The PLANETARY REPORT

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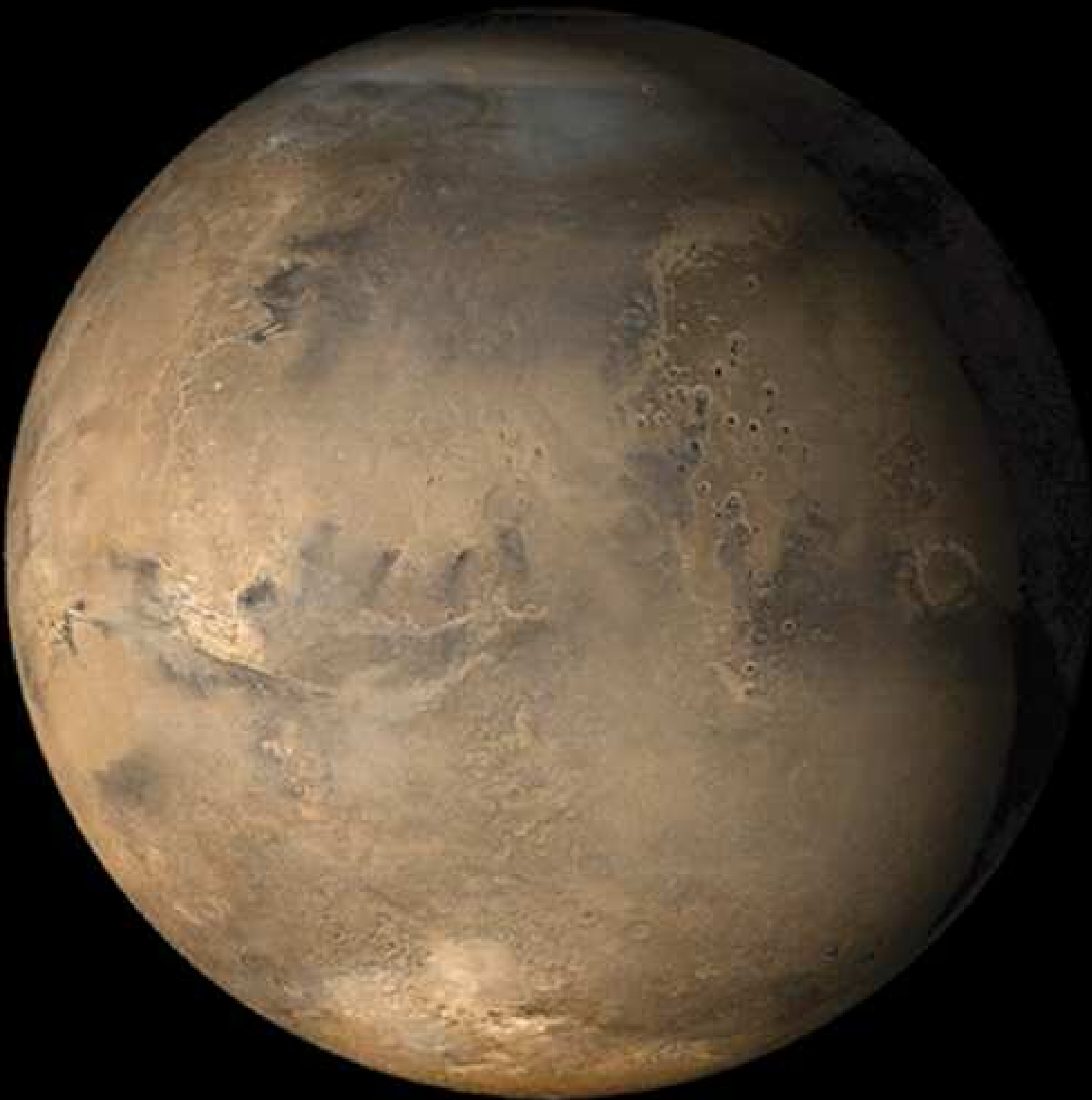

Mars Reconnaissance Orbiter Arrives

A PUBLICATION OF THE PLANETARY SOCIETY

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From The Editor

There's an ominous sense of déjà vu around The Planetary Society today. The political outlook for space exploration has not been this bleak since the early 1980s, when the White House Office of Management and Budget (OMB) tried to pay for the space shuttle by cutting missions to explore other worlds.

How close a parallel is it? David Stockman, then head of OMB, floated the idea of switching off the *Voyager* spacecraft even before *Voyager 2* reached Uranus and Neptune. Did you hear something eerily similar last year?

Now, in the proposed fiscal year 2007 budget, the administration is cutting the long-sought mission to Europa, not funding telescopes to search for planets around other stars, and slashing research into the possibilities of life elsewhere in the universe.

A quarter-century after our founding, Society members are again being called to action. In this issue, you see how effective we can be: *New Horizons* is on its way to Pluto, after a years-long Society push. Stardust@home is analyzing samples from space with our members' help. A fleet of spacecraft is exploring Mars in fulfillment of our shared hopes.

Yes, today there are other demands on the US budget, but we will not give up on the future. We will fight to keep alive the hope of reaching other worlds. Join us.
—*Charlene M. Anderson*

On the Cover:

Mars Reconnaissance Orbiter has arrived! This powerful spacecraft is capable of returning 10 times as much data as all previous Mars missions combined. Because every new look at the Red Planet has been full of surprises, our view of this neighboring world is in for some dramatic changes.

This image of the Acidalia/Mare Erythraeum face of Mars was compiled from images taken by *Mars Global Surveyor*'s Mars Orbiter Camera in January 2005.

Image: NASA/JPL/Malin Space Science Systems

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Members' Dialogue

Society Priorities

I have been a supportive Planetary Society member, donating to a number of Society appeals for funds. Recently I donated to the campaign to influence the US Congress and NASA to restore funding for a Europa mission. While I trust this money will be used wisely to try to restore at least some funding to science missions, I must reconsider my support for the Europa campaign given the astounding news from Enceladus. I now feel that many of the goals we hope to achieve at Europa can be more likely attained at Enceladus (since I am too realistic to believe funding for both missions can be expected for many years).

If The Planetary Society is too entrenched in its position to change with new information, it is showing itself to be as inflexible as the bureaucracy we lament at NASA. I still support a mission to Europa, but only after a mission to Enceladus. I hope the Society can quickly redirect its effort in this attainable and exciting direction!
—WILLIAM LAUB,
Denver, Colorado

While I am dismayed with the cutting of valuable science missions in NASA's fiscal year 2007 budget proposal, I am glad to see the Society stepping up once again and defending what we believe in. Be that as it may, I am still very concerned that NASA's priorities will be spread too thin. While I would be ecstatic about a Europa mission, I passionately feel that NASA's most important priority is the timely fielding of the Crew Exploration Vehicle (CEV), preferably before 2014. Above everything else related to space, the things I want to see most are humans on the Moon for the first time in my life, and significant strides made toward getting some of our kind to the Red Planet. For me, and I think for many Society members and space buffs, getting people to other planetary bodies for the sake of exploration and science is more exciting, engaging, and important than any remote sensing mission, unmanned planetary probe, or astronomical research program.

As we, The Planetary Society, prod NASA and Congress in what we believe to be the right direction, let us be sure NASA does not get more on its plate than it can handle. It would crush my hopes to see the Vision for Space Exploration flounder into oblivion.
—KIRBY RUNYON,
Spring Arbor, Michigan

The Planetary Society has strongly supported NASA's new focus on getting the CEV built, and if you read our statements on planetary.org, *one of our concerns with NASA's proposed fiscal year 2007 budget is that it is the tip of the iceberg in the diversion of funds from the rest of NASA for the space shuttle. That could lead to delays in flying the CEV and transitioning away from the shuttle.*

We also are very excited about the possibility of liquid water on Enceladus. This news is only a few weeks old, and there is still a working orbiter in the Saturnian system. The proposed Europa mission has two decades of synthesis and study behind it. Nothing has lessened the importance of Europa's ocean as a place to explore. If we start all over now because of another water spot, we'll end up delaying the outer planets' exploration for years. It's too early to conclude anything about which satellite is the most important for investigating possibilities of life, so our judgment is to follow the water—first to Europa, and then think about what is next.
—Louis D. Friedman,
Executive Director

Space Mission Drama

The *Hayabusa* article (see the January/February 2006 issue) was excellent. The mission was incredibly complex for what I assume most consider a "fledgling" spacefaring nation. *Hayabusa* should be considered a success—a major one. The public needs to be kept informed throughout the development of a space mission so the "winner or loser" media splash can be avoided and the incremental intrigues and accomplishments can be experienced as they occur. People like a mystery, and missions should be treated that way—the journey being as important as the destination. The [staff of] The Planetary Society—and we members—should take satisfaction in trying to do just that! Keep up the great reportage!
—STEVE FRANKS,
Yorba Linda, California

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We Make It Happen!

by Bruce Betts

Several months ago, we went to you, our members, to help us save data from the *Pioneer* mission so that we can help study what is known as the *Pioneer* "anomaly." Thanks to you, we have succeeded in saving and validating more data than we could have hoped for.

The *Pioneer* Anomaly

The *Pioneer* anomaly refers to a slowing of the *Pioneer 10* and *Pioneer 11* spacecraft relative to what would be expected from basic gravitational physics. The effect is small but big enough to measure. Its cause could be something having to do with the spacecraft, such as heat radiating preferentially in one direction. Less likely but a real possibility, it could be due to some new subtlety in our understanding of physics.

Data Saved!

Until just recently, only about 11 years of the more than 30 years of *Pioneer* Doppler data (velocity data derived from the Doppler shift of the received frequency of the *Pioneer* signal) had been analyzed, and the mystery remained. NASA was not funding the rest of the data's recovery, so The Planetary Society stepped in and funded the effort to recover and validate these precious data. I am happy to report that we have recovered large parts of the 30-year histories of the two spacecraft. The data are now being collected, arranged, validated, and written to modern media. They will then be provided to teams of scientists for analyses.

There was also another success beyond what we had hoped. Data about the spacecraft themselves, as well as science data, were contained in what are called Master Data Records (MDRs) at NASA Ames Research Center. Nominally, data like these would be kept for only 7 years, but fortunately, much of the history still existed. The recovered MDRs cover most of both missions. They, too, are now being collected, arranged, and written to modern media.

The MDR data include temperatures measured throughout the spacecraft during the course of the missions. This information will be critical for modeling the thermal radiation from the spacecraft, its variations over time, and whether it could help explain the anomaly.

What's Up?

In the Sky—April and May

Bright Jupiter is at opposition (opposite side of Earth from the Sun) on May 4, rising around sunset in the east and setting around dawn in the west. In the evening sky, Mars, looking orangish, is in the west after sunset and is near the star Aldebaran in Taurus in early April and near Castor and Pollux by late May. Mars also grows closer in the sky to yellowish Saturn, also up in the west in early evening. In the predawn sky, Venus is the very bright starlike object in the east.

Random Space Fact

NASA's Deep Space Network has tracking stations each roughly one third of the way around Earth, so it can maintain constant communication with spacecraft. Tracking locations are Goldstone, California; Madrid, Spain; and Canberra, Australia.

Trivia Contest

Our November/December contest winner is Sharon Day of Tulsa, Oklahoma. Congratulations!

The Question was: What was the first spacecraft to return images from the surface of another planet?

The Answer: *Venera 9* from Venus in 1975. Note that although *Venera 7* and *8* returned data from the surface of Venus, they did not return images.

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

On what body in the solar system will you find a crater named Sagan, after Planetary Society cofounder Carl Sagan?

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 June 1, 2006. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of "What's Up?" complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to Planetary Radio at *planetary.org/radio*.

Pioneer 10, Phone Home

In March 2006, Earth and the expected pointing of the *Pioneer 10* spacecraft lined up, providing an opportunity to once again try to communicate with the spacecraft, which was last heard from about 5 years ago. The *Pioneer* anomaly team sent signals from the NASA Deep Space Network's Goldstone 70-meter radio antenna in the California desert. If all went well, signals would return from the spacecraft more than 24 hours later (the one-way light time for *Pioneer 10* is now more than 12 hours) and could be detected at the same Goldstone station.

Alas, silence was all that was heard. Whether because of weakened power or some other issue, signals from our intrepid explorer were nowhere to be found. A sufficiently strong signal would have given one more data point in the *Pioneer* anomaly study. The good news is that the data recovery made possible by Planetary Society members has provided many tens of thousands of new data points that can be analyzed to help understand this mystery.

More Information

You can find background on the *Pioneer* mission and the anomaly, as well as detailed project updates from the Jet Propulsion Laboratory's Slava Turyshev, on our website at *planetary.org/programs*. You can also hear the discoverer of the *Pioneer* anomaly, JPL's John Anderson, on a recent Planetary Radio show and both Turyshev and Anderson on a past show talking about the *Pioneer* anomaly.

Bruce Betts is director of projects at The Planetary Society.

ON TO PLUTO! *NEW HORIZONS* HEADS OFF TO EXPLORE THE NEW FRONTIER

BY JOHN SPENCER

On January 19, 2006, New Horizons *blasted off perfectly into a clear blue Florida sky. On each of the two previous days, windy weather at Cape Canaveral had scrubbed the launch of the Atlas V rocket carrying the spacecraft.*

New Horizons *will reach Pluto and Charon in 2015 and then will continue on its flight to study the Kuiper belt. Riding on board the spacecraft is a CD carrying the names of all Planetary Society members and many friends and supporters who fought to make this Pluto mission a reality.* *Photo: NASA/Kennedy Space Center*

Hi, this is John Spencer, one of the members of the science team on the *New Horizons* mission to Pluto and the Kuiper belt. The Planetary Society asked me to report in from time to time on the long-awaited launch of our *New Horizons* spacecraft to provide another perspective on this exciting mission. All my reports are posted at *planetary.org/explore/topics/new_horizons/*, but I picked a few to share with you here.

December 28, 2005: *Looking Forward to Launch*
Pluto has been part of my life for a long time. I've been working, off and on, on some version of the Pluto mission since 1993, when *New Horizons* Principal Investigator Alan Stern invited me to join a team designing a multiwavelength camera/spectrometer (grandfather of the Ralph and Alice instruments on *New Horizons*) for one of NASA's earlier Pluto mission concepts.

As launch draws near, I've been looking back at all those fading and blurring memories of 13 years—e-mails, teleconferences, proposals, team meetings, and the innumerable photos that document the spacecraft assembly. It's amazing to watch all those years of abstract planning turn into something very real, to watch a CCD array millimeters wide integrated with a camera a foot across, bolted onto a spacecraft about the size of its designers, and finally to see that spacecraft hoisted atop its massive rocket, the whole 200-foot-tall edifice poised to hurl itself off the planet.

We continue to plan for the Jupiter encounter, which will occur, astonishingly, a mere 13 months after launch. For comparison, in the 1970s it took *Pioneer 10* 21 months and *Voyager 1* 18 months to cover the same distance. The heavier and slower *Galileo* followed a roundabout trajectory and took 6 years (1989 through 1995) to get to Jupiter.

Detailed planning of our observations of Jupiter and its satellites must wait until after we launch, because the launch date determines the Jupiter flyby date, and that in turn determines the orbital positions of the satellites during the flyby and the timing of many of our observations, including critical events like satellite eclipses by Jupiter. We're planning a team meeting to hash out the details once the spacecraft is safely on its way and we know the geometry.

January 13, 2006: *We're at the Cape!*
We're at the Cape! More properly, we're at Cocoa Beach, just down the coast, having flown in from Denver today. The spacecraft has passed its launch readiness review, the weather forecast looks favorable for Tuesday, and no obvious barrier stands between us and the Kuiper belt.

It's hard to believe this is really happening. All my life, Pluto has been inaccessible. Yes, we've been working on this mission for more than a decade, but we work on so many mission proposals that come to naught. It's hard to grasp that this one, to the most outrageously faraway destination of all, has become something real, with a spacecraft sitting at a launchpad a few miles from here. I guess it will all seem real enough very soon.

January 15, 2006: *Preparing for Launch*
Yesterday was our final prelaunch meeting of the science

team. The mood was quite different from previous meetings, which are normally enjoyable but fairly sober affairs. People broke into applause for the engineering team as they described the success of the final tests before launch. We're all excited. Project Manager Glen Fountain always shows a chart at these meetings, describing his list of top worries—things that might still go wrong and jeopardize the mission. Yesterday, the list was empty!

Our principal investigator, Alan Stern, the driving force behind this mission, gave his own retrospective at the end of the meeting, starting all the way back when he began pushing for this mission while still a graduate student in the late 1980s. The room erupted with laughter as people recognized their much younger looking selves and colleagues in Alan's slide show. What will we look like when we finally get to Pluto, 9 years hence?

January 16, 2006: *Less than 24 Hours to Go!*

New Horizons just experienced what we hope will be its last ever sunset on Earth. Once it blasts off, there will be three more sunsets to come. One will be about 20 minutes after launch, as the spacecraft plunges into Earth's shadow and prepares for the final rocket burn that will take it out of orbit. Its last-ever pair of sunsets will be behind Pluto and Charon, 9 years from now, as we use the setting Sun as a probe of their atmospheres. After that, the rapidly diminishing Sun will shine on our spacecraft forever, though the Sun will eventually be indistinguishable from the billions of other stars in our galaxy.

This morning, the science team and some press folks gathered at a viewing area near the launchpad to watch the spacecraft slowly make its way from its hangar to the pad, a process that took about half an hour. Once the rocket was in place and the work to configure it for launch got under way, we were able to approach within a few hundred feet and pose for pictures that we'll always treasure.

Tomorrow should be even more memorable. The weather forecast still looks good, and so far there are no technical hang-ups.

January 17, 2006: *Philosophical After the First Day's Launch Attempt*

Oh well, the Sun sets on an earthbound *New Horizons* at least one more time. The first day's launch attempt was a strange experience in retrospect—lots of excitement but nothing to show for it at the end of the day. We feel sorry for all the people who have to leave tomorrow, who will never see a launch that they came within 2 minutes and 40 seconds of experiencing this afternoon. But those of us who can stay a few more days can afford to be philosophical—delays like this are a normal part of spaceflight, and there's a decent chance that we'll be able to launch tomorrow, and an even better chance the day after.

There were a few temporary technical problems with our rocket and the ground stations, but it was the weather that got us in the end—a restless wind that kept the mosquitoes away from the bleachers but never stayed below the "red line" limit long enough to let us off the launchpad. For 2 hours we sat and waited, our hopes rising as the end of each planned hold in the countdown approached and falling again as another delay was announced. Despite the tension, it was quite a party atmosphere—we were surrounded by friends, and it was a beautiful day to watch history almost being made.

There was a big postlaunch party planned for the evening, and by the time the launch was scrubbed, the food was already prepared, so we held the party anyway. The mood was relaxed, not much disappointment. We'll try again tomorrow.

January 19, 2006: *Here We Go!*

Wow! Now it's real. We just got back from the real postlaunch party, following two non-postlaunch parties on the last two evenings. This was more like it, with whoops and hollers and congratulations all around, but especially for the launch team. They performed magnificently, launching the most-powerful-ever configuration of Lockheed Martin's Atlas V rocket, with a third stage built by its archrival, Boeing. It took off faster than any rocket had gone before, and it did so flawlessly.

Though I haven't seen any actual numbers yet, provisional reports suggest we are very close to our planned trajectory, which is great news for the science team, because less of the spacecraft's fuel will be needed to fine-tune the trajectory to Jupiter and more will therefore be available to steer us to a Kuiper belt object after the Pluto encounter. We have also, as they say, "retired a lot of risk"—the most dangerous part of the mission is over, and the spacecraft is in the environment for which it was made. One of the ceremonies at the party was to burn copies of the very detailed contingency plans that had been developed to cover all possible launch failure scenarios. We won't be needing those anymore.

I'm still processing the actual launch experience. The spectacle was brilliant, amazing, and over very quickly as the rocket disappeared into the clouds. The joy was overwhelming as we saw our baby go. We were all hugging each other very hard until the buses revved up to take us back to the visitor center.

Now that the engineers have done their work so magnificently, it's time for us scientists to get to work. Once the trajectory folks can spare the time from making sure we're pointed in the right direction, we'll be getting the details of the Jupiter flyby geometry from them. Then we can finalize our plans for the Jupiter encounter only about a year away. This exciting journey is just beginning.

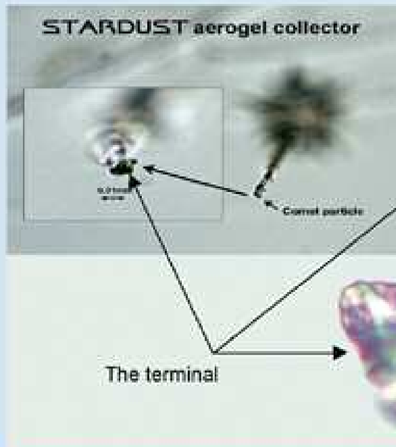
John Spencer is a staff scientist at Southwest Research Institute's Department of Space Studies in Boulder, Colorado and a member of the science team on the New Horizons *mission to Pluto.*

Stardust@home:

You Can Help Find Particles

Looking like a bright comet itself, the Stardust *capsule streaked through Earth's atmosphere in the early morning hours of January 15, 2006. NASA's DC-8 Airborne Laboratory captured this photo.* Photo: NASA Ames Research Center

Home from its 7-year expedition, the Stardust *Sample Return Capsule and its precious cargo of pristine comet particles and interstellar dust grains made a perfect landing in the Utah desert.* Photo: JPL/NASA



At upper right, a triangular slab of aerogel shows a track from an impacting comet particle. At upper left are close-up views of the particle stuck in the gel, and at bottom is the heart-shaped, gem-like particle itself. Images: JPL/NASA

On January 15, 2006, after a voyage of 7 years and 3 billion kilometers (close to 2 billion miles), the *Stardust* spacecraft swung by Earth and released a cylindrical metallic container. It entered the atmosphere and streaked across the skies of the western United States before parachuting gently onto the Utah desert. So ended the dramatic and successful *Stardust* mission, launched on February 7, 1999 to collect samples from space and bring them back to Earth.

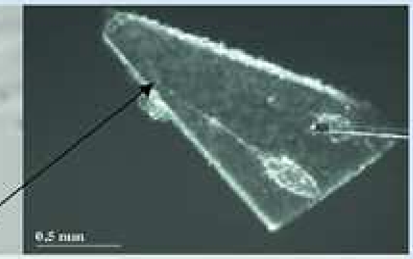
The container, about the size of a truck tire, was in fact *Stardust*'s Sample Return Capsule (SRC). Nestled within it was *Stardust*'s aerogel collector, carrying two distinct types of samples, one on each side of the collector. On one side, the spacecraft collected cometary dust grains during its dramatic encounter with comet Wild 2. On the other side, *Stardust* carried grains of interstellar dust, the first such particles ever captured in space and brought to Earth.

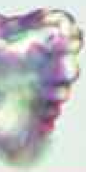
Stardust collected the cometary particles on January 2, 2004, when it flew through the cloud of gas and dust surrounding comet Wild 2, all the while undergoing a terrific bombardment by debris shooting out from the comet's nucleus. A few hours later, the spacecraft emerged safely on the other side of the cloud, with a sample of pristine cometary dust preserved in its collector. The interstellar dust grains were picked up earlier in *Stardust*'s journey—between February and May 2000, and again between August and December 2002—when the spacecraft traversed a stream of particles that flows into our solar system from interstellar space. As it passed through this stream, *Stardust* extended its tennis racquet-shaped aerogel collector, picking up and storing dust grains from distant stars, light-years away.

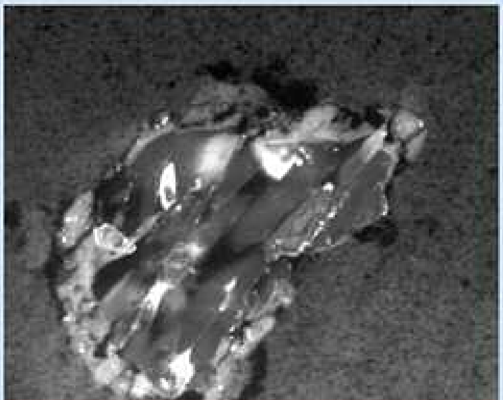
Once the cometary encounter was over, the collector plates carrying both types of samples were inserted into the SRC, where they remained through the rest of the journey. They were still there when the capsule landed safely in the Dugway proving ground in Utah.

from Distant Suns!

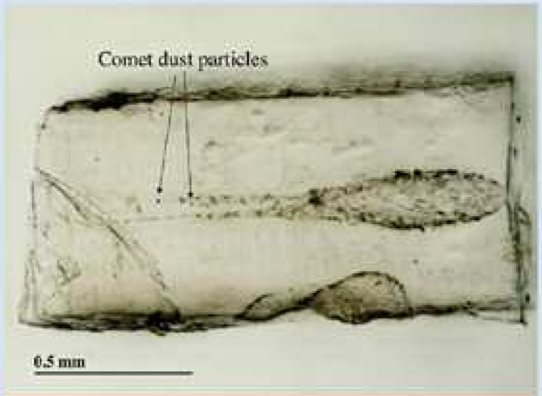
by Amir Alexander







This comet particle, one of the many collected by Stardust, *is about 2 micrometers (about one fiftieth the width of a human hair) across. Scientists are surprised to find that comets may not be simple conglomerations of ice, dust, and gas but instead may have diverse and complex histories. According to* Stardust *team member Michael Zolensky of Johnson Space Center, "It seems that comets are a mixture of materials formed at all temperatures, at places very near the early Sun and at places very remote from it."* Image: JPL/NASA



An ultrasonic blade was used to excise this thin slice of aerogel from the collector. It shows the skidmark-like tracks of impacting comet particles. Image: JPL/NASA

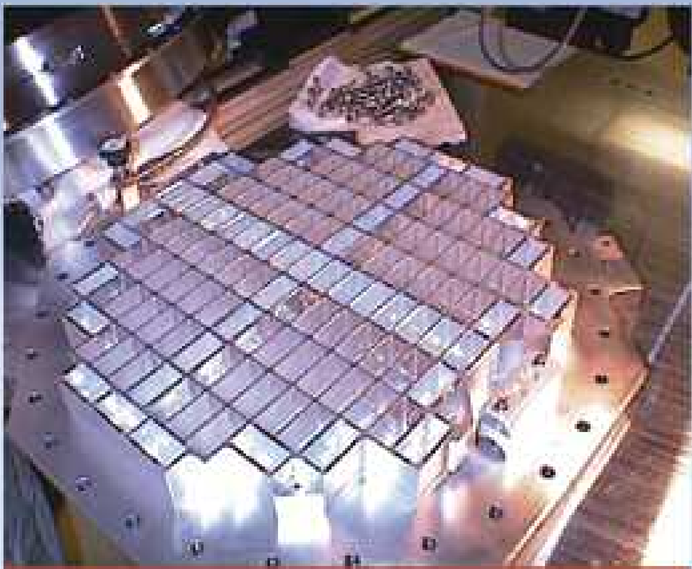
A few days later, at the Johnson Space Center, scientists opened the treasure chest that is the Sample Return Capsule and examined the collector. The cometary dust particles embedded in one side of the collector were easy to spot. Some were clearly visible to the naked eye, and others could be found easily with simple microscopic equipment. Almost immediately, scientists began their study of these pristine samples in laboratories around the world.

The interstellar dust grains on the opposite side of the collector were a different matter: they remain invisible for the time being.

Small, Few, and Precious

Interstellar dust particles are very small compared with cometary particles; the largest ones probably measure no more than a few microns across. They are also very few, probably no more than a few dozen, compared with close to a million particles scientists estimate were gathered from Wild 2. These small and rare interstellar dust grains are, furthermore, embedded in about 1,000 square centimeters (more than a square foot) of aerogel, which after years in space is likely to be crisscrossed with cracks and flaws. All in all, a very few very small particles are scattered in a very messy neighborhood. Before scientists can think about extracting and studying them, they first have to find them.

Locating these proverbial needles in a haystack became the quest of Andrew Westphal, an associate director of the Space Sciences Laboratory at the University of California at Berkeley. His first idea was to try an automatic scan: an automated microscope would image and record every tiny portion of the aerogel interstellar dust collector, focusing on varying depths beneath the surface of the collector. The images would then be stored, creating a digital archive of the collector. This in turn would be run through a computer program designed to detect the telltale signs of an impact from an interstellar



Stardust's aerogel sample collector in the lab before launch. Guinness Records has named the Jet Propulsion Laboratory's aerogel the "World's Lightest Solid." This substance is a special type of foamed glass, made so lightweight that it is barely visible and it almost floats on air. Image: JPL/NASA

This is the automated microscope at the University of California, Berkeley (before it was moved to Johnson Space Center) that will scan the *Stardust* aerogel collector containing the interstellar dust samples. It will create 1.6 million "movies" to be scanned by Stardust@home participants.
Photo: Bruce Betts, The Planetary Society

dust particle. The program would register the locations, and they would then be examined manually by scientists.

A similar approach had worked well for Westphal in the past, when he and his team developed a method for detecting particle tracks in high-energy astrophysics experiments. In that system, the microscope scanned the collector twice, focusing on two different depths. A computer program then matched the two scans and registered the locations where both revealed a possible track. This way, local flaws in the collector were excluded, and only "tunnels" deep enough to pass through both levels of the scan became candidates for actual tracks. In the last stage, Westphal and his team visually observed the candidates to determine whether they were indeed true tracks.

The *Stardust* interstellar dust collector, however, posed a far more difficult challenge. This is because the minuscule particles are expected to penetrate only the very top layer of the aerogel plates, to a depth of no more than 100 microns. At that depth, it is likely that the aerogel from Stardust, returning from 7 years in space, will be filled with cracks and flaws. As a result, the automated scans will likely be flooded with false identifications, and the 40 or so actual interstellar dust grains may never be found.

To get around this problem, Westphal and his teams considered using sophisticated pattern recognition software that would be able to distinguish between cracks in the aerogel and actual particle tracks. They consulted with Professor Jitendra Malik, a UC Berkeley computer scientist, who suggested that such a finely discriminating program was, in principle, possible. For it to work, however, they would have to "train" the computer with real images of aerogel containing grains of interstellar dust. But no such particles had ever been collected! Scientists can only approximate what real grains embedded in aerogel would look like. For a computer program, this was simply not good enough, and the plan to automatically scan the aerogel collector seemed to lead to a dead end.

How, then, can these precious grains from faraway stars be located?

Stardust@home

Although sophisticated computer programs could not tell interstellar particles from cracks and dirt, there was one instrument available that could do the job: the human eye. From his experience with high-energy physics particles, Westphal knew that unlike computers, humans using microscopes could recognize true tracks quite easily, with only a limited amount of training. If humans could scan all of the aerogel, then detecting the interstellar dust particles would be easy.

This, however, raised a different problem: microscopically covering the entire collector at the required magnification would require millions of separate images. The human eye might be a good tool for identifying particle tracks, but who are the humans who can be expected to scan that many images? And if they do, how long would it take, and can they be expected to stay alert for the chance discovery of a single particle among hundreds of thousands of empty images?

At this point Westphal remembered another project that was being conducted from the very same building where he has his office and laboratory. Only a few doors down the hall at the Space Sciences Laboratory, David Anderson, Dan Wertheimer, and their crew run SETI@home—the largest and most successful distributed computing project in history. With SETI@home, millions of computer users worldwide have joined in the search for extraterrestrial intelligence. Would it be possible to apply a similar approach and have people from around the world join in the search for interstellar dust?

It was possible, and—with help from the SETI@home veterans—Westphal set out to figure how it could be done. Unlike SETI@home, the new project would be based on actual human observation rather than automated computer processing of data. But like SETI@home, it would rely on the participation of a multitude of users, who would divide a seemingly intractable job into small and manageable parcels. In tribute to the project that inspired it, the new program would be called Stardust@home.

Here's how it will work. As in the original plan, the automated microscope will scan the entire surface of the collector, recording digital images of each minuscule portion of the aerogel. Because each image will cover an area of 260 by 340 microns, and because each image will include a 10 percent overlap with its neighbor, the microscope will need to focus on 1.6 million locations to cover the entire surface of the collector.

The microscope will take 40 images of each location, each focusing on a different depth, from 20 microns above the surface to more than 100 microns within the aerogel. These 40 images will be packaged into a "movie" representing a continuous in-depth look at each location through different depths. Only a track that is visible continuously through a large portion of these images can be considered a serious candidate for the "real thing."

Thousands of users around the world will be able to log on to the Stardust@home website and use a simple web-based program called a "virtual microscope" to scan these movies. The program will contact the Stardust@home server and download a movie of a tiny portion of the *Stardust* collector. Once the scan is complete, the program will send the results back to the server and download the next movie. Overall, each user will view only a portion of the collector, but together, thousands of users around the world will be able to survey the entire collector in just a few months.

Stardust@home relies on users' dedication and competence. The users themselves, not the computer, will identify suspected particles. Because it is hard for Westphal and his team to evaluate the competence of each individual user, they will rely on majority opinion to decide whether a particular location deserves a second look: each movie will be sent out to four users, and only if at least two of them report a detection will it be considered a candidate. In that case, it will be sent out again to several more users, who will not know that it has already been flagged by others. If a majority of users in this second round also report detections, then professional scientists will observe the location to determine whether it does indeed contain an interstellar dust particle.

With Stardust@home and the power of distributed computing, a task beyond the endurance of any scientist and beyond the capacity of even the most sophisticated computer programs will be accomplished in short order by human volunteers. "It's simply the only way we know how to do it," said Westphal.

Amir Alexander is a writer and editor for The Planetary Society's website, planetary.org, *and he coordinates the Stardust@home project for The Planetary Society.*

Join the Hunt for Interstellar Dust Particles!

Stardust@home launches in just a few weeks. To take part in Stardust@home, you can preregister on the project website at *http://stardustathome.ssl.berkeley.edu.* You will then be notified when the first Stardust@home movies will be made available.

As an official collaborator on the Stardust@home project, The Planetary Society will spread the word, recruit users, and inform the public about this new and exciting way to share in real space exploration. For more information about this remarkable project, check out The Planetary Society website at *http://planetary.org/programs/projects/stardustathome/.*

Mars Reconnaissance Orbiter: Th

by James Graf and Richard Zurek

Mars is a complex planet. Vast channels cross its cratered terrain, with some ending in the braided patterns of river deltas. Streambeds meander across the floor of its narrow valleys. Gullies—some new—mark the walls of its dunes, craters, and canyons. Fantastic layering over large areas points to multiple cycles of deposition and erosion. Vast expanses of water ice cover its north pole, while in the south, the icy carbon dioxide patch left at the end of summer shrinks from year to year. Clouds form in its atmosphere, and great dust storms swirl across its surface. In some years, they obscure the entire planet.

Mars' climate is changing. It is markedly different from the past, and modern spacecraft show that it continues to change even today. This aspect of Mars has fascinated humankind for more than a century. Mars challenges our ideas about how planets evolve and leads us to wonder whether conditions ever were right for life to gain a foothold there.

Today, the role of water—where it has been, where it is today, how much of it there is, and how its presence has changed over time—remains the driving theme of NASA's Mars Exploration Program. Understanding the role of water is key to understanding the climate of Mars, as well as the shape and composition of its surface—and ultimately to answering the vital question of whether life ever developed there. Water, in addition to being important in Mars' history, is a potential resource for the planet's future, when humans go to the Martian surface.

Over the last decade, NASA has successfully placed two spacecraft (*Mars Global Surveyor* in 1997 and *Mars Odyssey* in 2001) in orbit around Mars and has landed three spacecraft (*Mars Pathfinder* in 1997 and the twin Mars Exploration Rovers in 2004) on its surface; the European Space Agency added its own orbiter, *Mars Express* in 2003. With the exception of *Pathfinder*, all these continue to return data from Mars today. Even with these stunning successes, the path to Mars has not been easy. Several other spacecraft launched to Mars during this period failed to orbit or land safely. Our need to learn about the mysteries of the Red Planet drives us to continue to explore, even though we face occasional failures, and we're now ready for the next step in Mars exploration.

A Close Look at Mars

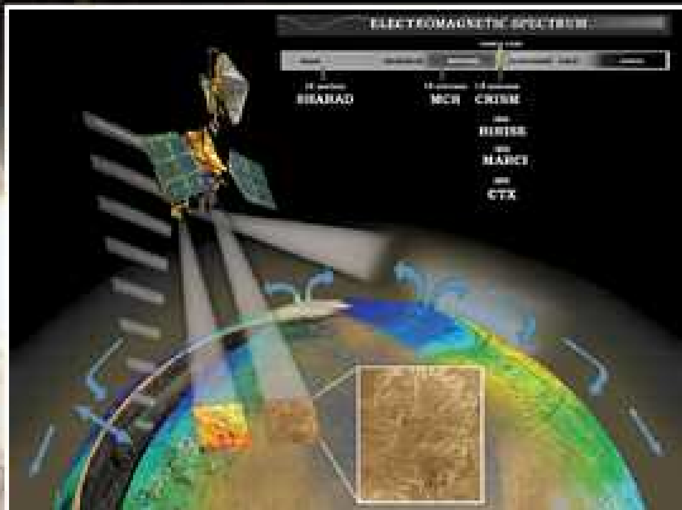
The *Mars Reconnaissance Orbiter* (*MRO*) mission will "follow the water" on Mars from orbit, conducting a program of global monitoring of the Martian atmosphere for a full annual cycle. It will also conduct regional surveys of vast areas of Mars' surface and subsurface and will image hundreds of local areas at high and very high resolution, creating the highest-resolution images yet of the Red Planet.

Like its prolific predecessors *Mars Global Surveyo*r and *Mars Odyssey*, *MRO* has an ambitious agenda. We hope to learn more about the present Mars climate, including processes currently changing the surface of the planet. We also hope to better understand the nature of the ground structure and composition, including the presence of aqueous minerals. Finally, we want to understand the extent to which water has played a role on Mars over time. Specifically, *MRO* will search for sites characterized by aqueous or hydrothermal activity, as these may indicate environments conducive to life.

In addition to its scientific mission, *MRO* will verify the

e Next Step in Mars Exploration

In this artist's rendering, Mars' Schiaparelli crater and its surroundings are illuminated by the rising Sun. Mars Reconnaissance Orbiter (MRO) has reached its destination and slipped seamlessly into orbit around the Red Planet. Once its 6-month aerobraking maneuver is complete, the most powerful Mars orbiter yet will seek answers to the mysterious history of water on our neighboring world. *Illustration: Kees Veenenbos*

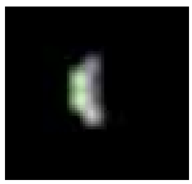


Once MRO *gets to work at Mars, its instruments will use a variety of techniques to "follow the water." At far left, the Shallow Radar Subsurface (SHARAD) antenna beams down and "sees" into the first few hundreds of feet (up to 1 kilometer or 0.6 mile) of Mars' crust. The beam to the immediate right highlights the data received from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) that identify minerals on the surface. The next beam overrepresents the High Resolution Imaging Science Experiment (HiRISE) camera, which can zoom in on local targets, returning the highest-resolution orbital images ever received of features such as gullies, rocks, and craters.*

The nearly horizontal beam is that of the Mars Climate Sounder (MCS), which will analyze the seasonal and year-to-year variation of the Red Planet's climate by observing temperature, humidity, and dust content of the atmosphere. Meanwhile, the Mars Color Imager (MARCI) will image ice clouds, dust clouds, hazes, and ozone distribution, producing multicolored global maps to monitor daily weather and seasonal changes. In the bar representing the electromagnetic spectrum, shown at upper right, the individual instruments are placed in the positions where their capabilities lie. Illustration: JPL/NASA

safety of the landing site for the next Mars lander—the *Phoenix* Mars Scout mission to be launched in 2007. *MRO* data will be used to identify and characterize sites for future landed missions, such as the *Mars Science Laboratory* (*MSL*), and will provide relay support for *Phoenix* and for the *MSL* rover once they have landed on Mars.

To accomplish *MRO*'s scientific goals, NASA selected eight investigations, six of which provided instruments for flight and two of which will use spacecraft subsystems to characterize the Martian environment. Instruments include a Mars Color Imager (MARCI) to monitor global weather and surface change; a Mars Climate Sounder (MCS), which measures atmospheric temperatures and distributions of dust and water vapor; a Compact Reconnaissance (visible and near-infrared) Imaging Spectrometer for Mars (CRISM) to determine surface composition; a Context Imager (CTX); a High Resolution Imaging Science Experiment (HiRISE); and a Shallow Subsurface Radar (SHARAD).



This color composite image of Earth was taken 3 days after MRO*'s August 12, 2006 launch, when the spacecraft was turned toward our planet and the Mars Color Imager (MARCI) was powered up to take a set of color and ultraviolet images of Earth and the Moon.*

With these Earth/Moon images taken soon after launch, the MARCI science team can measure the instrument's sensitivity and check that the camera was not contaminated during launch. *Image: NASA/JPL/Malin Space Science Systems (MSSS)*

With these instruments, we'll get the best look ever at Mars' atmosphere, surface, and subsurface. For targeted areas, multiple instruments will observe the same localized area, even when that area does not fall directly beneath the orbiter. For example, CTX observes in a 30-kilometer (18-mile) swath at resolutions comparable to the best current

How's the Weather on Mars?

The Planetary Society is an official outreach partner on the Mars Climate Sounder instrument on board the *Mars Reconnaissance Orbiter*. As part of our role, we're developing the instrument website at *planetary.org/mars_climate_sounder/*.

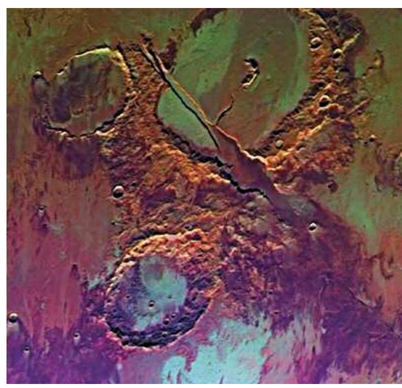
The Mars Climate Sounder is designed to monitor the global temperature and pressure of, as well as the dust, water, and carbon dioxide content in, the atmosphere of Mars up to a height of 80 kilometers (50 miles) over the course of a full Martian year. To get the most complete possible view of Mars' atmosphere, Mars Climate Sounder operates nearly continuously, every second of every day, almost independently of *Mars Reconnaissance Orbiter*'s five other science instruments.

The extensive data set will enable Mars climatologists to follow water and carbon dioxide around Mars as the Martian seasons wax and wane. Many of the measurements that Mars Climate Sounder will perform have been made in the past. In particular, several landed Mars missions have acquired extremely detailed profiles of temperature and pressure as they descended to the surface, and these profiles have provided important inputs into climate models. No mission, however, has been able to acquire this kind of information for all of Mars for all of a Martian year.

Mars scientists have wanted to perform a detailed, systematic study of Mars' climate for decades, but they have been foiled—twice—by the loss of the spacecraft that were carrying Mars Climate Sounder's precursors to Mars. The first precursor, called PMIRR (Pressure Modulator Infrared Radiometer), was first launched with *Mars Observer* in 1992, but *Mars Observer* disappeared without a trace just 3 days before orbit insertion. A duplicate, PMIRR II, was of central importance on the *Mars Climate Orbiter*, launched in 1998. That spacecraft was lost upon orbit insertion. For *Mars Reconnaissance Orbiter*, the PMIRR team started over with a completely redesigned instrument, now called Mars Climate Sounder, but the science objectives have remained the same. —*Emily Stewart Lakdawalla, Science and Technology Coordinator*

Mars is a complicated, dynamic world—a place whose surface features document a history of ongoing, often mysterious, climatic and geologic change. Many of these features tell a story of a place that was once warmer and wetter, where liquid water carved its signature into the planet's surface.

On May 16, 1999, a massive dust storm blew over Valles Marineris' Ius and Melas Chasms. *Image: NASA/JPL/MSSS*



False color was added to this **Viking 2** ***orbiter image of Memnonia Fossae in Mars' ancient, cratered highlands to highlight the range of subtle color variations, which show a diversity of surface composition there. This area may contain different types of lava flows, variable amounts of weathering, and possible alterations by water and wind redistributions.*** *Image: JPL/NASA*

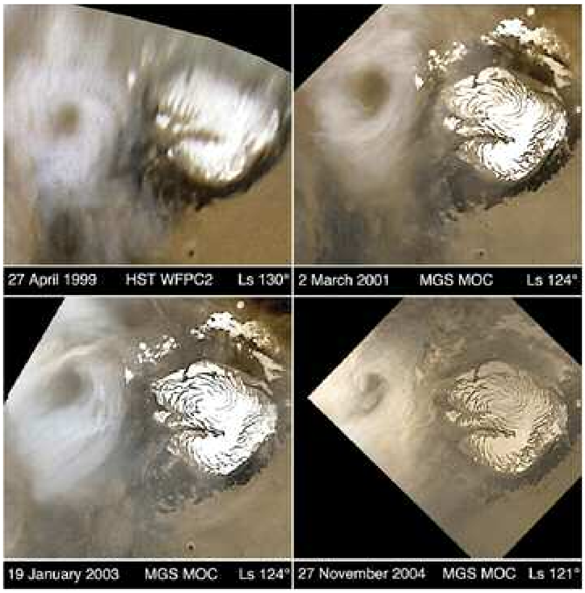
images from Mars orbit, while HiRISE can zoom in on a 6-kilometer (3.5-mile) central stripe, making it possible to see objects (such as boulders) the size of a small desk.

To operate such a complex payload, *MRO* required a new orbiter design and a different orbit than had been used in the past. The chosen orbit is a near-circular, near-polar orbit at an altitude of approximately 300 kilometers (180 miles), with an inclination that fixes the (average) local time of the orbit at midafternoon (about 3:00 p.m.) on the dayside. With an orbit period of 112 minutes and a ground repeat cycle of 17 days, this orbit enables *MRO* instruments to see, with good resolution, any site on the planet by rolling the spacecraft left or right by up to 30 degrees.

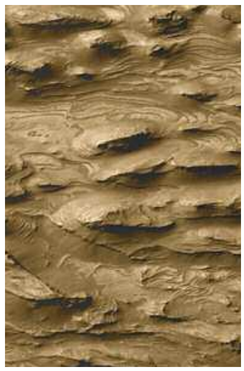
The spacecraft itself is considerably larger in mass and

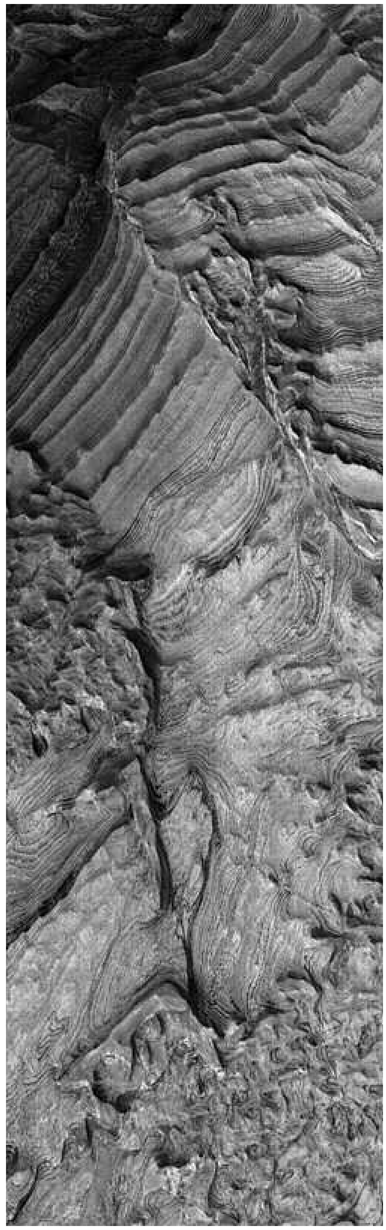
The pictures on these two pages represent a sampling of the Red Planet's many facets—the features and processes that **Mars Reconnaissance Orbiter** *will examine in unprecedented detail. All images were taken by* **Mars Global Surveyor***'s (*MGS*) Mars Orbiter Camera (MOC), unless otherwise noted.*

A suite of gullies on a crater wall in Mars' southern mid-latitudes may have been cut by runoff from liquid water. *Image: NASA/JPL/MSSS*



These four images—the first one taken by the Hubble Space Telescope—show an example of Mars' repeating weather patterns. Each picture shows the planet's north polar region during the northern summer season. The images were taken about 1 Martian year apart, and each shows an annular (circular) cloud located over the same region every summer.
Images: NASA/Space Telescope Science Institute and NASA/JPL/MSSS





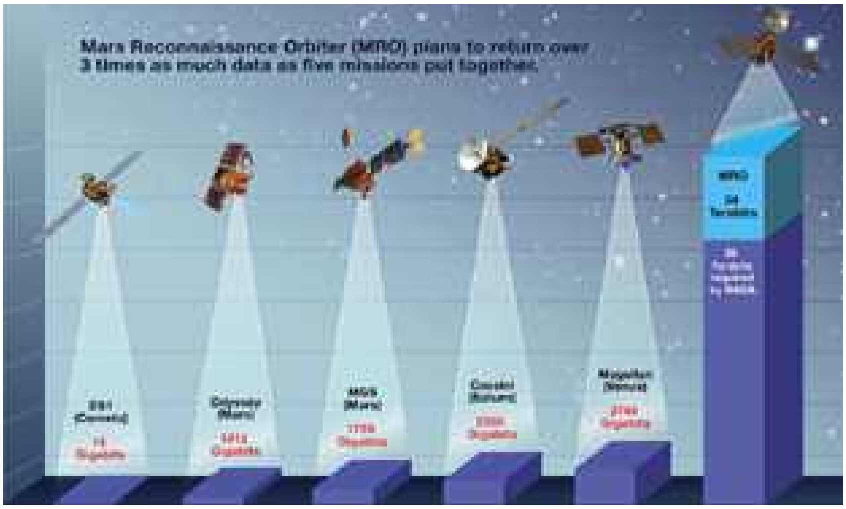
Geologic layers indicate change, and although scientists are not yet certain about how they formed on Mars, the layers in these images resemble similar features on Earth that usually point to the presence of sediments deposited in underwater environments. The image at right shows the layered floor of western Candor Chasma in Mars' Valles Marineris. At far right, the layered, sedimentary rock outcrops in western Arabia Terra's Becquerel crater suggest that the crater may have once hosted a Martian lake.
Images: NASA/JPL/MSSS

size than *Mars Global Surveyor* and *Odyssey* because of the need to operate a complex payload, even while rolling to image targets, and to return the enormous data volumes produced by higher-resolution instruments. The greatly enhanced *MRO* telecommunications system, highlighted by a 3-meter-diameter high-gain antenna, will return an order of magnitude more data than previous missions—a necessary advancement in order to return its many high-resolution images.

Anxious Moments

Built by the Lockheed Martin Space Systems Corporation in Denver, Colorado, the *MRO* spacecraft was developed, integrated, and tested over a 4-year period. The pace of work accelerated once the spacecraft made it to the Kennedy Space Center complex, where it underwent final assembly and testing. Finally, with *MRO* inside its 4-meter-diameter payload fairing, the nearly 60-meter-tall Atlas V 401 rocket blasted into space on August 12, 2005 from the Cape Canaveral Air Force Station.

This trip to Mars took 7 months, during which we checked out all the instruments to make sure they were functioning properly. We performed a few trajectory correction maneuvers, making subtle corrections to our flight path. *MRO* encountered Mars on March 10, 2006, at which time it fired its six main thrusters and entered into a highly elliptical orbit. The burn lasted nearly 27 minutes; a burn shorter than 23 minutes would have *MRO* flying right by the planet! As viewed from Earth, the orbiter disappeared behind Mars 21 minutes into the burn, leaving us waiting anxiously for its reappearance in orbit around Mars. When it did reappear, it sent back a signal to Earth, and shouts of celebration erupted in mission control—we had made it into orbit!



Mars Reconnaissance Orbiter ***needed an orbiter design different than any used in the past to operate the complex payload that will deliver such high-resolution images.*** *Image: JPL/NASA*

Orbiting Mars

Three weeks after orbit insertion, the new orbiter will begin a 6-month process of aerobraking (using the atmosphere to slow the spacecraft). *MRO* will dip into the upper atmosphere of Mars, down to about 100 kilometers (60 miles) above the surface, on more than 500 orbits. Each time this happens, friction with the atmosphere will slow the spacecraft, and it will not climb back as far from the planet as before. Over time and repeated aerobraking maneuvers, the spacecraft will gradually decrease its greatest distance from the planet from about 40,000 kilometers (25,000 miles) to about 400 kilometers (250 miles).

The period of aerobraking has dangers of its own: if the spacecraft goes too deeply into the atmosphere, frictional heating may damage instruments or some part of the solar array. The reason to take these risks is that aerobraking saved more than 500 kilograms (1,100 pounds) of fuel at launch, which is three times the payload mass.

Aerobraking will end in September 2006 with a series of small engine firings, which will perfect the orbit. At that time, Mars and *MRO* will be on the far side of the Sun (a period known as *solar conjunction*), and communications with the orbiter will be difficult. In November, it will be safe to resume normal communications, and *MRO* will then begin 2 Earth-years of intense study of Mars. Formally, the *MRO* mission ends on December 31, 2010, but its fuel supply should enable continued operation of the orbiter for science and data relay as late as 2014.

Data returned by the *MRO* instruments will be used much longer. This storehouse of information on atmospheric, surface, and subsurface structure and composition will be mined for years to come and will make it possible to conduct future robotic and human missions to Mars more safely and productively. Each improvement in observational capability taken to Mars has brought new phenomena to our attention and provided a deeper understanding of our planetary neighbor. That's why *MRO* is the logical next step in Mars exploration.

James Graf is the project manager of the Mars Reconnaissance Orbiter, *and Richard Zurek is* MRO*'s project scientist. They have worked on the* MRO *mission since 2000.*

Acknowledgment: The work reported here was done as part of the *Mars Reconnaissance Orbiter* (*MRO*) Project at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. NASA's Jet Propulsion Laboratory manages *MRO* for the NASA Science Mission Directorate. *MRO* is supported by Lockheed Martin (Denver), the prime contractor for the spacecraft design, build, and flight operations.

A new chapter in Mars exploration has begun. In this view, **MRO** ***fires its six main thrusters to enter Mars orbit on March 10, 2006.*** *Illustration: JPL/NASA*

World Watch

by Louis D. Friedman

Washington, DC—In the endeavor to explore space, it's common for great visions and reality to collide. From October to December 2005, there was a lot of discussion about the need for the NASA budget to grow significantly—NASA Administrator Mike Griffin called for 9 percent growth in fiscal year 2007—to accommodate both President Bush's Vision for Space Exploration and the space shuttle return-to-flight costs that had been included in previous budgets at an unrealistically low level. The extra costs were estimated to exceed $3 billion over the next 5 years. Griffin gave hints that without such a budget increase, the NASA program was in trouble. He warned that compromises in priorities would have to be made, but he also pledged that "not one thin dime" of science money would be transferred to pay for the shuttle.

He was right about compromises and wrong about that "one thin dime."

NASA's FY 2007 budget, as proposed by the administration, would increase by 3.2 percent (about $500 million) from 2006—far short of the estimated $1.4 billion needed. One might have thought that cutting costs in the new Vision for Space Exploration would be one of the compromises. Instead, the administration decided to pay for the shortfall entirely out of the planned growth in the space science program, which includes NASA's robotic missions and the basic research that underlies NASA's entire program. Some $3 billion would be shifted from planned solar system exploration and science to make up the $3 billion shortfall.

So, you might think Griffin hates science, right? He doesn't care about robotic missions, or he is just a shuttle guy who can't let go of the old to make way for the new?

Wrong, wrong, and wrong. Griffin's whole career has involved developing robotic spacecraft to explore space. He was co-leader of The Planetary Society's seminal study that called for the early retirement of the shuttle. He, ex-astronaut Owen Garriott, and I presented the results of that study to NASA, and Griffin strongly defended the need to retire the shuttle with many fewer flights than currently planned.

So, what happened? Politics.

First, European, Japanese, and Canadian governments have pressured the United States to honor its commitment to use the shuttle to deliver their modules to the International Space Station. Risk alone would justify having a backup plan for flying those modules, but politics dictates not even thinking about that. If the shuttle can't deliver the modules, the worst case is that they would reach the station several years later, launched either by new vehicles being developed in the United States or by a combination of Russian and European vehicles.

Second, congressional interests in preserving existing shuttle contracts pressured the administration to fund 16 more shuttle flights and to take no action to terminate the shuttle before 2010. That plan requires about one flight every 3 months, which is hard to achieve even with four or five orbiters, let alone with two or three.

Third, there is political pressure to prevent a gap in the US capability to launch humans into space after the shuttle's retirement and the beginning of Crew Exploration Vehicle flights, pushing the administration to move full speed ahead with funding for new launch vehicles. Never mind that the United States has survived several such gaps before: after the end of the *Apollo* program, after both the *Challenger* and *Columbia* accidents, and today, following the foam problems with *Discovery*.

Fourth, budget constraints limit the amount available for NASA. Given only slightly increased funds for NASA, the administration proposed what it saw as the only solution—to cut science profoundly for the next 5 years.

To fight this shortsighted move, The Planetary Society has launched our S.O.S. (Save Our Science) campaign. These deep cuts to planetary science and missions are the biggest political issues for the Society since the 1980–1981 attempts to cancel NASA's planetary program as a means to provide funding to finish building the shuttle. This is not a conflict between human and robotic exploration, or between science and exploration, but one of how exploration should be conducted. Please keep up to date on the NASA budget at *http://planetary.org* and join our S.O.S. campaign.

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

The US federal budget process for agencies such as NASA begins sometime in August, more than 1 year prior to the time the budget is to take effect. In August 2005, for example, NASA began drafting its request to the Office of Management and Budget (OMB) for its budget for fiscal year 2007, which begins in October 2006.

NASA, the OMB, the White House Science Advisor's office, the National Security Council, the Domestic Policy Office, and other parts of the administration iterate the budget proposal for several months before it is buttoned down. During December and January, it is integrated into the president's overall budget request to Congress, which is submitted in February.

Then the budget is debated in Congress through three committees: Budget, Authorization, and Appropriations. The process culminates in an appropriations bill scheduled to be passed by the end of summer. If the bill is not passed by the next fiscal year, a continuing resolution is passed, allowing agencies to continue to be funded at the previous year's rate.

This is an election year, and Congress will be highly motivated to pass the budget for FY 2007 early so its members can get home and campaign. —*LDF*

Annual Report to Our Members

Dear Planetary Society Members, Donors, and Friends,

Please join me as we look back at 2005 and explore what lies ahead in 2006 for The Planetary Society. 2005 was an extraordinary year for space exploration and for The Planetary Society. We celebrated the 25th year since our founding, and, with members in more than 125 countries, we remain the world's largest independent space interest group.

The Planetary Society Leads by Example

The Planetary Society and its members made history with our attempt to fly the first solar sail spacecraft, *Cosmos 1*: we tested an innovative technology, we took a step toward a private role in space exploration, and we became the first public interest organization to attempt to fly a space mission. The loss of *Cosmos 1*, due to a failure in the launch vehicle, was a blow to us all, but the loss unleashed an international cry to try again—and we will continue to pursue this dream. Our solar sail mission also demonstrated that private initiatives might stimulate novel innovations to exploration: witness NASA's 2006 Solar Sail Centennial Challenge.

While we champion private space ventures like our solar sail, we also strongly support government space programs. We will continue forging public-private partnerships, and we will encourage more space agency cooperation and more private involvement in international missions.

We Are Recognized Throughout the World as the Public's Voice for Space Exploration

Tenacious and passionate, our members create grassroots victories. For example, after years of political activism to convince NASA to undertake a mission to Pluto, we at last saw the *New Horizons* spacecraft embark on its 9-year journey to that beloved ball of ice and rock. Now, we are trying to unite the world's space agencies in a mission to Jupiter's icy moon, Europa. We are also fueling public support for a return to the Moon as a step toward Mars.

We Promote Grand and Ambitious Adventures

We are encouraging all the space agencies involved in lunar projects (those of the United States, Europe, Japan, India, and China) to accomplish more through international cooperation. This is essential if the public is to support human spaceflight from the Moon all the way to Mars.

The Planetary Society Engages You and Others Interested in Space in a Dazzling Array of Solar System Exploration

We followed the continually amazing Mars Exploration Rovers and *Cassini-Huygens*; we invited the world to guess the diameter of the crater caused by *Deep Impact*; we flew Society members' names aboard *Cassini*, *Deep Impact*, *Stardust,* and *Cosmos 1*; and we brought sounds of Titan to Earth from the *Huygens* probe.

Generous donations from supporters like you have enabled the Society to attempt to solve a great spacecraft mystery: the *Pioneer* anomaly. Thanks to funding from The Kenneth T. and Eileen L. Norris Foundation and Lockheed Martin, we produced a new version of our acclaimed *Explorer's Guide to Mars* poster.

Your support in 2006 will enable us to complete our catalog of extrasolar planets, to begin the only dedicated optical search for extraterrestrial intelligence, and to propose ideas for missions to asteroids that potentially threaten Earth. This year, we are also pursuing Mars Microphone experiments on the *Phoenix* mission in 2007 and on the *Mars Science Laboratory* in 2009.

Our 25th Anniversary—A Joyous Celebration

The year 2005 ended with the Society's 25th Anniversary Gala Awards Dinner. We honored author and Society Adviser Ray Bradbury, who received the Thomas O. Paine Award for the Advancement of Human Exploration of Mars, and film director James Cameron, who received the Society's inaugural Cosmos Award for Outstanding Public Presentation of Science. This award, which will be given to individuals who communicate science to the public in an authentic and inspiring way, was made possible by a grant from The M.R. and Evelyn Hudson Foundation. The anniversary celebration, complete with a live charitable eBay auction to support the Society, was sponsored by the Northrop Grumman Corporation, as well as other corporations and individuals. It was a fundraising success and a great launch into our next age of exploration.

With You, We Are Shaping the Future of Space Exploration

Thanks to our members and donors, over the past 25 years The Planetary Society has become the largest independent space advocacy group in the world. With your continued interest and support, we will lead the way in seeking other life and exploring other worlds. With you, we will help unravel the mysteries of the universe.

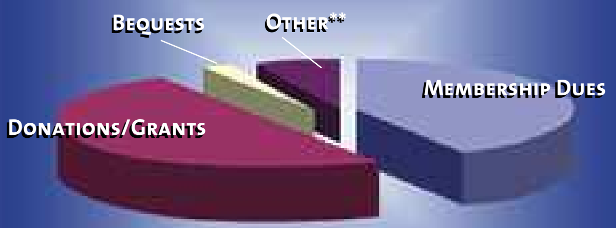
Sincerely yours,

Neil D. Tyson

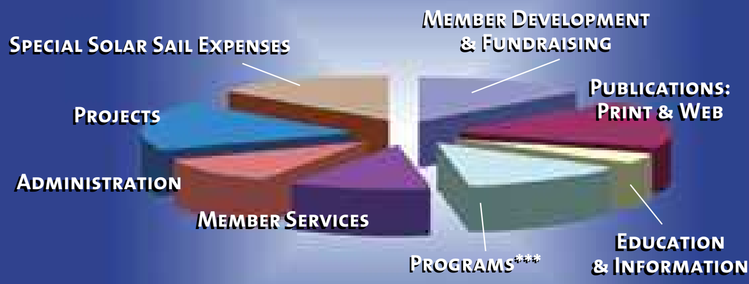
Neil deGrasse Tyson
Chair, Board of Directors

Neil deGrasse Tyson is chair of The Planetary Society's Board of Directors. He is also an astrophysicist and director of the Hayden Planetarium of the American Museum of Natural History in New York City.

Fiscal Year 2005 Revenues



Fiscal Year 2005 Expenses



Balance Sheet

For the Fiscal Years Ended September 30, 2001, 2002, 2003, 2004, and 2005 in thousands of dollars.

	Total All Funds:				
Assets	**FY2005**	**FY2004**	**FY2003**	**FY2002**	**FY2001**
Current Assets					
Cash and Cash Equivalents and Investments	1511	1,572	1,959	2,274	1,104
Membership Dues and Misc. Receivables	277	209	114	5	113
Inventories	64	53	47	49	45
Prepaid Expenses	49	51	21	20	42
Total Current Assets	**1,901**	**1,885**	**2,141**	**2,348**	**1,304**
Land, Building, and Equipment	**683**	**638**	**658**	**698**	**760**
Total Assets	**2,584**	**2,523**	**2,799**	**3,046**	**2,064**
Liabilities	FY2005	FY2004	FY2003	FY2002	FY2001
Liabilities					
Accounts Payable and Accrued Expenses	206	129	101	170	164
Deferred Dues and Grant Revenue*	1,147	1,247	1,420	1,864	1,614
Total Liabilities	**1,353**	**1,376**	**1,521**	**2,034**	**1,778**
Net Assets (Deficits)	FY2005	FY2004	FY2003	FY2002	FY2001
Unrestricted	844	(96)	60	28	(254)
Temporarily Unrestricted	385	1,241	1,217	983	540
Permanently Restricted	2	2	1	1	0
Total Net Assets	**1,231**	**1,147**	**1,278**	**1,012**	**286**
Total Liabilities and Net Assets (Fund Balances)	**2,584**	**2,523**	**2,799**	**3,046**	**2,064**
Revenues	FY2005	FY2004	FY2003	FY2002	FY2001
Membership Dues	1,366	1,538	1,636	1,703	1,780
Donations/Grants	1,610	1,230	1,495	1,285	1,797
Bequests	72	0	10	631	59
Other **	208	282	258	288	335
Solar Sail Grant	0	0	0	677	2,226
Total	**3,256**	**3,050**	**3,399**	**4,584**	**6,197**
Expenses	FY2005	FY2004	FY2003	FY2002	FY2001
Member Development & Fundraising	421	380	342	339	518
Publications: Print & Web	554	721	629	749	711
Education and Information	117	121	102	129	310
Programs ***	418	455	551	430	324
Member Services	343	331	312	394	379
Administration	312	338	408	394	753
Projects	579	703	561	1,097	841
Special Solar Sail Expenses	428	132	228	326	2,369
Total	**3,172**	**3,181**	**3,133**	**3,858**	**6,205**

* Income received but not yet recognized ** Admissions, interest, net sales, royalties, etc. *** Events, lectures, tours, expeditions

Questions and Answers

When do scientists estimate that Saturn's ring system came into being? When do they estimate that it will dissipate?
—Robert Gorby
Santa Ana, California

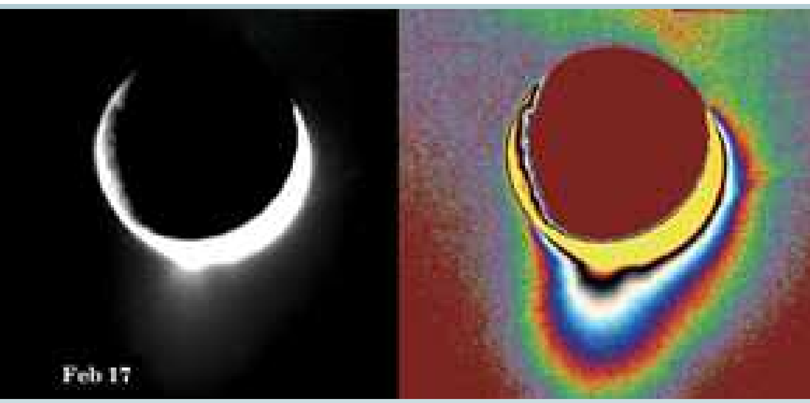
Scientists are studying the age of Saturn's rings because the answer is a fundamental key to understanding the origin and evolution of the Saturnian system. New observations by *Cassini* should help us resolve this question, which may have a complicated answer.

Although the rings have a number of features that appear to be young, this doesn't necessarily mean that the rings haven't been around as long as Saturn has. It just means that they likely looked very different hundreds of millions of years ago. For example, Saturn's rings appear to be too clean to have been exposed to a constant bombardment from dark meteoroids since the beginning of the solar system.

Examination of this and other processes, including collisional spreading, and the lifetime of small moons in the rings due to impact disruption, shows the age of the rings to be closer to 100 million years than 4.5 billion years. However, the material that makes up Saturn's rings is likely leftover debris from the formation of Saturn and its retinue of moons. Impacts onto small, ancient moons by comets and meteoroids can shatter them, producing new, young-looking rings.

Your second question is easier to answer, and it may hold clues to the answer to the first. Although Saturn's rings are evolving and may look very different in 100 million years, or maybe even 100,000 years, the rings are

Factinos



Saturn's moon Enceladus has now been promoted to one of the most exciting places in the solar system. Towering plumes of icy material erupt from the south pole in these Cassini *images taken in February 2005. Some scientists think these jets may be erupting from near-surface pockets of liquid water.* Images: NASA/JPL/Space Science Institute

Plumes of liquid water may be erupting from the south pole of Saturn's moon Enceladus. *Cassini* images (above) show icy jets and towering plumes ejecting large quantities of particles at high speed—evidence that the geologically young south polar region of Enceladus may possess reservoirs of liquid water close enough to the surface to form geysers like those found in Yellowstone National Park. This finding and others were reported in the March 10, 2006 edition of *Science*—a special issue on Enceladus.

"We realize that this is a radical conclusion—that we may have evidence for liquid water within a body so small and so cold," said *Cassini* imaging team leader Carolyn Porco of Boulder, Colorado's Space Science Institute. "However, if we are right, we have significantly broadened the diversity of solar system environments where we might possibly have conditions suitable for living organisms."

The scientists ruled out the idea that the particles are produced, or blown off the moon's surface by, vapor created when warm water ice converts to a gas. Instead, they found evidence that the jets might be erupting from near-surface pockets of liquid water above 0 degrees Celsius (32 degrees Fahrenheit), like cold versions of the Old Faithful geyser in Yellowstone.

"As *Cassini* approached Saturn, we discovered that the Saturnian system is filled with oxygen atoms. At the time we had no idea where the oxygen was coming from," said Candy Hansen of the Jet Propulsion Laboratory. "Now we know that Enceladus is spewing out water molecules, which break down into oxygen and hydrogen."
—from NASA and the
Space Science Institute

On January 27, 2006, *Cassini* captured this image (right) of a new storm on Saturn. *Cassini* scientists believe the storm is a possible source of radio emissions—from the most powerful electrical storm ever detected—deep in Saturn's atmosphere. *Cassini* began detecting the radio emissions, which are like those from lightning, on January 23. At the same time, amateur astronomers reported seeing a storm in the planet's southern hemisphere.

The spacecraft was not in a good position to take images of the storm on Saturn's dayside because only a thin crescent of the planet was visible at that angle. However, light from Saturn's rings (called "ringshine") allowed *Cassini* to see the storm and other cloud features at night. The storm's north-south

eroding very slowly. The rings lose material through two processes: by sputtering of atoms and molecules off the ring particles by high-energy solar photons and high-energy particles in the magnetosphere, and by erosion of particles due to impacts resulting in dust, which then is lost to the atmosphere or the magnetosphere. Both of these processes are so slow that most of the ring material should still be orbiting Saturn in 4 or 5 billion years, when the Sun becomes a red giant.
—JOSHUA COLWELL,
University of Colorado

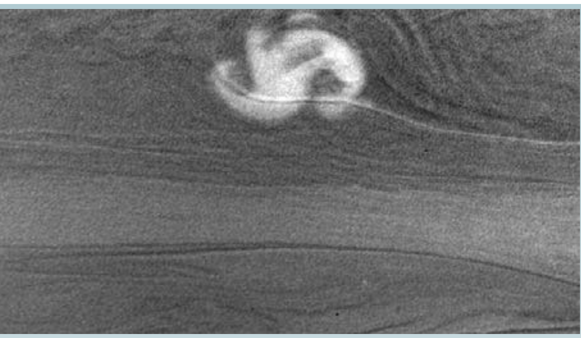
Was the* Deep Impact *team able to measure how much damage the* Deep Impact *spacecraft did to the nucleus of comet Tempel 1?

And what happened to the craft? Was it destroyed, or is it part of the comet now?
—Joe Lacey
Sierra Madre, California

Deep Impact's damage to the comet overall was negligible. To describe it, we often use the analogy of a mosquito hitting a semi truck. We had hoped to image the crater formed by the collision, but the material excavated by the impact was a fine powder, so the ejecta didn't clear very quickly. However, based on our observations of the material ejected (spectra, velocity, composition, etc.) we expect that a crater 100 to 250 meters in diameter was formed by the impacting spacecraft. Comet Tempel 1 is about 3 by 4 by 5 kilometers (about 2 by 2.5 by 3 miles) in size, so the crater is pretty small relative to the nucleus.

Team member Pete Schultz of Brown University did a lot of experiments in the lab that involved shooting various materials into other materials. He found that metal pellets leave melted fragments at the bottom of the resulting crater. We expect that *Deep Impact*'s copper impactor got pulverized, and a good portion of it probably vaporized in the collision.

Planetary Society members' names were included in the "Send Your Name to a Comet" campaign and were put on a CD that was installed on the impactor. It is very likely that the CD was destroyed in the collision, so all of the names literally helped to make a Deep Impact!
—ELIZABETH WARNER,
University of Maryland



A new lightning storm—the most powerful ever recorded—recently appeared on Saturn. In late January 2006,* Cassini *detected radio signals from lightning flashes more than 1,000 times more intense than similar radio signals from Earthly storms. Sunlight reflected off Saturn's rings allowed* Cassini *to take this image of the storm on the planet's nightside. This view was derived by reprojecting the original image as a cylindrical map and enhancing the contrast to bring out faint features. *Image: JPL/NASA*

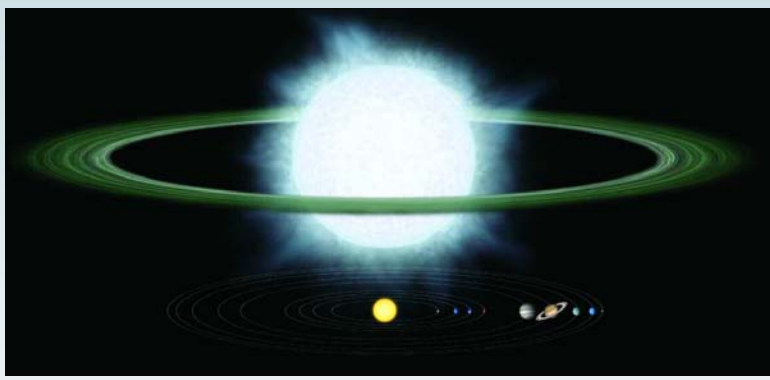
dimension is about 3,500 kilometers (2,175 miles) in this image, which was taken from about 3.5 million kilometers (2.2 million miles).
—from JPL/NASA

Scientists using the Spitzer Space Telescope have found two "hypergiant" stars circled by monstrous disks of what might be planet-forming dust (see illustration at right). The detection of these disks is surprising, because enormous stars like these were thought to be inhospitable to planets.

"These extremely massive stars are tremendously hot and bright and have very strong winds, making the job of building planets difficult," said Joel Kastner of the Rochester Institute of Technology in New York. "Our data suggest that the planet-forming process may be hardier than previously believed, occurring around even the most massive stars that nature produces." Kastner and his team reported on their research in the February 10, 2006 issue of *Astrophysical Journal Letters*.

Spitzer captured the huge dust rings around the stars R 66 and R 126, both located in the Large Magellanic Cloud, the Milky Way's closest neighboring galaxy. They are 30 and 70 times the mass of the Sun, respectively.

Such huge stars don't live long, however—just a few million years. "We do not know if planets like those in our solar system are able to form in the highly energetic, dynamic environment of these massive stars, but if they could, their existence would be a short and exciting one," said team member Charles Beichman of the California Institute of Technology.
—from NASA/JPL/Caltech



NASA's Spitzer Space Telescope has detected dusty disks around R 66 and R 126, two gargantuan stars in the Large Magellanic Cloud. This illustration compares the size of our solar system (planets are not shown to scale) with a gargantuan star and its surrounding disk. *Illustration: NASA/JPL/Caltech*

Society News

Join Us for the Premiere Public Space Event for 2006!

International Space Development Conference
Los Angeles • May 4–7, 2006

For the first time ever, The Planetary Society and the National Space Society will cosponsor the annual International Space Development Conference (ISDC), May 4–7, 2006 at the Sheraton Gateway Hotel in Los Angeles, California.

ISDC will exemplify its 2006 theme, “Exploring New Worlds,” with a stellar gathering of space entrepreneurs, scientists, engineers, visionaries, and celebrities. Confirmed speakers include *Apollo* astronauts Buzz Aldrin and Rusty Schweickart, *SpaceShipOne* designer Burt Rutan, NASA Deputy Administrator Shana Dale, JPL Director Charles Elachi, Bill Nye the Science Guy, SpaceX CEO Elon Musk, National Space Society Chairman Hugh Downs, Planetary Society Chairman Neil deGrasse Tyson, Planetary Society Executive Director Louis Friedman, and many more.

For more information or to register online, visit *www.isdc2006.org* or call 1-800-9WORLDS or 202-429-1600.
—Susan Lendroth, Manager of Events and Communications

Winning Postcards from Venus Chosen

Venus, as the goddess of beauty, has been celebrated in art and myth for millennia. Now, The Planetary Society and the European Space Agency (ESA) celebrate the imagined rugged beauty of the planet’s natural landscape with the winning entries in the “Postcards from Venus” art contest in coordination with ESA’s *Venus Express* mission.

The grand prize winner is Tatianna Cwick, age 17, from Cape Girardeau, Missouri. Cwick has won a trip to the European Space Operations Centre in Darmstadt, Germany when *Venus Express* arrives at its destination on April 11, 2006.

Yoo-Hong Sun, age 10, of South Korea was the first place winner in the youth category, and Alejandra Gonzalez Quintana of Spain won first place for adults. Additional winners in the youth category include second place winner Upamanyu Moitra, age 12, India; and third place winner Nabila Nindya Alifia Putri, age 17, Indonesia. Jason Tetlak of the United States took second place in the adult category, and two artists tied for third place: Alessandro Migliaccio of Italy and Edgar Tibori of Germany. All winning entries may be viewed at *planetary.org/postcards_from_venus/*.

Two months or more after the arrival of *Venus Express*, another judging panel will review the entries to select two Special Prizes (one Youth and one Adult). These prizes will be awarded for that artwork which most closely resembles a view of Venus returned from the *Venus Express* spacecraft.

All winners’ artworks will be displayed at ESA’s European Space Operations Centre during the *Venus Express* arrival at Venus.
—Emily Stewart Lakdawalla, Science and Technology Coordinator

Comet Crater Contest Winners

When NASA’s *Deep Impact* mission slammed into comet Tempel 1 in July 2005, The Planetary Society expected to make an immediate announcement about the winners of its “Great Comet Crater Contest” to guess the diameter of the crater created by the impact. One learns to expect the unexpected with space exploration, however; 6 months after the impactor kicked up an opaque cloud of comet debris, team scientists have learned a lot about Tempel 1 but can still only estimate the crater’s size as being somewhere between 100 and 250 meters in diameter.

The Planetary Society has, therefore, selected at random three grand prize winners from the 1,865 contest entrants who submitted a guess within the estimated size range. The grand prize winners and their respective crater estimates are Wojciech Karcz, Tarnowskie Gory, Poland (161 meters); Michael Ramo, Danielson, Connecticut (153 meters); and Tim Thomas, Hayward, California (141.4272 meters). Additional information on the contest can be found at *planetary.org/explore/topics/comet_crater/*. —*ESL*

OUR RETURN TO THE RED PLANET!

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**

NEW! An Explorer's Guide to Mars
Explore Mars! Our recently updated Explorer's Guide to Mars features images from the *Mars Odyssey*, *Mars Express*, *Mars Global Surveyor,* and *Viking* orbiters as well as images of Mars' surface from the *Spirit* and *Opportunity*, *Pathfinder,* and *Viking* spacecraft. Informative captions and charts enhance a detailed US Geological Survey map produced from data returned from *Mars Global Surveyor*'s Mars Orbiter Laser Altimeter. On the reverse side, find even more detailed information about Mars.
24" x 37"   1 lb.   **#505 $15.25**

"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**

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   1 lb.
#565 $13.50

Set Sail for the Stars! Poster
22" x 34"   1 lb.   **#571 $13.50**

"Is Anybody Out There?" Poster
39" x 16"   1 lb.   **#320 $13.50**

Pale Blue Dot Poster
12" x 30"   1 lb.   **#326 $10.00**

Nebula Poster
22" x 34"   1 lb.   **#315 $13.50**

Mars in 3-D Poster
12" x 39"   1 lb.   **#306 $13.50**

Solar System in Pictures
Nine 8" x 10" mini-posters.
1 lb.   **#336 $11.25**

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

Surf Titan T-Shirt
Adult sizes: S, M, L, XL, XXL   1 lb.   **#593 $20.00**

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

Planetary Society Cap
1 lb.   **#673 $13.50**

Winds of Mars and the Music of Johann Sebastian Bach
1 lb.   **#785 $15.00**

SETI@home Mug
2 lbs.   **#550 $10.00**

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

Planetary Society Key Ring Medallion
1 lb.   **#677 $16.00**

Craters! A Multi-Science Approach to Cratering and Impacts
2 lbs.   **#109 $24.95**

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

The Planetary Society License Plate Holder
1 lb.   **#675 $5.25**

Planetary Report Binder
2 lbs.   **#545 $14.50**

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