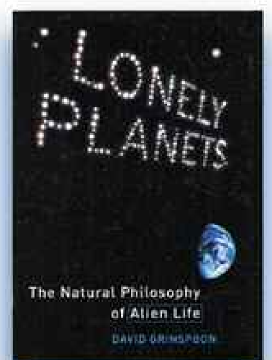
Reading these background reports, you can watch a vision for the future of Mars exploration—and a rationale for exploring there—evolve over time. One exemplary change: the press kit for *Mariner 6* and *Mariner 7* states that among the mission goals, the observers "will not determine the presence of life on Mars but will help establish whether or not the Martian environment is suitable for life." That same sentence could be present in a press kit for next year's *Mars Reconnaissance Orbiter* launch—with the verb tense changed, from "is suitable for life" to "was suitable for life."

Volume 1, published in 2000, covers the *Mariner*, *Viking*, *Mars Observer*, *Mars Pathfinder*, *Mars Climate Orbiter*, *Mars Global Surveyor*, and *Mars Polar Lander* missions. The materials included in this volume are a treasure trove of information about NASA's early Mars exploration efforts, much of which is not available on the Internet. All of the black-and-white diagrams, drawings, and tables are faithfully reproduced; even better, they are reproduced in line with the corresponding text, rather than being relegated to a block of plates elsewhere in the book. For the *Mariner* missions, NASA reports on "Mission Results" are also included. From *Viking* onward, though, any report on "Mission Results" would encompass too much information to fit in this already crammed volume. A CD-ROM with images and movies is included.

Volume 2, published in 2004, includes information released to the press on *Beagle 2*, *Mars Odyssey*, and the Mars Exploration Rovers. A DVD-ROM with images and movies is included. Unlike the older *Viking* and *Mariner* press information in Volume 1, the documents in Volume 2 are mostly readily available on the Internet, although that may not remain true forever. But the coverage of the Mars Exploration Rover and *Mars Odyssey* missions in *Mars: The NASA Mission Reports* has an advantage over that on the Internet: the editor has printed all the images released to the press in order, with their corresponding press releases in high-quality, glossy color. (Planetary Society members may enjoy checking pages 255 and 262 for color images of the Red Rover Goes to Mars DVD on the *Spirit* lander.) The lovely images make the book a valuable tool for browsing the accomplishments of the first weeks of the *Spirit* and *Opportunity* missions to Mars, up to Sol 47 for *Spirit* and Sol 29 for *Opportunity*. Color images are also included for some key *Mars Odyssey* press releases, such as that for the discovery of subsurface water.

What makes Volume 2 great is the inclusion of "Planetary Missions Study Task T2A600," a study performed by NASA in 1967 about the possibility of manned missions to Venus and Mars. One mission proposed in this study would have taken three astronauts on a two-year mission including flybys of both planets! One shakes one's head in wonder at the optimism and naïveté of the NASA planners who wrote this document before they had even landed men on the Moon. Copious diagrams show spacecraft designs that are intended to be modular, to be usable for multiple missions, and to have the potential to evolve into spacecraft for manned landings on Mars. It seems that in 1967, anything was possible.

—Emily Stewart Lakdawalla,
Science and Technology Coordinator



Lonely Planets

David Grinspoon
Ecco: 440 pp.

Lonely Planets is a fun book to read. The author, a planetary scientist who previously wrote an excellent book about Venus, has a breezy and irreverent style of writing that engages the reader. At times the breeziness turns to flippancy, which is OK if you agree with the author's flip.

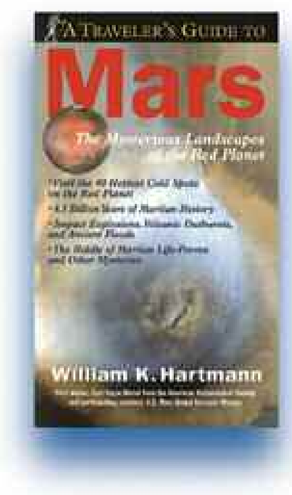
The book is subtitled *The Natural Philosophy of Alien Life*. Grinspoon does a terrific job putting the studies and theories of alien life into both their scientific and nonscientific contexts. The new hot topic in space science is astrobiology, a subject that wags (like me) like to say is a subject without subject matter. If you want to know what astrobiology is, why it is the new hot topic, how it guides planetary exploration today, and where the key questions lie, then *Lonely Planets* is for you. You'll read through it as you would a good historical novel—dealing with fact and fiction simultaneously. It contains history, biology, physics, and astronomy—and, as stated, a lot of philosophy.

The search for extraterrestrial intelligence (SETI) is covered well in this book (although Grinspoon manages not to mention The Planetary Society, which has supported more scientific searches than any other organization, governmental or nongovernmental, in the world). The search is the province of science and of pseudoscience, and Grinspoon recognizes that assumptions and principles of each are often shared. He is a SETI enthusiast, even though he clearly struggles to find a reason why that is better than "gut feeling." The case for intelligence (whatever that is) being ubiquitous in the universe and the case for it being rare are each well made. Grinspoon, invoking a lot of philosophy, comes out in favor of the former.

The book, both in title and in a fair portion of its content, is a response to *Rare Earths*, the controversial book by Brownlee and Ward. Of them, he says, "They make several crucial errors." But to refute them, he needs to invoke Gaia, a provocative and controversial idea that makes a planet itself part of the living system.

This is what makes the book so enjoyable—mixing ideas, insights, and investigations into a look at the most interesting subject outside ourselves: life elsewhere.

—Louis D. Friedman, Executive Director



A Traveler's Guide to Mars

William K. Hartmann
Workman Publishing: 468 pp.

Perfect. That is the only word to describe this book. It gives the reader a perfect understanding of what was known about Mars on the eve of the current multinational outburst of Martian exploration, with the European Space Agency's *Mars Express* in orbit, two American rovers on the surface, and the continuing orbital operations of *Mars Global Surveyor* and *Odyssey*.

In 468 pages packed with scientific discussion, lively anecdotes, splendid images, and guiding opinion, Bill Hartmann tells us about the history of human learning regarding Mars. Among the chapters describing how scientists have unraveled the planet's story, come to consensus about some ideas, and engaged in energetic debate on others, Hartmann inserts an account of his own life as a lunar and planetary scientist.

From the hazy and half-imagined picture of Mars at the turn of the 20th century, through the discoveries of the first spacecraft to visit the planet, and onward into the rich harvest of the *Viking* orbiters and landers, the book traces how scientists have given names to the ages of Martian lands—Noachian, Hesperian, Amazonian. Hartmann also describes how scientists have approached the challenge of determining the absolute ages of these stratigraphic provinces, using crater counts plus the measured radioactive ages of Martian meteorites.

Though uncertainties will remain until the ages of known samples are measured either in situ or by sample return to Earth, one aspect is clear: much of what we see on the Martian surface is very ancient, billions of years old. On Earth, this early record has been largely erased by the planet's internal activity and weathering. On the Moon, the cratering record survives, showing that the inner solar system was once a scene of huge bombardments. On Mars, there is a partial record: the old Noachian highlands are heavily cratered, while in the later Hesperian and Amazonian territories, the craters have been obliterated by surface activity, much of it clearly the action of water and perhaps ice.

The water story of Mars is fascinating, both for what it says about planetary evolution and for what it bodes in a human future. By the time of the *Viking*s in 1976, huge fluvial signatures were already evident. Now, with data from remote sensing instruments in orbit, it is apparent that water in some form is abundant below some parts of the Martian surface and may even have been released recently, forming gullies on steep slopes.

Mars is a planet of wind, and Hartmann gives us a comprehensive picture of Aeolian effects forming many visible features, including vast dune fields, dust-devil trails, dust storms, and clouds revealing cyclonic circulations in the thin atmosphere.

After a wonderful tour that anyone can enjoy, Hartmann—a talented painter as well as a leading scientist—takes us a little way into the future with some words of encouragement to those who will follow in exploring and perhaps settling Mars. His is a book to be treasured.

—James D. Burke,
Technical Editor for The Planetary Report

Isaac Asimov's 21st Century Library of the Universe: The Solar System, The Sun, Venus, Earth, the Moon, Mars, Jupiter

By Isaac Asimov
with revisions and updating by Richard Hantula
Prometheus Books: Each book, 32 pp.

This six-book series, targeted at readers age 8 and above, has individual volumes on the Sun, Venus, Earth, the Moon, Mars, and Jupiter. Each book serves as an introduction to understanding the body, past and current exploration, historical perspectives, and far-future possibilities. Overall, the series presents a good overview and introduction that should be of interest both to children and to the adults reading with them. They are softbound and printed on a nice-quality glossy paper.

Although the books vary slightly in format, they typically start with historical overviews of humans' perceptions of the body being discussed; move into a history of exploration of the bodies, both telescopic (including observing information in some) and with spacecraft; discuss some key science and current understanding; discuss possible futuristic scenarios for those bodies (e.g., terraforming Mars); then end with a summary of facts, other references, a glossary, and an index. I would like to have seen more on our understanding of these bodies, with less on historical perspective and fantasy of the far future, but that is more personal preference than general criticism. The glossaries are limited but well done.

The books are full of eye-catching photographs, sure to increase interest in the subject matter. I would like to have seen more actual images, as opposed to artists' conceptions, and more images from recent spacecraft. The series was originally released in 1988 and has been updated, most recently in 2002. For bodies about which an enormous amount of new data has accumulated since that time, such as Mars, better updates could have been made for the images and content. For example, there are no images from *Mars Global Surveyor* in the Mars book and far more *Voyager* images than *Galileo* images in the Jupiter book.

The books also contain a few minor technical errors, omissions, and slightly misleading science discussions, which is unfortunate. These typically are very minor, however, and the number is small in comparison with that of many books written for this age group.

The books present information in a way that will capture the interest of any student who has an interest in space. The books also excel in presenting the "gee-whiz" solar system facts that excite kids (and adults). The solar system is such a big, funky place, with amazing size comparisons and other fun facts, that it would be a shame not to emphasize these—and the books do a fairly nice job.

For readers near or below the recommended lower age of 8 years, the books would be best if an adult goes through them with the reader. They are perhaps a bit advanced for most 8-year-olds on their own but great even for those under 8 if an adult helps out. My 6-year-old in particular, and my 3-year-old to a lesser extent, have found them fun, and reading them together has prompted more than one "Wow, that is so cool!"

—Bruce Betts, Director of Projects and Science Editor for The Planetary Report

CASSINI

Captain's Log: 200

by Carolyn Porco

There are times when human language is inadequate, when emotions choke the mind, when the magnitude of events cannot properly be conveyed by the same syllables we use to navigate everyday life. Last night, the evening of June 30, 2004, was such a time.

In a history-making maneuver so flawless, so perfect it seemed dreamt, one comparatively tiny machine, along with its builders, its operators, its scientists, its well-wishers—indeed, all of humankind—fell into the embrace of giant Saturn, a place that had been a distant destination, in the mind and in the future, for nearly a decade and a half.

After seven years of design and development, *Cassini* was launched in October of 1997. Its initial years were spent cruising the inner solar system, with flights by Venus and Earth, and then a distant flight by Jupiter in late 2000, just to gather sufficient momentum to place it on its final, southerly approach to Saturn. Even at speeds approaching 6 kilometers (4 miles) per second, *Cassini* required more than three years to cross the empty abyss between the two giant planets, a distance as great as that separating Jupiter from the Sun. Then, last night, following instructions that had been uploaded into its memory two weeks earlier, the craft rose through a wide gap in Saturn's rings, glided swiftly up and over their northern unilluminated expanse, ignited its counter-thrusting main engine, and quietly took up orbital residence around Saturn. At that moment, *Cassini* became the farthest robotic outpost humanity had ever established around the Sun, a tiny but glistening newcomer to the skies of the ringed planet. We had arrived.

It was difficult to know what to say, what to feel. Fourteen years of thinking, designing, building, testing, planning, dreaming . . . fourteen years of anxious anticipation . . . had been insufficient to prepare us. Perhaps nothing could.

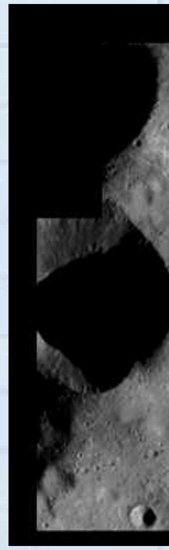
Not even Phoebe.

Prelude at Phoebe

Phoebe, a moon 220 kilometers (130 miles) wide, plies the outer reaches of Saturn's gravitational influence in a retrograde orbit, a clear indication that this body is an interloper, an intruder to this particular planetary system, captured into orbit probably billions of years ago as Saturn and its moons were forming. We had buzzed this small world only three weeks earlier, coming within 2,000 kilometers (1,200 miles) of its surface, in a daring flyby that already seemed far away and long ago. At that range, the relative motion between a spacecraft and the surface of a body can be so large that it impedes the acquisition of sharp images. However, *Cassini* had been designed for such maneuvers: a staggering 53 of them have been planned over the course of its nominal four-year investigation of the Saturnian environment. It had been programmed to pivot while it flies, keeping the sights of the cameras and other remote-sensing scientific instruments staring at a particular point on the surface of a body, despite the rapid movement between the two.

Planning and programming notwithstanding, we can never fully predict what such an encounter will produce. If we could, there would be no point in conducting one.

Ground-based observers had told of the presence of water on Phoebe's surface, an observation that strongly suggested that Phoebe had its origins not, for example, in the rocky waterless asteroid belt whence the moons of Mars arose, but most likely



Above: Phoebe's e
is ancient. Seven o
Phoebe during its
from left to right, a
grooves, or chains
the Martian moons

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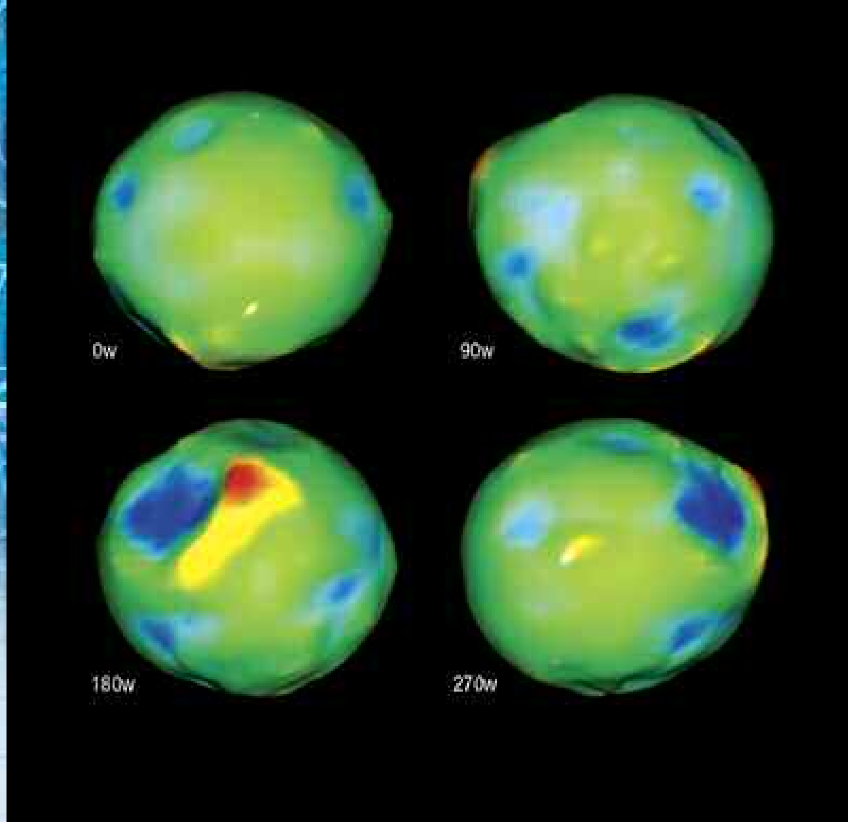
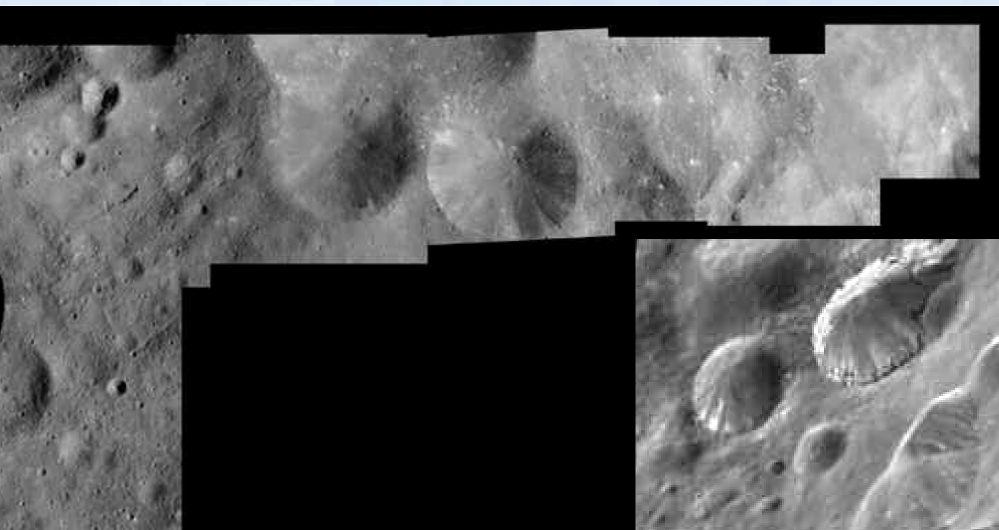
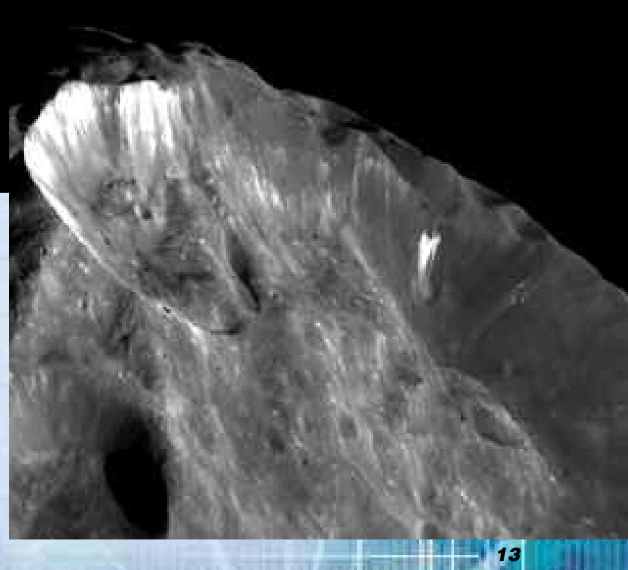


Right: As indicated by this digitally rendered shape model, based on Imaging Science Subsystem (ISS) data, Phoebe is fairly round, despite its irregular topography. The moon's average diameter is 220 kilometers (130 miles). Phoebe's rotation is shown here, centered at four points that are separated by 90 degrees. The colors correspond to the moon's surface elevation relative to the lowest point (a range of about 16 kilometers, or 10 miles) going from blue (low) to red (high). Much of this range occurs in the large crater at lower left. Model: NASA/JPL/Space Science Institute

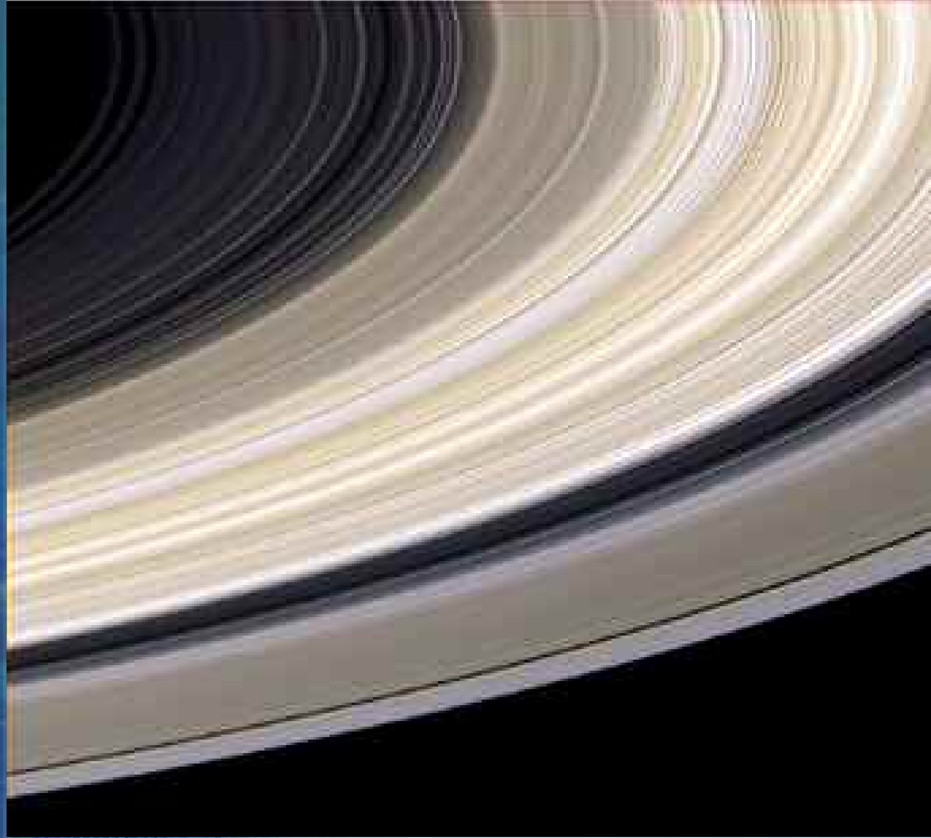


ntire landscape is heavily cratered, which suggests that its surface f the sharpest, highest-resolution images that Cassini *took of close flyby of the moon make up this mosaic. Resolution increases nd the image scales range from 27 to 13 meters per pixel. The , of pits at left are similar to those seen on other small bodies, like s, and are of unknown origin.* Mosaic: NASA/JPL/Space Science Institute

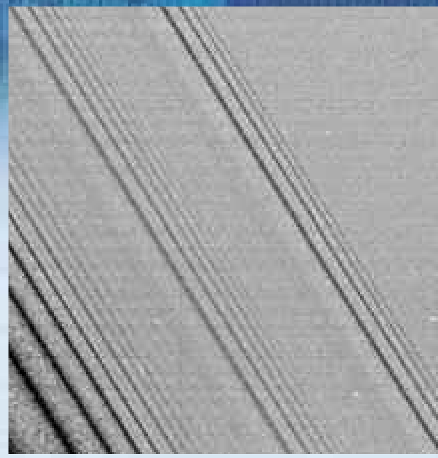


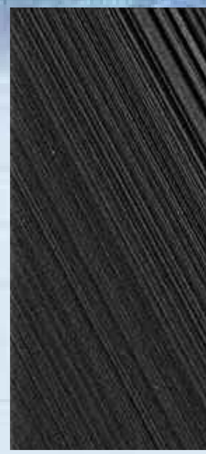
Inset above right: Cassini*'s observations of Phoebe add credence to the theory that the moon originated elsewhere and joined the ringed giant's family of satellites as they and the planet were forming. Saturn's oddball little moon appears to have an ice-rich upper layer overlain with a thin coating of dark material. This image was taken on June 11, 2004 from a distance of about 13,800 kilometers (8,300 miles). The image scale is approximately 80 meters per pixel.*

Inset right: Unlike the arid denizens of the inner asteroid belt, from which Mars' moons Phobos and Deimos came, ground-based observations showed Phoebe to have water on its surface. This means that Phoebe may have originated in the boondocks of our solar system as a relative of the icy bodies that populate the Kuiper belt. Scientists think that the bright wispy streaks (which are overexposed) in this image are ice. The crater at left, with most of the bright streamers, is about 45 kilometers (28 miles) in diameter from front to back. Images: NASA/JPL/Space Science Institute



On June 21, 2004, nine days before Cassini *entered orbit around Saturn, its Narrow-Angle Camera captured this natural, "watercolor" view from 6.4 million kilometers (4 million miles) below Saturn's ring plane. Because Saturn's rings are made primarily of water ice (and because water ice is pure white), scientists believe that the different colors in the rings result from differing amounts of contamination by other materials such as rock or carbon compounds.* Cassini*'s instruments will help to identify the compositions of various parts of Saturn's ring system.* Image: NASA/JPL/Space Science Institute





Once Cassini *entered Saturn's orbit, it snapped 61 images of the rings. These ring images—many times more detailed than those* Voyager *took—revealed a collection of phenomena, some of which scientists had never seen before and hadn't even predicted. The most common features were waves caused by the orbits of Saturn's moons. These Narrow-Angle Camera shots were taken from above the rings, which are illuminated by the Sun from below. The image above left shows the outer part of the A ring outside the Encke gap, with density waves created by the moons Janus, Pandora, and Prometheus. These features had been seen by* Voyager *at lower resolution, but the strawlike structure in the lower left corner was not, and it suggests the clumping of ring particles on scales not previously predicted. The image above right shows an inner and denser region of the A ring and the riot of structure that is found there. The scales of these images are about 268 meters per pixel (left) and about 338 meters per pixel (right).* Images: NASA/JPL/Space Science Institute

in the hinterlands of the solar system, out in the dark, cold regions patrolled by Uranus and Neptune.

However, in science, suggestions are one thing; direct, detailed evidence—the kind that speaks a thousand words—is quite another. As is often the case in the study of planetary bodies, what we found at Phoebe was similar in some respects to what had been seen on equivalently sized bodies, making what was different about Phoebe all the more intriguing.

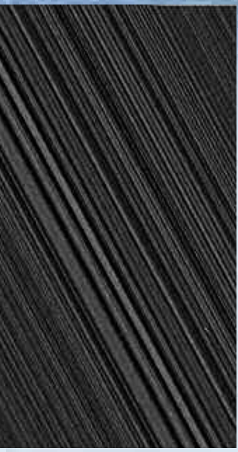
Phoebe's landscape is cratered all over, indicating an ancient surface, one not reprocessed, as on larger moons, by internal mechanisms. This alone was not unusual. Phoebe also was grooved in places, with grooves similar to those seen on the Martian moons, including Phobos. The origin of the grooves on both bodies is a mystery, but their forms suggest cracks in the "bedrock" of the moon, filled in by loose overlying rubble. The closest images, in which details as small as 15 meters can be seen, reveal blocks 50–300 meters across—again, a circumstance similar to that observed on the Moon and asteroids such as Eros.

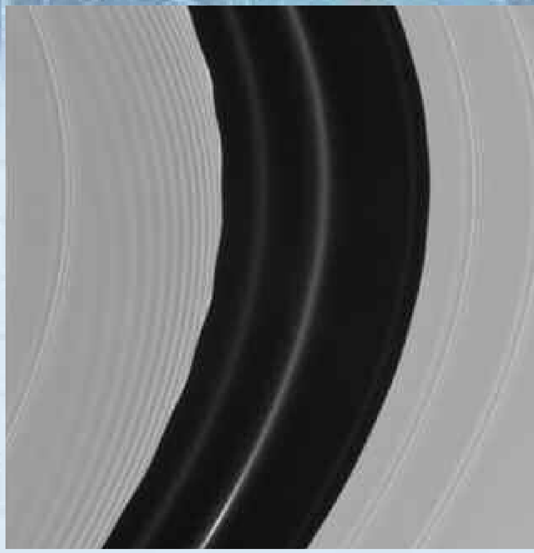
However, the variations of brightness across Phoebe's surface were larger than had been seen on a small body, with very bright areas exposed by large landslides and even very small craters. Furthermore, some of the larger craters revealed a layering of bright and dark material at the surface. In places, the upper layers were clearly several hundred meters thick. This was unusual. These and other imaging observations (such as a measure of Phoebe's volume) and readings from other instruments on board *Cassini*—in particular, the reading of the body's mass by Doppler tracking of the spacecraft—told of a body rich in ice though probably more rich in rock, with a mean density that could be explained best if Phoebe formed in the outer solar system. Its outer layers were clearly compositionally and spatially variable, and its surface was coated in a very thin, dark blanket of something. The Visual and Infrared Mapping Spectrometer, capable of discerning composition, found the "something" to be, in places, partly organic, also suggestive of an origin in the outer solar system.

We concluded, as Phoebe receded behind us, that we had just paid a visit to an ancient, primitive relic of the early solar system, one member of the population that formed Uranus and Neptune and a cousin to the dark bodies inhabiting the outer reaches of the solar system beyond Pluto, the famed Kuiper belt. If that conclusion is correct, we had just stared a Kuiper belt object lookalike in the eye. In our first historic episode at Saturn, we had just put a face to a name. Not bad for a prelude.

The Moons at Saturn

The superiority of our cameras over anything previously carried to Saturn would lead to other findings, both surprising and beautiful.





The Encke division cuts a 325-kilometer (about 200-mile) swath through this image of Saturn's A ring. Cassini*'s Narrow-Angle Camera took this picture as it looked upward at the lit face of the rings. The scallops and the white "streamers" that are visible along and interior to the gap's inner edge are caused by the perturbations of the tiny moon Pan, the gap's only known inhabitant.* *Image: NASA/JPL/Space Science Institute*

This was the first shot of Saturn's rings taken after Cassini *passed through to the illuminated side of the rings following orbit insertion. It shows, in a wide-angle view, never-before-seen features in Saturn's mysterious F ring. Perturbations caused by Prometheus (which is barely visible at lower left) as it orbits Saturn are responsible for drape-like features in the tenuous material interior to the bright core of the F ring. In this view, the image scale is about 9 kilometers (5.5 miles) per pixel.* *Image: NASA/JPL/Space Science Institute*

Even prior to Phoebe, we imaged the Saturn atmosphere and rings with exacting deliberation to search for variations over time. We made distant approach observations of Titan and the other known moons. We searched for new moons that had escaped detection from Earth and from *Voyager*. If *Cassini* did not make it into orbit, these data collected on approach would be all that we could show for years of effort and funding; our tour of the Saturnian system would devolve to a flyby. Deciding which images to take and which to leave out was a serious matter.

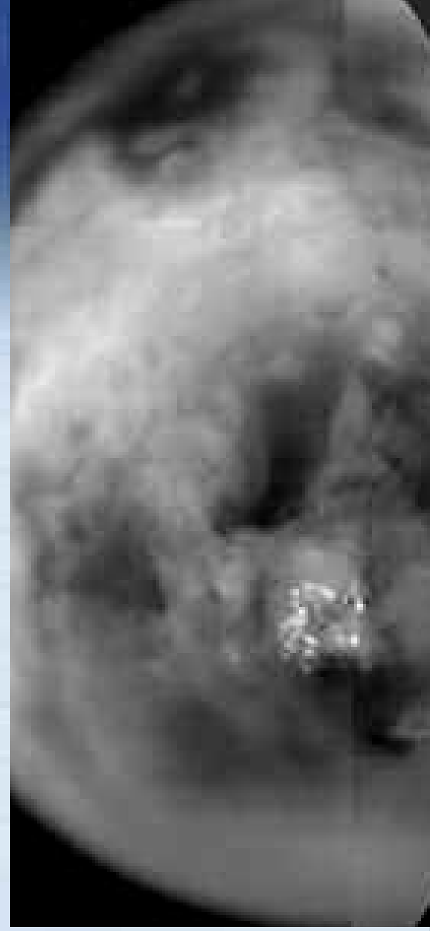
Our search for new moons was particularly gratifying. We looked among the main Saturnian moons, searched just outside the rings, and peered within the rings themselves, especially within the vacant gaps, where we surmised moons would be lurking. In doing so, we uncovered, once again, Atlas and Pan—two small bodies, about 32 and 20 kilometers (20 and 12 miles) across, respectively—orbiting just outside and just inside the main rings. These moons had not been seen by human eyes since the days of *Voyager*.

After a good deal of analysis of images taken in early June, we eventually discovered two very small objects, only several kilometers across—S/2004 S 1 and S/2004 S 2—between the orbits of Mimas and Enceladus. They had skipped around Saturn, presumably for billions of years, unnoticed until now. How lovely it was to know that our efforts to coax previously unseen bodies into view were successful and that our legacy would now include the discovery of new real estate within the Saturnian system.

These small bodies should have been broken apart easily by the great number of small, icy comets (only about 30 meters, or 100 feet, across) believed to have originated in the Kuiper belt and to have rained down on the bodies throughout the outer solar system over the course of billions of years. The very existence of these two bodies tells us either that the flux of the small comets is not as large as previously assumed or perhaps that our new finds have had a violent history of multiple cycles of collisional disruption, then re-accretion, followed again by collisional breakup and re-accretion. The answer to this riddle will be sought in images we hope to collect of the surfaces of moons such as Enceladus. These images should record, and therefore provide measures of, the flux of small comets within the Saturnian system.

Viewing Saturn's Rings

A week after the Phoebe flyby, the planet's rings appeared to our cameras as if painted in watercolor, with subtle shades of salmon, blue, gray, and brown. They are predominantly water ice, and their colors presumably reflect varying degrees and kinds of contamination



Titan is enshrouded in a thin layer of purple haze that appears to float above its main atmosphere in this colorized image taken one day after Cassini*'s first flyby of the moon. The* Voyagers *also saw this haze layer as they sailed past Titan in the 1980s. This image, which shows Titan's south polar region, was taken using a special ultraviolet filter. The picture has been colorized to approximate what our eyes would see if our vision extended into the ultraviolet wavelength. The globe of Titan is the soft orange we usually see, and both the atmospheric haze and the thin detached layer have been given their natural purple color, although they have been brightened for visibility.*
Image: NASA/JPL/Space Science Institute

by nonwater components. Future color imaging of the rings, along with data collected by the spectrometers on board *Cassini*, will readily tell us the composition of the rings and its variation across them. Disentangling the composition of the original ring progenitors—those bodies whose disruption and subsequent dispersal created the rings in the first place—from the composition of the tons of meteoritic material that daily falls onto them will be a more difficult challenge.

Finally, on June 30, we found ourselves flying over the rings at a swift 25 kilometers (15 miles) per second. We were closer to Saturn and closer to the rings now than we had ever been or ever would be again during the *Cassini* tour, and maybe even during our lifetimes. This was an opportunity that could not be missed, and mission scientists had been clamoring for years to be permitted to utilize it to full advantage.

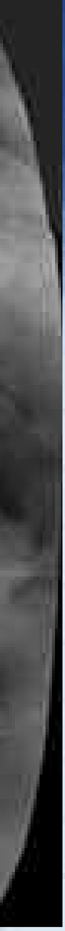
The speed of the spacecraft and the minute-long shoot-and-readout image acquisition cycle meant that consecutive images, one taken immediately after the other, did not overlap in their coverage of the rings: they were separated by about 1,000 kilometers (600 miles), several times the size of one field of view. We were not going to be able to make a complete scan of the rings. It would be hit and miss, but no one cared. Whatever we got would be the best we would ever get, and we were eager for it.

The ringscape, enormous and almost supernaturally flat, spread out beneath us; we were riveted by what we saw. For the 24 years since *Voyager 1*'s first passage by Saturn, I have carried around in my mind the geography of Saturn's rings. Their structure, their shape, and their behavior have been my profession and my life. Now, I looked upon familiar sights with unfamiliar clarity and saw something wholly new. I found myself almost without words to describe and explain.

Forty-three images, with spatial resolution some 25 times greater than we had seen with *Voyager*, were taken while the spacecraft sped in darkness over the rings, starting in the C ring, covering the inner B ring, and then beginning again at the outer B ring, continuing over the Cassini division and the A ring until we were once again staring down at empty space. We had chosen the shortest possible exposure time—5 milliseconds—to avoid any chance of smearing the images. After descending through the plane of the rings again and emerging onto the illuminated side, *Cassini* captured 18 more images—9 narrow-angle and 9 wide-angle images—from the F ring inward, terminating just interior to the Encke gap. These had a level of detail several times coarser than the dark-side views but still five times as good as anything we had obtained with *Voyager* and comparable to the closest images we will take of the rings during the remainder of our tour. They were spectacular.

It was immediately evident, upon inspection of these 61 images, that we had discovered a collection of phenomena never seen before, and some not even predicted.

We saw features without any sensible order at the limit of resolution in one dark-side image. In other



Above: This series of images shows the evolution of that field of clouds near Titan's south pole over a period of nearly 5 hours. **Cassini***'s ISS captured them on July 2, 2004 from a range of 339,000 to 364,000 kilometers (210,600 to 226,170 miles). This cluster of bright clouds, about the size of Arizona, is believed to be composed of methane. Ground-based observers had previously seen clouds on Titan in the south polar region. The scale of these images is about 2.2 kilometers (1.4 miles) per pixel.*

Image: NASA/JPL/Space Science Institute

Left: This mosaic of Titan's south polar region was assembled from images taken by **Cassini***'s ISS as it passed 339,000 kilometers (210,600 miles) from the Saturnian moon during its first flyby on July 2, 2004. Special filters allowed* **Cassini** *to see through Titan's thick haze and atmosphere to a surface mottled by dark and light features. The smallest features visible in this image are about 10 kilometers (6 miles) in diameter. A field of clouds near the south pole shows up as the bright spots near the bottom.*

Image: NASA/JPL/Space Science Institute

images, we saw very narrow ringlets standing apart from broader bands carved up in a profusion of seemingly incoherent structure. But mostly we saw waves, and more waves. These are the handiwork of orbiting Saturnian moons, which perturb the orbits of ring particles at the sites of gravitational resonances and force the particles into spiral patterns. Where the ring particles are perturbed into eccentric orbits, we found a density wave in which the enhanced concentration of particles takes the form of a spiral pattern wrapped around the planet; where the orbits are forced to be inclined by the action of an inclined moon, we found the height of the ring plane taking the form of a spiral pattern, wrapped round and round the planet. This latter structure is akin to a traditional wave created by a pebble thrown into a pond, only the crests are spiral and not circular.

Waves are precise but curious structures, and we don't have completely satisfactory explanations for why they look the way they do. Theories stumbled years ago, when sufficiently accurate data were lacking to guide them. Now, back at Saturn, we have collected a bounty of information we didn't have before, a circumstance that surely will advance the study of wave formation and propagation. We can expect deeper insights into the behavior of icy particles arrayed into the giant sheet that is Saturn's rings, and even into the behavior of icy particles that ultimately coalesced to form the outer planets billions of years ago. Saturn's rings are our closest analog to the great flattened structures we see throughout the cosmos: from the disks of material, being discovered as we speak, surrounding protostars in our galaxy, in which planets are forming even today, to the vast pinwheels of stars and gas we call the spiral galaxies. The scientific reach of *Cassini* and the investigations we hope to conduct with it are truly universal.

Our most artful image is surely one of the F ring, in which periodic drapelike scallops are carved by the action of Prometheus in the delicate, diaphanous material interior to the ring. But the image that kills at a thousand paces is our dayside view of the Encke gap, a 300-kilometer (180-mile) division in the outer A ring kept open by the perturbations of Pan, the gap's only known inhabitant. In this one image, we come face to face with the order and mathematical precision of countless icy particles influenced simultaneously by Saturn, Pan, and each other. The effects of Pan on the inner edge of the gap are particularly stunning and regular: scallops in the edge caused by the periodic and precisely phased in-and-out motion of many small orbiting bodies acting in unison; white streamers, marking the enhanced concentration of these bodies resulting from this phased motion, that spiral away from the edge and fade as they go; and ringlets within the gap, kept narrow by Pan's shepherding action. What a feast.

Last night, the world applauded us. We were exhausted and relieved. But our work had only begun. Titan loomed up ahead.

Imaging Titan

We are now thirty hours from the rings, and we are staring down Titan, making our first *Voyager*-class flyby in the Saturnian system. This is the telling event.

The hazy Titan atmosphere had prevented the *Voyager* cameras, which could only "see" at the visible wavelengths of light, from penetrating to the surface. However, ground-based observers had learned to see the Titan surface by looking in specific and narrow spectral regions in the near infrared, where the transparency of the atmosphere actually begins to increase in the "windows" between those spectral regions where Titanian methane is absorbing. We had this "peering through the window" trick in mind in outfitting the *Cassini* cameras, ensuring that they had the proper narrow, near-infrared filters as well as haze-reducing polarizers needed to see to the surface. But how far would this go? We were fairly confident we could see the large-scale, 300-kilometer (180-mile) features seen by the ground observers and that we would have greater visibility of these structures, whatever they might be. But would we be able to see features as fine as the cameras and closest approach distances of the more than 40 Titan flybys could serve up—in some cases, a few tens of meters per pixel? Even in the first Titan flyby, the image scale would be 2 kilometers (1 mile) per pixel. Would we see such detail?

Available models of the Titan atmosphere covered the full range of possibilities between two extremes: on one hand, the total abundance of haze is large, in which case we would do no better than seeing features about 100 kilometers (60 miles) in size; on the other hand, the total haze abundance is modest, like a smoggy Los Angeles day, in which case we might see the finest features, assuming they exist (and are of sufficiently high contrast) in the first place. Surface contrast observed through an atmosphere will be reduced by the scattering of light from the airborne haze, and the amount of scattering, and therefore the reduction in observed contrast, depends on the abundance of overlying haze and its vertical distribution. Thus, features on the surface with greater contrast have a greater chance of being seen by a spacecraft cruising overhead.

What we see on Titan certainly lacks the clarity of the Phoebe and Saturn ring images but is perfectly within the range of expectations. Between light and dark regions, we see nebulous boundaries so diffuse that we all find ourselves fighting the impression that we are looking at clouds and low-lying fog. But we are not: many of the features seen in the south polar region looked similar in their light and dark variations and boundaries to the motionless, and presumably surface, features seen in the midlatitude regions, first by ground-based observers and now by us.

One feature immediately grabs all of us—an obvious cloud complex hovering near the south pole as big as the state of Arizona. In a series of images, taken one after the other, we can see the evolution of its structure. It is likely to be a cloud field, similar to that seen with much less detail by ground-based Titan observers. Its study over the Saturn orbital tour should provide us with a sensitive probe into the thermal inertia of the Titan surface and convective character of the atmosphere.

With a bit of work, we can also make out a few sinuous features only 10 kilometers (6 miles) wide. It is seductive to imagine riverbeds and streams or deep canyons and channels, features perhaps caused by the rain of liquid methane and ethane that Titan theorists have long predicted. At this stage, however, there is no further evidence to develop this line of imagining into fact. Scientists pride themselves on their discipline and restraint. And so we remain restrained, unsure of what we are observing, awaiting future opportunities to view Titan in greater detail and with greater coverage, and awaiting the results of the investigations of Titan by other *Cassini* instruments, before offering any conclusions about the character of the markings we have seen on its surface.

However, one thing we can readily offer is the hope that greater detail will be available to us if indeed it exists on the surface at all. The putative visibility limit of 100 kilometers (60 miles) for a large-haze-abundance scenario clearly does not apply to Titan. If we see features 10 kilometers (6 miles) across with a 2-kilometer image scale, then we should be able to see features 100 meters across with the 20-meter image scale that we will have on future Titan flybys. That assumes again, of course, that such features exist. Thus, our first flyby of Titan leaves us more excited than ever that our investigations of Titan over the next four years will bear the fruit that we have come to enjoy. We may yet learn what this deeply mystifying body has kept hidden for so long. It's only a matter of time.

And time we have. We are now in orbit around Saturn. Like Phoebe, we have come to dwell in the house of this great patriarch of a planet. Now, it is we who are the interlopers . . . looking, probing, gathering, reading, measuring—silently, methodically, without disturbance. Now, it is we who are the new Saturnians.

Carolyn Porco is the Cassini *Imaging Team leader and director of the* Cassini *Imaging Central Laboratory for Operations (CICLOPS) within the Space Science Institute in Boulder, Colorado. She is the creator/editor of the CICLOPS website (*ciclops.org*), where* Cassini *images are posted. She holds adjunct professorships at the University of Arizona and the University of Colorado.*

World Watch

by Louis D. Friedman

One of the thorniest issues for the International Space Station (ISS) partners (the United States, Russia, Europe, Japan, and Canada) is how to complete the station. The proposed new Moon-to-Mars policy redirects American interest in the space station away from space station science to exploration beyond Earth orbit, leaving some ISS partners questioning if the US plans to complete the station.

International agreements created the space station—first with the commitment by Europe and Japan to build science modules for the ISS and then with Russian involvement permitting US astronauts to gain space station experience on the *Mir* and providing Russian vehicles to help construct the station. The latter are now the only means of transportation to the ISS.

The European (*Columbus*) and Japanese (*JEM*) modules are built and almost ready to fly, but only the space shuttle can deliver them because they were designed specifically for the shuttle's payload compartment. The shuttle is grounded, and it is uncertain when it will return to flight.

In addition, the shuttle is aging and is expensive to maintain and operate. Its long-term safety is in question. It is part of an architecture developed when there was no purpose for human spaceflight beyond repeated missions in Earth orbit. The architecture was conceived 30 years ago as part of a decision against space exploration—a decision to discontinue the *Apollo* program and abandon any plans to go beyond the Moon, on to Mars.

In the aftermath of the *Columbia* accident, the purposes of human spaceflight were widely debated, and nearly all the commentators and leaders in space programs around the world called for a purposeful human spaceflight program that focuses on exploration of worlds beyond Earth.

The aging shuttle, the outdated architecture, and the need for a human spaceflight program that leads somewhere all suggest that the shuttle should be retired as soon as possible and that the ISS partners should find an alternative means to complete the station. That certainly is our opinion— see *planetary.org/aimformars/ldf_statement.html.*

Europe and Japan do not want to delay the delivery of their modules to the space station and are therefore uncomfortable with talk of retiring the shuttle. They insist that the best plan is for the US to honor its commitment to launch the modules with the shuttle as soon as possible. No one can be sure what "as soon as possible" means—optimistic predictions say it could be in 3–4 years, but uncertainties about the shuttle, as well as its aging, make that prediction problematic.

The US Congress is now considering development of a new Crew Exploration Vehicle as part of the proposed Moon-to-Mars policy. The Planetary Society is playing an active role in this consideration. With the support of our members, we joined with other organizations last year in a space transportation workshop and have recently completed a study led by astronaut Owen Garriott and veteran aerospace engineer Michael Griffin. (For more information about the workshop, visit *www.planetary.org/workshop*, and to read the Garriott/Griffin report, see *planetary.org/aimformars/initiatives.html*.)

The Garriott/Griffin report recommended a specific approach for the proposed Crew Exploration Vehicle (CEV) and a new shuttle-derived heavy lift launch vehicle. It recommends that planning for CEV be started soon and that the shuttle-derived components be kept available. Early shuttle retirement could help provide the necessary funds to make that happen and get us on track for a purposeful human space exploration goal. The study also called for greater use of international capabilities in Europe, Japan, and Russia. Launch vehicles and international crews for both the ISS and future exploration ventures can be contributed to by all spacefaring nations. This would provide opportunities and benefits for all the ISS partners as well as for other spacefaring countries that might be part of a grander exploration venture.

These are all good ideas, but we must acknowledge one problem: instead of treating the ISS situation as an international problem needing an international solution, the US is treating it as a national problem and is telling each partner to solve its problem nationally also. This attitude is leading to a lot of bitter political discussion among partners. Such discussion creates more heat than light.

The US should honor its international agreements, but it should be obvious that all partners ought to confront reality and alter the agreements if there is a better course to be taken. Safety and age issues of the shuttle should not be ignored, and throwing good money after bad should not be encouraged just to honor agreements. At the same time, the US should engage the ISS partners in the space station and others in coming up with approaches that bring material benefits to their countries and advance their space goals. Long-range policy studies conducted in Europe, Japan, and Russia and those countries' aspirations for exploring other worlds and human spaceflight make such international cooperation appear to be attainable.

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

Questions and Answers

This perspective view of the western flank of Olympus Mons was taken on April 21, 2004 by the High Resolution Stereo Camera on Mars Express. *The scarp, or cliff, rises more than 7,000 meters above the surface. Most geologists think landslides are largely responsible for the scarps that surround this huge volcano.* *Image: G. Neukum, European Space Agency*

Mars' Olympus Mons slopes gently down to its edge, which then drops off into a cliff that almost surrounds the volcano. What caused this cliff?
—Ron Evans
Bella Coola, British Columbia, Canada

The extensive scarp around the base of Olympus Mons is indeed unusual (see image above). Scarps like this are not visible around the other extinct volcanoes that constitute Tharsis Montes. Very large landslide deposits surround the base of Olympus Mons, and these correlate to the shape and magnitude of the scarp. Geologists think the scarp was formed by the collapse of the volcano's flanks and the subsequent sliding of huge masses of debris out onto the surrounding plains. Some think that ground ice or groundwater may have assisted the sliding. These same types of landslides and scarps exist around the flanks of Earth's Hawaiian Islands.
—JAMES W. HEAD III,
Brown University

In 1976, NASA conducted biological tests on the surface of Mars with the* Viking *landers. At first some of the results seemed to point at life on Mars. These results were later dismissed as being due to inorganic oxidizing minerals.

Has the existence of these minerals been confirmed by the Mars Exploration Rovers?
—Rindert Bolt
Slite, Sweden

Spirit and *Opportunity* did not include instruments to search for, or to identify, the trace oxidants thought to exist in Mars' surface soil. However, mission planners for NASA's Mars Science Laboratory (MSL) mission, planned for launch in 2009, are currently evaluating proposals for a variety of instruments, some of which will have the capability to attempt such analyses.

We may need to return Mars samples to Earth before we can fully answer this question.
—BENTON C. CLARK,
Lockheed Martin Astronautics

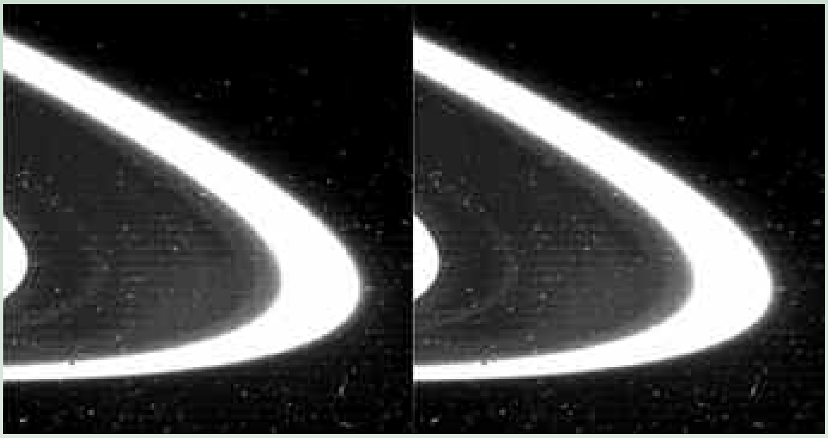
Send us your questions!

We enjoy finding answers to your queries, so please keep asking! But remember, we must restrict our attention to those topics that fall under the purview of The Planetary Society: planetary exploration and the search for extraterrestrial life—both in our own solar system and beyond.

This means we cannot answer questions on astronomy and cosmology—dealing with, for example, such things as supernovas, gamma rays, quasars, pulsars, black holes, the big bang, dark matter, and the expansion of the universe. We also do not cover human space travel to other star systems, faster-than-light travel, UFOs, or the aerospace industry.

Send your questions about the science and exploration of planets (and other solar system bodies such as comets and asteroids) and the search for extraterrestrial life, including the many facets of SETI, to "Questions and Answers," c/o The Planetary Society, 65 N. Catalina Avenue, Pasadena, CA 91106-2301. You may also e-mail them to *tps.des@planetary.org.*

Factinos



A newly found ring of material, R/2004 S 1, can be seen in this* Cassini *image of the region between the edge of Saturn's A and F rings. The image has been enhanced to show the presence of faint ring material just beyond the edge of the A ring and in the orbit of Atlas (indicated by the red line in the version at right). The moon Prometheus is visible close to the F ring at lower left in these frames.
Image: NASA/JPL/Space Science Institute

A new ring and one new moon, or perhaps two, have been detected around Saturn. Carl Murray of Queen Mary University in London and his team spotted the first object, temporarily designated S/2004 S 3, in *Cassini* images of the region just outside Saturn's twisted and mysterious F ring. They are not yet sure if the object is a moon or just a temporary clump of ring material. If it's a moon, it is 4 to 5 kilometers (2 to 3 miles) in diameter.

After searching for the object in other *Cassini* images, Joseph Spitale of the Space Science Institute in Boulder, Colorado reported, "When I went to look for additional images of this object to refine its orbit, I found that about five hours after first being sighted, it seemed to be orbiting interior to the F ring. If this is the same object, it seems to have an orbit that crosses the F ring, which makes it a strange object." This inner object is currently considered to be separate from the outer one and is provisionally named S/2004 S 4.

As he examined images of the F ring region, Murray discovered the previously unknown ring, R/2004 S 1. The new ring (see images above), located between the planet's A and F rings, is associated with the orbit of Saturn's moon Atlas.
—from JPL/NASA

An international science team, led by Gael Chauvin of the European Southern Observatory (ESO) in Santiago, Chile, may have captured the first image (below) of an extrasolar planet. In April 2004, the European and American team detected a faint and very red point of light near a brown dwarf called 2M1207. (For years scientists have looked at brown dwarfs—often called "failed stars" because their cores do not support nuclear fusion—as good places to search for planets.)

In June 2004, the team imaged the dim object and its infrared spectrum at ESO's Paranal Observatory in Chile. This spectrum shows the signatures of water molecules and confirms that the object must be comparatively small and light.

The observations suggest the presence of a planet of about 5 Jupiter-masses in orbit around 2M1207; however, they do not give clear-cut proof. Thus, the researchers refer to it as a "Giant Planet Candidate Companion" (GPCC). Observations taken over the next one to two years will verify whether the GPCC's motion in the sky is compatible with that of a planet in orbit around 2M1207.
—from the European Southern Observatory

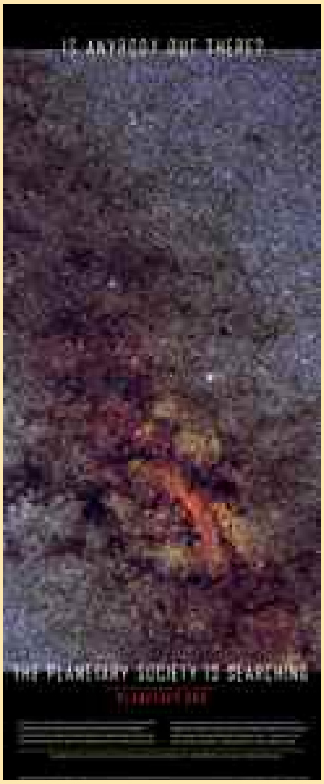
This composite of three near-infrared exposures shows the brown dwarf 2M1207 (center) and the fainter object that scientists think might be our first view of an extrasolar planet. Further observations, especially of its motion in the sky relative to 2M1207, will be needed to determine whether the object, designated "Giant Planet Candidate Companion" by its discoverers, is a bona fide planet or not.
Image: European Southern Observatory

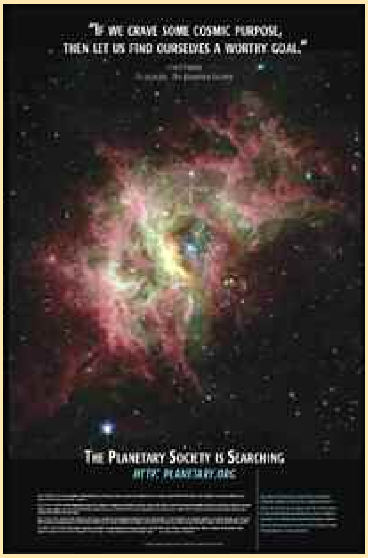
Scientists have discovered a striking similarity between certain ocean currents on Earth and the bands that characterize the surface of large, gaseous planets such as Jupiter. Boris Galperin of the University of South Florida's College of Marine Science in St. Petersburg and his international team reported their findings in the July 1, 2004 issue of *Geophysical Research Letters.*

"The banded structure of Jupiter has long been a subject of fascination and intensive research," says Galperin, who analyzes turbulence theory and applies theory and numerical modeling to the analysis of planetary processes. "The visible bands on Jupiter are formed by clouds moving along a stable set of alternating flows."

Galperin and his team have discovered that oceans on Earth also harbor stable alternating bands of current that, when modeled, are similar to the bands on Jupiter, resulting from the same kinds of "jets." "We think this resemblance is more than just visual," says Galperin. "The energy spectrum of the oceanic jets obeys a power law that fits the spectra of zonal flows on the outer planets."
—from the American Geophysical Union

THE PLANETARY SOCIETY 2005 CATALOG





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**

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Put on your red/blue glasses and step onto the Martian surface, where *Mars Pathfinder* still rests today. Red/blue glasses included.   12" x 39"   1 lb.   **#306 $13.50**

"Is Anybody Out There?" Poster

This astounding image, obtained by the Two Micron All Sky Survey, reveals only a fraction of the 400 billion stars in our own Milky Way galaxy.   39" x 16"
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NEW! 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"
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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**

Surf Titan T-Shirt

A Planetary Society classic—we first introduced this shirt after *Voyager* passed by Titan, revealing hints of a methane ocean. Now that *Cassini-Huygens* has arrived for a closer look at the mysterious moon, we decided to bring this old favorite out of retirement. This shirt is long-sleeved with "The Planetary Society" printed on the left sleeve. Adult sizes: S, M, L, XL, XXL   1 lb.   **#593 $20.00**

Future Martian T-Shirt

The future is full of possibilities, and today's Earth child just might be a future Martian.
Child sizes: S, M, L
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The Planetary Society's *Cosmos 1*, the first-ever solar sail, will take off into orbit this year. This commemorative T-shirt is a Society exclusive. Long-sleeved, with glow-in-the-dark ink, it's perfect for dark nights of solar sail watching. Adult sizes: S, M, L, XL, XXL   1 lb.   **#570 $25.00**

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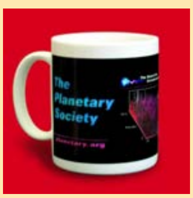
NEW! SETI@home Mug



More than 5 million participants have contributed their time and computers to SETI@home, the largest distributed computing experiment ever undertaken.
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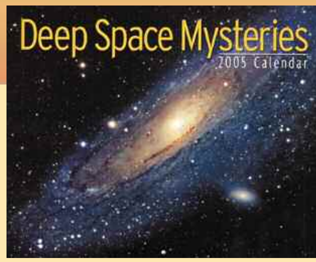
Images from *Mars Global Surveyor,* speculative paintings of the Red Planet's past and future, informative captions and charts, and images of Mars' surface from the *Pathfinder* and *Viking* spacecraft enhance a detailed US Geological Survey map. 24" x 37"   1 lb.   **#505 $15.25**



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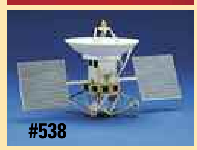
#531   *Mars Global Surveyor*
#538   *Magellan*
#560   *Voyager*



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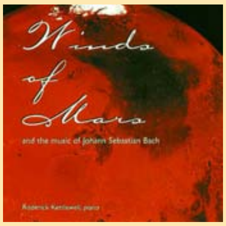

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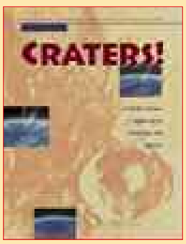

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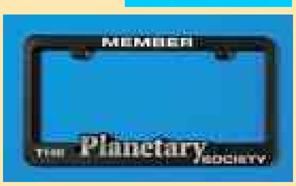

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Our studies of Saturn may help us, someday, to understand the mysterious worlds that orbit other stars in our galactic neighborhood. Here a ringed gas giant adorns the clear, frigid sky of its icy moon. Methane geysers erupt from the satellite's surface, and the Milky Way glows in the background.

Edwin Faughn is a space artist whose work has appeared in publications such as *Astronomy, Sky & Telescope*, and *Science News*. He is a graphic artist and animator at the Sharpe Planetarium in Memphis, Tennessee, and his work has appeared in many multimedia productions in the United States and elsewhere around the world.

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