The PLANETARY REPORT

Volume XX Number 6 November/December 2000

SETI@home Searches the Sky

On the Cover:

In what part of our galaxy will we first detect other forms of life? Simple logic dictates that starrier regions will have more planets, thus more possibilities. But who knows? The answer may lie in the wilderness of a nebula. John Gleason captured this image of the Orion nebula in October 1998 from the Sierra Nevada mountains in northern California.

Image: (c) John Gleason, Celestial Images

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We've expanded our usual Opinion section to encompass opposing views to Robert Zubrin's piece in our July/August issue. There, Robert expressed his view that neither human exploration of Mars nor samples returned from the Red Planet would pose a threat to life-forms on these worlds. We expect the controversy will be with us for a while, as it evidently touched a deep chord among Planetary Society members.

8 Life From Space? Testing Panspermia With Martian Meteorite ALH84001

That one little rock from Mars—ALH84001—may be the most-studied conglomeration of minerals in scientific history, and it still has lots to teach us. Just four years ago, it caught the world's attention when researchers announced they had found traces of ancient Martian life within its recesses. Now it plays a role in another possible story about life—that of panspermia, the transfer of life-forms between worlds.

12 SETI@home and The Planetary Society—The Bond Strengthens

When The Planetary Society was formed in 1980, its prime directive was to engage the people of Earth in the exploration of the solar system and the search for extraterrestrial life. No single program in our 20-year history has fulfilled that directive as well as SETI@home. The Society was the founding sponsor for SETI@home, and now with the help of the OneCosmos Network, we have been able to go far beyond our initial support. With nearly 2.5 million participants around the world, and the potential to involve even more in the search for other civilizations, who knows how far we will be able to go.

20 The Next Generation of Mars Explorers—Introducing the Red Rover Goes to Mars Team

What a time we've had with our Red Rover Goes to Mars international student contest! Just as we were launching the competition, NASA canceled the *Mars Surveyor 2001* lander mission, which was to involve our winners. Thanks to our ability to improvise, we reconstituted the contest to work with the *Mars Global Surveyor* mission, and now our nine winners from around the world are preparing to operate that spacecraft's camera and take pictures of possible landing sites on the Red Planet. You can meet our winners here!

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From The Editor

We humans are a very egocentric species. As we contemplate the vast universe in which we float, we tend to focus our interest on seeking phenomena like ourselves—that is to say, life. Judging from the two major features in this issue of *The Planetary Report*—one on searching for extraterrestrial life, the other on the possibility of life arriving here from space—this focus is shared by members of The Planetary Society. And, in fact, NASA has declared the search for life on other worlds to be the prime driver of its planetary program.

But, as in all tightly focused endeavors, we can miss something extraordinary lying just off to the side. Right now, this focus on life may cost us the opportunity to send a spacecraft to Pluto, perhaps for a generation.

As Society members know, NASA has ordered work stopped on the *Pluto-Kuiper Express* mission to explore the fringe of our solar system. One reason for halting the mission was that it did not fit NASA's current concentration on seeking evidence for life.

At moments like this, we face difficult choices. Is the prime reason we explore space to seek ourselves among the worlds, or is it to explore worlds as yet unvisited? Should NASA concentrate on Mars and Europa, worlds that might support life, and give up the rest of the solar system? Or should it complete the planetary reconnaissance started so boldly when *Mariner 2* traveled to Venus in 1962? I have no easy answer; I welcome your views. I can be reached at the address to the right.

—*Charlene M. Anderson*

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

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Members' **Dialogue**

Save Pluto Express?

I share every Planetary Society Member's sadness at the cancellation of the *Pluto Express* mission. However, I am not the least bit surprised that this mission faced the chopping block. I do not view the current situation as a disaster. In fact, I am pleased that NASA is getting more realistic about just what can be done given the "faster, better, cheaper" mantra. They are still on a learning curve, and mistakes are to be expected.

If we lose *Pluto Express*, delay the Europa orbiter, and keep all the approved Discovery missions, we are still way ahead of where we were before "faster, better, cheaper" debuted.
—JOHN DAY,
Los Angeles, California

While I am sorry to hear about the scrapping of the mission to Pluto, I can't help thinking it may be a small price to pay for the preservation of other, more important projects a little closer to home, such as the continued exploration of Mars, Europa, and Saturn.

As the International Space Station continues to gobble large amounts of money from NASA's ever smaller budget, you can be sure the attacks on the unmanned space exploration program will continue.

History over the past quarter century makes for grim reading: 21 years between Mars landings, 16 years between Jupiter missions, and 23 years between Saturn missions. There are no guarantees that any future missions to these worlds will actually take place; all we can do is hope that things don't get any worse and in the meantime fight to preserve what we already have.
—SHAUN GOODCHILD,
Cornwall, United Kingdom

The Planetary Society has not given up on a mission to Pluto just yet. Keep an eye on our website, ***planetary.org****, for continuous updates on our members' fight to ensure the planet is explored by this generation.*
—Charlene M. Anderson,
Associate Director

In Appreciation

It's been a few issues since I've seen Clark Chapman's News and Reviews in *The Planetary Report*, and I fear it has been stopped. I am saddened at the loss of this column, which I have enjoyed for years. In fact, wasn't News and Reviews a staple in the magazine from the first issue?

I found Clark's column full of interesting news, unexpected opinions, and novel ideas. It was a favorite part of *The Planetary Report* for me, because the contents were always straight from its writer's heart. News and Reviews was well written, incisive, and fun.

I remember being woken one morning in 1984, while doing asteroid research at Kitt Peak. Since I'd been up all night, I was startled by the noise of banging and tapping coming from the room next door. Wondering if something were wrong, I knocked on the door. Inside were Clark and his old manual typewriter. What had woken me was the sound of him typing one of his News and Reviews articles. The passion that went into his columns seemed to go physically from his brain, through his hands, and onto the keys of his poor typewriter. I've never seen anyone type so fast, or so loudly.

The mid-1980s were difficult years for planetary science, and Clark's many writings, including News and Reviews, helped keep this field of study alive. Thank you, Clark, for keeping our eyes on the ball, and for helping point the way. We'll miss your wisdom in these pages.
—DAVID H. LEVY,
Vail, Arizona

We agree completely—and we deeply appreciate Clark Chapman's devoted years as a contributor to The Planetary Report. *We were pleased to nominate him for the Carl Sagan Medal in the Division of Planetary Sciences of the American Astronomical Society and were honored when he won that prize.*
—Louis D. Friedman,
Executive Director

NEOS@home

I want to lend one more vote in support of the suggestion in the July/August 2000 issue for developing a NEOs@home type of distributed processing network for near-Earth asteroid identification and tracking.

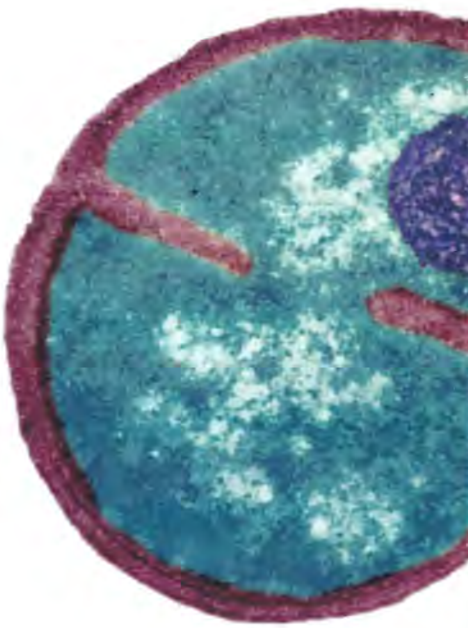
I've been logging more than the average amount of time on SETI@home but would much prefer to lend those hours to something closer to home. The processing model is there—it doesn't seem like too much of a stretch to apply the same system to optical scans of the skies.
—M. SCOTT MUSSETT,
Dhahran, Saudi Arabia

Erratum

We apologize to Barry E. DiGregorio for misspelling his name in last issue's column.

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

NO THREAT? NO WAY!



A whiff of life on another world, however faint, is enough to raise passions here on Earth. Dry channels snaking across a barren surface, gullies cut into the sides of craters, organisms resembling bacteria fossilized in extraterrestrial rock—these sorts of things suggest that life might once have existed on Mars and also make it difficult to rule out the possibility that life survives there today.

In our July/August issue, Robert Zubrin, president of the Mars Society, argued that fears of contamination—either by Martian life on Earth or terrestrial life on Mars—are nonsense. Not surprisingly, many of our readers wrote us, passionately arguing against Robert's position. Here we share three substantial responses by leading researchers into life elsewhere in our solar system.

—Charlene M. Anderson, Associate Director

A Case for Caution

by John D. Rummel

There are days when I ask myself, "Is it worth it?" After all, given the heightened awareness about Earth organisms and their newfound capabilities in extreme environments—to say nothing of the troubles that immune-compromised patients face with normally benign microbes—I figure the need for back contamination controls for missions to places possibly harboring life should be obvious. So I sometimes wonder if I, as Planetary Protection Officer, can really make a difference.

I want to thank Bob Zubrin for providing this week's job satisfaction. His opinion piece in the July/August 2000 issue of *The Planetary Report* was so off the mark that I found renewed joy in simply contemplating an answer. And I found it an interesting coincidence that David Jewitt's piece in the previous issue of *The Planetary Report* ("Astronomy: Eyes Wide Shut," May/June 2000) was introduced in the table of contents with the statement "It's always easy to make fun of things you don't understand. It's always easy to ignore threats when they have not yet loomed above the horizon." Of course, Zubrin has done just that with straw-man arguments placed for his own convenience. I very much admire Bob for his contributions to Mars exploration planning, but in this case he should know better.

Views expressed in this article are those of the authors and do not necessarily represent those of The Planetary Society.

First off, the potential for back contamination—that is, bringing organisms back to the Earth from Mars missions—depends on the potential for a solar system body (such as Mars) to harbor life. I shouldn't have to point out that we are ignorant about whether or not life exists on Mars and, if it exists, whether it is widespread enough to be picked up in a surface sample. The *Viking* results describe a Mars that is very cold most of the time and very dry, but the surface of Mars is neither always cold nor always dry—as recent *Mars Global Surveyor* pictures have shown. Let me remind readers that not until seven months after *Viking 1* landed on Mars did we know about life at deep-sea hydrothermal vents right here on Earth. And Mars is *big*. We have, literally, only scratched its surface. Mars may indeed be a living planet.

Well, what if it is? Would Mars life necessarily be dangerous?

Hardly. If there is life on Mars, it could be related to life on Earth (due to the natural interchange of materials occasioned by large impact events), or it might be completely unrelated to Earth life. Either scenario would argue for simple prudence in returning a sample from Mars. NASA's current policy, as recommended by the US National Research Council, is not extreme. Rather, it is based on the sound principle that a sample from Mars should be contained until scientists find it does not contain a biohazard. If Mars life is related to Earth life, then we should find it relatively easy to demonstrate it is not hazardous (if we are lucky enough to bring back anything living in the first place). But readers should be reminded that many Earth organisms, while not coevolved pathogens (for example, ergot fungus, botulism bacteria), are nonetheless

It might sound logical at first—the argument that organisms evolved on Mars could not survive on Earth—but nature is full of surprises. This false-color image shows a section of **Deinococcus radiodurans,** *an organism first discovered in nuclear power plants—toxic places new to the Earthly scene. The microbe has since been found in natural environments like dry lakebeds. This false-color electron microscope image shows the bacterium at 60,000 times its normal size. The round dark structures are inclusions of unknown composition.* Image: Courtesy John Battista

Earth. Strident arguments on one side ("Mars samples will kill us all!") or the other ("The threat of back contamination is 'hallucinatory'!") do not add value to the discussion about appropriate and reasonable precautions to take in the conduct of what promises to be a vital and intriguing scientific endeavor. The significance of Mars calls for responsible exploration, and Bob Zubrin should have taken more time to inform himself of the real issues at hand. In fact, the time he took to write the piece could have been spent learning enough to have made his opinion much more valuable.

John D. Rummel, Ph.D., is Planetary Protection Officer at NASA Headquarters.

dangerous. And Bob should consider his own example (Dutch elm disease) a reminder that organisms, while not human pathogens, can yet cause damage, both environmentally and economically. Still, he insists that Mars life unrelated to Earth organisms couldn't possibly cause harm. How does he know, when we have precisely *zero* experience with life unrelated to Earth life? Containment and testing are reasonable measures; why not take them? Why shouldn't we avoid the downside? How ought others judge the cost-benefit ratio of Mars exploration if we don't take simple precautions to avoid potentially harmful consequences? Harshly, I suspect.

Due to space limitations, I won't rebut item by item some of Bob's erroneous talking points. And I will agree with him that it would be a terrible loss to sterilize samples prior to their return—it may be difficult to sterilize such samples in any event. One canard to point out, however, is Bob's assertion that "microorganisms are adapted to specific environments," and thus Mars microbes would refrain from living on Earth. This is not a reliable speculation. A notable counterexample from Earth is *Deinococcus radiodurans*, an organism first isolated from nuclear power plants—environments that did not exist prior to the 1940s. Where did this microbe come from? *Deinococcus radiodurans* has since been found in natural environments (dry lakebeds) quite unlike Three-Mile Island. What other Earth organisms do we know nothing about?

A rational program of containment and biohazard testing will not only allow us to determine the safety of a returned Mars sample, but it will also allow us the best chance of detecting Mars life, if it exists, when a sample is brought to

Hazardous Until Proven Otherwise

by Margaret Race

When I read the opinion piece by Robert Zubrin ("Contamination From Mars: No Threat," *The Planetary Report*, July/August 2000), I didn't know how to react. As a biologist working on planetary protection and Mars sample return at the SETI Institute, I wondered how an engineer and Mars enthusiast like Zubrin could make such irresponsible and inaccurate statements. Obviously, Zubrin is entitled to his opinion, even if it's based largely on misuse of facts. But what about the readers of *The Planetary Report*? Don't they deserve more than op-ed humor?

The real business of planetary protection should not be taken as lightly as Zubrin suggests. What if readers accept the article at face value and believe the inaccuracies and misrepresentations he so carelessly throws about? What if they swallow the argument that "back contamination mavens need to back off" because "their warnings have no rational basis and are being used to urge crimes against science"? Therein would be the crime against science. To launch a mission without planetary protection measures would doom it to failure (or to borrow from Zubrin, it would be just plain nuts). More than just science and technology are involved. Rather than try to dissect Zubrin's arguments one by one, let me clarify several important matters—about policies, procedures, public concerns, and ethical issues.

Significantly, Zubrin's perspective fails to consider the extensive policy and procedural requirements behind back contamination controls for Mars missions. The Outer Space Treaty of 1967 specifically states that all space exploration must be done in a way that avoids harmful contamination to celestial bodies or adverse changes in the environment of the

Left: The Moon rocks gathered by Apollo astronauts have their own special building at the Johnson Space Center (JSC) in Houston. In the Lunar Sample Laboratory Facility, "pristine" lunar samples (which have remained in NASA's custody since their return from the Moon) are stored and handled in stainless-steel glove cabinets purged by pure nitrogen gas to minimize degradation of the samples. Pristine samples are always separated from human hands by three layers of gloves.

Below: These technicians are preparing to set up lunar samples for study in the Pristine Sample Laboratory at JSC.

Photos: Johnson Space Center

Earth from the introduction of extraterrestrial materials. Like it or not, NASA can't leave home without planetary protection measures. Based on recommendations of the Space Studies Board of the National Research Council (NRC), these measures include strict sample containment, special handling under quarantine, rigorous testing to determine if Martian materials are biohazardous, and yes, even sterilization under certain situations. The NRC is hardly an alarmist group—but its report specifically urges that NASA "adopt a prudent approach, erring on the side of caution and safety." Somehow I'd rather listen to the NRC than an errant rocket scientist when it comes to protecting my home planet and the science on board.

If the NRC's cautious opinion isn't convincing enough, repeated research surveys of the general public and expert biologists alike have indicated strong support for a conservative approach to sample return. In fact, more than 4,300 Planetary Society members from countries around the world responded to the first survey back in 1994. An overwhelming majority indicated that "all materials brought to Earth from Mars should be considered hazardous until proven otherwise."

In addition, like all responsible government agencies, NASA must follow the National Environmental Policy Act. Thus, for a sample return mission, NASA is required to prepare an Environmental Impact Statement and make it available for public review and comment well before launch. The public expects and demands nothing less. Gone are the days when experts could make decisions behind closed doors with assurances like "Trust me—I'm a rocket scientist." Considering everything that has been written about Mars and its potential for life, how could NASA possibly adopt a position like Zubrin's? No back contamination controls? No way! And don't forget the rest of the government. Once the Martian samples reach terra firma, agencies like the United States Department of Agriculture, Environmental Protection Agency, Centers for Disease Control, and others with jurisdiction over environmental, health, and safety areas will likely be involved. Once again, NASA can't ignore back contamination concerns, however small the risks.

Zubrin is correct when he recounts a NASA planning meeting in which someone seriously proposed that Martian samples be sterilized before being brought to Earth. What he doesn't mention are the many discussions at numerous other NASA workshops and meetings where experts have debated alternative mission plans, both with and without sterilization. There's not a scientist around who wouldn't rather return pristine samples as opposed to cooked ones—but still, scientists realize that they have to consider many alternatives (even unpalatable ones) before selecting the final mission configuration. What's more, every engineer recognizes this as standard procedure. On one point we can agree with Zubrin: it would be a terrible scientific loss to sterilize the samples—nevertheless, it might be better than no samples at all. (Yes, NASA must also consider the null alternative, which in this case means no sample return—period.)

Finally, consider the ethical implications of discovering Martian life—especially if detected on Earth in returned samples. What are the ethically acceptable levels of risk posed by the importation and handling of potential extraterrestrial organisms on Earth? Who will be involved in making decisions about these risks? Should scientific exploration proceed in the face of potentially novel life-forms and scientific uncertainty? Are current handling procedures adequate to safeguard Earth and its inhabitants? The concerns and questions about Mars sample return are actually quite similar to those encountered during the 1970s and '80s by ethicists debating the implications of genetic engineering. Now, as then, these questions require serious consideration, not flippant suggestions to "back off."

I can understand Zubrin's impatience about back contamination controls. He's confident in our impressive technological prowess; he's raring to go and doesn't want anything to slow down or stop our exploration of Mars—especially not burdensome regulations based on very small risks and scientific uncertainty. Yet when he suggests that there's no need for back contamination controls on Mars sample return missions, he's advocating an irresponsible way to cut corners. If he were an architect, would he suggest designing buildings without smoke detectors or fire extinguishers?

While I share Zubrin's enthusiasm for Mars exploration and hope that someday we find life on Mars, I'm one biologist who's glad to know that our government is doing the right thing. NASA, its scientists, and its engineers are taking a comprehensive view of what is required for a successful mission. Back contamination controls are most definitely part of the plan—for lots of good reasons—despite what Zubrin suggests.

Margaret Race is a biologist with SETI Institute who specializes in planetary protection and environmental impact analyses.

Practice Safe Science

by Kenneth H. Nealson

In the July/August issue of *The Planetary Report*, the opinion piece by Robert Zubrin, "Contamination From Mars: No Threat," takes a vociferous stand against any activities related to the question of back contamination. So sure is Zubrin that there is no threat, he accuses those who would worry about such things of "crimes against science." This is an interesting statement from someone who, according to my brief research, has no credentials in biology, microbiology, evolution, epidemiology, or pathology. Not that such credentials are prerequisite to speaking up for the right thing, but in the absence of supporting citations, one wonders what expertise bolsters such a strong stand.

For example, Zubrin claims that the microbial ecosystems on our planet are so well adapted that there is no fear of other organisms disrupting them; in essence he argues that microbial ecosystems are resistant to such outside effects. While most of us who actually work in the field see this as an unknown area, anyone who has witnessed a waste disposal facility crash or suffered from a disruptive organism in his or her intestinal tract (a very well adjusted microbial ecosystem) knows that just isn't so. In fact, the details of these sometimes fragile microbial ecosystems are not well understood, and to claim anything else reveals an immense lack of appreciation for the complexities of the science.

Nevertheless, Zubrin speaks with authority and (without citations or names) refers to "experts" who apparently support his views. I suspect that in general his so-called experts base their opinions on little more than belief. Certainly, they appear to have little if any compelling data on their side. Indeed, one might counter such arguments with views of bona-fide experts such as Gil Levin or H. P. Klein, who have actually conducted experiments on the surface of Mars.

Still, the difficulty with debating Zubrin in this case is that occasionally he says something true and/or believable, nearly persuading the reader to accept the rest of his argument. I (and most biologists) would (and do) agree with some of his statements. For example, the likelihood of life on Mars is small, and the likelihood of more advanced, mammalian-like life is even smaller. Moreover, the likelihood that a Mars organism pathogenic to Earth life exists and that, if it did, it could compete with highly adapted and competitive life on Earth is very small. None of this is new—it is comprehensively reviewed and discussed (with proper citations) in a National Research Council report ("Mars Sample Return: Issues and Recommendations," Washington, DC: National Academy Press, 1997). This report, produced by actual experts, visits virtually all of the issues brought up by Zubrin and is, in fact, in general agreement with many of his statements. The problem is that Zubrin selectively ignores other facts and takes things out of context. For example, the following cannot be ignored:

1. None of the unlikely events discussed in the above paragraph can be shown to have a probability of zero.
2. If the probability isn't zero, the potential risk is very high (only if we do not take precautions).
3. The public will not be swayed by the bluster of science (with no data) or any "Trust me, everything is going to be OK" arguments.
4. The samples will need to be protected from the Earth—contaminating them would truly be viewed as a "crime against science." It would therefore seem prudent to include in any relevant mission the technology to ensure that samples will be contained.
5. Technology for protecting samples and containing potential biohazards is not at all out of reach. The containment and shipping of samples known to be dangerous is routine. Moreover, the technology is adaptable and appropriate for the kinds of sample materials anticipated from Mars.

Two other points may be worth mentioning. First, a Mars sample return mission will probably take place a number of years in the future. Therefore, time is available to develop measures and methods (really, to adapt already available methods) necessary for containment and safe return. Indeed, it would seem wise to embark on this path now. The task is challenging but in no way impossible, and it should be approached in a proactive way.

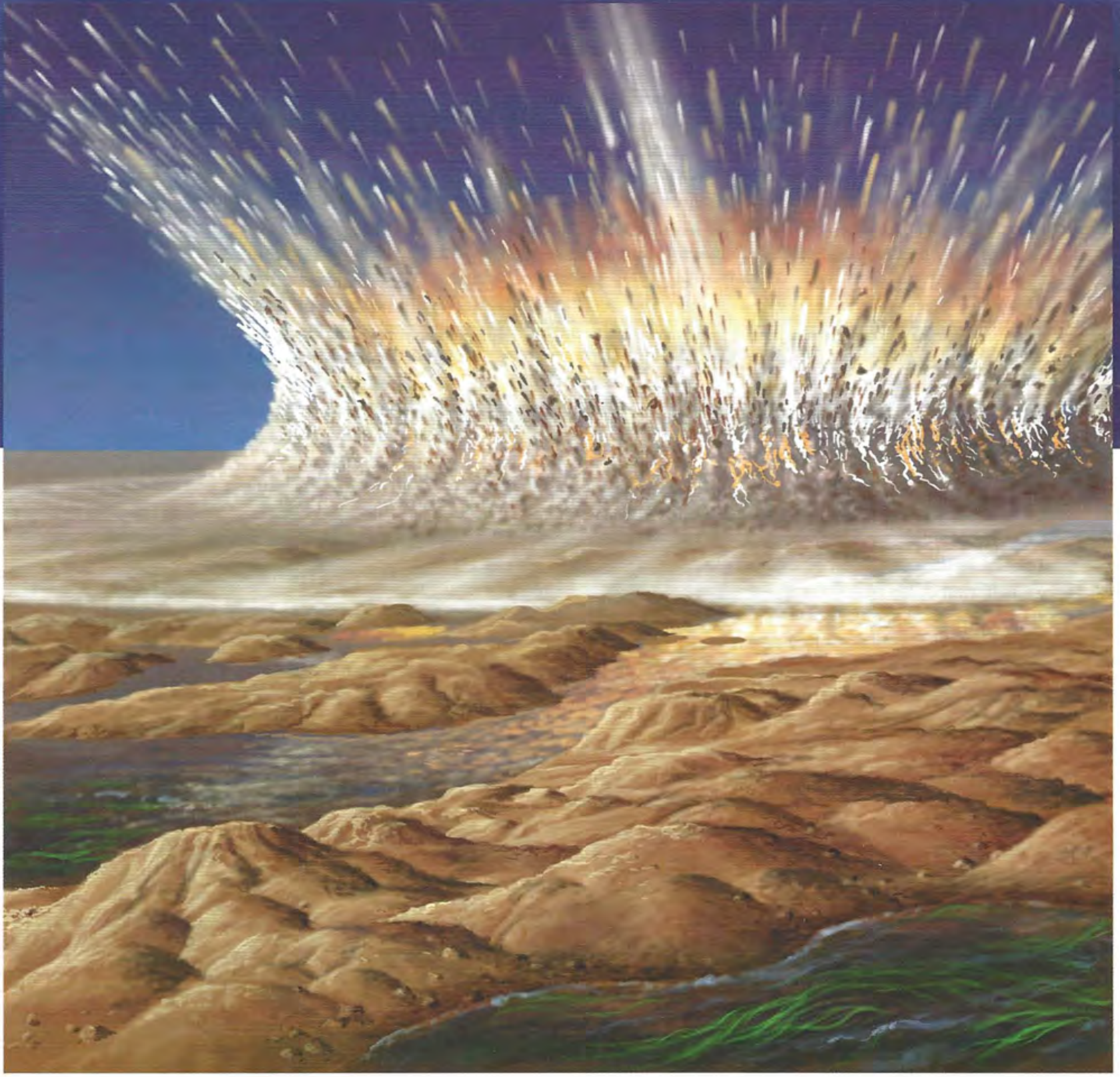
Second, a number of measurements could be made onsite (on Mars) that would help in the search for life. The technology of in-situ life detection has lagged behind many other efforts; now may be the time to push for the development of instruments capable of detecting without ambiguity the presence of life at a given site or, more particularly, in a given sample. Sending data back should be a major part of the planetary program, especially as we venture farther from Earth to where sample return is more difficult and expensive. To become more expert at this procedure while on Mars would seem a reasonable and useful endeavor. Why not be safe, have pristine samples to study, and take on our duties as responsible scientists and citizens? I believe that is not too much to ask; in fact, it is prudent and wise to follow such a course.

Doing solid science in a clean and safe way will help ensure the future of the space program. Alternatively, denigrating those who would argue for safe measures regarding the unknown is ultimately irresponsible.

Kenneth H. Nealson is Director of the Center of Life Detection at NASA's Jet Propulsion Laboratory.

Life From

Testing Panspermia With M



Can it be that some of the earliest life on Earth was "imported" from somewhere else? That concept, known as panspermia, is illustrated here. This panel depicts a meteorite from Mars crashing to Earth some 3.8 billion years ago. The meteorite was itself blasted Earthward by a larger impact event on Mars sometime earlier. The green masses drifting in the stream are the only visible living things on the scene.

by Benjamin P. Weiss and Joseph L. Kirschvink

The origin of life is a tricky problem. The probability not only of getting all the right ingredients together in one place, with the right amount of energy, but also of organizing those ingredients into a complex organism capable of replicating itself seems extremely small. Plus, this all had to happen very quickly—possibly within a few hundred million years.

For more than a half-billion years after it accreted into a solid planet, Earth was repeatedly sterilized by a rain of protoplanetary objects, effectively making it impossible to harbor life. Then, about 3.9 billion years ago, the rain turned into a drizzle of occasional impacts, and life could have gotten a toehold. But the window between the end of the bombardment and the era for which we have concrete evidence of life is short in geologic terms—there are hints of biological activity in 3.8-billion-year-old rocks found in

Space?

artian Meteorite ALH84001

This panel shows the aftermath of the impact, not only in the half-kilometer-wide crater in the distance but also in the new life-forms springing up along the water near the secondary impact pits. These life-forms developed from spores that hitched a ride on the meteorite, a process that might have occurred on both planets numerous times over geologic time.

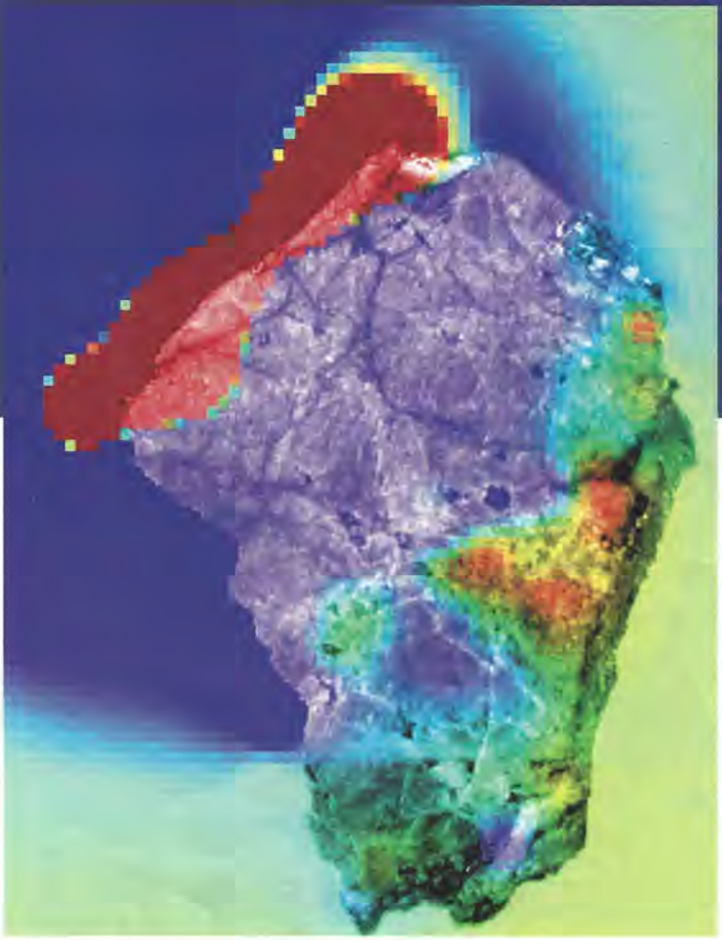
Paintings: Don Davis

Greenland and possible fossil bacteria in 3.5-billion-year-old rocks found in Australia.

One way around the problem is to posit that life did not begin here at all but rather came to Earth from somewhere else. This hypothesis, that life may have originated elsewhere than on Earth and spread from planet to planet throughout the cosmos, is called panspermia. A bit of cheating is involved, since panspermia begs the question as to how life started on whatever world it did. On the other hand, panspermia could have extended the time that life had to evolve after the period of bombardment, since life ejected into space could reseed the sterilized planet of its origin.

An Ancient Idea

Panspermia is an ancient idea and, despite its science fiction-like feel, one that has received serious scrutiny by many



Left: Magnetic microscope imaging of a 1-mm slice of Martian meteorite ALH84001, taken from near the outside of the meteorite. The fusion crust on the upper left side of the sample has been remagnetized in Earth's field, while the interior of the meteorite retains the weaker, heterogeneous magnetism it acquired on Mars.
Image: Francis MacDonald and Franz Baudenbacher

Right: Magnetic microscope images of a 1-mm slice of ALH84001, taken from the interior of the meteorite. (A) Magnetization of the sample at room temperature before heating. (B) Magnetization of the sample after being heated to 40 degrees Celsius (104 degrees Fahrenheit). Arrows point to some features that weakened following the heating. The scale bars represent 2 millimeters. *Images: © Science 2000*

famous scientists. Its essential elements can be traced back to at least 500 B.C., when the Greek philosopher Anaxagoras imagined that life infused and spread itself throughout the cosmos. Much later, in 1821, the Frenchman Sales-Guyon de Montlivault imagined seeds from the Moon inoculating the first life on Earth. Then, in the mid-1800s, German physicist H. E. Richter, recognizing that some meteorites contain abundant carbon, suggested that life could have traveled to Earth via meteorites. Lord Kelvin concurred: "We must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space."

But writing in his 1908 classic, *Worlds in the Making*, the Nobel prize-winning chemist Svante Arrhenius rejected this possibility:

Fantastic is the idea that organisms . . . caught . . . in meteorites . . . are carried out into universal space and deposited on other celestial bodies. The surface of meteorites becomes incandescent in their flight through the atmosphere, and so any germs which they might possibly have caught would be destroyed.

If Arrhenius had ever actually picked up a newly fallen meteorite, he'd probably have had fewer reservations: the rock would have been freezing cold. The frictional heat from atmospheric passage can only diffuse several millimeters into a rock during the few minutes it spends falling through the air; the ablating away of molten drops removes most of the heat. This leaves behind a thin, melted "fusion crust," but the inside remains unaffected.

By the early 1970s the idea of panspermia was well accepted. Another Nobel laureate, Francis Crick, proposed with Leslie Orgel that terrestrial life may have originated from "directed panspermia"—that is, intelligent extraterrestrials dispatching primitive organisms as proxy colonists.

Put to a Test

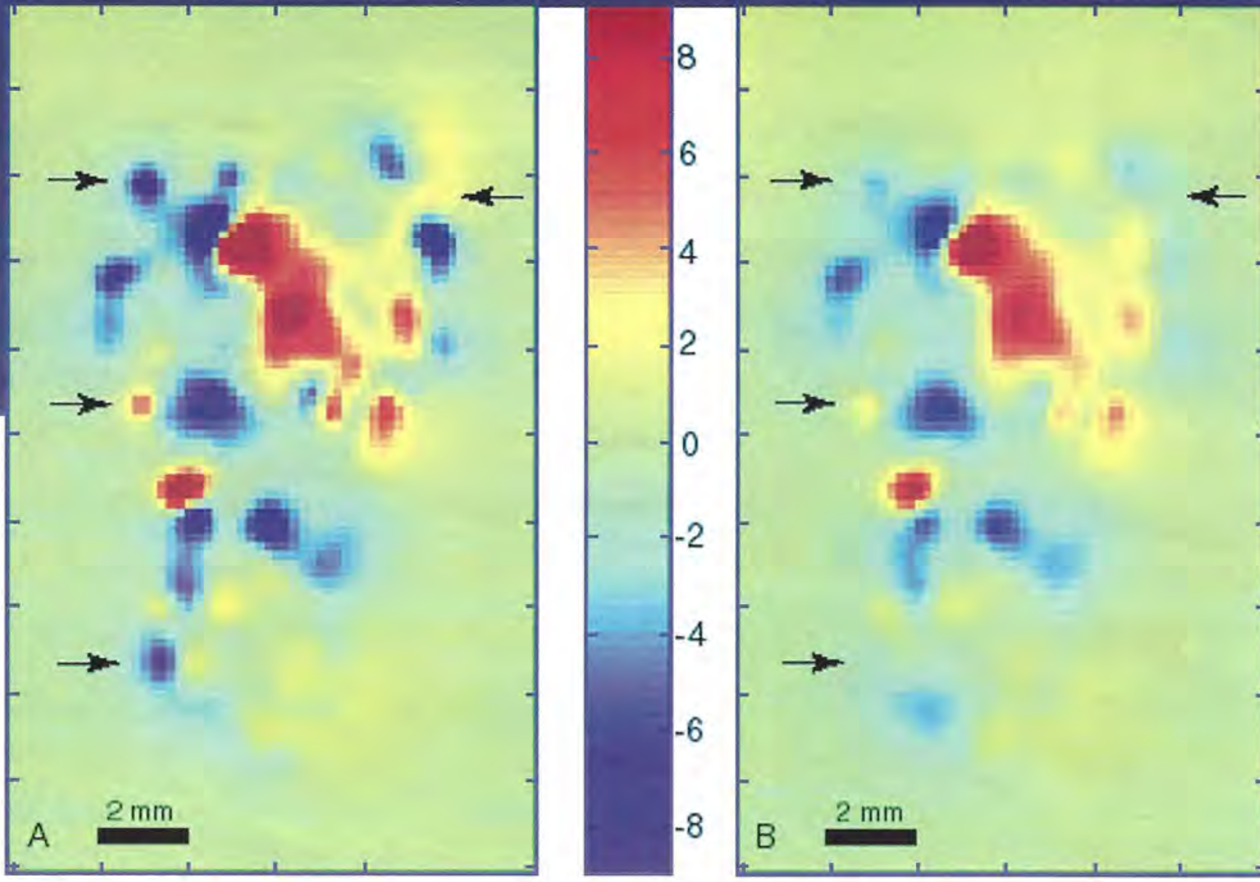
Clearly, Earth's atmosphere will not sterilize the interior of pebble-size meteorites; yet it's not known whether rocks can be ejected from the surface of a planet without a severe cooking. After all, the only natural process capable of ejecting a rock from the Martian surface is the impact of a comet or asteroid, a violent event indeed. (See "Swapping Rocks" in the July/August 1994 issue of *The Planetary Report*.)

For this reason Eugene Shoemaker, one of the fathers of modern planetary geology, 30 years ago declared that any impact ejecta managing to escape Mars' gravity would be vaporized or completely melted. In the 1980s the discovery of unmelted, largely intact (though highly shocked) meteorites from Mars discounted this idea. Consequently, Jay Melosh of the University of Arizona theorized that some rocks could be blasted off Mars by an impact without being shocked (and, by extension, heated) at all! We decided to test this theory by studying the magnetic properties of a Martian rock: the famous ALH84001.

ALH84001 is a strange rock for many reasons: it is a meteorite, it is from Mars, and it is the oldest known rock from any planet (more than a half-billion years older than any Earth rock). Plus it contains carbonate globules rimmed with tiny iron-oxide particles that have been interpreted as 4-billion-year-old fossils of ancient Martian magnetotactic bacteria.

ALH84001 came to our laboratory at Caltech through luck and happenstance: it was blasted off Mars by an asteroid or comet 15 million years ago and, after wandering through space, landed 11,000 years ago in Antarctica, where a team of NASA and National Science Foundation scientists found it in 1984. We convinced NASA to lend us a chunk so that we could study its magnetic properties, which can be changed by heat, and thus determine the rock's level of heat during its ejection from Mars.

For our study we used Vanderbilt University's SQUID (Superconducting Quantum Interference Device) Microscope. Designed by a physicist named Franz Baudenbacher, the SQUID Microscope is one of the world's most sensitive instruments for producing high-resolution images of the magnetic fields of rocks. The first slice of ALH84001 we



examined showed a piece of the outer fusion crust stuck to one edge, resulting in an enormously strong magnetic field (image on page 10).

But just a few millimeters in, the rock appeared to contain a weak, spatially heterogeneous magnetization pattern acquired on Mars. This is exactly what we expected and demonstrates that the interior of the meteorite could not have been heated more than several hundred degrees (and probably much less) during its passage through the Earth's atmosphere.

Using the same technique, we made two magnetic images of another slice of ALH84001, extracted from the interior of the meteorite. In the first image, taken without heating the rock, we observed the same heterogeneous pattern of magnetization as in the interior portion of the previous slice (image A, above).

We then heated the slice to 40 degrees Celsius (104 degrees Fahrenheit), cooled it in zero magnetic field, and reimaged it. Many of the magnetic features decreased or disappeared entirely (image B, above); they did not reappear when the sample was heated and cooled to the same temperature but in a weak applied magnetic field.

Confirming Evidence

These results demonstrate that ALH84001 had not been heated to even 40 degrees Celsius (104 degrees Fahrenheit) since before leaving the Martian surface, confirming Melosh's theory that rocks could be ejected off the surface of Mars without being heat sterilized.

At such temperatures, prokaryotes (simple, one-celled organisms without well-defined nuclei) and even simple eukaryotes (organisms with well-defined nuclei) like fungi or plant seeds might survive the launch. Unfortunately, we cannot constrain the formation temperature of the carbonate globules—although we think the observed magnetization originated on Mars, we don't yet know exactly when that took place. (Constraining the temperature at which the carbonate globules in ALH84001 formed would help settle the debate over possible life traces in the meteorite. A high formation temperature could rule out life as we know it in the rock; a low temperature would be conducive to life.)

Although it's unlikely that ALH84001 itself brought Martians to Earth (it spent nearly 15 million years wandering through cold, airless space), it is not unreasonable to assume that if there were life on Mars, other rocks have already transferred it here. Computer-dynamic simulations suggest that about a billion tons of Martian rock have landed on Earth since the solar system formed, and every million years or so about a dozen fist-size rocks are transferred from Mars to Earth in just a couple of years. In fact, one in ten million of the arriving Martian rocks could have been transferred in less than a year!

Finally, consider that researchers have brought back living bacterial spores from an orbiting satellite where the bacteria spent more than five years bathed in strong ultraviolet light in a deep vacuum. Consider, too, that such bacteria can survive the high pressures and shock they might encounter during ejection. Evidently it is likely that if Martian microorganisms exist, they have been transported to Earth throughout most of our planet's history. Maybe, then, we don't need to go all the way to Mars to find Martians.

Benjamin P. Weiss is a graduate student in planetary science at the California Institute of Technology. Joseph L. Kirschvink is Professor of Geobiology at the California Institute of Technology.

S E T I   H O U S E

SETI@home and The Planetary S

The Planetary Society's mission is to involve everyone on Earth who's interested in the adventure of exploring the cosmo And if ever that goal were embodied in a single project, it's SETI@home. Over 2.5 million people all over the globe are helping to crunch the data in search of a signal from somewhere else in the Milky Way. If that signal is found, it just may be with the aid of someone's home computer. And that computer could be yours! Painting: Don Dixon ociety—

The Bond Strengthens

by Charlene M. Anderson

Pick your superlative: SETI@home represents the greatest public involvement ever in a scientific experiment. SETI@home is the world's most powerful supercomputer. SETI@home is the largest distributed computing experiment ever undertaken. SETI@home marks the first time that members of the public have been able to join in seeking to answer one of humankind's Great Questions: are we alone in the universe?

Whatever your choice, it's clear that SETI@home is something amazing, with more than 2.5 million people from 226 nations participating. It's by far the biggest Planetary Society project in the Search for Extraterrestrial Intelligence (SETI). In our 20-year history, the Society has sponsored a dozen different projects, but none has approached the scope and popularity of SETI@home.

This summer we reached a new milestone in our relationship with SETI@home: through a new alliance with OneCosmos Network, The Planetary Society has assumed primary financial support for the experiment and assured its continuation. The new media venture is headed by Ann Druyan, Carl Sagan's wife and collaborator, and Joe Firmage, a noted Internet entrepreneur. Our alliance with OneCosmos Network is enabling SETI@home to continue beyond its scheduled May 2001 end date—as well as deepen its analysis and broaden its coverage of the skies.

Since it functions as a screen-saver and doesn't interfere with a computer's normal operation, people have been more than willing to volunteer their computers' spare time to run SETI@home. Connecting to the computers at the University of California at Berkeley, where the project is headquartered, people download "work units" of data collected by Project SERENDIP. That project, cosponsored by The Planetary Society, collects data from a receiver sitting on the giant radio telescope at the Arecibo Observatory in Puerto Rico. It scans the skies for beacons from other possible civilizations in our galaxy.

So far, participants have returned 205 million work units and compiled more than 467,000 years of computing time—that's more than 460 millennia donated by people around the world. No signal has yet been detected, but we're working on it.

New, Improved, . . . and Expanded

With the OneCosmos Network-Planetary Society alliance, SETI@home will improve and expand the program to cover more sky, analyze more data, and engage more people in the project.

The project leaders are developing a plan to extend the search to a radio telescope facility in Earth's Southern Hemisphere. Project scientist Dan Werthimer points out that using data from the Arecibo telescope, whose design limits its scope, SETI@home is currently surveying only about 30 percent of the celestial sphere. By expanding to the Southern Hemisphere, coverage of the sky will include the galactic center and a much larger portion of the galactic plane. This will open up a new frontier for SETI@home.

In addition, each work unit analyzed by SETI@home participants will now be examined more carefully. For example, the program will look at a wider range of frequency drift rates. So if an extraterrestrial civilization is transmitting from a planet orbiting or rotating rapidly, we will be able to detect it. The improved software will also look for pulsed signals that might be turning on and off regularly, like radar. And it will look for "triplets," three equally spaced spikes at the same frequency. Since we don't know exactly how extraterrestrials might transmit, trying different approaches may very well improve our chances of finding something.

Project Director David Anderson plans to take advantage of the new alliance to "make the SETI@home experience more personal and dynamic. We will show people more information, such as personal sky maps displaying the work they have accomplished. We will also provide more frequent and thorough coverage of the state of the project" to its users.

ARECIBO

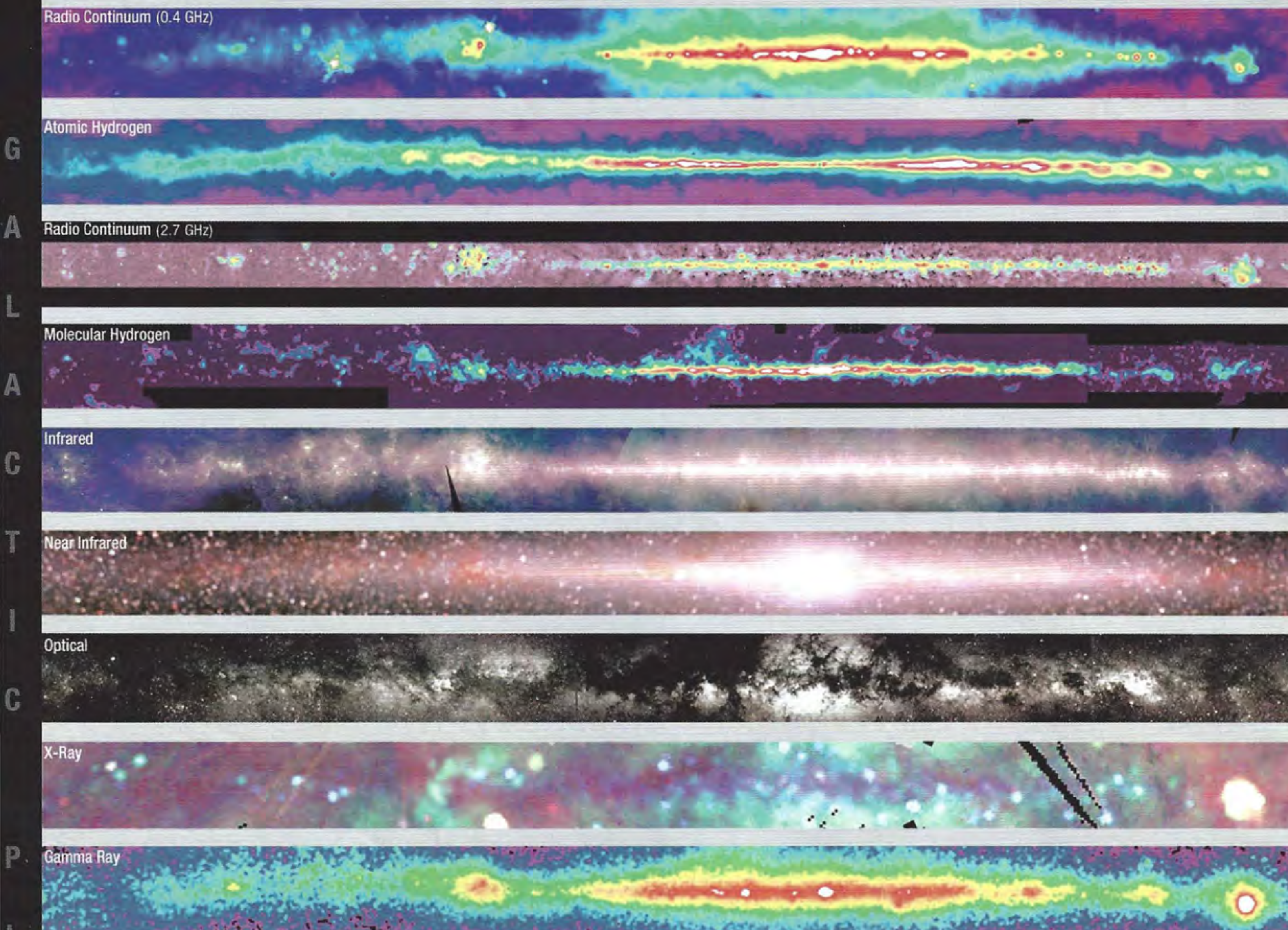
So far, Project SERENDIP has gathered an impressive amount of data using the Arecibo radio telescope in Puerto Rico. The telescope's huge dish covers an area of about 50 hectares (20 acres). *Photo: David Parker/Science Photo Library, courtesy of the NAIC Arecibo Observatory, a facility of the NSF*

David adds: "We will provide more and better ways for SETI@home users to discover and communicate with one another, such as a message board for SETI@home Macintosh users in Finland." (At this writing, there are 20,274 users in Finland, which ranks 11th in the country standings.)

The alliance will also improve educational resources for SETI@home users as well as the general public. Both The Planetary Society and OneCosmos Network will be creating background materials, explanations of technical terms, histories, and stories about the people involved in SETI@home.

We've come remarkably far in the past two years. And if the past is any guide, over the next two years, SETI@home will continue to astound even us with its achievements.

Charlene M. Anderson is Associate Director of The Planetary Society.



Just for fun, here is how the plane of our Milky Way looks at nine different wavelengths. These images were captured 28,000 light-years from the galactic center by a variety of ground- and space-based surveys. Each picture, taken within 10 degrees of the plane, represents a 360-degree false-color view. Go to http://adc.gsfc.nasa.gov/mw/milkyway.html for more information on these images.

Images: Goddard Space Flight Center/Astrophysics Data Facility

SETI@home— A Personal Reminiscence

In spring 1998, David Anderson and Dan Werthimer called us from UC Berkeley with an idea: they wanted to write some software, give it away for free, and build the largest virtual supercomputer on Earth, which they would dedicate to searching for radio signals from alien civilizations. Outlandish, perhaps? Audacious? Quixotic?

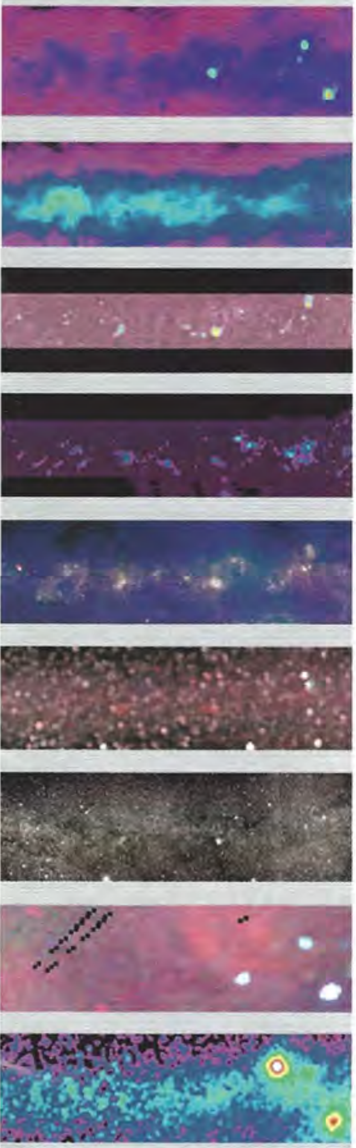
Just the sort of thing The Planetary Society might be interested in.

The pair's virtual machine would analyze data collected by Project SERENDIP, a receiver mounted on the Arecibo radio telescope, the largest antenna on Earth. The aim of the project would be to engage people around the world in one of the most potentially world-shaking experiments yet undertaken: the search for extraterrestrial intelligence. All they needed was money.

In the Beginning

The idea for SETI@home, as the project was called, came in 1996 from computer scientist David Gedye, along with Craig Kasnoff and astronomer Woody Sullivan. They took their idea to David Anderson from the UC Berkeley computer sciences department and Dan Werthimer from the Space Sciences Lab, who then developed the concept further.

Through 1997 David and Dan worked on the signal analysis code and developed prototypes of the client and server



software. In 1998 they turned their attention to serious fund-raising. It was a hard sell—the project would be giving away software, and commercial enterprises just couldn't see a return on their investment. David and Dan then contacted The Planetary Society.

To be frank, the decision to fund SETI@home was neither straightforward nor easy. We immediately saw the potential to involve people by giving them a chance to participate in a real scientific experiment. That is *exactly* what The Planetary Society was formed to do.

But there would be no financial payback. Plus there were doubts the demanding and sophisticated software would work. In every way, funding SETI@home would be a gamble.

But we were determined to find a way to make it happen. Ann Druyan, Carl Sagan's wife and collaborator, approved our drawing on the Carl Sagan Fund for the Future to support the project, commenting that it was just the sort of thing Carl would want the money used for.

We called David and Dan with our decision: the Society would put up $50,000, half the needed start-up budget—with a proviso. The SETI@home project had to come up with matching funds. We knew that wouldn't be easy; they'd already tried nearly every funding source they could think of. So, in true Planetary Society fashion, we found another solution.

Our home galaxy as it might look from a distant planet.
Painting: David Egge

In the Star Trek Universe

At the time, Paramount Pictures was looking to drum up publicity for its new release, *Star Trek: Insurrection*. The fit seemed obvious; part of the Star Trek creed is "to seek out new life, new civilizations." That is exactly the goal of SETI@home. We "pitched" the idea to Paramount, and the studio agreed to put up the other half of the start-up money.

Outlandish, audacious, and quixotic, SETI@home officially launched on May 17, 1999. Within the first year the number of participants passed 2 million. SETI@home is now the largest distributed computing experiment ever undertaken.

SETI@home has forcefully demonstrated our human passion to discover "what's out there." Its success has validated The Planetary Society's vision of ordinary people participating in the adventure of space exploration. It has proved that a small group of dedicated believers, like the folks at Berkeley, can bring together millions around our planet in a shared dream for the future.

And consider this: the largest distributed computing experiment ever undertaken, with the most participants enthusiastically contributing their time and computers, is directed to answering one of humankind's oldest questions: are we alone in the universe?

I find that comforting and uplifting. It means that people are concerned with more than making money; they still seek to answer the Great Questions. It also means that the Internet revolution is accomplishing more than producing a few gazillionaires in Silicon Valley and Seattle; it truly can bring people together in new ways. And it means that there is hope for our future on this small, blue planet—and out among other worlds.

All in all, it means that the vision of The Planetary Society—the people of Earth united in exploration of our solar system and beyond—has a chance of becoming real. —*CMA*

G A L A C T I C   C O R E

Think of the odds—each of these tiny specks is a star. How many of them have planets? By expanding SETI@home to a radio telescope in Earth's Southern Hemisphere, we'll be able to search our galaxy's core as well as a much larger portion of its plane. This Atlas Image mosaic of the Milky Way's center was obtained by the Two Micron All Sky Survey (2MASS), a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center at the California Institute of Technology, which is funded by NASA and the National Science Foundation.
Atlas Image mosaic: E. Kopan, R. Cutri, and S. Van Dyk (IPAC)

The Planetary Society SETI@home Group—Help Us Compete!

One of the most intriguing aspects of SETI@home has been the spontaneous generation of groups that compete to process the most work units. Some of the biggest names in the computer world—Microsoft and Intel, Sun Microsystems and Silicon Graphics, IBM and Compaq, among others—are battling it out for bragging rights in the SETI@home derby.

The Planetary Society, too, has a group—and we're doing very well, ranking sixth in the club category and thirteenth overall. But if more members join, we'll do even better!

Robert Ahle, a Society member from O'Fallon, Illinois, set up the group within a few days of the software's public release on May 17, 1999. "I noticed there was no group for The Planetary Society, so I took the initiative and set one up," he recalls. "For the first day or two, it was me alone. Now there are over 1,200 members."

Robert had always been interested in astronomy and the search for extraterrestrial intelligence, and when SETI@home came along, he "just had to be part of it." He thinks the team approach is a good idea, "adding interest to get people to push out more work units and help SETI@home be more successful."

Plus, he says, "With this many people processing data, I think there's a good chance of finding something."

Every member with a computer can join The Planetary Society group. Go to our website, **planetary.org**, and follow the links to sign up for SETI@home. Once you've downloaded the software, you can sign up at **setiathome.ssl.berkeley.edu/stats/team/team_707.html**.

So join the team! Help The Planetary Society move up in the standings and demonstrate, once again, that our members really do "make it happen."
—*CMA*

Sign Up for SETI@home
planetary.org

Join The Planetary Society SETI@home Group
setiathome.ssl.berkeley.edu/stats/team/team_707.html

Check Out the OneCosmos Network
OneCosmos.net

World Watch

by Louis D. Friedman

Paris, France—A mistake in the design and testing of the communications system of the *Huygens* probe, destined for Saturn's moon Titan, is causing a redesign of the *Cassini* mission. Built by the European Space Agency (ESA) in tandem with the Italian Space Agency, *Huygens* is the atmospheric probe to be carried aboard the NASA-JPL *Cassini* spacecraft to Titan.

Forget about blaming any "faster, better, cheaper" paradigm for the mistake. The *Cassini-Huygens* mission was developed and launched before the initiation of this paradigm. ESA is now reviewing how the extensive test program failed to catch the design error—which neglects to take into account the frequency shift due to the relative motion of the probe and the orbiter (the Doppler effect). If the mission design isn't changed, with some major compromises to the *Cassini* orbiter plan, data during the descent through the Titan atmosphere will be lost.

Washington DC—In the previous issue we expressed concern over the threat to cancel the Pluto mission, scheduled to launch in 2004 as part of NASA's outer planets program. We were told no decision would be made until the new US president submitted a budget in early 2001, but we were concerned enough to begin a letter-writing campaign to Congress.

Our concerns were justified. In September, NASA stopped work on the Pluto mission. Playing the semantics game, they called the action a stop-work order, not a cancellation. However, because of the loss of the the 2004 launch date, and with it the chance for a Jupiter gravity assist to reach Pluto, the effect is the same.

What surprised NASA, and frankly even us, was the popularity of the Pluto mission and the strength of public reaction against its cancellation. Consequently our campaign struck a responsive chord in the media—with relevant articles in newspapers across the country as well as on the Internet. Thousands of Planetary Society members (in fact more than 5,000 in the first three weeks) responded to our special appeal and sent in postcards to deliver to Congress.

On October 17, 2000 we delivered these postcards to Dana Rohrabacher and his committee in the House of Representatives and to Bill Frist and his committee in the Senate. The message was clear: Pluto exploration is popular, and it should figure in the NASA program with no delay in completing our solar system reconnaissance. While the impact on NASA budget deliberations is yet to be determined, I believe we have helped restore the priority of the mission.

Pasadena CA—The science instrument package for collecting solar wind samples has been delivered to the Jet Propulsion Laboratory for the *Genesis* spacecraft, scheduled to launch in February 2001. The spacecraft will travel to the L1 point (a point of gravitational balance in the Earth-Sun system, called a Lagrangian point after the mathematician who studied celestial mechanics of three-body gravitational systems). This point lies about 1.5 million kilometers (932,100 miles) away from Earth, toward the Sun.

There the spacecraft will obtain samples of solar wind particles in an innovative collector. *Genesis* will then return the collector to Earth in 2003 for analysis of the particles.

Louis D. Friedman is Executive Director of The Planetary Society.

NASA Outlines New Mars Exploration Program

NASA unveiled its revised Mars Exploration Program in a press conference held in October. The leaner plan, proposing roughly half the missions outlined in the previous plan, reaffirms a dedication to exploring the Red Planet—just at a slower and more deliberate pace.

At the press conference, NASA officials called the plan "carefully aggressive." A series of orbiters, landers, and rovers, leading up to a sample return mission tentatively scheduled for 2014, will focus on (1) examining records of Mars' past, (2) determining how to test for biological activity, and (3) executing a sample return mission.

Unlike the old plan, which launched both an orbiter and a lander every 26 months, the new plan alternates sending an orbiter, then, 26 months later, a lander, then, 26 months after that, an orbiter, and so on. This allows a little more than four years to plan, build, and launch each mission. Each new mission can therefore build on the information gained in previous missions. NASA's original plan—two spacecraft every two years—meant that future missions were planned and spacecraft built before fully analyzing results from earlier missions. For instance, when the *Mars Polar Lander (MPL)* was lost, engineers were already working on the next planned lander, *Mars Surveyor 2001*, a spacecraft similar to *MPL*. Consequently, the 2001 lander was canceled altogether.

Here's what the new plan proposes in the next decade:

• 2001: *2001 Mars Odyssey* orbiter, scheduled to launch next April

• 2003: Twin Mars Exploration Rovers

• 2005: Mars Reconnaissance Orbiter, with which NASA hopes to peer down on the Martian landscape at 20- to 30-centimeter (8- to 12-inch) resolution, good enough to observe rocks the size of beach balls

• 2007: Lander, what NASA describes as a long-range, long-duration mobile science laboratory

• NASA also proposes to create a new line of small Scout missions selected from proposals presented by the science community. The first Scout mission, planned for 2007, might involve a Mars balloon or Mars airplane.

• After 2007, the mission plan is more generalized. NASA expects to make steps toward sample return, hoping to launch the first sample return mission in 2014 and the second in 2016.

• Also in the next two decades, NASA envisions significant international participation, particularly by France and Italy. The French and Italian space agencies plan to collaborate with NASA on conducting scientific orbital and surface investigations. These agencies may also contribute to future sample collection/return systems, telecommunications assets, and launch services. *—LDF*

Questions and Answers

On page 14 of the July/August 2000* Planetary Report, *the story on* Mars Global Surveyor (MGS) *says, "Radio Science uses Doppler shifting in the radio frequency to determine the pressure and temperature of Mars' atmosphere . . ."

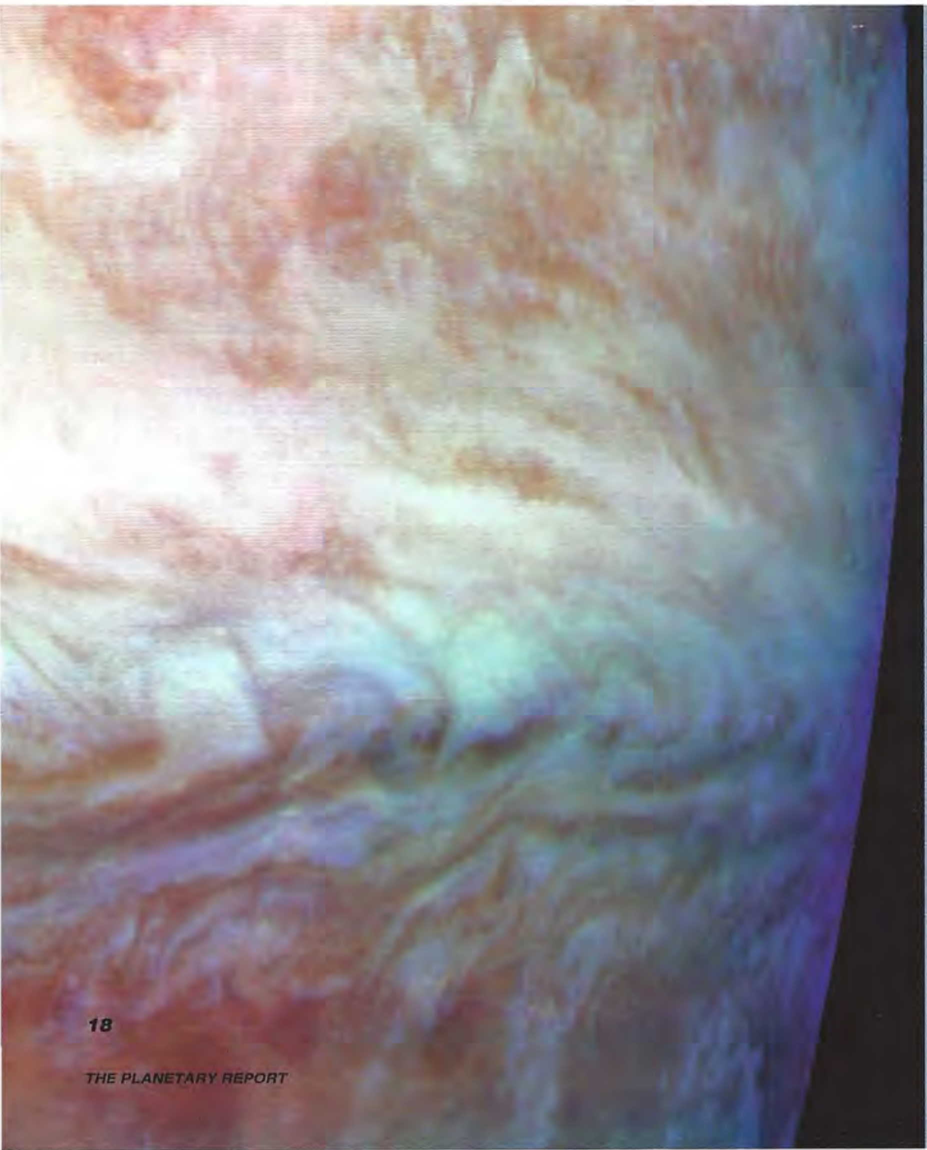
Since the same technique can be used to map out subsurface density variations, how does the radio science team distinguish between atmospheric and gravitational influences on the velocity of the spacecraft and consequently on the frequency of its radio signal?
—Brian Chapel,
Victoria, British Columbia, Canada

Good question. On each front-side pass of Mars, when the radio beam is well clear of the atmosphere, we monitor the two-way Doppler shift between Earth and *MGS* to sense local variations in the gravity field. Slowly, over time, we have built a very accurate model of the field. When we perform occultation measurements, we use this knowledge to compensate the data for gravity effects so that residual effects are attributed to the atmosphere. This is a very important issue for us.

Radio science team members from the Goddard Space Flight Center and the Jet Propulsion Laboratory are working on these gravity measurements, and I'm happy to say that both groups have obtained very nearly the same results.

We can detect errors in this process by examining baseline data collected just before and after the spacecraft passes behind the planet, so we are pretty confident the work has been done correctly.
—LEN TYLER,
Stanford University

Do we have sufficient data from* Galileo *to use Jupiter's atmosphere to safely aerobrake a spacecraft into orbit around the giant planet? Or would the radiation environment encountered on such a close approach be dangerous to spacecraft electronics?
—James D. Traill,
Melbourne, Australia



Jupiter's swirling atmosphere can be used to aerocapture a well-insulated spacecraft into a close orbit from a single pass. However, the gas giant's monstrous field of radiation makes it impractical to capture a craft into orbit by repeated atmospheric passes because the radiation damages the electronic and computer elements. This view near the planet's equator shows the lower cloud deck as bluish white while the higher layer looks pinkish. On November 5, 1996, from a distance of 1.2 million kilometers (about 750,000 miles), Galileo *took the images that comprise this false-color mosaic.* Galileo *is the first spacecraft to image different layers of Jupiter's atmosphere.*

Image: JPL/NASA

Aerobraking is the technical term for reducing the size of a spacecraft's orbit by repeatedly passing through a planet's atmosphere and using the friction to slow down. *Aerocapture* means using a single atmospheric pass to capture the craft into an elliptic orbit. Jupiter's strong field of radiation precludes multiple passes, and we can use Jupiter's strong gravity to capture a spacecraft into orbit by making a relatively small engine burn close to the planet. For example, *Galileo* slowed at a rate of about 600 meters per second to settle into a 200-day orbit, and then spent months using close flybys of Jupiter's major satellites to reduce to small orbits, allowing visits to those moons. A close circular orbit cannot be reached using the moons of Jupiter alone.

We know enough about the Jovian atmosphere to aerocapture into a small orbit around the planet a spacecraft with an appropriate thermal protection system. (The heat shield for *Galileo*'s entry probe comprised about 50 percent of its mass.)

We are also studying an alternative technique involving a large inflatable ballute able to perform aerocapture in one pass. The ballute stays much cooler functioning at higher altitudes (where there is lower atmospheric density) than does the standard reentry vehicle with aerodynamic lift. In addition, the ballute can be released after the spacecraft has slowed enough that its atmospheric exit conditions can be targeted accurately.

Detailed studies have not been made, but because of radiation, we can reject the idea of multipass aerobraking. We can, however, reasonably predict success with the other methods if enough thermal protection and a wide enough entry corridor are provided. (An entry corridor is a range of entry path angles over which the desired exit conditions can be reached by adjustments during the atmospheric pass.)
—ANGUS McRONALD,
Jet Propulsion Laboratory

Would a civilization 2 million light years away be able to detect us? After all, they would see Earth as it was 2 million years ago, before we were here.

Isn't it also possible that by scanning too far we could detect a civilization that is no longer there?
—Joao Miguel Matos,
Setubal, Portugal

You are right that a civilization 2 million light-years away would not be able to detect us. They would be getting light waves that left earth 2 million years ago, long before even the pyramids were built.

Whether we can detect a signal depends on how far away the civilization is and how long its people transmit detectable signals. If we detected a civilization 2 million light-years away, we would be seeing the signals it sent 2 million years ago. It might have died out since then. Still, even if we detect a dying civilization, it could have a lot to tell us. Perhaps we could learn from its mistakes.

Actually, most SETI research concentrates on our own galaxy, where distances typically measure thousands, not millions, of light-years. So, if we detect a civilization, there is a good chance it is still flourishing.
—TOM McDONOUGH,
SETI Coordinator

The rate of discovery of comets by the Solar and Heliospheric Observatory (SOHO) is amazing. [See "Hunting Snowballs in Hell" in the September/October 2000 issue of* The Planetary Report*.] The rough estimate of one detection a day suggests that previous estimates of the Oort cloud and total population of comets may be low.

Has any calculation of comet population been done based on this rate of discovery?
—Craig Nordeen,
Manchester, Connecticut

The SOHO discoveries are not a good indicator of the Oort cloud population. Well over 90 percent of the SOHO comets belong to the so-called Kreutz group of comets, which do not go anywhere near the Oort cloud. In addition, they have, over time, all broken off from the same original comet, which may or may not have ever been in the Oort cloud.

Most of the SOHO cometary fragments are very tiny, perhaps no more than 10 to 20 meters across. If a cometary fragment this size were to come into Earth's atmosphere, it would be destroyed harmlessly at high altitude.
—BRIAN G. MARSDEN,
Harvard-Smithsonian Center for Astrophysics

In this image the arrow points to one of Saturn's newly discovered moons, S/2000 S 1. A spiral galaxy is visible in the upper left corner.

Image: European Southern Observatory

Factinos

Scientists have discovered what looks like a reservoir of water ice about the size of Arizona just under the surface of Mars. "I'd say it's probably fairly large," said Nadine Barlow of the University of Florida in Orlando. Research by Barlow and graduate student John Koroshetz indicates that the huge pocket of ice may start just 200 meters below the surface and be a few kilometers thick.

The researchers sifted through *Viking* orbiter images of Mars' surface and studied the various shapes of craters and their ejecta. They scrutinized the smooth plains of Solis Planum south of Valles Marineris and found it pockmarked with craters and ejecta patterns consistent, Barlow said, with varying amounts of subsurface water, both in liquid and ice form. "Certain crater morphologies indicate ice. And other craters, we feel, are impacts into liquid reservoirs. We see both types in that area. Water may also be close to the surface, underneath the ice layer," she explained.

A high-resolution look at the area, along with other data from *Mars Global Surveyor*, is forthcoming, Barlow added.
—from SPACE.com

There's a new minor planet on the block, according to an international team of scientists. Officially named 2000 EB173, the 644-kilometer (400-mile) body was discovered in the outskirts of our solar system, between Neptune and Pluto. Because it is only one-quarter the size of Pluto, the planet is known as a *planetoid* or *plutino*, meaning "Little Pluto."

"The significance of this finding? It's just 'Wow! After all these years we can still find something new in our solar system,'" said Charles Baltay of Yale University and leader of the group that made the discovery. "Some of it is luck. We looked in the right place. The rest is the precision of our instrumentation."

In addition to scientists from the United States, the team included researchers from Venezuela, Spain, and England. The plutino was discovered using a powerful telescope at the CIDA Observatory in Merida, Venezuela.

Although many other bodies have been detected in the Kuiper belt just outside Pluto's orbit, none have been as large as 2000 EB173, Baltay said. It is customary that whoever finds a new object in the solar system is allowed to name it, but only after it has circled the Sun twice. Unfortunately for Baltay, it will take 243 years for 2000 EB173 to circle the Sun just once.
—from Yale University

Four new moons have been discovered around Saturn, raising the number in its collection to 22 (see image at left). That means the ringed beauty now holds the record for having the most known satellites of any planet in our solar system, bumping Uranus, with only 21 known companions, into second place.

The four faint new bodies were spotted in August and September 2000 from astronomical telescopes around the world. Subsequent orbital calculations indicate these objects are almost certainly new satellites of the giant planet.
—from the European Southern Observatory
[As The Planetary Report *went to press, 2 more new moons had been discovered]*

The Next Generation of Mars Explorers—Introducing the Red Rover Goes to Mars

by Rachel Zimmerman

For the first time in history, students have the chance to take a high-resolution image of Mars' surface. Nine extraordinary kids, chosen from an essay contest that attracted thousands of children around the world, will be the first civilians ever to program the Mars Orbiter Camera (MOC)—the camera onboard the *Mars Global Surveyor* spacecraft currently orbiting Mars.

The competition challenged 10- to 16-year-old students to research, write, and turn in their best 1,500-word essay about the (now canceled) *Mars Surveyor 2001* lander mission. Students had a little more than eight months—from October 4, 1999 to June 15, 2000—to submit their entries to one of the 45 regional centers set up around the world. By the deadline date, more than 10,000 children had submitted their essays.

The formidable task of judging these submissions was pulled off splendidly by our team of dedicated volunteers. Regional Center representatives completed the first round of judging, their selections subsequently sent on to the national Center for the next level of judging. The winners of the National round then advanced to the final round at The Planetary Society, where a panel of space science experts, including *Mars Pathfinder* Project Scientist Matt Golombek and former head of the Jet Propulsion Laboratory Mars Exploration Program Donna Shirley chose the best nine essays (three winners in each of three age categories).

Still one more step remained before the winners of the essay contest actually joined our team of student scientists: a telephone interview. During the round of interviews, emotions ran high. It's hard to stay cool when an international judging panel calls! Fortunately, the students skillfully answered questions about their essays, and when it was determined that all were indeed winners, Linda Kelly, Education Manager of Red Rover Goes to Mars, gave them the good news. Some winners were speechless, others cried, still others were ecstatic. In some cases the students' mentors cried. It was a moment that will be treasured

Iuri Jasper, 12, Santo Antonio da Patrulha, Brazil

"When we look back in time, we can get to the point in which someone had the idea of transforming an ordinary stone into a sharp instrument—and so the first tool was invented. This simple action triggered a new idea—that by making tools man could take control of the space around him and go beyond."

Shaleen Harlalka, 15, Udaipur, India

"Mars is but the first rung of the infinite ladder of celestial exploration. It is inevitable that a colony be established on Mars, a dynamic new frontier of human society. So then, forward to Mars!" Shaleen's essay proposes using a shortwave radio to detect water on Mars, because water has higher electrical conductivity than rocks. Shaleen, who expresses the desire to help others learn, says that "you can increase your own knowledge by helping others."

Kimberly DeRose, 13, Northridge, California, USA

"The [*Mars Surveyor 2001*] mission will . . . pave the way for a manned mission to Mars because it will provide scientists with the necessary knowledge to build much more superior equipment to be used for survival potential by the human race, including future astronauts . . . to . . . explore the unknown."

Hsin-Liu Kao, 11, Taipei, Taiwan

"Let's make history—to settle the Red Planet!" Hsin-Liu is looking forward to the chance to select a landing site on Mars. "We want a landing site that's interesting—maybe a crater." She thinks a safe landing site we haven't used before would benefit the mission by providing new information about Mars' climate, temperature, and radiation.

Tanmay Khirwadkar, 13, Nagpur, India

Tanmay's essay posits the use of a bionic chip to study the effects of radiation on living organisms. Tanmay got this idea while researching the impact of the Mars environment on life-forms. He states that "before we go to Mars, we need to know about hazards, and machines can study this without hurting people."

Student Scientist Team

Wojciech Lukasik, 10, Tarnow, Poland

"In my opinion, the future research of Mars will probably result in the development of many new scientific disciplines. The discovery of life traces on Mars could provide work for astropaleontologists, and the discovery of relicts of Martian civilization—for astroarcheologists. Cosmobiologists will perhaps examine the Martian forms of life that are hidden in the ground, in geothermal sources, or in other places. Today, such discoveries could be considered as a fantasy, but a fast development of technology could make them real in even a few tens of years."

Bernadett Gaal, 14, Hodmezovasarhely, Hungary

"If we don't know exactly the composition and the properties of the soil on the Red Planet, then a mission could be a complete failure, or the astronauts could even die. The possible cause is that the dust gets into the equipment . . . I can certify that . . . when I enter a sandy area with my roller skates, I definitely feel and hear as my skates go wrong: they get noisier and noisier, and finally just stop. . . . [I]n the case of the very expensive equipment, the life support systems, and the human body . . . if these things get dusty, the astronauts may spend several days cleaning their equipment and themselves. We can save them from this unpleasant work, and ourselves from an unsuccessful mission."

Vikas Sarangadhara, 10, Bangalore, India

Vikas designed three of his own experiments using algae to search for signs of life on Mars. His experiments test for the presence of life in the Martian soil, study the impact of Martian air on Earth-born life, and assess the compatibility of Martian soil with the Earth-born life. He chose algae because of its small size and portability and because unicellular organisms grow quickly.

Zsofia Bodo, 15, Budapest, Hungary

"Mars has been my favorite planet since my early childhood. I was always dreaming about going to Mars as an astronaut." Zsofia's essay, entitled "My Dear Diary," is a fictional first-person account of her activities as a flight controller for a Mars planetary exploration mission. The essay incorporates the science objectives of the *Mars Surveyor 2001* mission with Zsofia's own interpretation of the thoughts and feelings of scientists in mission operations.

Background image of Mars: Space Telescope Science Institute/NASA

around here for a long time.

So let us introduce these outstanding kids. Fifteen-year-old Zsofia Bodo lives in Budapest, Hungary; Kimberly DeRose, who is 13, is from Northridge, California, USA; Bernadett Gaal, from Hodmezovasarhely, Hungary, is 14 years old; Shaleen Harlalka, a 15-year-old, is from Udaipur, India; Iuri Jasper is 12 and lives in Santo Antonio da Patrulha, Brazil; 11-year-old Hsin-Liu Kao is from Taipei, Taiwan; Tanmay Khirwadkar, 13, is from Nagpur, India; Wojciech Lukasik is 10 and from Tarnow, Poland; and Vikas Sarangadhara, who is also 10, lives in Bangalore, India.

All these students have a strong interest in Mars exploration and in the possibility of someday sending people to Mars. In fact, many of them expressed the desire to be the first person to walk on Mars.

Now the next phase in the project begins: the students will be working hard to learn as much as they can about the geology and geography of Mars as well as about landing-site selection for a future sample return mission. At first they will work independently to choose a landing site that meets their own individual criteria regarding what to look for on Mars. Each student received a 130-page training book, coauthored by The Planetary Society and the Planetary Science Institute in Tucson, Arizona, for instruction on Mars landing-site selection. Each student is expected to keep a journal recording his or her thoughts on different landing-site options as well as choosing a favorite site among those options. By the time the students meet in California in the spring of 2001, they will have evaluated one another's choices and agreed on a single landing site to image with the MOC.

The team will then visit Malin Space Science Systems in San Diego, California, where they will learn how to program the MOC. In addition to creating the commands to image their landing site in the months after their visit, students will have the chance to bring home an MOC image they've programmed during their visit.

All in all, the students' essays demonstrate a strong awareness and interest in space among the youth of the world, indicating a bright future for planetary exploration.

Rachel Zimmerman is Education Projects Coordinator at The Planetary Society.

Society News

New Planetary Society Vice President

The Planetary Society has a new Vice President. Wesley T. Huntress, Director of Carnegie's Geophysical Laboratory and NASA's former Associate Administrator for Space Sciences, accepted the position after our current Vice President, Laurel Wilkening, announced her retirement.

Huntress enjoyed a 20-year career at the Jet Propulsion Laboratory prior to taking on the job of Associate Administrator for Space Sciences at NASA headquarters. A key architect of NASA's Mars Exploration and Origins programs, he spearheaded NASA's programs in astrophysics, planetary exploration, and space physics. Now at Carnegie, Huntress leads an interdisciplinary group of scientists in the fields of high-pressure science, astrobiology, petrology, and biogeochemistry.

Wilkening, a former chancellor of the University of California at Irvine, served on the Society's Board of Directors for six years. For nearly four of those years she held the office of Vice President.

We thank Laurel Wilkening for her invaluable guidance and assistance and now look forward to Wes Huntress' helming the Society's programs in the 21st century.

—Louis D. Friedman,
Executive Director

Student Journalists Discuss Life

The Planetary Society hosted two Student Press Conferences, where middle and high school journalists led the discussion by posing questions to the guest panelists. The theme for both press conferences was "The Search for Life."

The first event, held October 4 at United Nations Headquarters in New York City, celebrated World Space Week and featured Bill Nye the Science Guy and astronaut Franklin Chang-Diaz. The second, on October 27 in Pasadena, was held in cooperation with the Division of Planetary Sciences of the American Astronomical Society during its annual conference. Panelists included Planetary Society Vice President Wes Huntress, Ellis Miner and Ken Nealson of JPL, Francis MacDonald and Benjamin Weiss of Caltech, and Kimberly DeRose, a 13-year-old student scientist on the Red Rover Goes to Mars team. Linda Kelly of The Planetary Society moderated.

The Society has hosted five Student Press Conferences in the past year. Plans to reach a larger audience include webcasting the events.

—Susan Lendroth,
Manager of Events and Communications

Our New Logo for the New Millennium

Well, it wasn't easy, but we finally chose a new logo.

When we asked you to help us design the new logo, we expected to get a few good ideas—not over 200! We received so many great entries that even after we narrowed the choices down to a group of semifinalists, we still had 35 to choose from. The semifinalists were judged by the entire Planetary Society staff and many of our advisors. Then, after determining the top six submissions, our Board of Directors cast the final vote.

The winning concept was submitted by Jim Cubberly of Villa Park, Illinois. Jim submitted a simple line drawing featuring a sailing ship much like the ship in our original logo, but this ship appears to be speeding by an unspecified planet in close orbit. The logo is bold, simple, distinctive, and still tied to the original. We couldn't ask for more.

We're not yet ready to debut the winning design, however. First an artist will fully render Jim's concept. We'll need to view many versions of Jim's design before deciding on our new look.

Thanks, Jim, and thanks to all of you who participated in the contest. Keep your eye on *The Planetary Report* for our new logo.

—Jennifer Vaughn, Managing Editor

Two New Expeditions for Society Members

Discover "Olde England"—From Stonehenge to the Lake Country, From Herschel to Hawking, August 4–16, 2001. Join fellow Society Members in an introduction to archaeological, historic, and scientific sites, and charming villages of "Olde England," led by Ian Stone. Explore picturesque Salisbury; learn about England's Roman heritage at Bath; relive the discoveries of Herschel, Newton, and Jeremiah Horrocks; and hike in the breathtaking Lake District, home of some of Benjamin Franklin's famous experiments.

Costa Rica: Nature's Treasurehouse, With the Annular Solar Eclipse, December 8–16, 2001. The Solar Eclipse on December 14, 2001 will be the highlight of this outstanding nine-day expedition exploring the national parks of Costa Rica. Join Bob Nansen, plus local naturalists and a Costa Rican astronomer, on a visit to the Monteverde cloud forest, Volcan Poas, and the wonders of the forest canopy at Braulio Carillo National Park.

For information, call (800) 252-4910 or e-mail **BetchartEx@earthlink.net.**

The Planetary Society's International Space University Scholarship

The Planetary Society will launch a new education initiative in 2001 to help ensure a new generation of planetary explorers. As part of this initiative, a scholarship program for Planetary Society members will soon be announced.

Among the scholarships offered will be one to attend the International Space University's (ISU) Summer Session Program in Bremen, Germany in summer 2001. This scholarship is made possible by a generous donation from Planetary Society New Millennium Committee Member and ISU alumnus Eric Tilenius. The deadline for submitting applications is December 31, 2000. Students accepted by the ISU for the summer session are eligible.

For more information, I can be reached at (626)793-5100 or **rachel.zimmerman@planetary.org.**

—Rachel Zimmerman,
Education Projects Coordinator

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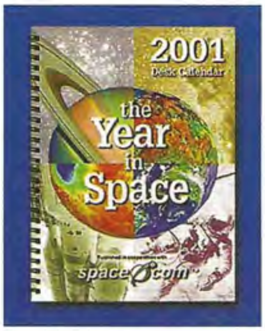
Explore the Universe!
2001 Wall Calendar
Enjoy full-color photographs, space art, and great reading on a variety of subjects each month. This 2001 wall calendar is produced by the creators of *Astronomy* magazine in cooperation with The Planetary Society.
2 lb. **#520 $11.50**



The Year in Space:
2001 Desk Calendar
A dazzling photograph awaits you each week as you plan your daily appointments. This planner includes 52 weekly calendars, 12 monthly calendars, a full-year planning calendar, and a four-year, long-range calendar. 1 lb. **#523 $12.50**

NEW! **20th Anniversary T-Shirt**
The Planetary Society is celebrating 20 years of "Making It Happen." This limited-edition long-sleeve T-shirt features our special 20th Anniversary Logo on the front and **planetary.org** on the back. Adult sizes: S, M, L, XL, XXL
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NEW! **20th Anniversary Mug**
Celebrate The Planetary Society's 20th anniversary with our 14-ounce "latte"-style mug. This one won't be around long!
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Planetary Society Cap
Our **planetary.org** cap is 100% cotton with an adjustable Velcro band.
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Search, Discover, Explore T-Shirt
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This fully scripted assembly presentation includes the original "Worlds to Discover" 55-slide package plus the 8-slide "Worlds to Discover Addendum 2000," in addition to updated fact sheets, posters, program announcements, a follow-up teacher's packet, and copies of The Planetary Society's magazine, *The Planetary Report*.
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If you already own the original "Worlds to Discover" program, add this 8-slide addendum featuring the latest finds from *Mars Global Surveyor, GEM,* and *NEAR-Shoemaker*, and bring your presentation up-to-date.
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27" x 40"
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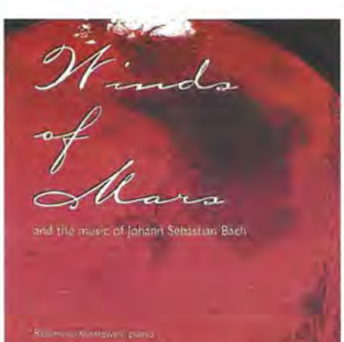
Winds of Mars and the Music of Johann Sebastian Bach
Audio CD includes extensive liner notes explaining the simulation of the Martian sounds and giving a general history of Mars exploration.
1 lb. **#785 $15.00**



Here we see how a Saturn-like world might look from the cloud tops of one of its orbiting moons. Edwin Faughn got the idea for this piece while enjoying the views from his window seat on a flight back home to Memphis from San Francisco.

Edwin Faughn's work has been featured in space science magazines, books, newspapers, and various other publications including *Science News*, *Astronomy*, *Sky & Telescope*, *Life & Work*, and *The Planetary Report*. In addition, his artwork has been exhibited nationally as well as internationally at museums, research centers, and universities. Such showings have included the 1997 world premiere of *Titanic: The Exhibition* and the International Association of Astronomical Artists traveling space art show, *The Artist's Universe.*

THE PLANETARY SOCIETY
65 North Catalina Avenue
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