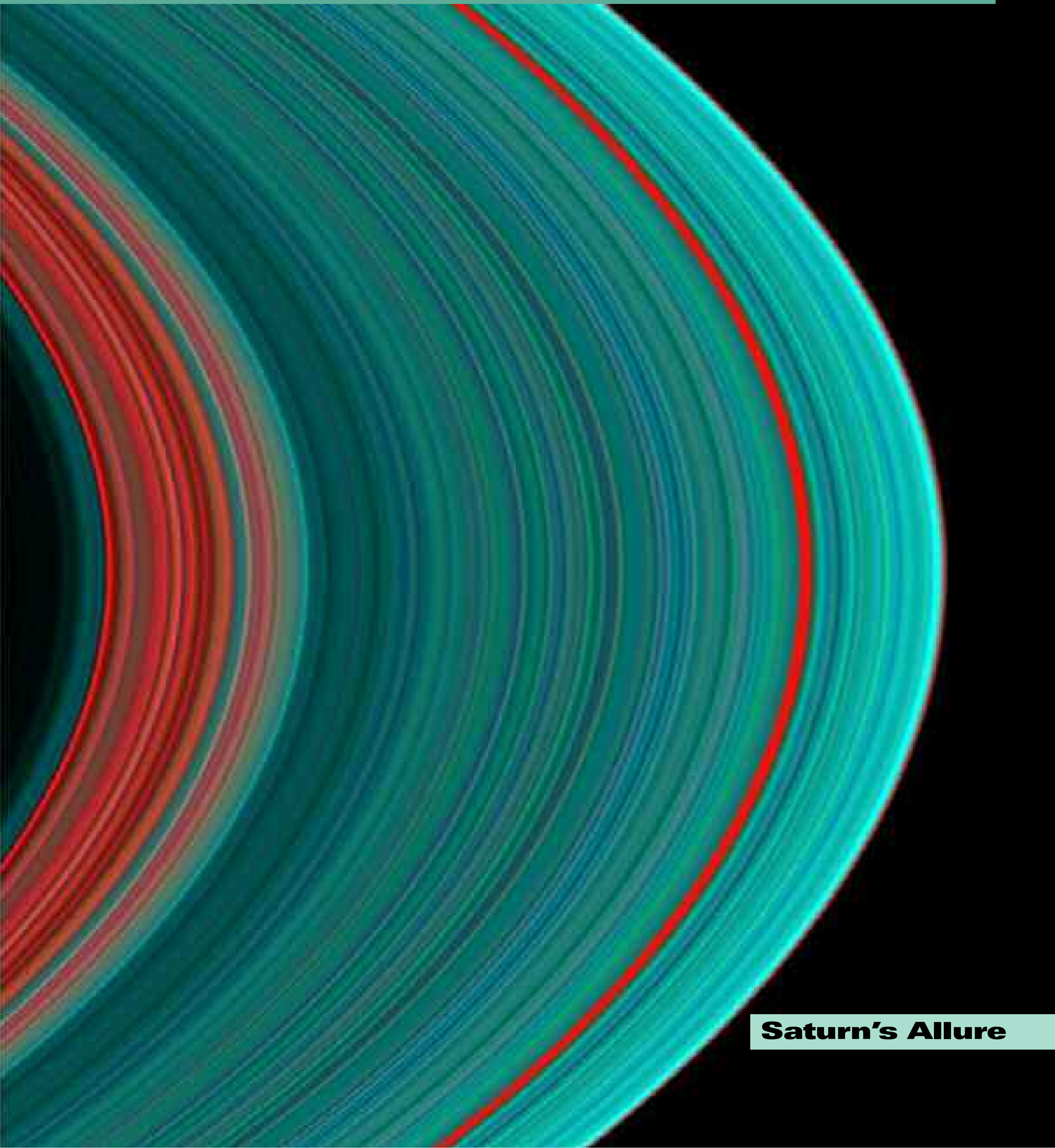
The PLANETARY REPORT

Volume XXIV Number 4 July/August 2004



Saturn's Allure

A PUBLICATION OF THE PLANETARY SOCIETY

Table of Contents

Volume XXIV
Number 4
July/August 2004

From The Editor

Every day, those who follow the adventures of our robotic explorers among the planets have something new to see and learn. On the Internet, images from Mars, Saturn, and other strange new worlds are posted regularly. At scientific conferences, scientists jostle each other to give papers on their latest work, and journals are filled with papers announcing new results. Seldom have Earthly explorers seen such a trove of discoveries.

When bringing these discoveries to Planetary Society members, it's often hard to decide what is most important to include in this magazine. Do we bring you breaking news at the expense of thoughtful historical pieces? Do we focus on the politics behind planetary missions or concentrate on hard science?

The answer to our questions is "all of the above," just spread out among many issues. We also have another matter to consider: at The Planetary Society, we are always looking to the future. So in this issue, along with a report on *Cassini*'s initial discoveries at Saturn, we bring you considerations for future Mars exploration, when humans join robots on the Red Planet.

It's always a juggling act when there's so much to cover. That's the downside of today's rich state of planetary exploration. It's one we're glad to deal with, and one we will fight to keep us busy for the next 25 years.

—*Charlene M. Anderson*

On the Cover:

This color rendition of Saturn's rings was constructed from data returned by *Cassini*'s Ultraviolet Imaging Spectrograph just after the spacecraft went into orbit on July 1, 2004. The *Cassini* division in faint red at left is followed by the A ring, which begins with an interior of red followed by more turquoise as it spreads away from the planet. Turquoise represents denser material made up of ice. The red band at right is the Encke gap.

Image: Larry Esposito, University of Colorado/JPL/NASA

Features

Departments

Contact Us

Mailing Address: The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106-2301
General Calls: 626-793-5100
Sales Calls Only: 626-793-1675
E-mail: tps@planetary.org
World Wide Web: http://planetary.org

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 US are $30 (US dollars); in Canada, $40 (Canadian dollars). Dues in other countries are $45 (US dollars). Printed in USA. Third-class postage at Pasadena, California, and at an additional mailing office.
Canada Post Agreement Number 87424.

Editor, CHARLENE M. ANDERSON
Associate Editor, DONNA ESCANDON STEVENS
Managing Editor, JENNIFER VAUGHN
Technical Editor, JAMES D. BURKE
Copy Editor, A. J. SOBCZAK
Proofreader, LOIS SMITH
Art Director, BARBARA S. SMITH
Science Editor, BRUCE BETTS

Members' Dialogue

Make It Robotic

As a child in the 1960s, my favorite fantasy was to be one of the first explorers on Mars. To be one of those explorers would be the ultimate thrill.

I came pretty close to experiencing that thrill in the early morning of July 20, 1976 in Beckman auditorium at the California Institute of Technology. Along with a few hundred other people, I had spent the night there, listening to updates from the Jet Propulsion Laboratory waiting for the landing of *Viking 1*. The first image to arrive was a close-up of one of the lander's feet and the surrounding soil, slowly painted onto the screen in vertical stripes as the data came in from the spacecraft. When enough stripes revealed the unmistakable image of a small pebble, the audience burst into cheers. The second image was a stunning panorama of a glorious afternoon on Mars. It brought tears to my eyes. I staggered out into a glorious Pasadena sunrise, sleep deprived and euphoric.

Most of what we know about our solar system has come from robotic explorers. *Spirit* and *Opportunity* are making more great discoveries even as I write. But the Hubble Space Telescope, another highly productive robot, is currently doomed to an early death because NASA will not risk putting astronauts into an orbit from which they could not reach the space station. This is the same NASA that says it will send astronauts on a voyage of many months, over tens of millions of kilometers, to Mars. Something is wrong with this picture.

I do not accept the view that the inspiration, excitement, and sense of unified purpose that our species so desperately need can only be had through the vicarious thrill of watching astronauts walking on other planets. Robotic spacecraft are better-suited even for these nonscientific goals because they at least have a chance of being built and flown with the limited funds available.

There may be some sensible need for humans in space. But for The Planetary Society to support human exploration of Mars could ultimately be self-defeating. As with the Superconducting Supercollider, we risk getting the worst of both worlds—huge expenditures that suck the funding from robotic exploration, followed by abandonment of the whole thing when cost overruns erode political support.

Many thanks for *The Planeary Report*. It's one of the things I most enjoy getting in the mail.

—JOHN C. WATHEY,
San Diego, California

I am a long time member of The Planetary Society and consider myself a strong advocate of space exploration. However, I am having a difficult time supporting a human mission to Mars. While I believe the exploration of Mars to be worthwhile (and necessary), I also believe this can be done almost as well robotically, at a far lower cost and with no risk to human life. Furthermore, the spin-offs in artificial intelligence and advances in robotics could be applied directly to industry and would certainly enrich all of our lives. Pride aside, I doubt the same could be said for a human mission. I wonder how many other Society members feel the same way?

—DIETER LOEWRIGKEIT,
Hackettstown, New Jersey

Shoemaker NEO Grants

The Planetary Society is right for funding this worldwide endeavor which is ultimately important for all of humankind. What is the use of preserving our historical past, of developing Third World countries, of doing scientific research such as controlling diseases, going into space, and making our environment safe to live in, if we ignore what is so obvious a danger—a danger that could wipe out all of what we've worked for and saved, for ourselves and for the world, in an instant?

It would be like making your house all pretty and expensive and then forgetting to buy fire or flood insurance—or at least to put in devices that could warn the household. Developing measures to counteract a possible hit by a sizable near-Earth object would be the same as a form of insurance.

Can it be explained any more clearly?

—MIKE MARTINEZ,
Lakeland, Minnesota

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

In addition to our standard "projects," The Planetary Society does a number of other things to advance space exploration. We perform space advocacy activities with the world's governments, many of which are covered in World Watch in *The Planetary Report*. As part of advocacy, we also fund a number of studies about the future of space exploration. Because The Planetary Society does not take government funding, we can support studies that are truly independent and sometimes more "out of the box" than those supported by government agencies or aerospace companies. Our international connections also allow us to examine topics from an international perspective.

Here I give a summary of our Lunar Waystation—Planetary Outposts study. We've also completed two other Planetary Society studies: one on "Extending Human Presence into the Solar System," discussed in World Watch on page 19; the other is a Russian study of concepts for first human missions to Mars. Full versions of all three are available on our website at *aimformars.org/initiatives.html*. These studies and others like them are used to help The Planetary Society define our positions and are provided to the world's space agencies to help them define their programs.

International Lunar Waystation: A Planetary Outpost Test Bed

In light of the recently proposed Moon-to-Mars space policy, many decisions on implementation must now be made. The Planetary Society has evolved a strategy for exploring solar system bodies called Planetary Outposts: a series of landed elements—first robotic, then human—working together at a specific location on a planetary body. We propose, as a first step toward Planetary Outposts, establishment of a Lunar Waystation to test aspects of Planetary Outpost implementation. This would make it possible to work out all operational aspects of Planetary Outposts in a closer-to-home environment and would provide a focus for lunar missions in the coming decade. Following this strategy would also serve to focus and organize future Martian exploration. Without some type of clear strategy to organize the exploration, we run the risk of running off in many disparate directions, losing momentum, and having the program fizzle, despite the best intentions.

Using a Planetary Outposts strategy, or its precursor at the Moon, creates a lot of advantages in addition to organizing and focusing. Planetary Outposts form a bridge

What's Up?

In the Sky

Planets have nearly vanished from the evening sky but are starting to appear in the pre-dawn sky. Venus looks like the brightest star in the sky before dawn in the East. Saturn, also in the pre-dawn sky, is getting higher as the months progress. It, too, looks like a bright star but will be dimmer than Venus. Saturn and Venus will appear to be very close in the sky in late August and early September. Mercury will be low on the horizon, below Saturn and Venus, during much of September. Jupiter will be visible in the evening sky just after sunset during August but mostly gone (too near the Sun) by September. It will return to the pre-dawn sky in October. Watch a crescent Moon pass by the morning planets on September 9–13. There will be a total eclipse of the Moon on October 27–28.

Random Space Fact

The mass of Jupiter is greater than the mass of all the other planets combined!

Trivia Contest

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

What is the farthest object from Earth that was made by humans?

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

The July/August contest closes on October 1, 2004. The winner will be chosen by a random drawing from among all the correct entries received.

Our May/June contest winner is Tom Reesor of Conway, South Carolina.

The Question was: Which planet in our solar system has the lowest average density?

The Answer: Saturn, with an average density less than that of liquid water.

For a weekly dose of "What's Up?," listen to Planetary Radio at *planetary.org/radio*.

between robotic and human exploration, something that has been lacking in the often divided robotic and human camps. Robotic precursors and advanced emplacement of human infrastructure (e.g., power, return vehicles) increase safety of eventual human missions. Yet Outposts are flexible to budget variations—infrastructure can be emplaced in steps or stages while still working logically toward a unified goal.

Planetary Outposts are also flexible regarding international and private participation. As long as certain standards are established early on (the topic of a follow-on Planetary Society study under way), spacecraft from a variety of countries or contributions from many countries or private entities can all work together at a Waystation.

Additionally, Planetary Outposts and the precursor Lunar Waystation are public-friendly—imagine becoming familiar with a certain location on the Moon or Mars, watching step by step as we prepare for human explorers, then exploring right along with astronauts as they set off to examine the new neighborhood!

For the complete text of these studies and to learn more about our Aim for Mars! Campaign, visit *aimformars.org*.

Bruce Betts is director of projects at The Planetary Society

Society News

International Lunar Workshop

The Planetary Society organized a special International Lunar Session in Beijing, China as part of the United Nations/European Space Agency Basic Space Science Workshop. The Society has cosponsored the UN workshops annually in different parts of the world.

The lunar session included presentations from China, Europe, India, and Japan, in addition to presentations from Society representatives Louis Friedman and Jim Burke. Also included was a comprehensive discussion of planned international lunar missions (see the May/June *Planetary Report* World Watch).

In Beijing, the Society established cooperative arrangements with Chinese space organizations to promote international cooperation and dissemination of information to the public.

—Louis D. Friedman,
Executive Director

Planned Giving to The Planetary Society

Would you like to invest in the future? Create a lasting legacy? Your planned gift to The Planetary Society will make a difference.

Planned gifts can endow projects, operations, and grant and scholarship programs or provide crucial funds for unanticipated initiatives. Your memory and legacy are celebrated with your gift to the future.

A bequest in your will—of specified amounts of cash, securities, real estate, or other property—is one way of making a significant planned gift. Gifts of life insurance and retirement plan assets are other ways to meaningfully support the Society and our mission of engaging the world's people in the excitement of space exploration.

If you have included The Planetary Society in your estate plans, please let us know. We would like to thank you and include you as a member of a group of very special friends to whom we send news releases about the Society's activities and invitations to special events.

Contact Andrea Carroll at 626-793-5100, extension 214 or *andrea.carroll@planetary.org* if you would like to inform us of your estate plans or if you would like to discuss making a planned gift.

Thanks to all of you who have already so generously included us in your plans.

—Andrea Carroll,
Director of Development

Planetary Radio Coming to Your Airwaves

Planetary Radio is now available to hundreds of public radio stations via National Public Radio's Public Radio Satellite Service. Let us know if there's a station near you that should carry our program by e-mailing us at *planetaryradio@planetary.org*. Better yet, let the program director of your local station know that public radio's best-produced and most informative series about space exploration is available at no charge.

In the meantime, you can also listen at our website. Visit *planetary.org/radio*.

—Mat Kaplan,
Planetary Radio Producer

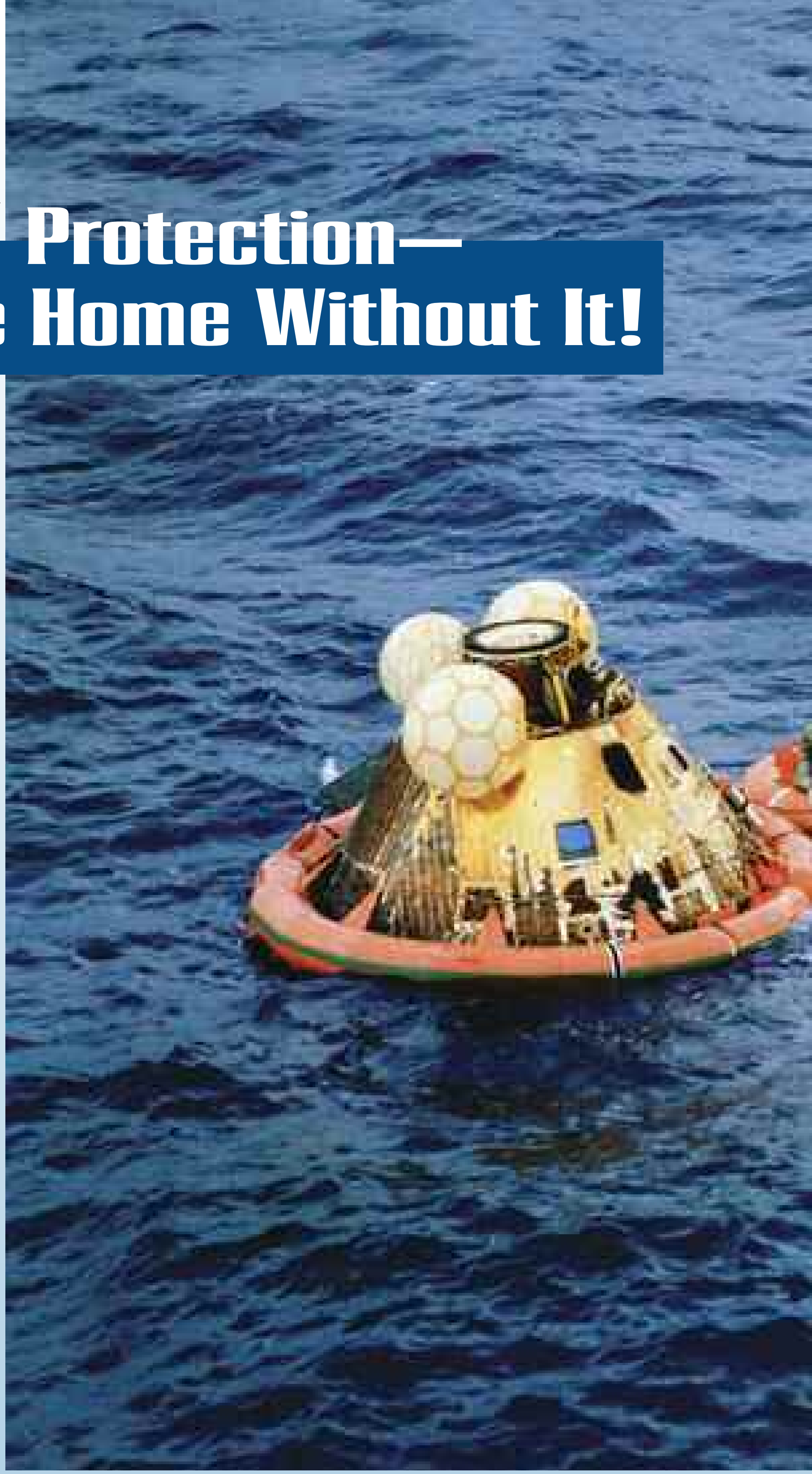
What's Happening in Your Neighborhood?

Did you know that the Society maintains an events calendar at *www.planetary.org/html/society/calendar.html*? If you are aware of events related to space exploration, please let us know about them by e-mailing Vilia at *tps.vz@planetary.org*.

—Vilia Zmuidzinas,
Events and Project Coordinator

PLANETARY Protection—Can't Leave Home Without It!

by Margaret S. Race



Before future astronauts can take their monumental first steps onto Mars, engineers, scientists, designers, and developers will analyze the mission from every perspective to plan the spacecraft hardware, life support, equipment, and operational controls needed to sustain future human explorers. And just like the *Apollo* missions of earlier decades, planetary protection will be an important part of the preparations. According to the Outer Space Treaty, protecting the planets is essential; the treaty requires that space exploration be done in a way that avoids harmful cross contamination of planetary bodies. For future human missions, this means that space hardware and activities must not adversely affect Mars during exploration or expose Earth to biohazards when astronauts return. Even before long-duration, round trip missions are designed, it will be important to know whether and how human exploration can be accomplished in the face of current international planetary protection requirements.

While it's admittedly too early to define precise requirements and designs to address all these concerns, it is possible to identify and analyze major risk factors for preliminary planning purposes. Perhaps it would not be premature to give early attention to estimating the general scale of risks involved, as well as identifying possible steps to control, mitigate, or eliminate risks through appropriate mission designs and operations.

Planetary Protection—Integral to Space Exploration

Shortly after the successful launch of *Sputnik* in 1957, scientists recognized the very real potential of contaminating locations in our solar system by sending microbes on launched spacecraft and equipment. Any "hitchhiker" microbes that survive transport to distant planetary targets amount to *forward contamination* that might cause irreversible impacts on extraterrestrial life or ecological systems beyond Earth. They might also interfere with scientific exploration by making it difficult to determine whether discovered life-forms are truly extraterrestrial or were carried there from Earth. In addition, if extraterrestrial life-forms are transported back to Earth via

Left: The Apollo 11 *astronauts arrive on the USS* Hornet *during recovery operations in the Pacific Ocean. Their biological isolation garments were designed to shield Earth from any harmful organisms they may have brought back from the lunar surface.*

Below: The traditional postflight cake-cutting ceremony was altered to accommodate the three Apollo 11 *astronauts confined to the mobile quarantine facility at the right of the frame. This quarantine van was then flown to the Manned Spacecraft Center in Houston, where the astronauts spent the remainder of their 21-day quarantine.* *Photos: JSC/NASA*

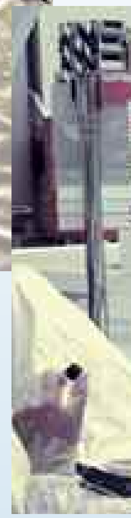
When the Apollo 11 *crew returned to Earth on July 24, 1969, people all over the world were introduced to the concept of planetary protection. Here Neil Armstrong, Buzz Aldrin, Mike Collins, and a recovery worker—all clad in isolation suits—await pickup by a helicopter that will take them to the USS* Hornet. *Photo: KSC/NASA*

spacecraft, samples, or astronauts on a return trip, such *back contamination* might adversely affect Earth's biota and ecosystems. Because of these concerns, the Outer Space Treaty was signed in 1967, requiring that exploration of celestial bodies and studies of outer space be done in ways that avoid harmful cross contamination—on both the outbound and inbound portions of missions. (For more information on planetary protection requirements and history, see NASA's planetary protection website at *planetaryprotection.nasa.gov.*)

The first major experiences with planetary protection occurred during the *Apollo* missions. Returning astronauts were isolated and rigorously studied under quarantine conditions in order to verify that nothing was returned from the Moon that was hazardous to life on Earth—including the astronauts themselves. The lunar rock and soil samples were studied in similar detail to search for evidence of possible extraterrestrial life or unusual findings. When no adverse effects or extraterrestrial life forms were found after extensive testing, the astronauts and lunar sample materials were cleared for release from containment.

These same planetary protection concerns apply to space missions today and in the foreseeable future. Although no evidence of extraterrestrial life has been discovered in the years since *Apollo*, our scientific knowledge about the diversity of microbial life on Earth has increased significantly. We recognize the remarkable abilities of microbes to flourish in extreme environments on Earth—thriving in diverse environments like deep sea vents, arctic permafrost, highly acidic streams, even living in rocks many kilometers below the Earth's surface. In the context of space missions, this biological hardiness translates into an increasing potential for life to exist on extraterrestrial bodies or to survive if transported between planets during exploration. Consequently,

Rocks and "soil" returned from the lunar surface were treated with great care to ensure that they were not contaminated by Earthly organisms. These researchers, wearing germ-free clothing, are examining a sample from* Apollo 17 *that is inside a sterile isolation chamber. *Photo: JSC/NASA*



Before the Mars Exploration Rovers launched off the surface of the Blue Planet for their trip to the surface of the Red Planet, they had to be examined thoroughly to make sure they weren't carrying any unwanted microorganisms. Above: Larry Kirschner samples the outside of the backshell covering the encapsulated spacecraft; right: Bob Koukol and Lori Shiraishi perform microbiological sampling of the instruments and the Instrument Deployment Device.
Photos: Jennifer Law, courtesy of JPL//NASA/Caltech

concerns about planetary protection requirements for spacecraft and mission operations are particularly important for places like Mars. Although Martian environmental conditions are decidedly extreme, they are not beyond the biological limits of life as we know it. And recent scientific verification of past liquid water by the Mars Exploration Rovers increases the prospect of finding evidence of Martian life, either living or dead, during future missions.

Planetary Protection and Human Missions

Because we aren't sure whether Martian life exists, and are unlikely to know with certainty prior to near-term launches, the Space Studies Board of the National Research Council recommended that NASA take a conservative approach to planetary protection for all missions to Mars. This means that all outbound robotic spacecraft and scientific equipment will be extensively cleaned, sterilized, and tested during assembly to minimize microbial and organic contamination prior to launch. Looking ahead, plans for the first round-trip sample return mission in about a decade will require the design and construction of a sample-receiving facility where returned Martian materials will be quarantined during rigorous testing and analysis.

Before humans can be sent to Mars, information from robotic precursor missions will be essential to identify and mitigate potential hazards to astronauts. For example, more detailed information will be needed on Martian geology and terrain to ensure safe landing and to help humans and rovers maneuver during their travels on the surface. An understanding of the surface regolith or soils is needed to determine mechanical properties such as aggregate strength, stability, and abrasive characteristics. Unstable or shifting surface materials could cause mobility problems for rovers or undermine the strength required at habitat or landing sites. In the long term, abrasion or friction from surface materials could cause excessive wear and tear on equipment and space suits. Information on radiation hazards as well as the potential for airborne dust intrusion and accumulation will also be needed in order to design safe artificial life support for human crews. If dusts are toxic or contain biological hazards including possible life-forms, they could expose the astronauts to unsafe or unhealthy working conditions both outside and indoors.

Regardless of whether extraterrestrial life may be discovered in the intervening years, it's clear that a human mission to Mars will require extensive and careful planning. It's recognized that human explorers will contaminate the planet by their very presence. The question is whether this inevitable contamination will be at a level considered harmful under the terms of the Outer Space Treaty, and whether the presence of humans and their symbiotic microbes and organic contaminants will confound the very scientific exploration they seek to conduct. For mission planners, the questions are fundamental—is it even possible to design human missions in the face of existing planetary protection restrictions? Could concerns about forward and back contamination interfere with mission success? Is it possible to develop mission plans that are both prudent and permissive of human activities while providing robust operating procedures that recognize planetary protection requirements, yet are tolerant of potential human errors and the unknown?

Technological and Scientific Challenges

Although human exploration of Mars is decades in the future, it's not too early to consider the implication of planetary protection on mission designs and plans. In

In spite of all precautions, human explorers will contaminate the surfaces of other worlds by their very presence. In this Apollo 12 *image, a halo of cooling water vented from his spacesuit surrounds Alan Bean as he stands on the surface of the Moon.* Image: JSC/NASA

fact, recently, the Moon-Mars Commission, headed by astronaut Pete Aldridge, recommended that NASA adopt policies of "spiral, evolutionary development" as a way of incrementally reaching the difficult long-range goals. Each robotic mission, whether one-way or round trip, offers an opportunity to develop and test new systems and to collect important precursor data that will contribute to the ultimate success of human missions on Mars. Already, scientists and engineers have begun to brainstorm about the challenges and questions ahead. The preliminary findings of various NASA work groups and studies provide a tantalizing view of the research and development (R&D) needs and logistical concerns that must be addressed.

It's certain that the first human mission to Mars will face significant risks. Astronauts literally will venture into the unknown using complex transportation and life support systems with state-of-the-art features. They'll face transportation times of two to three years, with periods of dynamic flight conditions and demanding flight navigation. The conditions and demands will be unprecedented. Consider their everyday activities. What will they eat, and how will it be supplied? What should be done about human wastes and their disposal to avoid contaminating Mars? Can life support systems, space suits, and vehicles for surface locomotion be designed as closed-loop systems that minimize venting of respiration gases and ambient air to the outside? What kinds of tools will be needed to safely probe, explore, and dig on the Red Planet—and how will they be cleaned and maintained throughout the mission? And what would be done in the case of an accident or emergency that debilitated an astronaut many months and hundreds of millions of miles away from assistance? Clearly there are many challenges to overcome.

Regardless of the development efforts and the extent of component and prototype testing, the first human mission will likely be the initial experience of fully operating the complete system for all its intended purposes. Many of the overall mission risk factors typically identified by engineers will affect both crew safety and planetary protection, especially those risk factors involving contamination. Thus, crew safety, integrity of planetary protection, and overall mission success are closely related, interdependent goals.

When early human missions take place, it's likely that both astronauts and robotic devices will be important elements in exploring the planet together. Both will require planetary protection controls of different types, and each will impact design and operational considerations. To understand the many interrelated planetary protection issues ahead, it's necessary to dissect the mission and consider the complex mixture of human presence, physiological and biomedical requirements, scientific objectives, mission equipment, exploration activities, and space hardware

Protecting the health and safety of astronauts confined to close quarters during a long-duration mission to Mars will be one of many complex and interrelated planetary protection issues. Here the crew of space shuttle mission STS-110 takes a relaxation break between duties. *Photo: NASA*

from three distinct perspectives:

- protecting Mars and scientific exploration from forward contamination,
- protecting astronauts' health and safety throughout the long-duration mission, and
- preventing back contamination of Earth from possible Mars contaminant sources upon return.

In addition, it will be important to anticipate how various operational scenarios could affect each of these critical planetary protection perspectives. For example, what are the effects of scientific sample collection activities on either astronauts or Mars itself? If there is a need to excavate and collect large amounts of materials for use in making fuels or growing food at a Martian base, might it cause widespread, irreversible damage to Mars? Would plant growth experiments or food production using Martian soils in greenhouses cause a harmful hybridization of Earth and Mars ecologies that might jeopardize astronauts or be detrimental to putative Martian life? How should subsurface sampling be done safely and productively in areas with evidence of ice or possible liquid water? Finally, what should be done if and when Martian life is detected during a human mission, either during sample analysis in the laboratory or outdoors away from the base?

Typically, one-way robotic missions to Mars involve extensive cleaning and sterilization of the entire spacecraft prior to launch in order to prevent unwanted microbial hitchhikers from going along for the ride. With astronauts, microbial hitchhikers are unavoidable, since humans are hosts to a complex microbiological community related to digestion and other body functions. Many planetary protection issues and risks will arise due to the fact that a key component of human missions—the astronauts themselves—cannot be sterilized before launch. This fundamental problem can be addressed by designing all operations of the initial human mission to include isolation of humans from any direct contact with Martian materials. This planned isolation serves two important purposes—protecting Mars from Earthly microbial contaminants and avoiding contamination of scientific experiments and observations during the mission. To meet these dual needs, we must address planetary protection controls as a part of the initial stages of mission and hardware design, especially for surface exploration missions that include humans.

Planning for human missions must be based on detailed knowledge about Mars and local site information from precursor robotic evaluation and sample return missions. A comprehensive site classification system is needed that describes and categorizes Martian areas by special scientific interest and by level of contamination concern. This will serve as an important aid in selecting base site locations and mission objectives and should guide the development of operational plans in ways that avoid harmful contamination of the Martian surface. Additional development and design attention will be needed for many exploration, sampling, and base activities in order to ensure effective operations and the required level of planetary protection assurance.

Finally, general human factors also need to be considered along with planetary protection issues for human missions to Mars. Physical or psychological effects that lead to debilitation and reduced performance capability in astronauts may contribute to unintended actions or behaviors, which could in turn result in mishaps with potentially serious planetary protection consequences. Mistakes are much more likely when people are tired, ill, and/or overstressed, and the best-designed equipment will work only if it is used as intended.

R&D Needs

The report also identified many specific questions and concerns that will need further R&D in the years ahead. For example, to protect Mars and avoid forward contamination, it will be necessary to develop upgraded space suits, rovers, and habitats for human activities, with special emphasis on venting systems, filtration, and equipment for detecting and monitoring the release or escape of microbes. Effective cleaning methods and appropriate cleanliness and sterility guidelines will be needed for equipment used on Mars. Subsurface drilling equipment will be a special challenge—because of size and weight considerations as well as cross contamination concerns. In addition, there will be a need to analyze and understand the likely nonbiological ecological impacts on Mars (e.g., from excavation, construction, resource use, road systems) and their possible mitigation.

To protect human health and safety throughout the mission, R&D will be needed on measures to control exposure to risks inside the habitats and during habitat occupancy and exploration operations, concentrating on factors such as ionizing radiation, dust and electrical discharges, dust composition and toxicity, and possible biohazards from Martian life, if it exists. Special emphasis will be needed on life support, habitat design, and mobility, as well as waste handling, waste disposal, and research laboratory procedures.

Protecting Earth upon return will involve preparations for handling and testing both crew and Mars samples during transit and upon arrival on Earth. NASA recently completed a multiyear international study to develop a draft protocol for robotic sample return that involves strict biocontainment and testing in a special sample-receiving facility. For human missions, the handling, containing, transporting, and testing of Martian materials during the mission and the return of astronauts and Martian samples to Earth will be even more complex. Methods for isolating Martian materials and samples from astronauts while on the planet and during the return flight will be critical to eliminate major concerns. In the event of a breach in containment, lapse in protocols, or inadvertent exposures, there must be a mission architecture that can accommodate containment for the crew, spacecraft, and equipment, if needed, until they arrive at a containment facility on Earth.

Anticipating Ethical and Societal Concerns

Finally, as if scientific, technological, and planetary protection issues aren't enough to consider in planning human missions to Mars, there is yet another perspective to add. NASA's research roadmap for astrobiology affirms the need to consider the broad implications of astrobiological research and exploration, including examination of the societal and ethical issues. Since long-distance, long-duration exploration missions are essentially without precedent, serious discussions of broader issues have likewise begun. NASA is jointly supporting a project with the American Association for the Advancement of Science (AAAS) to examine "the philosophical, ethical, and theological issues associated with origin of life studies, the search for extraterrestrial microbial life, and space exploration that may transport microbial life beyond Earth, or have an impact on extraterrestrial microbial life." As part of the AAAS Dialogue on Science, Ethics and Religion program, participants include biologists, planetary scientists, astronomers, ethicists, historians, and religious scholars.

In addition, the European Space Agency (ESA) recently convened an international Ethical Working Group to consider the implications of exploration and detection of extraterrestrial microbial life on the space program and society at large. Both efforts recognize the importance of publicly communicating the meaning and ramifications of space exploration along with the exciting scientific discoveries and technological accomplishments.

Although space ethics as a discipline has not yet come of age, the engagement of experts from many areas is important to begin framing the deliberations and developing guiding principles for exploration that supplement scientific, technological, and policy considerations. We know that the ambitious visions and goals expressed by the space community are likely to lead to huge steps for humankind in exploring the solar system. As we reach for the heavens, it is right to begin on sound footing—considering plans for human space activities in a very broad, interdisciplinary context from the start.

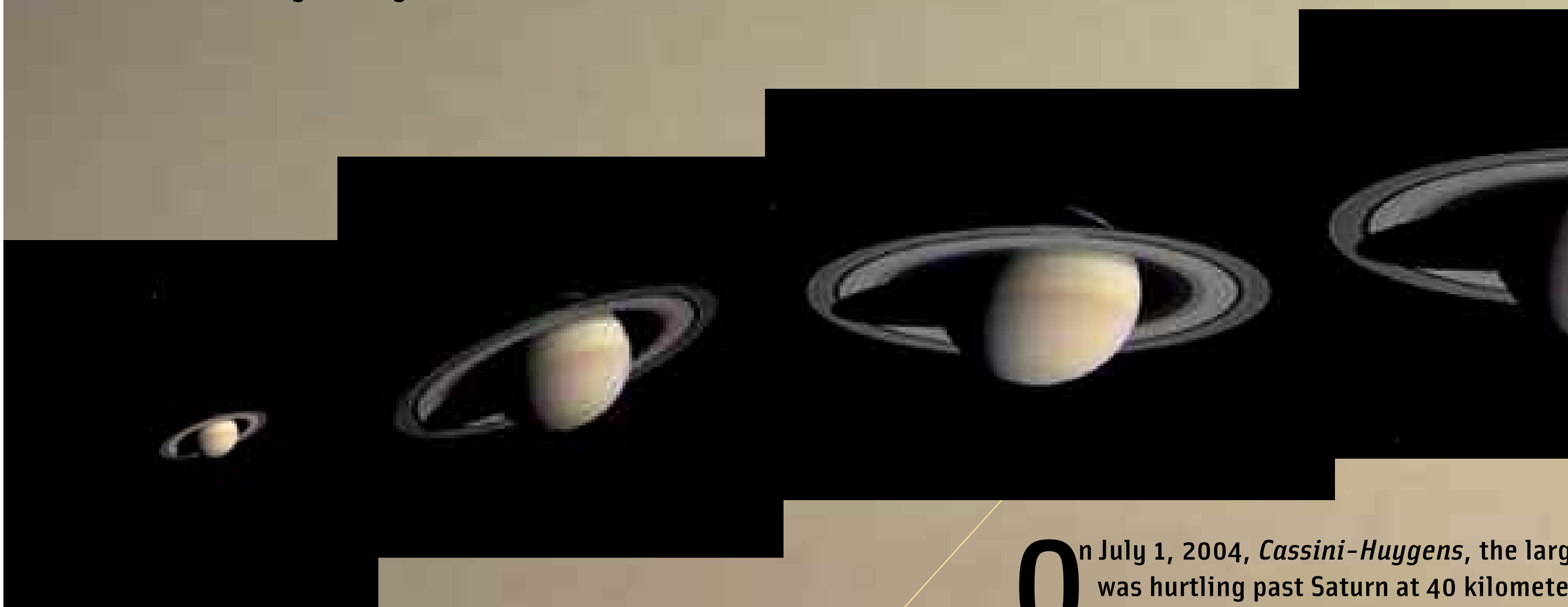
If a human base on Mars is to become a reality in the next few decades, scientists and engineers will have to study human missions to other worlds from every angle. Key to these preparations will be the development of a solid plan for planetary protection. *Illustration: NASA*

Margaret S. Race is an ecologist working with NASA through the SETI Institute in Mountain View, California. Her research focuses on planetary protection, environmental impact analyses, legal and policy issues, risk communication, and ethical concerns related to solar system exploration and astrobiology.

Cassini-Huygens' New Home

The First Days in Sa

by Emily Stewart Lakdawalla



On July 1, 2004, *Cassini-Huygens*, the larg
was hurtling past Saturn at 40 kilomete
crossed their fingers for luck but had to w
enough to drop it into orbit around the ringed planet?
out of Saturn's system, never to return?

We now know the answers: *Cassini-Huygens*' orbit insertio
spacecraft is now traveling farther and farther from Satur
gravity will eventually make it return. *Cassini* will spend the rest of

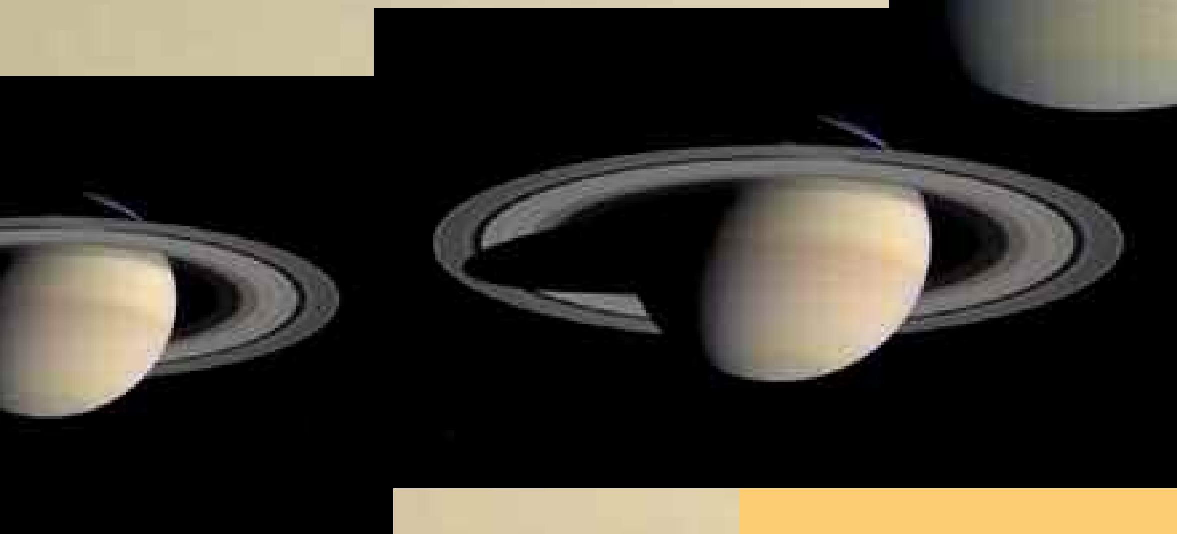
Before and after its death-defying maneuver, *Cassini* was already doi
system began nearly two years ago, when the spacecraft was still a
miles) from the planet. On its path into the Saturnian system, it flew close by
The only previous flyby of Phoebe, by *Voyager 2* in 1981, had been at about 1,00

Immediately following the 96-minute burn of the main engine that placed *Cassini*-
views of Saturn's rings from the closest vantage point that it will ever obtain thro
Finally, as it flew away from Saturn again, it accomplished a *Voyager*-class encounter of Sat

All the images that you see on these pages were captured by *Cassini* before it completed its
Cassini were a flyby mission, like *Pioneer* and the *Voyagers*, this stunning array of images
would have been perfectly satisfying to the scientists. The fact that this rich trove of data represents
year mission boggles the mind and whets the appetite for what is to come during *Cassini*'s 76 future orb

Emily Stewart Lakdawalla is The Planetary Society's science and technology coordinator.

turn's Orbit



gest spacecraft ever to leave the Earth's environs,
rs (25 miles) per second. Back on Earth, scientists
wonder: would the tiny thrust of its main engine be
Or would its tremendous speed carry it right back

on maneuver worked flawlessly. Although the
rn every day, the inexorable force of Saturn's
f its life circling the planet.

ng science. Its observations of the Saturnian
lmost 300 million kilometers (190 million
Saturn's outermost icy satellite, Phoebe.
00 times the distance.

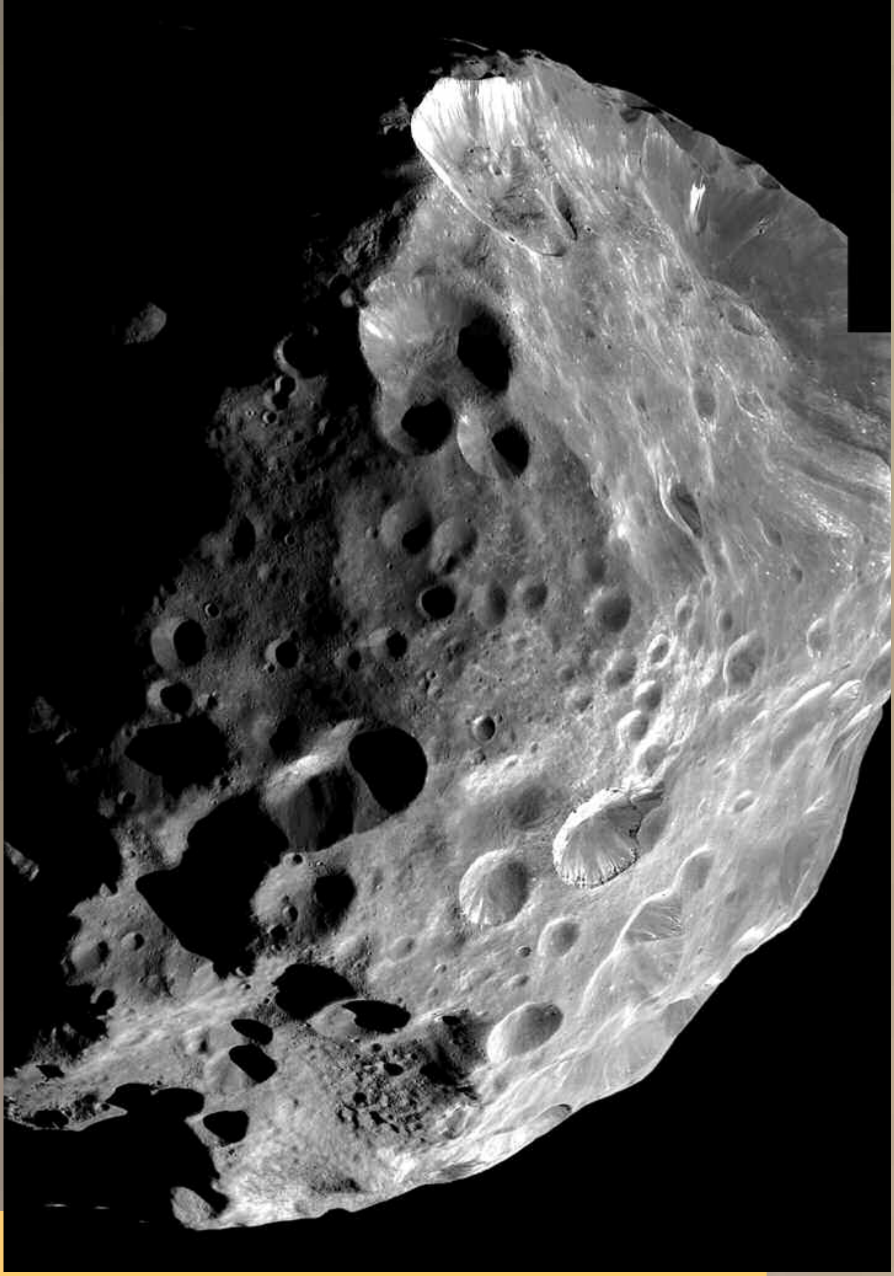
-*Huygens* into orbit, *Cassini* captured
ughout its four-year primary mission.
turn's haze-shrouded moon Titan.

first orbit of the giant planet. If
s and spectrographic measurements
only a few days' work out of a four-
its around the Lord of the Rings.

Cassini *captured its first view of Saturn on October 21, 2002, when it was still 285 million kilometers (177 million miles) away. As it approached the end of its journey, Saturn loomed ever larger. March 27, 2004 was the last day that the entire ring system would fit within one frame of its Narrow-Angle Camera. From then on, capturing the full majesty of the ringed planet would take more than a single image.*

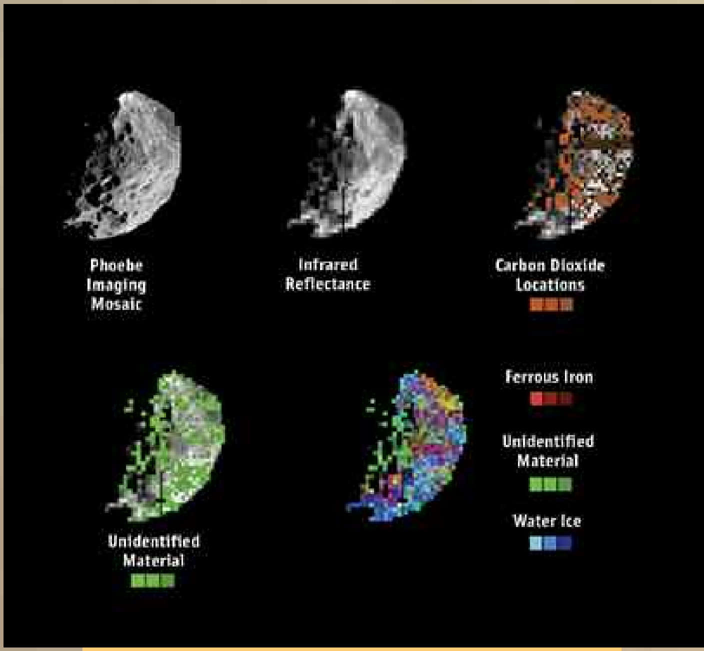
All the images shown here are true-color composites, representing approximately what Saturn would look like through human eyes. Visible in most of the images are Saturn's bright equatorial band of clouds, the darker outer A ring, the inner brighter B ring, and the Cassini division separating the two. As Cassini *got closer to Saturn, the inner Crepe Ring, or C ring, became visible. In the final image in the series, the C ring resolves into many narrow, dark rings, each of which casts a shadow onto Saturn's cloud tops.*

The images, left to right, were captured on October 21, 2002; November 9, 2003; and February 2, March 3, March 27, and May 21, 2004. Images: JPL/NASA/Space Science Institute



The views of Phoebe that Cassini *returned when it flew by on June 12, 2004 stunned scientists with the sheer number of impact craters dotting that moon's surface. Most of the craters are undoubtedly very old, but some relatively fresh craters have a bright white material—almost certainly water ice—cascading down the interior slopes.*

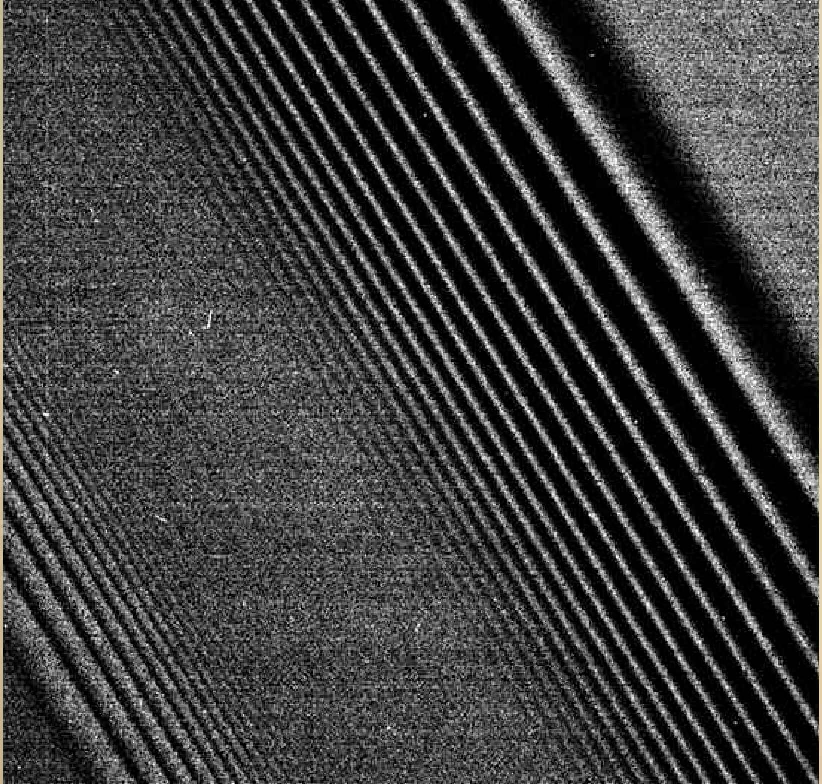
The presence of water ice on Phoebe confirms long-held suspicions about the moon's origin. Phoebe is in a distant, highly inclined, retrograde orbit around Saturn, which means that it must have been captured after its formation elsewhere in the solar system. The water ice clearly indicates that Phoebe is not an asteroid but is instead a wanderer from the outer solar system. ***Image: JPL/NASA/Space Science Institute***



Cassini*'s Visual and Infrared Mapping Spectrometer (VIMS) made the most exciting discovery of the Phoebe encounter: carbon dioxide ice exposed on the surface. For carbon dioxide ice to be present in large quantities on Phoebe, the moon must never have been hotter than –125 degrees Celsius (–193 degrees Fahrenheit). Tellingly, the carbon dioxide ice exists not as a frost but rather as an intimate mixture with dark (possibly organic) material on Phoebe's surface. The VIMS also identified water ice and ferrous iron (which is an important component of the most common silicate minerals in the solar system—that is, rocks), as well as indicating an as-yet-unidentified material possibly of organic origin.*

The carbon dioxide is powerful evidence for Phoebe's formation in the most distant reaches of the solar system, possibly even the Kuiper belt. Cassini*'s encounter with Phoebe therefore might be the first time that a spacecraft has ever flown by a Kuiper belt object.*

Image: JPL/NASA/University of Arizona

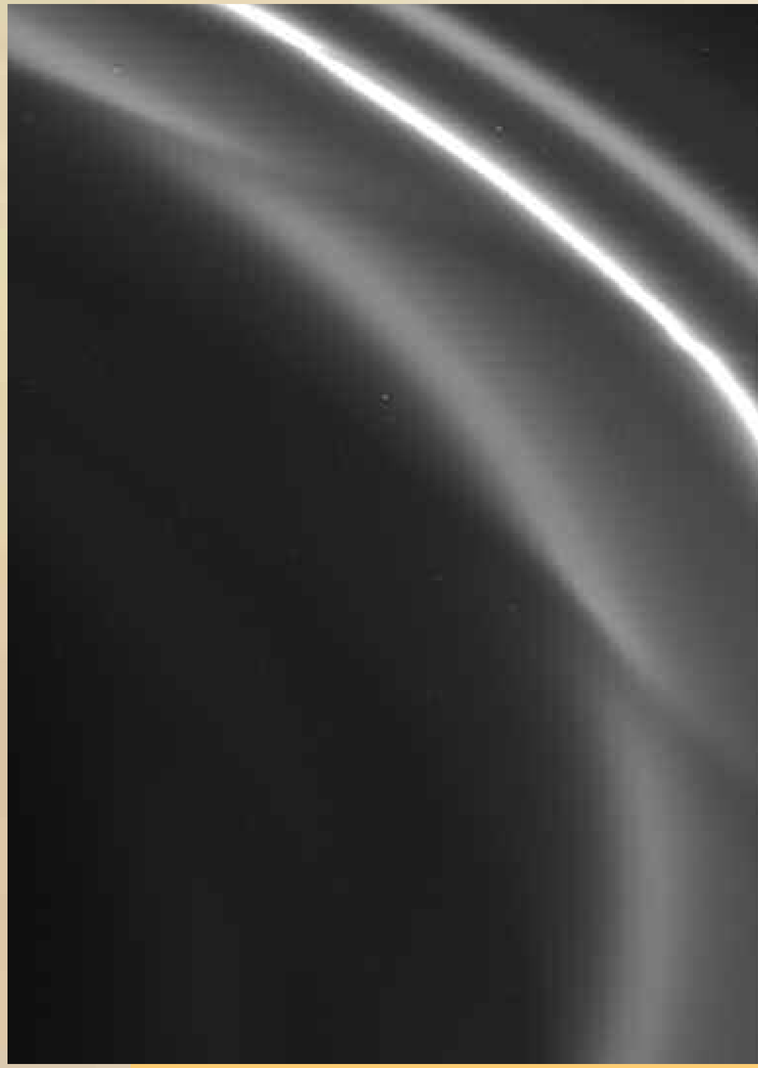


A tight close-up of Saturn's A ring, captured immediately after Cassini-Huygens *achieved Saturn orbit on July 1, 2004, shows textbook ring physics in action. Scientists had hoped—but dared not believe—that the* Cassini *images of Saturn's rings would so perfectly match mathematical predictions of what their forms should be.*

The striations in the ring result from two different physical processes. The stripes in the lower left corner are a single spiral density wave, a periodic clumping and attenuation in the rings that occurs when the ring particles are in a resonant orbit with one of Saturn's moons. In this case, the ring particles orbit Saturn 12 times for every 11 times that nearby Prometheus does. The density wave propagates outward from Saturn, with decreasing wavelength over time, making a tightly wrapped spiral around the planet. The bright stripes represent regions where there are fewer ring particles than in the dark stripes.

The stripes at the upper right corner are a single spiral bending wave, a vertical corrugation in the ring. The ring particles are excited into motions above and below the otherwise flat ring plane because of an orbital resonance with the moon Mimas. Mimas' orbit is inclined to Saturn's ring plane by 1.6 degrees, so it exerts up-and-down forces on ring particles. The ring particles in the bending wave orbit Saturn 5 times for every 3 times that Mimas does. The bending wave propagates inward over time, making another spiral about the planet. The bright stripes are the sunlit faces of the corrugations, while the dark stripes are in shadow. Horizontal striping across the image is an artifact caused by the spacecraft's electronics and does not actually represent features in the rings.

Image: JPL/NASA/Space Science Institute



As it sped away from Saturn, Cassini *looked back at the F ring, a narrow, faint ring that was discovered in 1979 in* Pioneer 11 *images. Because the F ring is so narrow, it was predicted that it required two so-called shepherd moons to herd it into shape. Those two moons, inner shepherd Prometheus and outer shepherd Pandora, were discovered in* Voyager 1 *images in 1980.*

In this extremely close view, captured when Cassini-Huygens *was only 157,000 kilometers (97,600 miles) above the ring plane, we can see the brightest central core of the F ring as well as wispy material inside it that is perturbed into twisted wakes by the gravitational influence of Prometheus.*

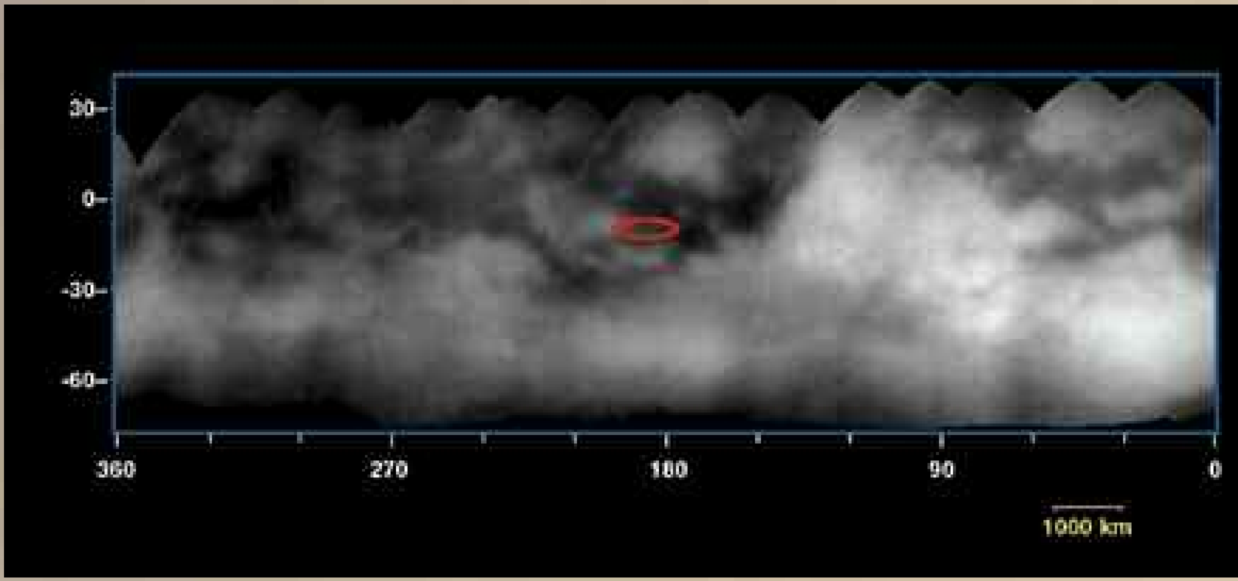
Image: JPL/NASA/Space Science Institute

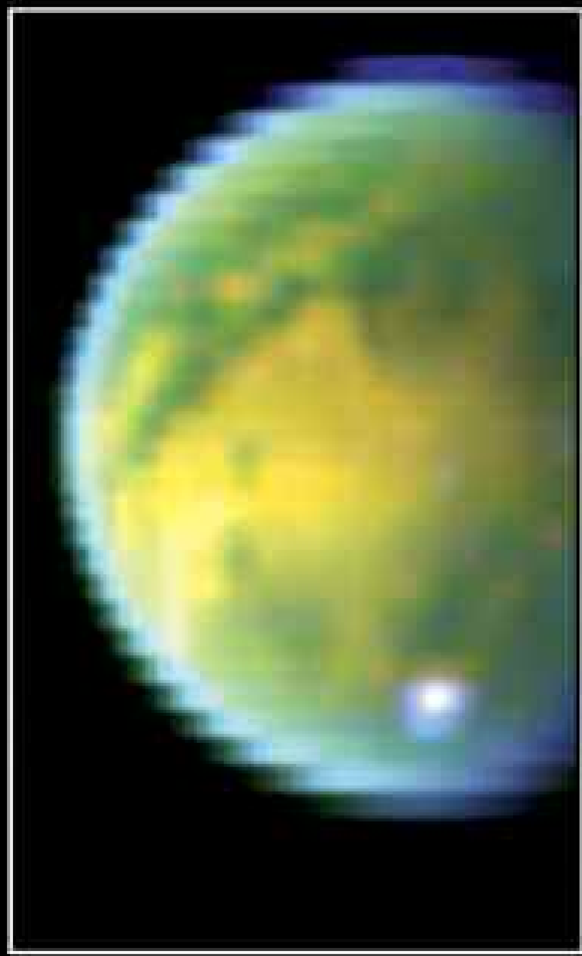
As seen in visible light, Titan is a nearly featureless orange ball. It has a thick atmosphere containing mostly nitrogen, with a few percent methane and trace amounts of a host of different carbon-containing chemicals such as ethane, propane, and carbon monoxide. In a word, Titan's sky is smoggy. The Voyager *cameras were not equipped to see through this atmosphere, but* Cassini*'s are.*

Images: JPL/NASA/Space Science Institute

A combination of two filters—one of them at an infrared wavelength through which methane is relatively transparent, and another a polarizing filter that reduces the light-scattering effect of the haze—permits Cassini *to see through the atmosphere to the surface. The bright and dark features are actual brightness variations on the surface of Titan.*

At lower right in the photo is a large bright area named Xanadu that was discovered in 1994 through Hubble Space Telescope imaging with an infrared instrument. Toward the top are dark, linear features of enigmatic origin.





Cassini's VIMS can also penetrate Titan's atmosphere to see the surface. Although the VIMS does not have the stunning spatial resolution of the Narrow-Angle Camera, its spectral resolution—that is, its ability to discern minute differences in color—is far higher. VIMS images can be processed to create maps of the abundance of different materials on Titan.

In this false-color composite of three VIMS images captured at infrared wavelengths of 2.0, 2.8, and 5.0 microns, yellow areas correspond to hydrocarbon-rich regions, while greenish-black areas are icier. Near the South Pole, at the bottom of the image, is a bright white spot where methane clouds reflect infrared light across all wavelengths. *Image: JPL/NASA/University of Arizona*

For the latest information about the Cassini-Huygens *mission to Saturn, visit* planetary.org/saturn

A mosaic of 16 images taken through infrared and polarizing filters creates this map of the brightness variations across the equatorial and south polar regions of Titan. Bright Xanadu is at lower right. Near the equator, at upper left, is a feature that looks like a giant black "H."

Counterintuitively, the dark areas appear to represent regions rich in water ice, while the bright areas appear to be relatively rich in hydrocarbons. The sharp-edged linear features probably did not result from meteorite impacts, which would have produced circular features. Instead, they imply that Titan, like the other large outer-planet satellites, has had a lengthy and complex geologic history. Because Titan has an atmosphere and weather, some linear features could even have resulted from wind or fluid erosion of the surface, like canyons on Earth and Mars.

The red ellipse indicates the region in which the Huygens *probe will descend to Titan's surface on January 14, 2005.* Cassini *scientists hope that the* Huygens *data will provide ground truth for their orbital observations and solve some of the mysteries surrounding Titan's surface features.* *Image: JPL/NASA/Space Science Institute*

THE 2004 SHOEMAKER NEO GRANTS—
Send in Those Applications!

A near-Earth object collides with Earth. Illustration: Pat Rawlings

By Daniel D. Durda

Since its founding, The Planetary Society has actively supported a number of efforts to discover and characterize the population of near-Earth objects (NEOs) that both threaten our planet and hold great promise for future exploration. In 1997, the Society began the Gene Shoemaker NEO grant program to help in the global effort to meet the Spaceguard Foundation's goal of discovering 90 percent of the 1-kilometer (0.6-mile) and larger NEOs that have the potential to collide with our planet. The program honors pioneering planetary geologist Gene Shoemaker, who did so much to help us understand the process of impact cratering on the planets and the nature of the NEO population. Through Shoemaker NEO grants, the Society seeks to assist amateur observers, observers in developing countries, and underfunded professional observers in contributing to vital NEO research.

To date, the Society has awarded 17 Shoemaker NEO grants totaling more than $120,000 to observers around the world. Grant recipients have played critical roles in recovering small asteroids newly discovered by the major asteroid survey programs; they have provided the crucial follow-up observations to determine precise orbits for these objects (see "We Make It Happen" in the May/June 2004 issue of *The Planetary Report*).

It is time to continue and expand this work by beginning the selection process for the next round of Shoemaker NEO grants. When originally conceived, the program focused on helping to provide larger telescopes and more sensitive CCD cameras to observers, with the goals of helping broaden the survey coverage of the sky and increasing the rate of NEO discovery. As we look at the observing programs that are now contributing the most, we can rejoice that we have made the awards wisely and that the field as a whole has benefited as a result.

Over time, the half dozen or so large professional NEO survey programs, particularly the LINEAR (Lincoln Near-Earth Asteroid Research) program run by MIT's Lincoln Laboratories, have made great leaps forward in automated searches of wide swaths of the sky for very faint asteroids. Although amateur observers still contribute many valuable NEO observations, their most significant contributions have evolved away from NEO discovery toward astrometric follow-up (observations to help refine data on the orbits of new NEOs discovered by the professional surveys) and valuable studies to help better characterize the physical nature of these planetary projectiles. The next round of Shoemaker grants will focus on advancing amateur contributions in these latter areas (astrometric follow-up and physical studies).

The need now is for larger telescopes (apertures larger than about 24 inches, or 60 centimeters), or telescopes that are effectively larger because they are located at superior observing sites, and for automation of observing facilities and equipment. Large telescopes at sites with dark, clear skies allow for observation of NEOs fainter than magnitude V = 20 (at which professional surveys are discovering many new small objects), and automation of observing facilities allows observers with "day jobs" to utilize their facilities more nearly full-time and much more efficiently. Priority will be given to applicants seeking to improve facilities with large telescopes and/or for automation. Priority also will be given to programs that can leverage Shoemaker grant funds through matching contributions from other sources.

Applications for the current round of Shoemaker NEO grants are due October 1, 2004. Grant sizes typically are $3,000 to $10,000. The Planetary Society welcomes applications from amateur and underfunded professional observers anywhere in the world. All applications will be reviewed by an international panel of NEO experts.

For further information and instructions for completing a proposal application, visit the Society's NEO web page at *planetary.org/html/neo/index.html*.

Daniel D. Durda is a planetary scientist at the Southwest Research Institute in Boulder, Colorado, where he studies the collisional evolution of asteroids and the effects of their impacts on Earth. He is also the coordinator for The Planetary Society's Shoemaker NEO Grant program.

World Watch

by Louis D. Friedman

Washington, DC—The report of the President's Commission on Moon, Mars and Beyond was released in early June. The commission, chaired by former Secretary of the Air Force Edward (Pete) Aldridge, was set up shortly after President Bush announced the new space exploration policy in mid-January. The commission was charged with making recommendations on the actions necessary to enable NASA to carry out the change of direction for US human spaceflight.

The commission included Society Board members Neil deGrasse Tyson and Maria Zuber, along with Society Advisor Laurie Leshin.

The commission's report focused more on the organization and management of the new exploration policy than on either the missions or technology that will be required. The commission called for restructuring in NASA, more private sector involvement, and a shift from government centers to new, privately administered, federally contracted research centers. The commission also endorsed the strong scientific content of the exploration policy and the synergism between the human and robotic spaceflight programs.

Although the commission endorsed international cooperation, it did so with a market-oriented philosophy.

NASA responded quickly, announcing a major reorganization streamlining its headquarters offices and putting more administrative controls at headquarters instead of at the individual NASA centers. These changes affect the workforce, especially in Washington, but the actual plans for launch vehicles, propulsion technology, robotic and human missions to the Moon and Mars, and even the International Space Station (ISS) remain to be determined. And two major unresolved questions remain: when will the shuttle be ready for return to flight, and will the ISS be completed before the anticipated 2010 retirement of the shuttle?

The Planetary Society asked an independent study group, chaired by former Skylab astronaut Owen Garriott and veteran aerospace engineer Michael Griffin (now Director of Space at the Johns Hopkins University Applied Physics Laboratory), to consider the questions of launch vehicles, technology, and architecture for human spaceflight. The study group made strong recommendations (differing from current policy) concerning the development of a crew exploration vehicle, a new shuttle-derived heavy-lift launch vehicle for human missions beyond Earth orbit, and shuttle retirement after the core-complete (instead of final assembly) of the ISS. Their report is now available online at *planetary.org/aimformars/initiatives.html*

Washington, DC—As we go to press, no action has yet been taken on the NASA budget in the US Congress. Committees have started taking positions, but it is too early to tell how it will all come out. The Planetary Society has been contacting congressional committee members to urge strong support for the new exploration policy and the NASA budget, and we will present the thousands of names collected in our Aim for Mars! Campaign to the committees. You can still add your support for Aim for Mars! at *aimformars.org*.

Mojave, CA—*SpaceShipOne*, a rocket plane piloted by Mike Melvill, successfully soared out of Earth's atmosphere in history's first privately financed human spaceflight, then glided back to an unpowered landing in California's Mojave Desert on June 21, 2004. Scaled Composites, which built the rocket plane as well as its carrier aircraft, the White Knight, is directed by noted aircraft designer Burt Rutan and financially backed by Paul Allen, cofounder of Microsoft. Rutan also designed *Voyager*, the first aircraft to fly around the world without refueling.

SpaceShipOne briefly entered "space" during its suborbital flight, going above 100 kilometers (62 miles) in altitude. Rutan's group is considered the front-runner for the Ansari X Prize, a private prize challenge that will award $10 million to the first privately funded group to send three people to space in the same vehicle twice within two weeks.

Whether the *SpaceShipOne* flight is the precursor to rampant space tourism in the future remains to be seen. Whatever happens, the flight was a milestone in the history of space travel. Perhaps most important, the flight served to excite the public about space through the tremendous media coverage it generated.

For more information on the flight and pictures, see *planetary.org/news/2004/spaceshipone-lands0621.html*

Hear audio from the flight and interviews on Planetary Radio at *planetary.org/audio/pr20040628.html.*

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

Questions and Answers

Even if Mars could be terraformed and given a thicker atmosphere, it still has no magnetic field. Would Mars need a magnetic field to be habitable, or even to keep its terraformed atmosphere from being stripped away by the solar wind?
—Ivy Emerson
Dayton, Ohio

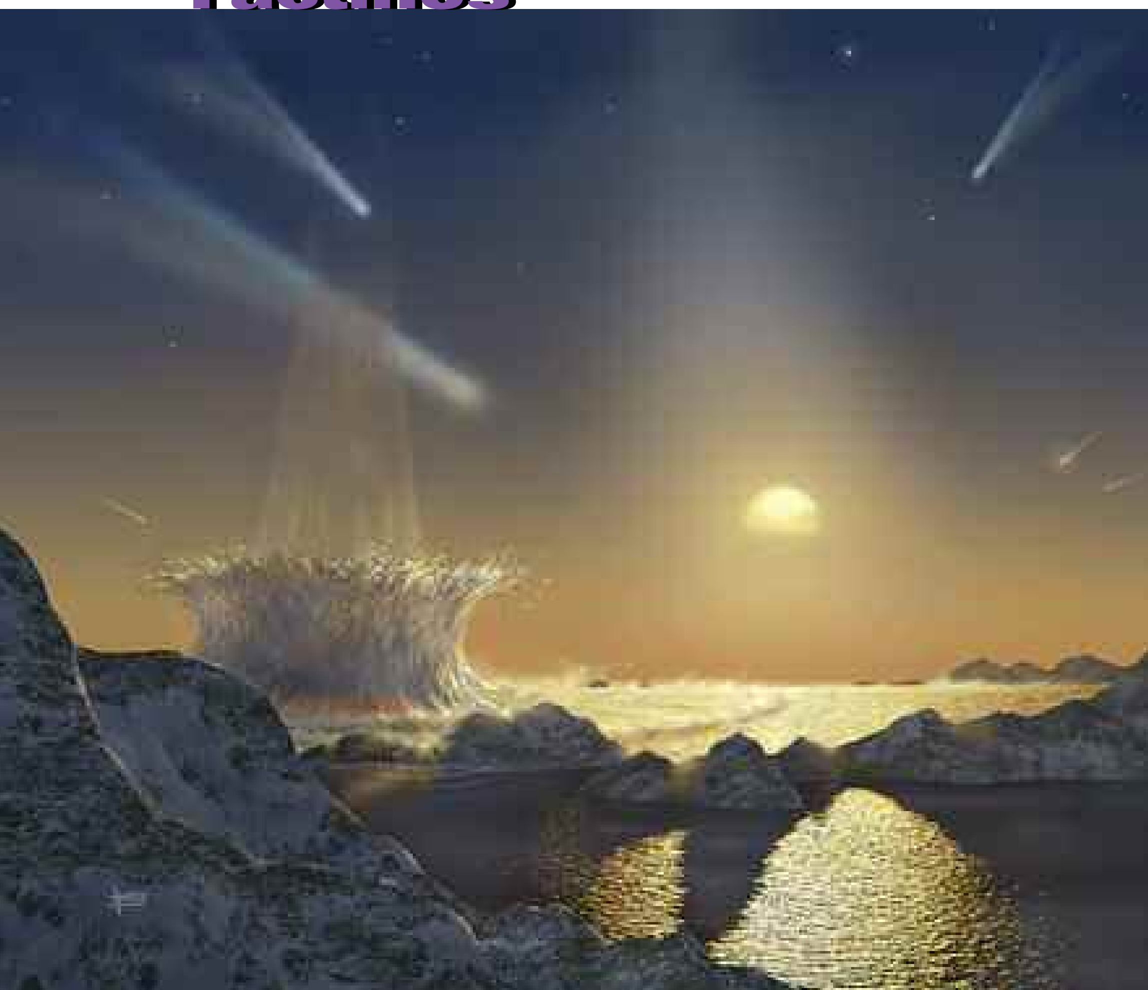
Mars probably does not need a strong magnetic field to be habitable. Two main reasons people sometimes think a magnetic field is necessary for terraforming the planet are to provide shielding against radiation and to prevent solar wind erosion of a thick (terraformed) Martian atmosphere.

In regard to particle radiation, even Earth's magnetic field does not deflect galactic cosmic rays (high-energy particles from interstellar space) because they are much too energetic. These particles are stopped before getting to the surface by Earth's atmosphere. The best gauge for determining the "stopping power" of the atmosphere is to measure mass per unit area, which on Earth is equivalent to 1 kilogram per square centimeter. (This figure represents the mass within an imaginary column 1 by 1 centimeter in size that would stretch from the ground up through the entire atmosphere.)

Earth's magnetic field does deflect lower-energy solar protons and channels these particles to the polar regions, which then create the aurora. However, even without the magnetic field, these particles would not reach the surface, again because they "run into" the atmosphere itself.

If we were to succeed in terraforming Mars' atmosphere and it had an Earth-like surface pressure of 1 atmosphere, its atmospheric mass per unit area would be 2.6 kilograms per square centimeter. This is much greater than Earth's value of 1 because to reach the same surface pressure as Earth with a lower gravity (Mars' gravity is 0.38 that of Earth) would require a more massive atmosphere. Thus, the radiation shielding effects of the Martian atmosphere would exceed those for Earth, making a mag-

Factinos



Although the star Tau Ceti is similar to the Sun, any planets it has are unlikely to be havens for life, say a team of scientists from the United Kingdom. Tau Ceti, only 12 light-years away, is the nearest Sun-like star and is the first star to be found to have a disk of dust and comets around it similar in size and shape to the disk of comets and asteroids that orbits the Sun.

But the similarity ends there, explains Jane Greaves of the Royal Astronomical Society. "Tau Ceti has more than ten times the number of comets and asteroids than there

Scientists have discovered that our close stellar neighbor Tau Ceti may be much like our own Sun, but its planets may never be able to develop life due to an onslaught of impacts from comets and asteroids.
Illustration: David A. Hardy

netic field nonessential for radiation protection.

Regarding atmospheric erosion, because Mars does not have a magnetic field, the solar wind (mostly protons) impacts the planet's upper atmosphere directly. The current "loss rate" for Mars is not significant. For example, the rate at which Mars currently loses water is comparable to the loss of a layer of water 2 meters thick over 4 billion years.

The same would be true for a terraformed atmosphere because loss rates due to solar wind for a thick atmosphere would be similar to loss rates for the current thin atmosphere. That is because the solar wind intensity would be the same in both cases, and the gravity at the top of the atmosphere (what is holding the atmosphere to the planet) would be nearly identical even with an atmosphere that was tens of kilometers thicker.
—CHRIS McKAY,
NASA Ames Research Center

I couldn't help but notice, while reading "Return to Saturn's Realm" by Charley Kohlhase [see the March/April 2004 issue of* The Planetary Report*], some rather odd temperature equivalents in the section on the* Cassini *orbiter. The last time I checked, a temperature range of 10–40 degrees Celsius translates roughly to 50–104 degrees Fahrenheit, not 18–72. I think someone there forgot to add the 32 after multiplying the Celsius figure by 1.8.
—Ron Jennings
London, Ontario, Canada

The phrase in the article was, "It [*Cassini*] can control subsystem temperature levels to 10–40 degrees Celsius (18–72 degrees Fahrenheit)." The conversion is actually correct because it refers to a range of temperature differences, not to absolute temperatures. So, it could be mean within 10–40 degrees of 100 Celsius or 10–40 degrees of –50 Celsius or whatever absolute temperature you choose.

When we talk about relative temperatures, phrases like "within 10 degrees" or "10 degrees hotter," the conversion involves only how many Fahrenheit degrees are in a Celsius degree—1.8 or 9/5. One way to think of it is that there are 9 Fahrenheit degrees in every 5 Celsius degrees.

The offset between the temperature systems cancels out whenever relative temperatures are involved because it involves a comparison (subtraction) of two absolute temperatures. So, although the conversion for 10 degrees Celsius by itself is $1.8 \times 10 + 32 = 50$ degrees Fahrenheit, when you are talking about a temperature being within 10 degrees (of whatever absolute temperature), as it said in the article, then the conversion process would be $1.8 \times 10 = 18$ degrees Fahrenheit.

This issue doesn't arise in most conversions because there usually is no offset; for example, 0 kilometers equals 0 miles. However, with temperature scales it is different, because 0 degrees Celsius equals 32 degrees Fahrenheit.
—BRUCE BETTS,
Director of Projects

are in our solar system. We don't yet know whether there are any planets orbiting Tau Ceti, but if there are, it is likely that they will experience constant bombardment from asteroids of the kind that is believed to have wiped out the dinosaurs. It is likely that with so many large impacts life would not have the opportunity to evolve." (See illustration at left.)

The new results are based on observations taken with the world's most sensitive submillimeter camera, SCUBA. The camera, built by the Royal Observatory, Edinburgh, is operated on the James Clerk Maxwell Telescope in Hawaii.
—from the Royal Astronomical Society

A new image by NASA's Spitzer Space Telescope of a spiral galaxy called NGC 7331 has revealed a virtual twin of our Milky Way (see image, above right).

NASA's Spitzer Space Telescope took this picture of the spiral galaxy NGC 7331, located about 50 million light-years away in the constellation Pegasus, showing its striking similarities to the Milky Way. Such an outside perspective will help teach scientists how our own galaxy, and others like it, might have formed and evolved.
Image: Spitzer Space Telescope/NASA

"Being inside our galaxy makes it difficult to see what's going on in the center," said J. D. Smith, a member of the team that observed NGC 7331 and an astronomer at the University of Arizona. "By looking at a very similar galaxy, we gain a bird's-eye view of what the entire Milky Way might look like."

The latest observations are the first in a large-scale effort to observe 75 nearby galaxies with Spitzer's highly sensitive infrared eyes. The program, called the Spitzer Infrared Nearby Galaxies Survey, will combine Spitzer data with those from other ground- and space-based telescopes operating at different wavelengths to create a comprehensive map of the selected galaxies.
—from the California Institute of Technology

Spirit's View of Mars!

"Top Three Reasons I Want to Move to Mars" Mug
Would you want to live on Mars? This humorous mug featuring an image of *Spirit*'s landing site suggests three added benefits of life on the Red Planet.
2 lb 1 lb. **#610 $16.00**

***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**

***Winds of Mars* and the Music of Johann Sebastian Bach**
This audio CD features digitally simulated sounds of the winds of Mars heard between 17 of Bach's finest compositions, played on piano. Liner notes explain the production of the Martian sounds and offer a general history of Mars exploration. 1 lb. **#785 $15.00**

Panoramic View of Mars Poster
This famous panoramic view from the Carl Sagan Memorial Station is accompanied by a "tour guide" caption to help you navigate the rocky landscape.
10" x 36" 1 lb. **#328 $13.50**

Mars in 3-D Poster
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**

An Explorer's Guide to Mars
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**

Pale Blue Dot Poster
This 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**

"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" 1 lb. **#320 $13.50**

Explore the Planets Poster
34" x 22" 1 lb. **#310 $11.50**

***Pathfinder* Images of Mars**
20 slides. 1 lb. **#215 $7.50**

***Cosmos 1* Team Jacket**
Special order only (allow 6–8 weeks for delivery).
Adult sizes: M, L, XL 1 lb. **#573 $60.00**

***Cosmos 1* T-Shirt**
Adult sizes: S, M, L, XL, XXL 1 lb. **#570 $25.00**

"Is Anyone Out There?" T-Shirt
Adult sizes: S, M, L, XL, XXL 1 lb. **#586 $19.95**

Wild About Mars T-Shirt
Adult sizes: S, M, L, XL, XXL 1 lb. **#590 $15.00**

Future Martian T-Shirt
Child sizes: S, M, L 1 lb. **#565 $13.50**

The Planetary Society Cap
Our redesigned Planetary Society cap is 100% cotton with an adjustable Velcro band. The royal blue cap features our logo on the front and *planetary.org* on the back.
1 lb. **#673 $13.50**

Spacecraft Science Kits
Build your own spacecraft and learn how it works.
Each sold separately. 1 lb. **$15.75**

#524 ***Galileo***
#525 Hubble Space Telescope
#529 Keck Telescope
#530 ***Lunar Prospector***
#531 ***Mars Global Surveyor***
#538 ***Magellan***
#560 ***Voyager***

Mini Mars Polar Lander Science Kit
1 lb. **#778 $3.00**

***Craters!* A Multi-Science Approach to Cratering and Impacts**
By William K. Hartmann with Joe Cain. 224 pages (softcover). 2 lb. **#109 $24.95**

***Cosmos 1* Thermal Mug**
2 lb. **#575 $18.00**

The Planetary Society Mug
2 lb. **#607 $10.00**

The Planetary Society Lapel Pin
1 lb. **#680 $3.00**

The Planetary Society License Plate Holder
Let your Planetary Society spirit travel with you on our members-only license plate holder.
1 lb. **#675 $5.25**

We're Saving Space for You! Bumper Sticker
1 lb. **#695 $3.00**

The Planetary Society Key Chain
This elegant key chain features our Planetary Society logo—planet, rings, and sailing ship—etched in black on solid brass. 1 lb. **#677 $16.00**

***Planetary Report* Binder**
Each hardcover binder will hold two years worth of issues. 2 lb. **#545 $14.50**
Special Value— order two binders for $25.00!

"Worlds to Discover" Presentation
This fully scripted assembly presentation includes the original "Worlds to Discover" 55-slide package plus the 8-slide "Worlds to Discover Addendum," updated fact sheets, posters, program announcements, a follow-up teacher's packet, and copies of The Planetary Society's magazine, *The Planetary Report.* Adaptable to multiple grade levels. 2 lb. **#791 $45.95**

Attention, teachers— submit your order on your school letterhead and receive a 20% discount.

ORDER TODAY! **PHONE: 1-626-793-1675**
FAX: 1-800-966-7827 (US AND CANADA)
OR 1-626-793-5528 (INTERNATIONAL)

SHOP ONLINE AT THE PLANETARY STORE! ***HTTP://PLANETARY.ORG***

The End of Galileo depicts the *Galileo* spacecraft's fiery suicide plunge into the cloud tops of Jupiter on September 21, 2003—a spectacular example of planetary protection. Mission planners decided that once *Galileo*'s long and fruitful tour of duty was complete, it would be best to maneuver it into Jupiter's atmosphere, where the giant planet's gravity would quickly pull apart and vaporize the spacecraft. Why? To prevent the possibility that *Galileo* would crash into Europa and contaminate the icy, ocean-covered moon with Earthly microorganisms.

David A. Hardy illustrated his first book (*Suns, Myths and Men* by Sir Patrick Moore) in 1954 at the age of 18. Since then, his space and science fiction art has appeared in hundreds of books, magazines, and other media. Hardy and Moore have teamed up again on a new book, *FUTURES: 50 Years in Space—The Challenge of the Stars*.

THE PLANETARY SOCIETY
65 North Catalina Avenue
Pasadena, CA 91106-2301

PRINTED ON RECYCLED PAPER

Printed in USA