The PLANETARY REPORT

Volume XXIX Number 4 July/August 2009

What's Our Next Step?

From The Editor

And now for something completely different . . .

The Planetary Report is the flagship of Planetary Society communications, the primary channel through which we communicate with Members. I've been editor for longer than I care to admit, but aside from that, I'm proud of our magazine and the passionate loyalty you've shown it over the last *mumble-mumble* years.

The Internet has revolutionized the ways people communicate, and, for many, printed publications are no longer the medium of choice. We've adapted by creating a lively, yet massive, website (*planetary.org*, in case you don't have it bookmarked), with a timely and informative blog, and I'm proud of those efforts as well.

But I want to direct you to a newer and even livelier communications channel: The Planetary Society's "fan" page on Facebook.

There you can get immediate updates on space happenings and Planetary Society doings. It's an interactive space where Members share thoughts with one another and comment on the latest news. Our Facebook page has become the gathering place for a true Planetary Society community, and it's getting better every day.

So, do it. Please go to our Facebook page (*facebook.com/planetarysociety*) and become a fan, as well as a Member, of The Planetary Society. (I admit that my teenage daughter, exasperated at my sluggishness in adapting to this new world, had to take charge and sign me up for Facebook.) It's a great way to be even more involved as we work together to advance space exploration.

—Charlene M. Anderson

On the Cover:

Forty years have passed since human beings first walked on the surface of the Moon. This is astronaut Buzz Aldrin's boot, creating what would become one of the most iconic images of the 20th century—a human footprint in the grainy soil of another world. On page 4, Buzz and executive director Louis D. Friedman offer their opinions about our next steps off Earth. Image: NASA

Background:

This is a small portion of a newly released image of the Omega nebula taken at the European Southern Observatory in La Silla, Chile. The Omega nebula, sometimes called the Swan nebula, is a dazzling stellar nursery located about 5,500 light-years away toward the constellation Sagittarius. In recent years, scientists have discovered that this is one of the youngest and most massive star-forming regions in the Milky Way. For a full view of this image, go to *http://www.eso.org/public/outreach/press-rel/pr-2009/pr-25-09.html.*

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A PUBLICATION OF THE PLANETARY SOCIETY

Beyond *Apollo*: Where Next in Space?

by Buzz Aldrin and Louis D. Friedman

Above left: In time for Apollo 11*'s fortieth anniversary,* Lunar Reconnaissance Orbiter (LRO) *has returned the first of several planned images of the* Apollo *landing sites. This is* Apollo 11*'s Eagle lander as viewed from lunar orbit. Future* LRO *images of these sites will have two to three times greater resolution.* Image: NASA/Goddard Space Flight Center/Arizona State University

Above right: Buzz Aldrin descends the steps of the Apollo 11 *lunar module ladder to become the second person to walk on the surface of the Moon. Neil Armstrong snapped this photo with a 70-millimeter lunar surface camera on July 20, 1969.* Photo: NASA

Forty years ago, humankind visited another world for the first time. It was an incredible moment for one of us—stepping off a ladder onto the Moon with Neil Armstrong, we two frail humans taking the first steps on that distant shore. It was also an amazing experience for command module pilot Michael Collins—who watched, breathlessly, along with about half a billion other people on home planet Earth.

Apollo 11 was heralded as the beginning of a new Space Age. Horizons appeared limitless, and those first crisp footprints in Moon dust were to be a precursor of journeys to other, more distant worlds. So they were—for our robotic emissaries.

But 40 years later, the Moon is still the farthest outward destination to which humans have ventured. When will we go farther? And who will go—Americans, Russians, Europeans, or astronauts from new spacefaring nations such as China, India, and Japan?

It is now time for humans to go beyond the Moon. Mars is the next compelling goal for human exploration. It is the only planet in our solar system where humans could land and perhaps someday settle. Mars has oxygen and water accessible to future explorers, and its surface shows signs of ancient liquid water, suggesting an environment that may have given rise to life in the planet's distant history.

But we should not make the journey in a single step.

Landing men on the Moon was one of the most complex and ambitious endeavors ever undertaken, and it took three big steps: *Mercury*, *Gemini*, and, finally, *Apollo*. Landing humans on Mars will be more difficult still, and taking us beyond the Moon and into the solar system will require a systematic, step-by-step approach. Fortunately, we are poised to take the next steps.

The impetus behind the *Apollo* program was not only a quest for new horizons but also a desire for national prestige. The Moon was the finish line in a space race between the United States and the Soviet Union. America won that race and should not try to re-run it against other nations.

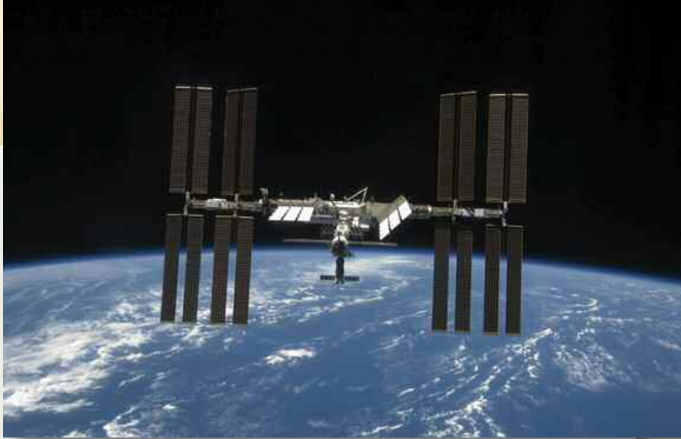
Our world has changed. Peaceful international cooperation now pervades space exploration, from the operation of the International Space Station to the exploration of the solar system, with such organizations as NASA and the European Space Agency (ESA) teaming for the *Cassini-Huygens* mission to Saturn and its moon Titan. America can return to the Moon with other nations while at the same time setting sights on new goals.

As the United States retires the space shuttle, it needs to develop new rocket capability, not only to replace the shuttle but also to take humans into interplanetary space. There are milestones beyond the Moon, just as the *Mercury* and *Gemini* programs represented milestones on the way there. Those milestones might include reaching a Sun-Earth "Lagrangian" point (of gravitational stability) for starting our venture to interplanetary space, near-Earth asteroids, or the Martian moons Phobos and Deimos. Finally, there is Mars itself.

European and Asian nations are now developing their capabilities to reach the Moon. America can help make that endeavor an integrated international venture. It can lead the way in building an international space exploration team, a peaceful technological challenge that will captivate the entire world. The political interest and support will be far greater for such a worldwide program of robotic and human missions taking us to the Moon and on to Mars than it would be for such an endeavor undertaken by one nation alone.

In a way, we have already started. Both the Japanese and the Chinese recently completed successful orbiter missions at the Moon and are planning their first landers. India also has an orbiter there and is planning future missions. At the Red Planet, NASA's *Spirit* and *Opportunity* rovers still explore the Martian surface while *Mars Reconnaissance Orbiter* observes from space. ESA's *Mars Express* spacecraft has been sending data from Mars since 2003. Russia and China are launching a joint Mars mission in fall 2009 with a Chinese Yinghuo-1 satellite and the Russian *Phobos-Grunt* lander.

In short, the nations of Earth are already at work on the necessary precursor steps—building their national capabilities and working together on more ambitious ventures. NASA and ESA have already announced that future landers on Mars must be international. Imagine what we could do if all missions leading to Mars were



The International Space Station was photographed on March 25, 2009 from the space shuttle Discovery just after the two craft had undocked. Earlier in the day, the STS-119 and international Expedition 18 crews finished nearly 10 days of work together on the shuttle and station. *Image: NASA*

coordinated and executed as part of an integrated program, designed to achieve the ultimate goal of settling humans there. Can we evolve that far—from space race to space partners—in less than two generations?

Yes, we can. If the world launches a cooperative effort, humans might set foot on Martian soil within 25 years, instead of having to wait another 40 years or more. In fact, if we start now, humans could take their first new steps beyond Earth orbit within a decade.

America's lunar program was originally undertaken to showcase one country's engineering achievements, but the *Apollo 11* Moon landing has come to represent the spirit of exploration in all of us. Mars beckons. Let's answer its call together.

On July 20, 1969, Apollo 11 *astronaut Buzz Aldrin became one of the first humans to walk on the Moon. Since that day, Aldrin has remained at the forefront of efforts to ensure a continued leading role for the United States in human space exploration. Louis D. Friedman is executive director of The Planetary Society.*

Early morning clouds are visible on the floor of Noctis Labyrinthus in Mars' giant Valles Marineris system of canyons. Here, the first human explorers prepare for a day of weather monitoring and rock sample gathering. *Illustration: Pat Rawlings for NASA*

We Make It Happen!

LIFE Biomodule *Ready for Launch!*

by Bruce Betts

Could cosmic hitchhikers have played a role in the origins of life on Earth? For life to travel between the planets, certain organisms must be able to survive for years in the punishing environment of space and still thrive when they reach their destination. The Planetary Society is testing whether microorganisms could survive such a long journey in interplanetary space with the LIFE (Living Interplanetary Flight Experiment) module, set to launch on board Russia's *Phobos-Grunt* ("soil") mission later this year.

The LIFE biomodule—about half the size of a hockey puck—will contain 10 distinct organisms and a soil sample, and it will be able to withstand an impact of at least 4,000 times the force of gravity. As the launch date approaches, the Phobos LIFE

Above: Our sealed LIFE biomodule.
All photos: Bruce Betts, The Planetary Society

Organisms at American Type Culture Collection (ATCC) are often stored in evacuated soda glass vials with an additional container inside. This is a freeze-dried sample of Bacillus safensis *prior to being opened and loaded into the LIFE module capsules.*

Left: Our experiment, LIFE, will go to Mars' moon Phobos and return to Earth. This color image of Phobos, taken by Mars Reconnaissance Orbiter*'s HiRISE camera, has been stretched to exaggerate color variations within and around the prominent crater Stickney.*
Image: NASA/JPL/University of Arizona

Here again is the loading of freeze-dried organisms (the white, powdery substance includes the organisms and dried, sterilized nutrient material from the original solution from which they were freeze dried). Some LIFE samples were air dried in the capsules, but most were freeze dried, like this Bacillus safensis.

team has been extremely busy, negotiating bureaucratic hurdles and accomplishing the loading of the organisms and sealing of the modules.

Loading and Sealing the Biomodules

Early in June 2009, I went to ATCC (American Type Culture Collection) in Manassas, Virginia for the final loading of organisms and sealing of all parts of the Phobos LIFE biomodules. ATCC is a crucial partner in our experiment, providing many of the LIFE organisms from its collections and lending expertise in handling, characterizing, drying, and storing the microorganisms. A nonprofit organization, ATCC is charged with storing and characterizing microorganisms for scientific uses in the United States, and it is where researchers go to obtain microorganisms for study. I had a great time visiting its facilities and working with its researchers.

I was joined at ATCC by the lead designer for Phobos LIFE, Bud Fraze, of Vector Design, LLC, working with Stellar Exploration, Inc. He was there not only for oversight but also to perform the final sealing of the biomodules once ATCC biologist Amy Smith was done preparing the organisms and loading and sealing individual sample tubes. We were also joined by ATCC Research Scientist Tim Lilburn, who has been guiding most of the details of the ATCC activities, and ATCC Director of Microbiology Collections Marian McKee, who has been guiding ATCC's overall involvement with

Biologist Amy Smith and Research Scientist Tim Lilburn of ATCC load the desert soil sample into one of the LIFE biomodule soil sample containers.

Inside a glove box filled with the inert gas argon, each vial is heat sealed using a specially designed machine. Prior to sealing, each vial is opened and exposed to the argon, then closed for sealing.

Amy Smith loads LIFE vials into a LIFE biomodule. Two sets of vials containing organisms sit in specially designed holding trays on the lab bench waiting to be loaded into their appropriate biomodules.

the project. LIFE's Scientific Principal Investigator David Warmflash, from the University of Pennsylvania, also joined us for the sealing of the biomodules.

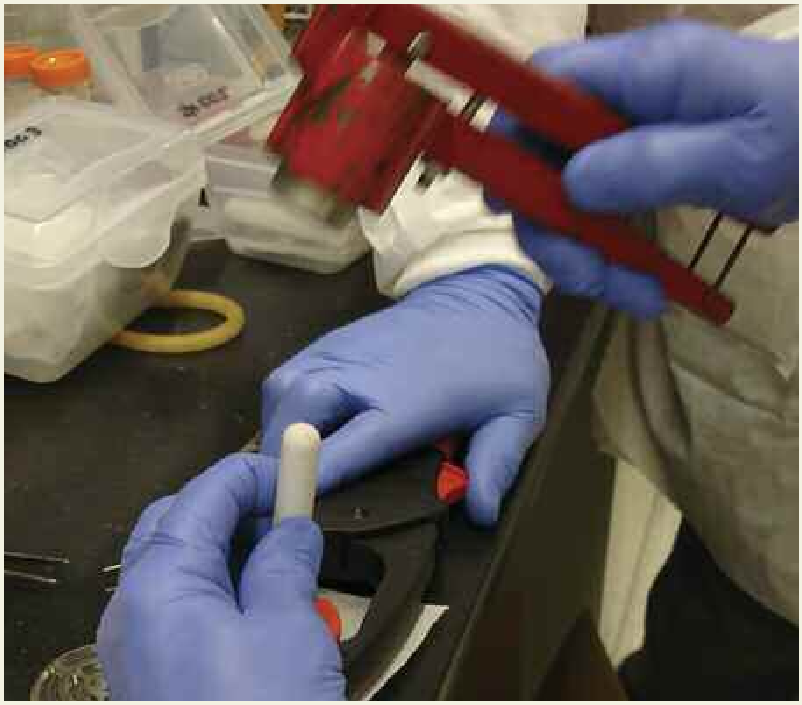
We loaded four complete, identical biomodules: one flight model, one flight spare that will become a scientific control, and two additional scientific controls to stay on Earth and be compared with the sample in the flight model after it returns from space. As planned, 10 different sets of organisms (in triplicate) and one soil sample were loaded into each of the biomodules.

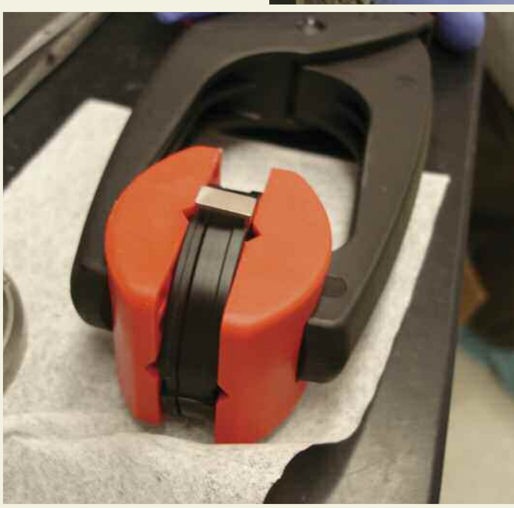
In addition to samples from ATCC, radiation-resistant bacteria samples were provided by Petra Rettberg's group from the Institute for Aerospace Medicine of the German space agency DLR. Tough, tiny animals called tardigrades were provided by Ingemar Jönsson of Kristianstad University in Sweden. Finally, we obtained a desert soil sample from Elena Vorobyova of Moscow State University. For more on the organisms themselves, see the March/April 2009 issue of *The Planetary Report* or check out our website at *planetary.org/ programs/projects/life/*.

We show here the story of the loading and sealing of the biomodules, told in pictures. You can see more pictures and video online at *planetary.org/programs/ projects/life/*.

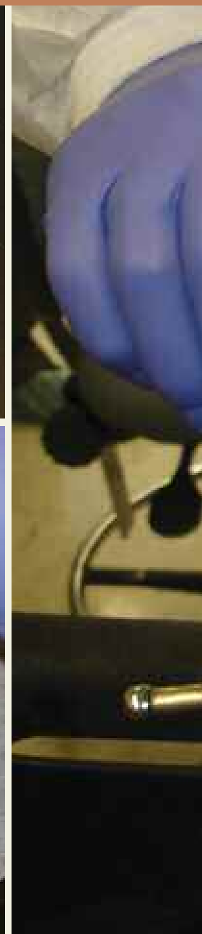
This image shows a filled LIFE biomodule carrier, lid, and titanium outer cases. Individual vials are labeled and color coded differently for each biomodule. The reddish-colored item is a silicone O-ring. It is one of many different seals used in the biomodule for redundancy.

Right and below: This set of three pictures shows the process of attaching titanium cleats, four of which hold the carrier and its lid together. Such a brute-force technique is used deliberately. The cleats actually embed in the Delrin (black plastic) when they are hammered down, increasing their grip.





From left to right: LIFE biomodule titanium bottom with two temperature stickers, each of which will cover a different range of temperatures and will show maximum temperatures experienced; a poron shock pad; a loaded carrier seen from the bottom (radiation detectors are the small white squares covered in yellow Kapton tape); a poron shock pad; and a titanium lid.



Cutting the indium wire that forms yet another redundant seal in the LIFE biomodule. It is laid into a groove in the lower part of the titanium case, and it "flows" to fill the groove and the contact with the upper piece of the case once it is attached. The indium actually chemically bonds with the titanium over time, increasing the strength of the seal.

Feeding the Bureaucracies

Much nontechnical preparation has been necessary for the Phobos LIFE project. It certainly is not as much fun and not as interesting as the technical challenges, but it is just as important and, sometimes, just as complex. One of the first challenges involved getting an export control license from the U.S. State Department for the LIFE biomodule. This is necessary because anything that flies on a foreign spacecraft, no matter how benign, is subject to International Trafficking in Arms Regulations (ITAR). The Planetary Society therefore registered as "arms traffickers" and got a Technical Assistance Agreement for the project and an export control license for the hardware.

Earlier in the project, we also carried out technical studies to make sure we were well within planetary protection guidelines set by COSPAR (the Committee on Space Research of the International Council for Science). As we anticipated, our experiment is indeed well inside COSPAR guidelines.

We also had an initial set of agreements with the Space Research Institute (with whom we are collaborating on this project), which were followed by other agreements with various groups, along with our contributions to more formal agreements within and between the many Russian agencies involved. We also put much effort into completing all the layers of paperwork necessary for Russian customs and into finding and arranging the best shipping methods for the biomodule.

Loaded and Ready to Go

We have been informed that the Phobos LIFE biomodule has been successfully integrated into the *Phobos-Grunt* sample return capsule. The product of our hard work and your support is ready for launch. As we go to press, *Phobos-Grunt* is still scheduled to launch in October for a trip to Mars' moon Phobos and back—taking our experiment on a 34-month journey through deep space. We really did make it happen.

Now, what will happen to the organisms? We truly don't know. If any of the organisms survives the trip into space and back, that will provide strong evidence favoring the transpermia hypothesis.

Whatever the result, we do know that this mission will be one very tiny step for microbes and one giant leap for The Planetary Society.

Bruce Betts is director of projects for The Planetary Society.

Above: Happy faces followed the successful loading of all biomodules (flight, spare, and scientific controls). From left to right are biologist Amy Smith; Bud Fraze, an engineer and LIFE biomodule designer; Bruce Betts, LIFE project manager and Planetary Society director of projects; research scientist Tim Lilburn; and David Warmflash, the LIFE scientific principal investigator.

Left: The LIFE biomodule is about to have its titanium case lid rotated into place. Specially designed tooling is used to rotate lugs that lock the lid.

What's **Up?**

In the Sky—

From mid-August through mid-October, Venus is extremely bright in the predawn east, with dimmer, reddish Mars above it and the two separating as weeks pass. In early October, low in the predawn east are Venus, Mercury, and Saturn. Saturn is particularly close to Mercury on October 8 and to Venus on October 13. The thin crescent Moon joins all three on October 16. Very bright Jupiter is low in the east in the early evening in late August, moving to high in the early evening sky by mid-October. Look for it near the nearly full Moon on September 2.

Random Space Fact

Both Pluto and its moon Charon are tidally locked with each other; in other words, the same face of Pluto is always facing the same face of Charon.

Trivia Contest

Our January/February contest winner is Rafael Moro-Aguilar of Madrid, Spain. Congratulations!

The Question was: Including the initial launch, and as of the end of 2008, how many space shuttle missions have been flown to the Hubble Space Telescope? *The Answer is*: Five—the initial launch (1990) and four servicing missions: 1 (1993), 2 (1997), 3A (1999), and 3B (2002). A final servicing mission (numbered 4) flew in May 2009.

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

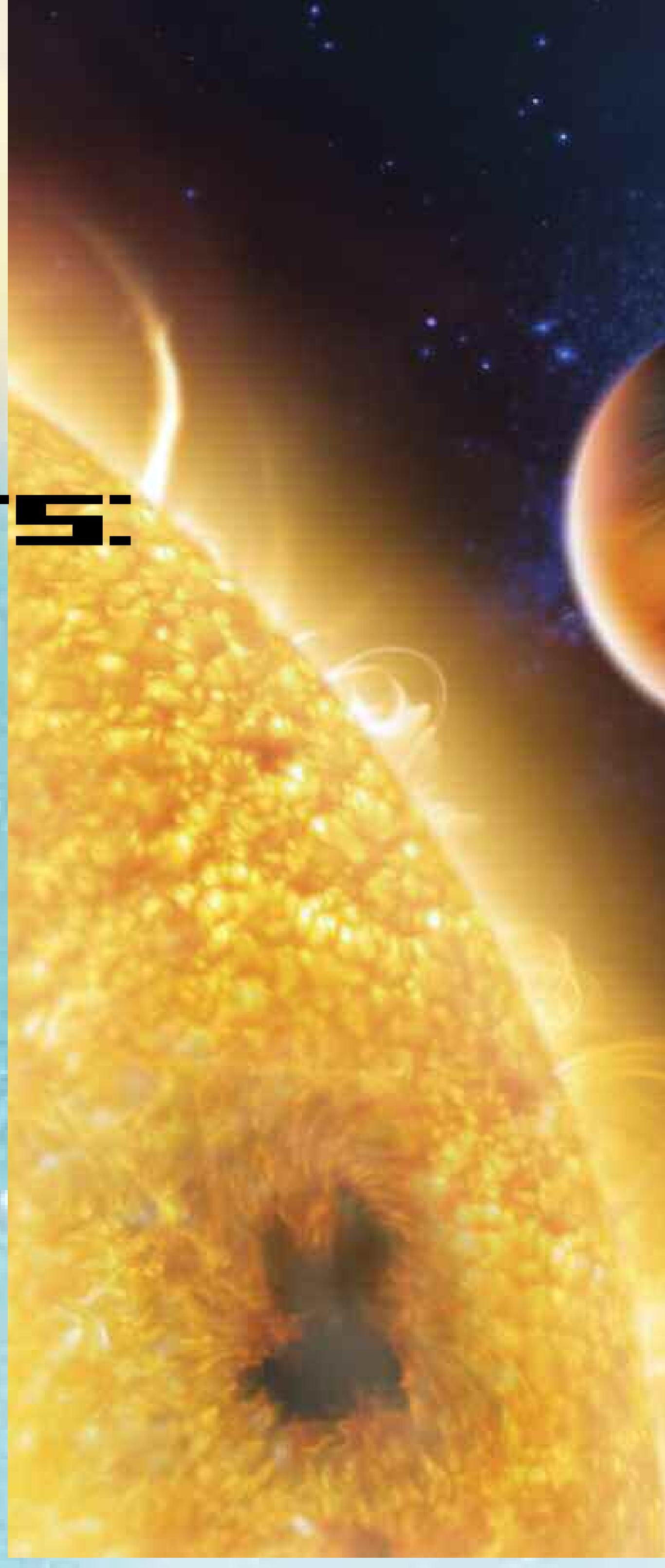
On what body in the solar system will you find a volcano named Pele, for the Hawaiian volcano goddess?

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 October 1, 2009. 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.*

SEARCHING FOR New Worlds: THE POWER OF MANY



BY DEBRA FISCHER

When I was in the first grade, I was in a hurry to learn. I remember asking my teacher if I could move up to the fourth grade so that I could begin studying multiplication and division. Education seemed like a process of collecting a finite number of facts. I must have imagined that I would eventually learn everything, because I remember the day when I confronted a paradox: the more I learned, the less I knew. The answer to every question simply produced a cascade of new questions.

Of course, this is the nature of science, and the interplay between theory and observational data is used to tease out answers to our questions. Frequently, new evidence forces us to backtrack and correct previous misconceptions. In the end, our questions become more refined, and we hone our observational tools so that human knowledge edges forward.

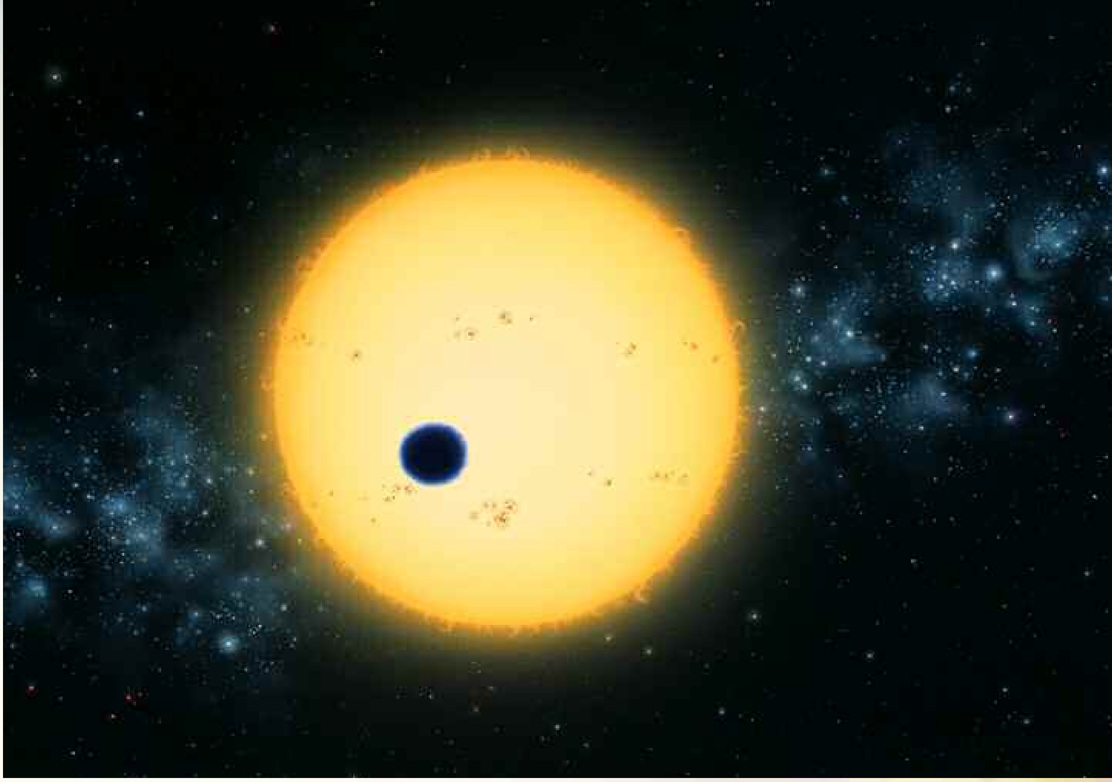
A case in point is the search for exoplanets (planets orbiting other stars). In the early 1990s, our question was simple: "Do other stars have planets?" Science fiction writers answered with a resounding "Yes," but the possibility that our planetary system was a rare occurrence could not be excluded. People had searched, and nothing had been found. In retrospect, the state-of-the-art observational tools simply were not adequate to detect exoplanets.

STUDYING GAS GIANTS

Before the first contradicting detection, theorists assured us that gas giant planets formed at great distances from stars. One astronomer from the University of California at Santa Cruz, Doug Lin, hypothesized that sometimes the gas giant planets might migrate inward and park in stable orbits close to their host stars. It was an intriguing theory, but we did not observe gas giant planets close to our Sun, and no exoplanets had been discovered in the early 1990s, when Lin worked through his hypothesis.

Then, the first detected gas giant planet was discovered orbiting the star 51 Pegasi by Michel Mayor and Didier

In early 2008, scientists using the Hubble Space Telescope detected the first organic molecule (methane) ever found in the atmosphere of a Jupiter-size planet orbiting around another star. Scientists had already found that the planet, HD 189733b, had water vapor in its atmosphere. Under the right circumstances, methane can play a key role in the chemical reactions necessary to form life as we know it. *Illustration: ESA, NASA, G. Tinetti (University College London, UK and ESA), and M. Kornmesser (ESA/Hubble)*



In 1999, scientists witnessed, for the first time, an alien planet passing in front of its parent star (HD 209458). This event provided direct and independent confirmation of the existence of extrasolar planets. Before then, scientists could only infer their existence, from the wobbles of their stars. Painting: Lynette Cook

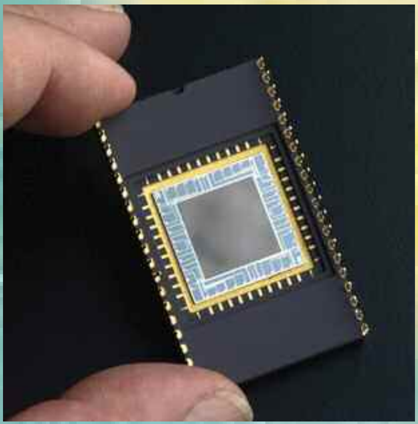
Queloz in 1995. The exoplanet completed one orbit in just 4.231 days. The short orbital period meant that the planet resided very close to the star, in a fiery-hot environment.

Although this environment probably is hostile for life (as we know it), these close-in hot Jupiters offer a scientific portal: because the radius of the Sun is a factor of 10 larger than that of Jupiter, the probability that close-in planets will transit in front of their looming host star is geometrically enhanced.

Of course, the orbital plane may be tilted, so that the planet does not pass in front of the host star, but statistically, about 1 in 10 close-in planets will transit. During a transit, light from the star dims; the larger the planet, the greater the dimming. Therefore, the planet's radius can be calculated from the incremental dimming of starlight.

With this simple measurement, one can combine the Doppler-measured planet mass with the transit-measured planet radius to calculate the mean density of the planet. Armed with these data, astronomers can estimate the interior structures of planets that we can't even see, orbiting stars that are hundreds of light-years away.

Indeed, astronomers have peered even farther into the transiting planet portal, using the Spitzer Space Telescope to measure the difference in brightness of the unresolved star-planet system during transit and out of transit and when the planet passes behind its star ("secondary eclipse"). Incredibly, these observations tell us how well energy is circulated from the "day" side of the planet to the "night" side and



Above: A charge-coupled-device (CCD) is used to record astronomical data, including spectra for measuring the Doppler velocities of stars. The high efficiency and stability of CCDs makes it possible for researchers to observe very faint objects and to gather reliable data. Photo: NASA

Right: A planet like our own blue world is the "holy grail" for extrasolar planet hunters. We hope to find many like this—with oceans of liquid water, a breathable atmosphere, organic chemistry, and life. Painting: Lynette Cook

provide measurements of wind speeds in the atmospheres of these faraway planets.

New Questions

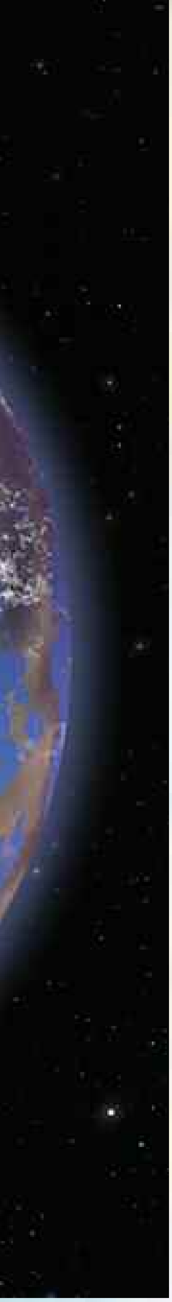
We've come a long way from our original question, "Do other stars have planets?" If we had detected only one or two gas giant planets, our understanding would be seriously skewed and biased. It is the menagerie of hundreds of detected exoplanets that paints a surprising picture of the chaotic and wildly diverse nature of gas giant exoplanets and that provides the insights that lead to ever more sophisticated questions and new directions for technology development.

One of the simple questions that we have yet to answer is, "Are there other worlds like Earth?" A planet "like Earth" would reside at a distance from its star where it was not too hot and not too cold to foster conditions favoring life—a distance where oceans of water could pool on the surface of the planet. A planet like Earth would have a nearly circular orbit, for a stable temperature.

A planet like Earth also would have a mass that is very near the mass of our world. Smaller planets, such as Mars, do not have enough gravity to hold onto their atmospheres and surface water. If we could drag Jupiter's moon, the ice-covered Europa, to the distance of our own Moon, it would not take long for the ice to melt and the water to evaporate from the surface of that object. In contrast, planets that are much more massive than Earth might also be problematic, with more active mantle convection and enormous atmospheric surface pressure that could stunt biological evolution.

A Need to Measure the Minuscule

The race is on to find an Earth-like world. Few people doubt that such worlds exist, but small planets on



In 2003, scientists discovered a planetary system more similar to our own than any other known at the time. The bright, Sun-like star, HD 70642, was found to have a planet, twice Jupiter's mass, in a nearly circular orbit at about half the orbital distance of Jupiter. Such an orbit would allow the possibility of habitable Earth-like planets closer in. Painting: © David A. Hardy/ISTC

orbits similar to Earth are extremely difficult to detect. Jupiter tugs on our Sun, resulting in a reflex velocity of 12 meters per second. To put this in concrete terms, imagine that a quarter represents one meter per second—our current technological currency for Doppler planet searches. It's easy to count out three dollars worth of quarters. The tug of Earth on our Sun, however, causes our star to move with a speed of only 10 centimeters per second—a factor that is one-tenth the size of what can be measured with our current ability to detect stellar speeds. How do we count out three cents with our stack of quarters? Like all analogies, this one has shortcomings, but the point is that we can't measure speeds that are far below our single measurement precision. We need to improve our precision and develop a Doppler "currency" that, in the foregoing analogy, has units of pennies.

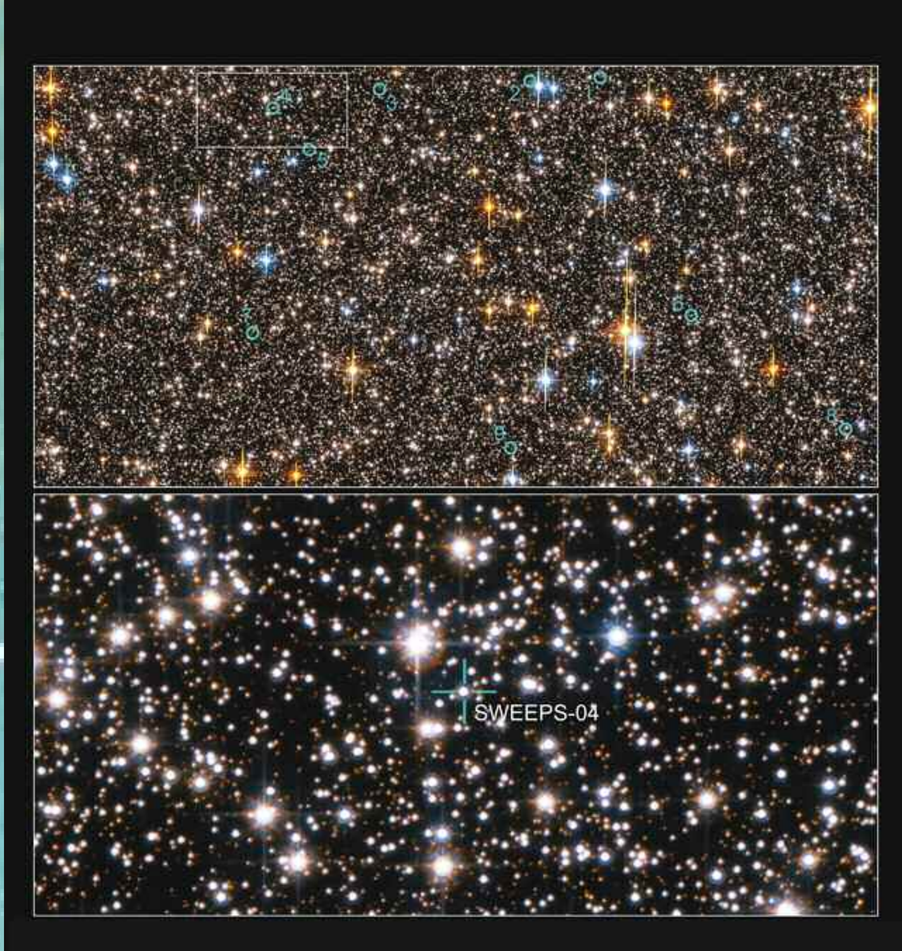
This technological advancement is difficult. With the Doppler technique, we clock stellar speeds by measuring tiny shifts in the positions of absorption lines in the stellar spectrum. The spectra are recorded on charge-coupled devices, or CCDs, like the ones in digital cameras today, and we routinely measure line shifts at the level of one thousandth of a pixel. Physically, this shift is about one billionth of a meter. To detect an Earth-like planet, we need a corresponding precision that is one hundred times better. We need to measure line shifts comparable to the sizes of the molecules in the silicon substrate of our CCD detector.

The demand for instrumental stability for the Doppler technique has never been greater. This is the reason that our group is developing a fiber-optic feed to stabilize the light cone that illuminates our spectrometer in the FINDS Exo-Earth project (see page 17), which The Planetary Society is supporting. These detections are so challenging that supporting observations from space missions are critical for the confirmation and ultimate characterization of candidates for Earth-like status.

One thing is certain: finding a single Earth-like planet is not enough. Rocky worlds are likely to be at least as diverse as the gas giant planets that have been detected, and our own planet is ever evolving. Looking back 500 million years, Earth was a frozen ice world. Looking ahead 1 billion years, our planet will lose its oceans of water.

To understand the nature and evolution of rocky worlds, we will need a menagerie of hundreds of Earth-like planets. Once we begin finding Earth analogs, we will begin studying exoplanet atmospheres, geologic processes, and water content. We then will learn whether life is common or rare on worlds like our own.

Debra Fischer is a professor of astronomy at Yale University and an adjunct professor at San Francisco State University. She has been working on the detection of extrasolar planets since 1997 at Lick Observatory and Keck Observatory. At the Cerro Tololo Observatory in Chile, she is also carrying out an intense search for Earth-like planets orbiting our nearest neighbors: Alpha Centauri A and B.



It's hard to believe that 15 years ago we did not know with certainty of a single extrasolar planet. Since then, we've found hundreds. In 2006, a Hubble Space Telescope survey called the Sagittarius Window Eclipsing Extrasolar Planet Search (SWEEPS) peered at 180,000 stars in the central bulge of the Milky Way, 26,000 light-years away. SWEEPS detected 16 extrasolar planet candidates, 5 of which represent a new class of body called Ultra-Short-Period Planets (USPPs)—worlds that whirl around their stars in less than one Earth day. ***Images: NASA, ESA, K. Sahu (STScI), and the SWEEPS Science Team***

More than half the stars we see twinkling in the night sky are actually binary or multiple star systems. Here two suns set over a lake channel on their distant, Earth-like planet. ***Painting: Edwin Faughn***

Fine-Tuning the Search

The Great Lick Refractor, completed in 1888, is located in the main dome of California's Lick Observatory. This grand old instrument laid the foundation for Lick's three-meter telescope with its ultramodern Doppler spectrometer and data system.

Photo: Joe Mercier, Shutterstock

The Planetary Society is working with author Debra Fischer and Geoff Marcy of the University of California at Berkeley to detect a special—and still elusive—type of object. These veteran planet hunters are searching for other terrestrial planets like our own—other "Earths."

Their new optical system, Fiberoptic Improved Next-generation Doppler Search for Exo-Earths (called FINDS Exo-Earths for short), will be installed on the three-meter telescope at California's Lick Observatory. Not only will this new project ramp up our discoveries of exoplanets, but it also will develop and test technology that can play a crucial role in verifying any Earth-sized planet candidates found by the *Kepler* planet-hunter mission.

The most common method of planet hunting is the radial velocity technique, which relies on measuring tiny Doppler-effect changes in a star's light. Currently, the powerful Lick telescope can detect a Doppler velocity of roughly five meters per second. That's good enough to find a Jupiter-sized planet, but a precision of less than 0.5 meters/second would be needed to spot a planet the size and density of Earth.

Thanks to Planetary Society members, Fischer and Marcy will be vastly improving their planet-hunting ability at Lick Observatory while testing technology that can be adapted to the even more powerful Keck Observatory. Fischer, Marcy, and their colleagues have devised two optical systems that will work in tandem to greatly improve their Doppler measurements. The first is a fiber-optics array that will make the cone of light entering the telescope's spectrometer uniform and, therefore, resilient to naturally occurring changes that interfere with Doppler measurements. The second part is an adaptive optics system that will keep the maximum amount of light flowing, thus providing a better signal-to-noise ratio.

The bundle of technology that combines these two parts is FINDS Exo-Earths. At Lick, it could improve detection to the one-meter/second range, enabling additional discoveries of many planets the size of Neptune and larger. If the FINDS technology is successful, it will be adapted for Hawaii's Keck telescope. Once Keck is equipped with FINDS Exo-Earths, we hope to be able to make Doppler measurements that will enable finding exo-Earths, including performing the crucial step of verifying any detections of Earth-sized planets found by *Kepler* and ruling out false positives.

Once again, Planetary Society members are supporting the groundbreaking work and innovative technology that may one day change the way we see our place in the cosmos. Thank you!

—*Bruce Betts, Director of Projects*

Members' Dialogue

A Hardy Organism

I was surprised to see that the article by Amir Alexander (See "Who Will Survive?" in the March/April 2009 issue of *The Planetary Report*) did not include desulfovibrio (commonly known as sulphate-reducing bacteria, or SRB) as one of the 10 organisms selected for the trip to Mars.

I am not a microbiologist, but I have spent many years in the oil industry dealing with this very persistent, prolific, and tenacious bacterium and its damage to oil and water reservoirs, production equipment, and pipelines. It survives extreme conditions of cold and heat, high pressures, concentrated brines, acids, and drilling muds, and although it is an obligate anaerobe, it can even survive oxygenated conditions. Currently this bacterium is also being used to process toxic waste metals, such as uranium. It seems to me a good bet that if anything can survive a trip to Mars it would be our friend SRB.

—DON DORAN,
Merseyside, England

A Wonderful Feeling

Thank you to the staff members who picked my entry from all the many entries you must have had. (See "All Hail Hubble" in the May/June 2009 issue.) Celebrating Hubble this way was a great idea.

I always look forward to the magazine. I just wish it was monthly. The Planetary Society gives its members so many different ways to get involved. I can't tell you how much I appreciate everyone's efforts in helping to make membership so enjoyable and worthwhile. You help us to realize that we can, and do, make a difference.

I could easily write a long letter about all the good things that come with being a member, but I've already gotten my caption for the Hubble Deep Field image included in the magazine. That, by itself, is awesome, as is knowing my name is on several bodies in the solar system. The Seti@home certificate I have on the wall always impresses visitors. I could go on but, in short, it's just such a wonderful feeling to be a real part of what's happening and to be associated with a large international group of like-minded people who care about the future of humankind and are eager to learn more about the true nature of our universe.

—RICK BLAIR,
Bloomington, Indiana

The following letter was sent in response to Ken McLean's letter in the March/April 2009 issue on saving money (and trees) by not mailing materials. For information on going paperless, see page 23 of Society News.

Hard Copy, Please

You are a young man with young eyes. Us 65-plus fogies like to sit down with the magazine. I'm tired of computer screens. I hope the Society never e-mails its magazine.

—MARTIN KOVAR,
Westlake, Ohio

Robots Versus Humans

I am responding to Hans Buhrer's letter in the May/June 2009 issue and, particularly, to his claim that "adventure and excitement have no place in today's space exploration programs." To the contrary, I tend not to involve myself in any issues if they're not exciting! Why not make all of life as fun as possible? I will be a graduate student in planetary geology starting this fall, and I'm doing that precisely because I think studying other planetary bodies is exciting. Furthermore, I am working at a science camp this summer where our science demos are purposefully exciting in order to get kids interested in pursuing science. One sure way to kill any important undertaking—especially science and space exploration—is to make it unexciting.

—KIRBY RUNYON,
Spring Arbor, Michigan

I fully agree with Mr. Buhrer's disappointment about the amount of money drained over the years from robotic missions (which have been so productive) to manned missions (which, in comparison, have not).

The saying "No buck$ without Buck Rogers" to justify elevating manned exploration over robotic may have been true for the generation that led us from the 1960s to the 1980s, but it is less and less so. The rising generation is excited with the "experience" of discovery through robotic missions they all can participate in remotely via the Internet—not just the select few who (at great cost) can actually "experience" space flight.

—WILLIAM LAUB,
Denver, Colorado

Editor's note: We will print more letters on this topic in the next issue of The Planetary Report.

Erratum:

World Watch (page 19) states that the Russians "are still the only nation to have landed on Venus." On December 9, 1978, one of the American *Pioneer Venus* Multiprobes unexpectedly survived impact and transmitted data from Venus' surface for 67 minutes.

—BOBBY BAUM,
Bethesda, Maryland

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*

World Watch

Europe/United States—NASA and the European Space Agency (ESA) have started implementing their new policy to explore the surface of Mars together. Earlier this year, the two agencies announced that they would jointly plan future Mars landers. The policy was dictated as much by need as by the desire for international cooperation. The next U.S. Mars rover—the Mars Science Laboratory, *Curiosity*—had just suffered a two-year delay and an increase in cost, as had the European ExoMars rover/lander, now scheduled for 2018. Future missions, such as the Mars sample return mission desired by both agencies, will be even more complex and costly than currently planned endeavors. International cooperation is likely the best way to accomplish such missions.

In June, ESA announced the first step in paring down the ExoMars mission by removing a previously selected instrument package that would be used to measure seismic activity on Mars. NASA also took on a major role by committing to launch the mission, a move that should permit ESA to carry out the ambitious surface exploration within the budget allocated by the nations participating in the project.

NASA deferred its plan for a 2016 lander until 2018 or 2020. However the agency will launch an orbiter in 2016, ensuring communications for the ESA landers and the anticipated high volume of data return. ESA will be expected to invest similarly in NASA's '18 mission, and American and European scientists will collaborate on each other's missions. NASA and ESA are also working together on planning for a future Mars sample return mission in an activity called International Mars Architecture Systems (iMARS).

Losing the seismic measurement instrument package was a blow to those who, for years, have been promoting the establishment of a Mars "network" both to investigate seismic activity and the interior of the planet and to provide meteorological data on the Martian environment. Russian and Finnish scientists are developing small Mars landers for a future network mission, so perhaps there will be opportunities for even more international collaboration.

Great Britain—A change of policy seems to be in the wind. Even in these troubled economic times—and even in Great Britain, which has a history of avoiding significant involvement in human spaceflight—the British are considering increasing investment in human space missions. Perhaps the specter of China's human program and India's plans to send humans to space are motivating the British government to consider increased participation in human space exploration. Such news will be welcome to ESA, which may be stuck with increased costs of the International Space Station if the United States goes ahead with plans to scale down its participation after 2015. Great Britain reportedly is also considering if it should form a British national space agency.

Russia/Europe—Personnel completed the first trial stay in the Mars 500 facility, built in Russia to provide Earth-based simulation of a human mission on Mars. Mars 500 is a cooperative project operated by both Russian and European space agencies. The six-person crew—originating from Germany, France, and Russia—stayed in the isolation facility for 105 days. This mission was a precursor to the planned 500-day mission, which will simulate a full human mission to Mars. This program—and the public outreach by the Russians and Europeans involved in it—demonstrates strong interest in and motivation for the goal of sending humans to Mars.

Planetary Society Presents to The Review of U.S. Human Space Flight Plans Committee

The Review of U.S. Human Space Flight Plans Committee, chaired by Norm Augustine and known more popularly as the Augustine Committee, is finishing its three-month review and preparing to give the Obama administration (including NASA) its final conclusions. The group of outstanding individuals, including former astronaut Sally Ride and Space Science Board Chair Charlie Kennel, has worked intensively for three months, hearing from hundreds of individuals and organizations with varying views and insights about the future for human space exploration.

In July, I presented The Planetary Society's *Beyond the Moon: A New Roadmap for Human Space Exploration in the 21st Century* (see the January/February 2009 issue of *The Planetary Report*) to the committee. The Roadmap is the result of the Society's year-long process of deliberating on the future of human spaceflight. I also presented the results of our Road to Mars petition to the committee.

I'm proud to say that the Augustine Committee very much appreciated our nongovernmental, citizen-based representation of popular interest in space exploration. The Planetary Society continues to fill a much-needed niche in space exploration advocacy.

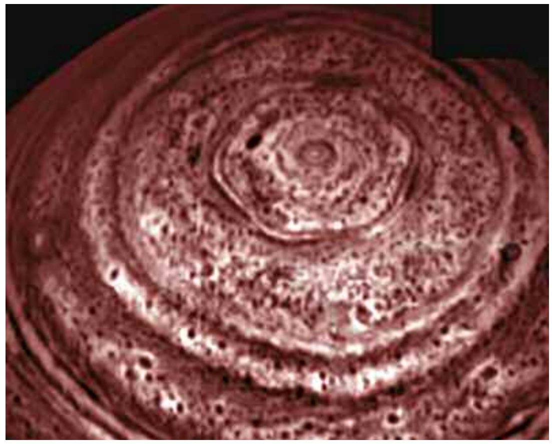
For more on the Roadmap and our Road to Mars petition, as well as updates on our advocacy campaigns, visit *planetary.org/programs/projects/space_advocacy/*.

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

Questions and Answers

Can anyone explain that permanent, six-sided cloud formation around Saturn's north pole?
—Mike Martinez
Inver Grove Heights, Minnesota

Scientists have yet to establish a definitive explanation for this bizarre-looking hexagonal feature. A plausible possibility, first promoted in 1990 by Michael Allison of NASA's Goddard Institute of Space Studies, is that it is a planetary wave. Specifically, it may be a "Rossby wave," a type of slow-moving wave similar to the jet streams of Earth. Although the winds in Earth's jet streams are quite high, typically more than 100 knots (more than 185 meters per second), the wave form itself propagates westward at a very slow rate of just centimeters per second (a few kilometers per day), or slower. On Saturn, clouds have been clocked moving around the "racetrack" of the hexagon at more than 450 kilometers (280 miles) per hour, much faster than the hexagon itself rotates about the planet. (The actual speed of the hexagon is unknown due to the uncertain rotation rate of Saturn.)



This is one of the first clear images ever taken of the bizarre six-sided feature on Saturn near 78 degrees north latitude. On October 29, 2006, Cassini *captured this image of a hexagon encircling the planet's pole. The phenomenon was first discovered and last observed by the* Voyager *spacecraft in the early 1980s. The new 2006 views prove this to be an unusually long-lived feature on the ringed planet.* Image: NASA/JPL/Space Science Institute

In general, waves oscillate due to a "restoring force." A familiar example is a swinging pendulum, where the restoring force is gravity. For a Rossby wave, the restoring force is produced by the latitudinal variation of the Coriolis force, which is caused by the planet's sphericity and depends on the planet's rotation rate and wind speed. At the high latitudes where the hexagonal feature appears on Saturn (near 78 degrees north), the Rossby wave circumscribes the planet in six undulations (wavelengths). It may be that only at this latitude can six complete wavelengths be sustained in such a wave. Without the curvature of Saturn's globe, much of the undulation would look relatively straight, with periodic sharp kinks. The globe's curvature causes these kinks to look like the corners of the hexagon.

To set the Rossby wave in motion, a perturbation to the typical east-west (zonal) winds is required. Allison suspected that a large dark feature that is located just outside the hexagon and was observed in the same *Voyager* imagery that first revealed the hexagon might be responsible for the perturbation that sets the wave in motion. That feature, however, has not yet been observed by *Cassini* scientists who have been looking for it for several years.

Another possible explanation is that the hexagon is not a planetary wave but, instead, is a manifestation of fluid motions occurring at the interface of two dynamical regimes, or sets of physical conditions, of the atmosphere. Laboratory experiments have shown that if a rotating plate is centered at the bottom of a larger cylinder, then

Send Us Your Questions!

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

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

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

regularly spaced eddies may develop above the edge of the plate—the number of eddies is dependent on the rotation speed of the plate. At just the right plate-rotation speed, six eddies formed that appeared to be connected by flows that followed relatively straight lines.

The hexagon is just now coming into daylight as the planet's northern winter ends. The spring equinox for Saturn's northern hemisphere, when the Sun will be directly over the equator, occurs in August of this year. Thus, *Cassini*'s very high resolution Imaging Science Subsystem (ISS) is beginning to see this feature, which until now has been viewed only in silhouette in the thermal glow of Saturn by *Cassini*'s Visual Infrared Mapping Spectrometer (VIMS). The ISS should be able to detect clouds just a few dozen kilometers across and to follow their motions in exquisite detail. It should allow us to see the intricate north-to-south motions of individual clouds, in particular, if they follow Rossby wave-like, or fluid mechanical, motions. Perhaps these new movies will reveal even more exotic dynamical mechanisms at play in the depths of Saturn's atmosphere.

—KEVIN BAINES,
Jet Propulsion Laboratory

Factinos

A small comet or asteroid slammed into Jupiter on July 19, 2009, creating a dark bruise about the size of the Pacific Ocean. The bruise was first noticed by Anthony Wesley, an amateur astronomer in Australia.

Paul Kalas of the University of California at Berkeley took advantage of previously scheduled observing time on the Keck II telescope in Hawaii to coordinate imaging of the blemish in the early morning hours of July 20. The near-infrared image (below left) showed a bright spot in the southern hemisphere, a sign of reflective particles suspended high in Jupiter's relatively clear stratosphere.

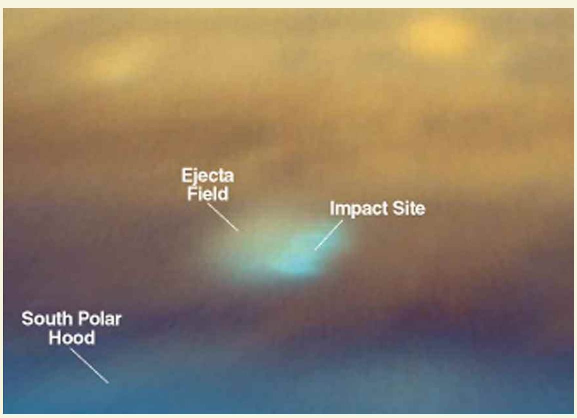
A few days later, on July 23, NASA scientists interrupted the newly upgraded Hubble Space Telescope's checkout and calibration to image, in visible light, the expanding dark spot on the giant planet (below right). Amy Simon-Miller of the Goddard Space Flight Center said, "details seen in the Hubble view show a lumpiness to the debris plume caused by turbulence in Jupiter's atmosphere." Simon-Miller estimated the diameter of the impacting object to be several hundred meters. The force of the explosion on Jupiter was thousands of times more powerful than that of the bolide that blew up over Siberia's Tunguska River Valley in June 1908.

This marks only the second time observers have seen the results of an impact on the giant planet. The first collision occurred exactly 15 years ago, between July 16 and 22, 1994, when more than 20 fragments of comet Shoemaker-Levy 9 collided with Jupiter.

—Compiled from news stories from the University of California at Berkeley, and from the Space Telescope Science Institute

New meteorological findings from *Cassini* indicate that Saturn's rotation period could be more than five minutes shorter than scientists previously believed. The rate at which Saturn spins provides important data for planetary scientists studying the ringed planet. Getting an accurate fix on that number is critical to helping researchers understand the planet's evolution, formation, and meteorology. The report on this discovery, led by *Cassini* scientist Peter Read of Oxford University, England, appeared in the July 30, 2009 issue of *Nature*.

—from the Jet Propulsion Laboratory



This infrared image, taken with Hawaii's Keck II telescope on July 20, 2009, shows the new impact feature observed on Jupiter. *Image: Paul Kalas, UCB; Michael Fitzgerald, Lawrence Livermore National Laboratory/ UCLA; Franck Marchis, SETI Institute/UCB; and James Graham, UCB*

On July 23, 2009, the Hubble Space Telescope's new Wide Field Camera 3 returned the sharpest visible-light image yet of atmospheric debris from the July 19 impact on Jupiter. *Image: NASA, ESA, Heidi Hammel (Space Science Institute), and the Jupiter Impact Team*

Society News

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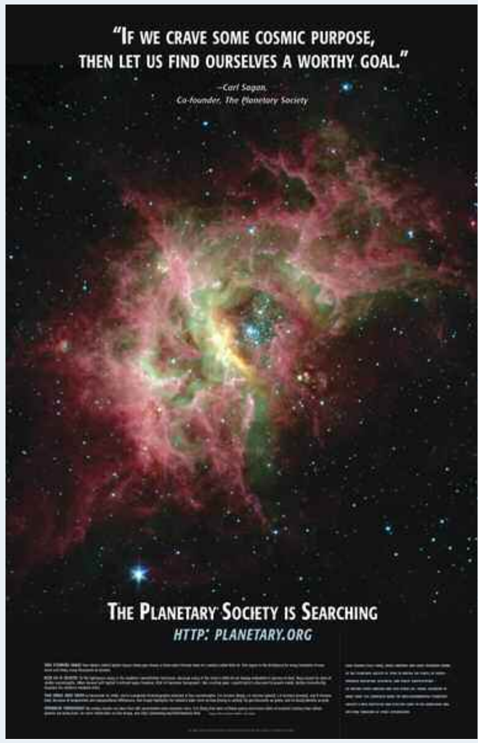

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—Stephanie Lam,
Data Processing Manager

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Please let me know if you have any questions (or more suggestions). E-mail me at *andrea.carroll @planetary.org*, call me at (626) 793-5100, or send mail to my attention at The Planetary Society, 65 N. Catalina Ave., Pasadena, CA 91106-2301 USA.

It's always great to hear from you!
—Andrea Carroll,
Director of Development

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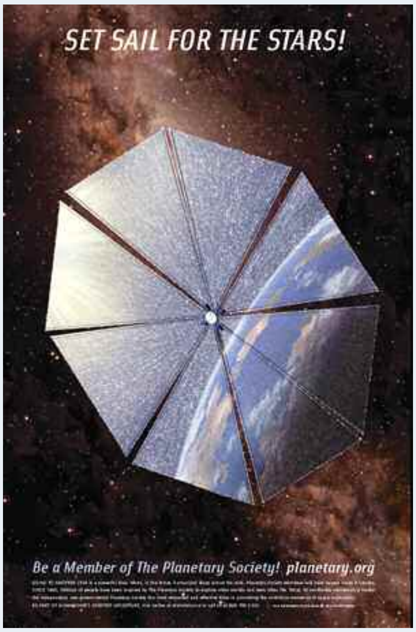

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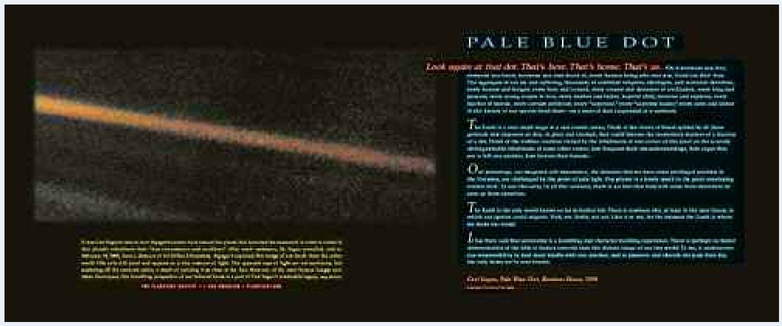

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In *Extrasolar World,* an alien gas giant planet looms in the blue sky of its icy moon. The moon's atmosphere is rich in nitrogen and oxygen, resulting in a familiar-looking sky. Two other crescent moons are visible, parallel to the planet's equator. The system's parent star lies at upper left, out of the field of view.

Edwin Faughn's artwork has appeared in, or on the covers of, numerous space science magazines as well as in planetarium productions and exhibitions. His credits include *Scientific American*, *Science News*, *Astronomy*, *Sky & Telescope*, and the world premier of Titanic: The Exhibition. He is assistant director of Rainwater Observatory in French Camp, Mississippi.