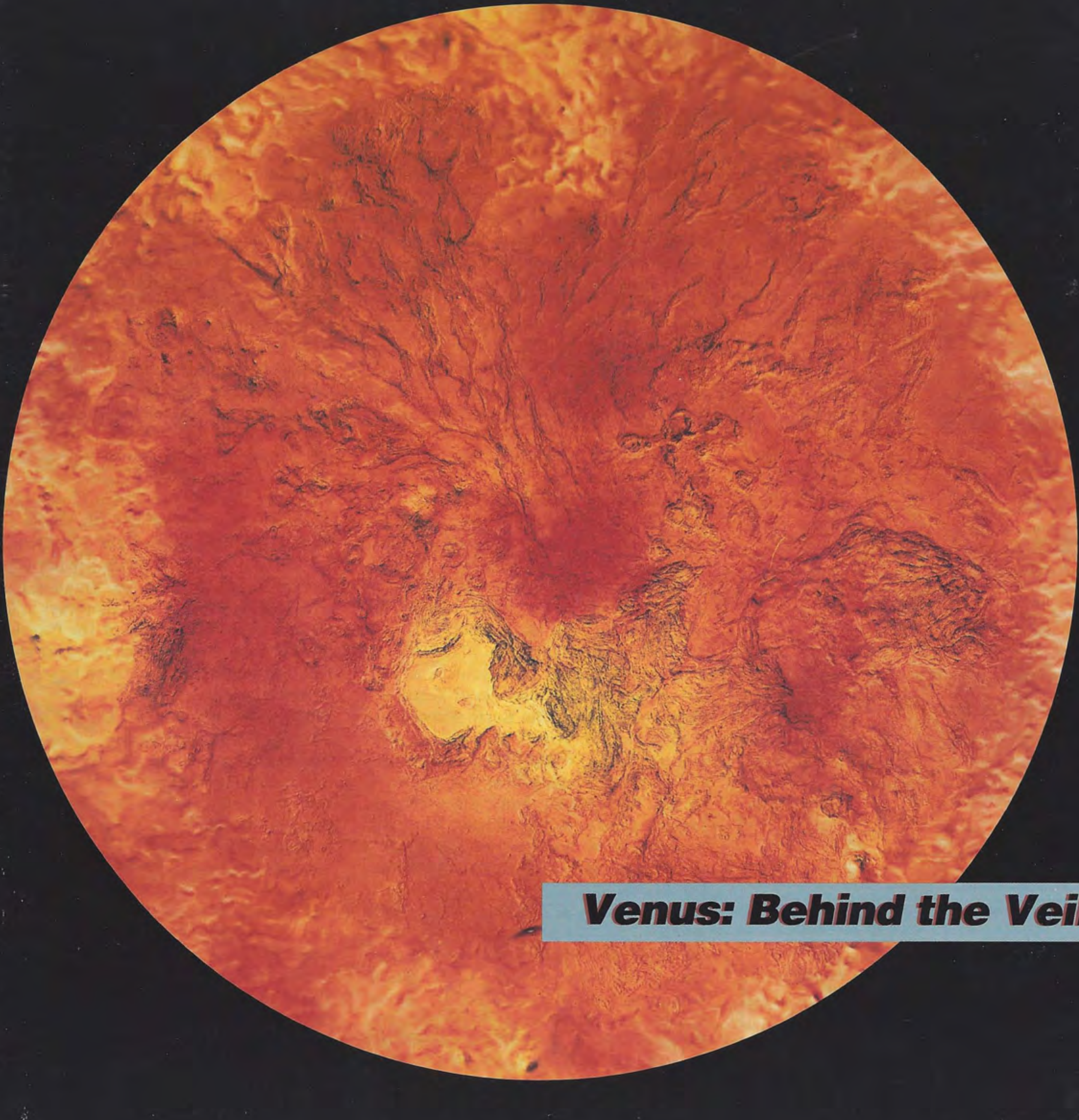
The PLANETARY REPORT

Volume IX Number 5 September/October 1989



Venus: Behind the Veil

A Publication of
THE PLANETARY SOCIETY

The Planetary Report (ISSN 0736-3680) is published six times yearly at the editorial offices of The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106, (818) 793-5100. It is available to members of The Planetary Society. Annual dues are $20 in the US, $25 in Canada, and $30 outside the US or Canada.

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In Canada, Second Class Mail Registration Number 9567

COVER: Using data from the* Venera 15 *and* 16 *radar orbiters, the* Pioneer Venus *altimeter and the Arecibo radio telescope, mapmakers at the United States Geological Survey in Flagstaff prepared this topographic map of Venus' northern regions. Bright yellow regions are the highest areas, dark orange areas the lowest. The large yellow area near the center is Ishtar Terra, which contains Maxwell Montes, the highest mountains on Venus. This map is being used to help plan the* Magellan *radar-mapping mission to Venus.

Map: United States Geological Survey

FROM THE EDITOR

At The Planetary Society, we're all trying to recover from the activities surrounding *Voyager 2*'s encounter with Neptune. The Society hosted some 15,000 people at Planetfest '89, threw a "wrap party" for the *Voyager* team that was broadcast internationally, and simply celebrated this final visit on the Grand Tour of the solar system. We'll bring you some of the highlights in our next issue.

Page 3—Members' Dialogue—In an organization as large as The Planetary Society, with members from around the world, it's inevitable—and healthy—that those members will disagree with the Society's officers and with each other. With such a diversity of opinion, it's important to listen and consider each other's views.

Page 4—Venus: Behind the Veil—The *Magellan* spacecraft will enter orbit about Venus next August, and planetary scientists are busy preparing by studying in even more detail the information returned by previous missions to the veiled planet. Researchers and map-makers at the United States Geological Survey in Flagstaff have combined data from three sources to produce some spectacular images of Venus.

Page 6—*Galileo*: The Earth Encounters—With the triumphs of *Voyager 2* at Neptune fresh in our minds, it's time to look toward two upcoming flyby encounters by another interplanetary craft. On its way to Jupiter, *Galileo* will make two close approaches to its home planet, giving us a fresh perspective on a world that we must know better.

Page 11—News & Reviews—This column previews our coverage of the *Voyager 2* encounter with Neptune, its rings and satellites. In the next issue of *The Planetary Report* we'll bring you a report on the encounter and related activities conducted by the Society. Next year you'll be receiving a special issue of the magazine dedicated to the amazing scientific discoveries of this doughty little spacecraft.

Page 12—The Case for a Multinational Mars Surveyor Program—President George Bush has committed the United States to landing humans on Mars in the next century. But we have a lot of exploring to do before we are ready to land people on the Red Planet. A crucial early step will be to send roving robots to survey the surface. Scientists and engineers are already busy planning this mission, which can and should be an international endeavor.

Page 16—The *Apollo* Anniversary—On the twentieth anniversary of the day humans first set foot on the Moon, President Bush presented his vision of the United States' future in space. NASA at last has a series of goals by which it can set its course. If the country follows the President's lead, The Planetary Society's initiative to send humans to Mars is now official US policy.

Page 17—Consolidating the Presidential Initiative—While the much-needed goals for the United States' space program have now been set, we still must find ways to implement them. The officers of The Planetary Society have thought long and hard about this, and here are some ideas on how to turn dreams to reality.

Page 18—World Watch—Despite the loss of both *Phobos* spacecraft, Soviet space planners are preparing for another step in the exploration of Mars: The *Mars '94* mission that may carry a balloon probe partly designed by The Planetary Society. We report on their plans and on the controversy surrounding the launch of *Galileo* to Jupiter.

Page 20—Q & A—Determining the age and distance of solar system objects, north and south among the planets and Earthrise from the Moon are some of the topics our readers have been wondering about.

Page 22—Society Notes—We announce the winner of our "Help Design a Mars Rover" contest and report other Planetary Society news.

—Charlene M. Anderson, Director of Publications

Members' Dialogue

As leaders of a membership organization, The Planetary Society's Directors and staff care about and are influenced by our members' opinions, suggestions and ideas about the future of the space program and of The Planetary Society. We encourage members to write us and create a dialogue with us on topics relating to the planetary program, such as the space station, the lunar base and the exploration of Mars.

Send your letters to: Members' Dialogue, The Planetary Society, 65 N. Catalina Avenue, Pasadena, CA 91106.

I was born during the *Apollo* missions and remember as a young child the telecasts of men in puffy white suits bouncing around an oddly lit, rocky landscape. The wonder of space exploration has disappeared from this country. People want to know what good the space program is doing. They don't care about planetary study. They see it as a waste of money because they don't realize the ways that space exploration has benefited them personally and will continue to if it's given enough support. They say, "Let's solve all our problems here before we go into space," as though [space exploration] is frivolous and totally unbeneficial.

The American people need to know how space exploration directly benefits them—and we must hurry, before our government militarizes space and ruins our chances of a good space program with the Soviets.
DAVID GRAHAM, *Cincinnati, Ohio*

As a new member of The Planetary Society I am very surprised by *The Planetary Report's* incessant advocacy of a joint US/USSR Mars mission. It would appear from reading *The Planetary Report* that the Soviet Union is the only worthwhile partner for exploring Mars due to its highly touted space prowess. What I am fairly certain of is that a US/West German/Japanese Mars mission should be considered before making overtures to the Soviet Union. The combined economic and technological potential of the democratic countries of Western Europe and Japan could be a formidable factor in any major space effort.
ANDE RYCHTER, *Vancouver, British Columbia*

The Planetary Society has become synonymous with the push to resume the exploration of space. But its refusal to support space station *Freedom* seems to me to be a grave mistake. Vital to any new human mission initiative in space is the construction of a space station. Although *Freedom*'s present design is not ideal for a Mars mission, it is much closer to this ideal than no station at all. Getting Congress to fund an expensive station designed specifically for supporting a Mars project that entails even more money will be harder than getting it to fund the current station design. Once *Freedom* is in orbit it will be simple to expand it to support a Mars mission.

The call to Mars will probably not come for some years yet, wish as we may otherwise. Both the wait and the cost will increase if NASA does not build its station now. There is a time for idealism and a time for realism, and it is well past time for the Society to promote *Freedom* as is so we can get back on the road to the stars.
JON R. WELTE, *Berkeley, California*

I am getting a little sick and tired of the ongoing bickering among space scientists over the merits of human versus robotic space exploration. This factionalism among our most bril-

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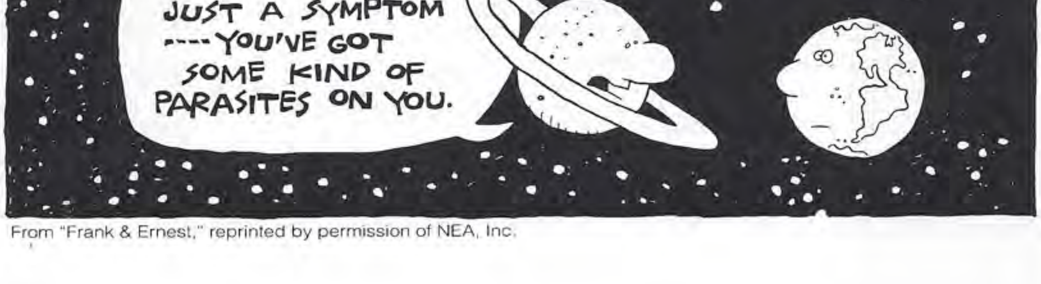


From "Frank & Ernest," reprinted by permission of NEA, Inc.

NEWS BRIEFS

Scientists analyzing photographs from *Voyager* said that they believe they've discovered active ice volcanoes on Neptune's moon Triton. The strange volcanoes appear to have blasted frozen nitrogen crystals into the air, possibly up to 15 miles above Triton's surface.

"I believe these things are occurring now," said planetary geologist Larry Soderblom of the US Geological Survey in Flagstaff, Arizona. He added that the "volcanoes" on Triton appear to be "gentler" than those on Earth. They compare very loosely to geysers but are unique in the solar system.
—from Lee Dye in the *Los Angeles Times*

Pegasus, a winged rocket built to be launched from under the wing of a NASA B-52, was unveiled this summer at Edwards Air Force Base in California. The rocket is designed to carry small satellites into orbit at low cost—about $6 to $8 million per launch.

Because of its adaptation of technology from military missiles, Antonio Elias, the project's chief engineer, called *Pegasus* "a noteworthy example of swords turned into plowshares."
—from the Associated Press

. . . though 22 million miles from Neptune, [*Voyager*] has discovered three previously unknown moons around the planet. We don't imagine that mankind will derive any immediate utility from knowing this. We're certain though, that the mere act of sending this small ship 2.7 billion miles to discover something that the day before had never been known by anyone is an important event. It is proof that mankind's daily problems can't deter its movement forward to

(continued on page 19)

VENUS: BEH

Of all the planets in our solar system, Venus is most like Earth in size, in proximity to the Sun and, we think, in early evolution. These similarities have led many to call it Earth's sister world. Yet until *Mariner 2* flew by Venus in 1962, in humanity's first planetary encounter, we knew little of our planet's closest relation.

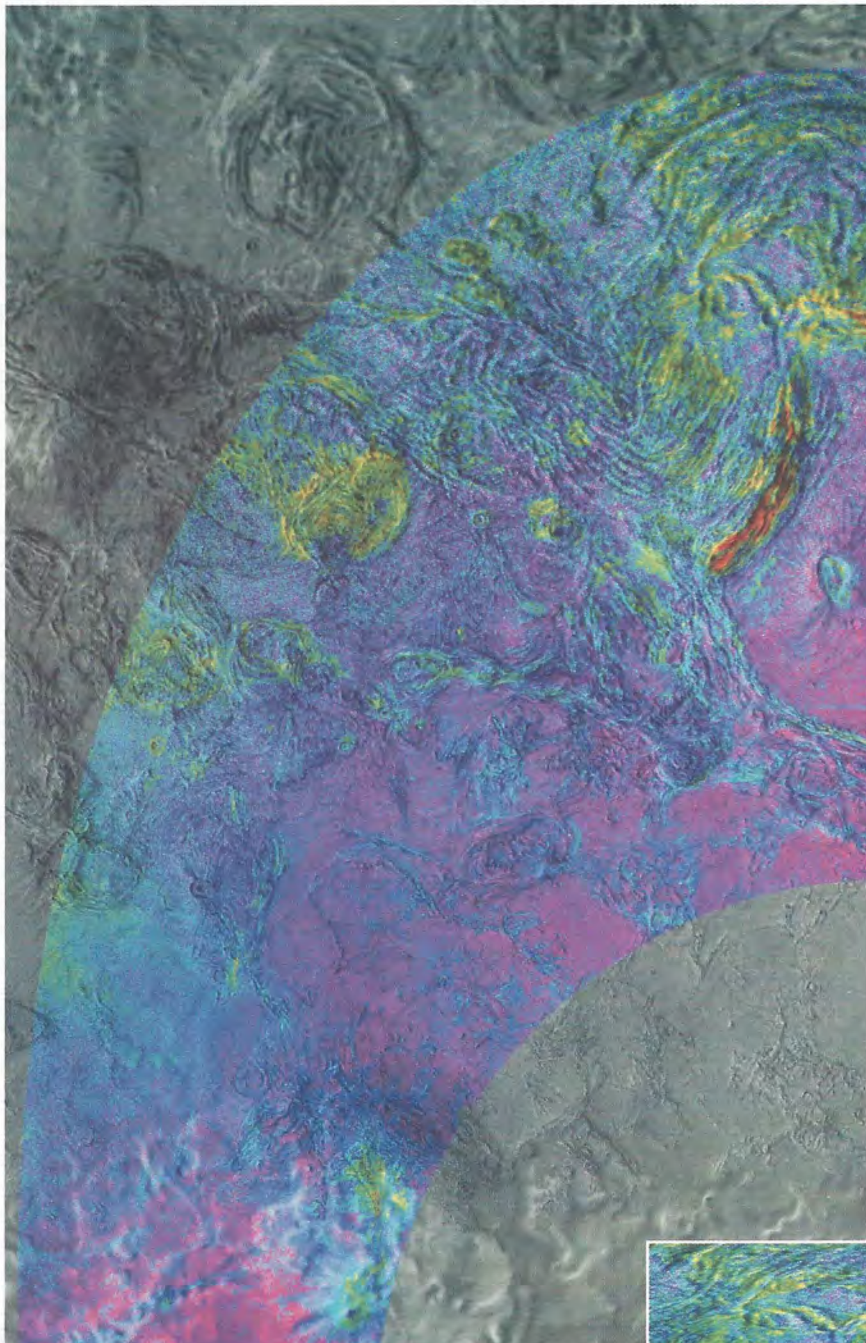
Other worlds, such as Mars with its clear atmosphere or Jupiter with its brilliant banding, reveal much more of themselves to a telescope. Enshrouded in thick, yellowish clouds, which we now know to be made primarily of sulfuric acid droplets, Venus presents an impenetrable face to instruments that observe in visible light. Scientists have had to devise clever and cunning ways to map this planet's surface.

Electromagnetic waves in the radio portion of the spectrum—the sort used in radar—are able to penetrate Venus' cloud cover and reach the surface. The *Pioneer Venus* orbiter, launched in 1978, carried a radar altimeter to record the varying heights of surface features. *Venera 15* and *16* followed in 1983 and, with a technique called synthetic aperture radar, mapped Venus' north polar region, revealing details as small as one kilometer (0.6 mile). Meanwhile, back on Earth, scientists used radar instruments such as the Arecibo radio telescope in Puerto Rico to map the planet and determine the roughness of the surface.

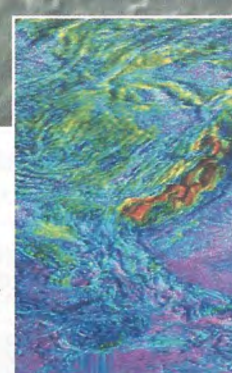
By combining data from all these efforts, workers at the United States Geological Survey in Flagstaff have created this Mercator projection of Venus showing the region from latitude 20 to 80 degrees and longitude minus 110 to 40 degrees. The base is a shaded-relief airbrush map by Pat Bridges, reflecting *Venera* and *Pioneer* data. The colors are derived from Arecibo radar data. The purples and blues represent smooth areas, with the green showing rougher regions; the reddish areas are the most reflective—and therefore roughest.

The reddish areas in this map all lie more than 6 kilometers (4 miles) above the mean level of Venus. In other words, they are the tops of mountain ranges. The most prominent here are the Maxwell Montes (brightest region, right of center), which rise 11 kilometers (7 miles) above the planetary mean.

The smooth plain to the left of Maxwell Montes is Lakshmi Planum, a "continent"



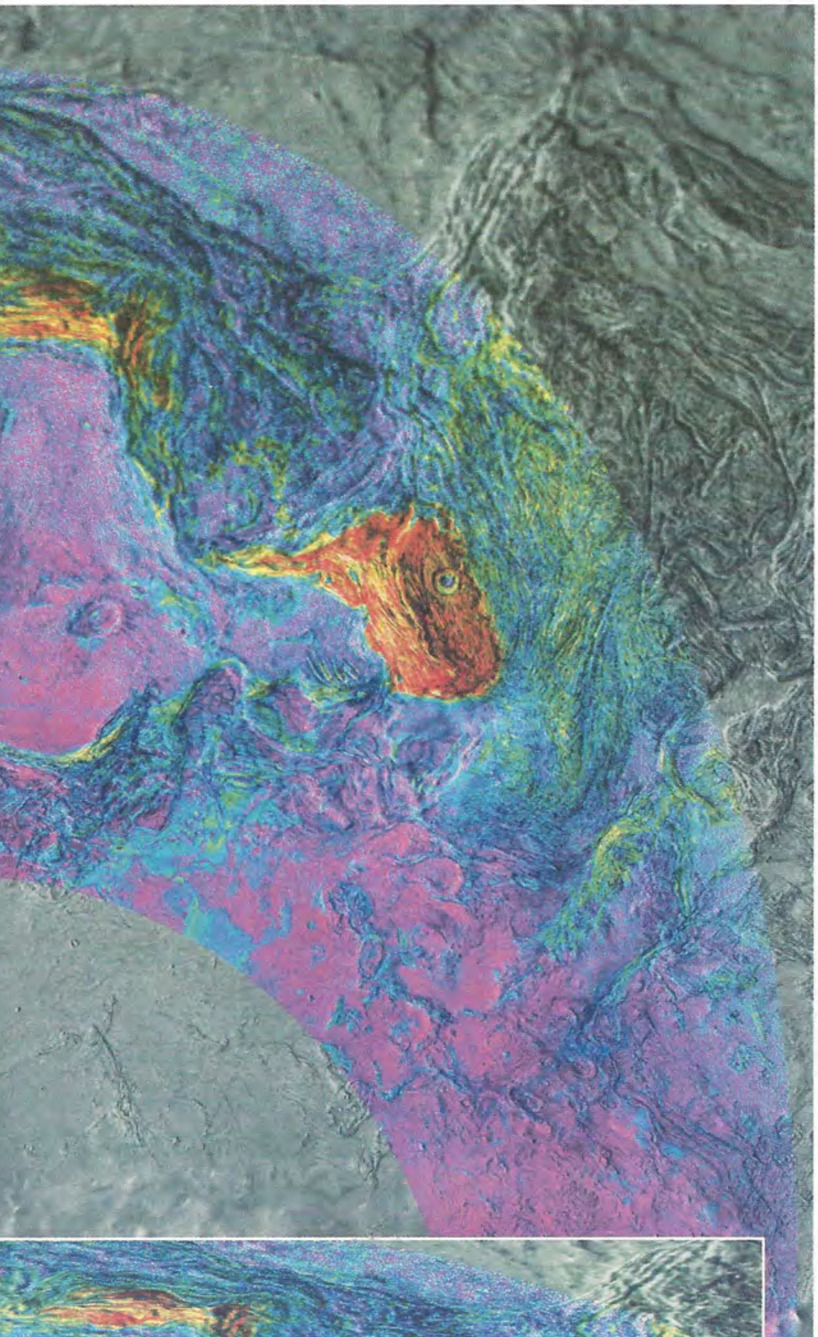
***ABOVE:** Computer processing of data from the US* **Pioneer Venus,** *the Soviet* **Venera 15 and 16** *and the Arecibo radio telescope made possible this Mercator projection of the Lakshmi Planum region of Venus.*

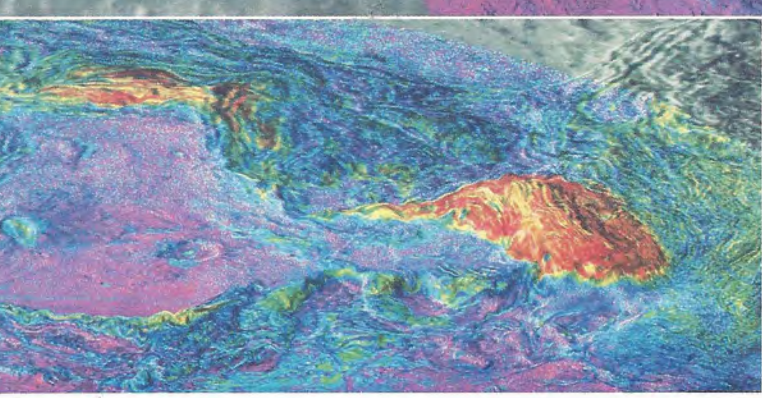


***RIGHT:** This oblique view of the Lakshmi region gives an idea of what an observer might see from 25 degrees above the horizon. To better illustrate the topography, the features are stretched 50 times.*

Image processing by Alfred McEwen, USGS, Flagstaff

IND THE VEIL





about the size of Australia. Lakshmi lies 5 kilometers (3 miles) above the planetary mean. In its center are two large volcanic calderas named Colette (left) and Sacajawea.

To the west of Lakshmi Planum we can see several coronae, which are large, circular or oval features surrounded by concentric ridges. We don't know the origin of coronae, but they are probably related to hot spots in Venus' crust, where molten material from inside the planet wells up to the surface.

The *Magellan* spacecraft is now on its way to Venus, carrying a radar mapping instrument that should increase our knowledge of Earth's sister world. *Magellan* will be able to pick out surface details as small as 120 meters (400 feet) across. At this resolution, the spacecraft may be able to uncover clues to Venus' history, and help us understand how the two sister worlds grew to be so different.

Venus is an example of a planet gone bad, where a massive carbon dioxide atmosphere generated a runaway greenhouse effect, raising the surface temperature to an astonishing 900 degrees Fahrenheit. In Earth's early history, moderation of the amount of carbon dioxide allowed the atmosphere to reach a temperature balance conducive to life.

Studies of the carbon dioxide cycle show that plate tectonics—the recycling of Earth's crust—plays an important role, carrying carbon-bearing rocks down into Earth's mantle, later releasing the gas through volcanic activity. In the *Magellan* data, scientists will be looking for the telltale ridges that could indicate that plate tectonics have played a role on Venus as well as on Earth.

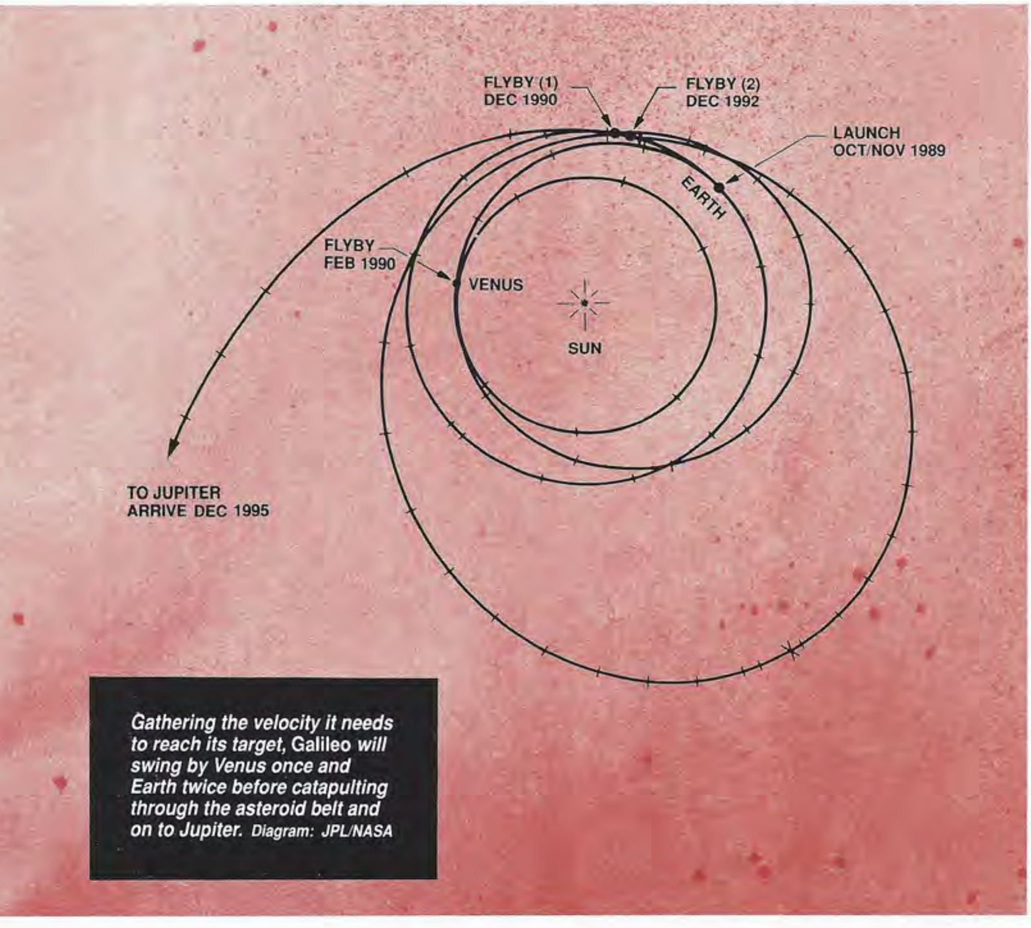
Magellan will also search for traces of ancient shorelines and riverbeds that would betray a distant, wetter past. Some scientists suggest that liquid water might once have flowed on Venus but was eventually boiled off into space by the inexorably warming atmosphere. This hypothesis remains controversial (see the November/December 1988 *Planetary Report*) but *Magellan* could help settle the debate.

In August 1990, *Magellan* will enter orbit about Venus and begin teaching us about our sister world. We have a lot to learn. —*Charlene M. Anderson, Director of Publications*

GALILEO

The Earth Encounters

by Theodore C. Clarke and Fraser P. Fanale



Gathering the velocity it needs to reach its target, Galileo *will swing by Venus once and Earth twice before catapulting through the asteroid belt and on to Jupiter. Diagram: JPL/NASA*

With the sensational exploration of Neptune this past August by *Voyager 2,* every planet in the solar system has now been encountered from deep space by an Earth-launched spacecraft except Pluto . . . and Earth. When *Galileo* thunders off its Cape Canaveral launch pad, the stage will be set for not only one but two extraordinary Earth encounters.

The primary mission of the *Galileo* spacecraft, consisting of an orbiter and an atmospheric probe, is to investigate the planet Jupiter, its magnetosphere and its four Galilean satellites (discovered by astronomer Galileo Galilei in 1610). The Earth flybys were not originally part of this mission, since *Galileo* was scheduled to be launched on a direct trajectory to Jupiter using the space shuttle and the *Centaur* upper stage. After the *Challenger* accident, the space shuttle version of the *Centaur* upper stage was cancelled for safety reasons, and the smaller Inertial Upper Stage (IUS) was designated by NASA for use on *Galileo*. The IUS does not have the power necessary to inject the spacecraft into a direct trajectory to Jupiter. Instead, a series of gravity assists, one by Venus and two by Earth, will sling *Galileo* to its target. On its Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory, *Galileo* will encounter the Earth and the Earth-Moon system first in December 1990 and again in December 1992.

It was not a foregone conclusion that *Galileo* would be allowed to turn on its cameras and sensors during the Earth flybys. One school of thought held that there would be little public or scientific interest, because any Earth observations that might be proposed could be done much better from Earth orbit. Furthermore, it would cost money to plan the encounter sequences, track the spacecraft during the sequences, and distribute, analyze and archive the data obtained. Estimated conservatively, the price tag would be $2 million. Finally, scientists were concerned that Earth-Moon science activities might compromise the primary mission to Jupiter.

On the other hand, maybe the public would be intensely interested in the first-ever encounter from deep space with our own planet. At the least, these unique opportunities were worth a closer look, to see if there was worthwhile science to be done.

Accordingly, *Galileo* Project Scientist Torrence Johnson assigned Fraser Fanale, Chairman of the Satellite Working Group, the task of organizing a workshop to study the Earth-Moon science opportunity provided by the VEEGA trajectory. As a ground rule it was established that the Earth encounter should not in any way compromise the primary mission at Jupiter.

Held at Ames Research Center on May 10, 1988, the workshop developed a prioritized list of science objectives. NASA headquarters then approved plans for the Earth and Moon encounters for both 1990 and 1992.

The observing conditions at the Earth and Moon—that is, lighting and range—are fixed by the Jupiter arrival

Galileo *will fly past the Moon's leading hemisphere, giving us a view of a region that we can't see from Earth. Mare Orientale, a huge, multi-ringed impact crater some 1,000 kilometers (600 miles) across, dominates this hemisphere. The material dredged up by the tremendous force of the impact that created the basin may give us clues to the Moon's interior.*

Image: Lunar Orbiter 4/NASA

date, December 7, 1995, when the moons Io, Europa, Ganymede and Callisto will be properly aligned for a two-year, 10-orbit tour around the jovian system by the spacecraft.

The beginning date of the Earth encounters will be determined by the range of the low-gain antennas that *Galileo* must use while in the inner solar system (the high-gain antenna will remain folded because of thermal conditions). The telemetry rate for the low-gain antennas will be able to support science operations starting when the spacecraft is approximately 45 days from closest approach to Earth (E minus 45 days). At E–45 days, for both of the Earth gravity assists (EGA1 and EGA2), the spacecraft will be approximately 34 million kilometers (21 million miles) from Earth, and the Earth encounter sequence will begin. For both encounters *Galileo* will see principally the dark side of the Earth on approach, passing over the terminator (the line between night and day) when it flies closest to Earth. On departure *Galileo* will see a well illuminated Earth.

Lunar Science Objectives

Far-Side Mapping. Outbound from EGA1, *Galileo* will cross the Moon's orbit and look back to see the well illuminated leading hemisphere of the Moon. In the middle of the leading hemisphere is Mare Orientale, the bull's-eye-like feature with a 1,000 kilometer (600 mile) diameter, centered just south of the lunar equator.

Maps of that part of the lunar surface, not visible from the Earth, date back to the Lunar Orbiter series of spacecraft flown in the mid-1960s. They provided virtually no direct information on soil mineralogy. *Galileo*, with its Near Infrared Mapping Spectrometer (NIMS), can provide the first mineralogical data on lunar features not visible from Earth.

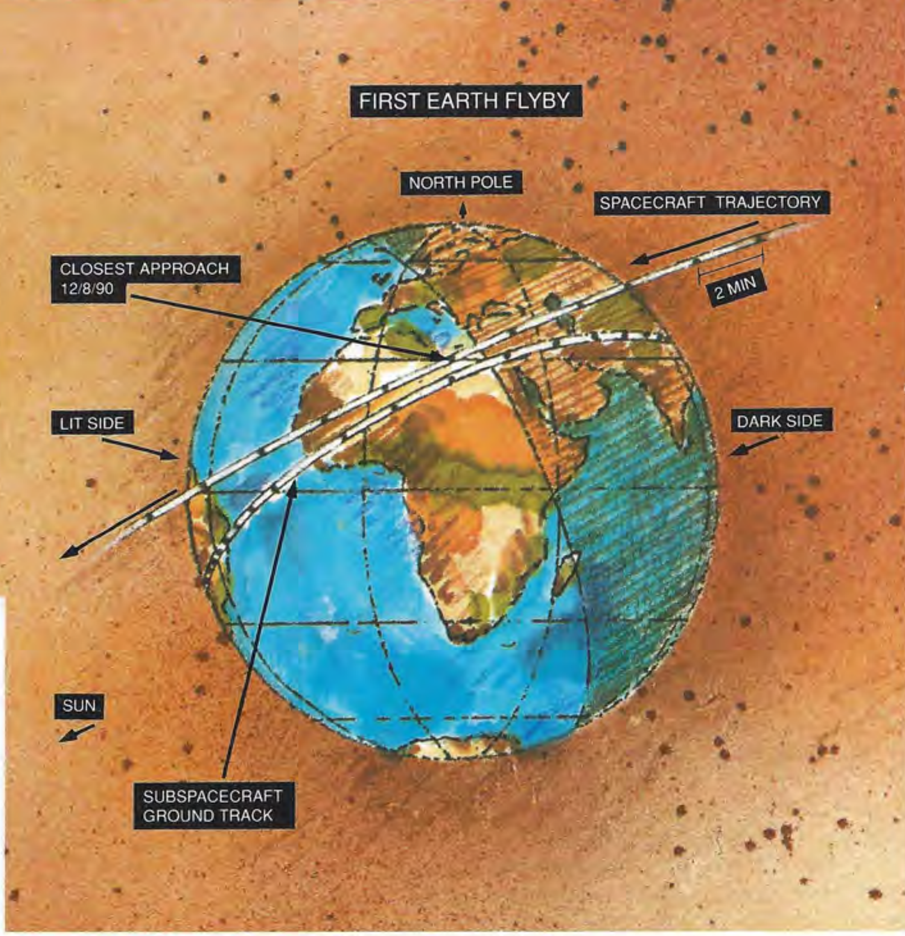
Perhaps the most important opportunity for improving our knowledge of the Moon and its relationship to the Earth will come from these compositional measurements. Mare Orientale, having been formed by an especially high-velocity impact by a very large object, is our best "window" to the deep interior of the Moon. We'll be studying the material in the central peak dredged up by the impact. Data from two experiments—the NIMS and the solid state imaging (SSI, commonly known as the TV)—will be interpreted in tandem and compared to data we already have from the near side of the Moon. We hope to obtain key insights on the evolution of the lunar interior and crust. Then we may come to understand the reasons for the sharp differences in terrain between the far side and the near side of the Moon.

There is a strip south of Orientale, extending from 50 degrees south latitude to the south pole, for which there are no maps, spatial or spectral. *Galileo* will have an excellent view of this strip in the departure phase of EGA1.

Search for Water. The Moon rivals Mercury as the most water-poor body in the solar system. Unfortunately, it is also the body where we would most like to find and use water as a resource. It would be much easier and more cost-effective to maintain a lunar base for human crews if a source of water were available on the Moon.

Resourceful Galileo *mission planners have found a way to turn adversity to opportunity. An almost unbelievable saga of delays and launch-vehicle cancellations has forced the spacecraft to make close flybys of Venus and Earth before traveling on to the jovian system.* Galileo *will turn its powerful array of instruments to its home planet and observe Earth as it has never been seen before. RIGHT: If* Galileo *launches as scheduled on October 13, it will fly past Earth on December 8, 1990 at a distance of 955 kilometers (595 miles). MIDDLE: On December 8, 1992, the spacecraft will make its second Earth flyby, skimming only 305 kilometers (190 miles) above the surface. FAR RIGHT: The loneliness and fragility of our planet can only be grasped from a perspective in space, as we learned when* Apollo *astronauts returned to Earth with photographs such as this.*

Illustrations: S. A. Smith/Photograph: NASA, from Apollo 12



There is a possibility, first proposed by Planetary Society Vice President Bruce Murray, that ice from cometary impacts has been preserved in permanently shaded areas, as in craters near the poles. When *Galileo* passes nearly over the north pole of the Moon during the second Earth encounter, the SSI and NIMS instruments may peer into the craters in a search for water ice. Starlight will have to provide the illumination needed for this investigation, proposed by Carl Pilcher, member of the SSI Science Team.

It is also possible that we could find water on the Moon in the form of hydrates. Such compounds, formed when a substance is chemically combined with water molecules, might have been created by cometary impacts of up to 30 kilometers per second (70,000 miles per hour). Robert Carlson, NIMS Principal Investigator, has proposed that the NIMS instrument be used to search for such hydrated material.

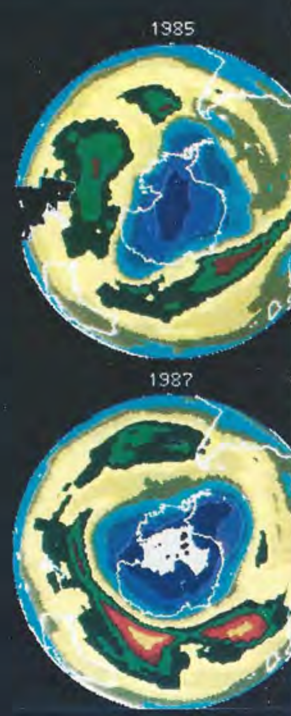
The absence of atomic hydrogen (H) in the lunar atmosphere, as noted by *Apollo 17*, is another potential focus of investigation. This absence suggests that solar-wind protons (positively charged hydrogen atoms streaming from the Sun) have combined to form molecular hydrogen (H_2) at the lunar surface. Charles Hord, Principal Investigator for the ultraviolet spectrometry (UVS) experiment, has proposed UVS observations to search for the existence and extent of a molecular-hydrogen cloud diffusing from the Moon.

Earth Science Objectives

Greenhouse Gases. Carl Sagan, Interdisciplinary Scientist on *Galileo*, proposed global mapping by the NIMS instrument of methane and other important greenhouse gases, particularly chlorofluorocarbons. Such maps could prove powerful in mobilizing public support for action on the greenhouse effect. Sagan also proposed SSI and UVS observations of the ozone hole at the south pole. The south pole will be visible to *Galileo* during departure from the Earth at EGA1. This observation, coupled with similar observations at EGA2, could reveal more exactly the damage to the ozone layer, which protects life on Earth.

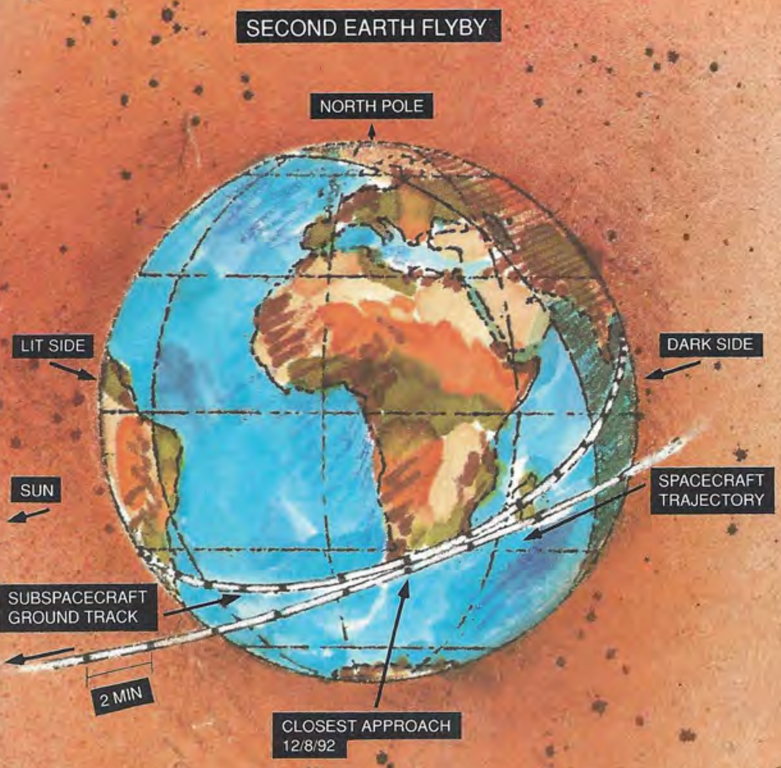
Mesospheric Water. Bob Carlson, NIMS Principal Investigator, suggested NIMS observations in the equatorial regions to search for water clouds in the mesophere, the layer of Earth's atmosphere (above the stratosphere) where temperature decreases as altitude increases. This observation could confirm and quantify the presence of mesospheric water in the equatorial regions, thought to be caused either by thunderstorm-generated clouds rising or by the oxidation of methane.

Magnetotail. There are, for all practical purposes, no measurements of the plasmas (hot, neutral-charge gases) in

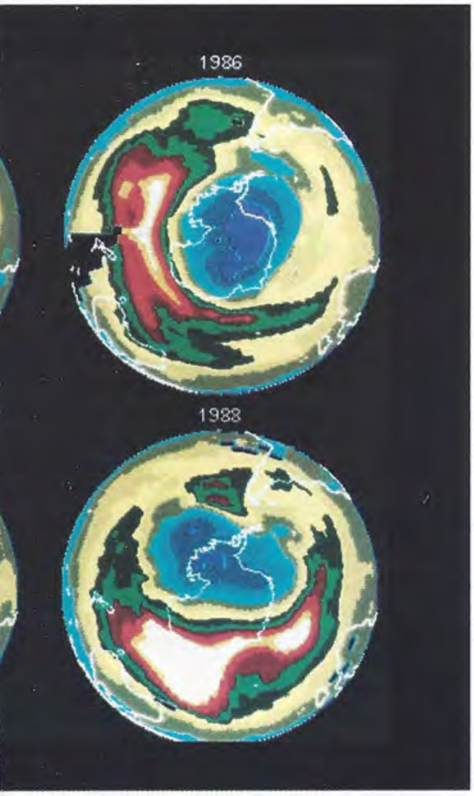


Based on studies of the chemistry in Venus' atmosphere, Sherwood Rowland and Mario Molina were the first to predict that human activities could deplete Earth's protective ozone layer, and satellite data revealed that over Antarctica the layer was indeed thinning. These images from the Nimbus 7 *satellite show variations in ozone, with the thinnest region in purple and the thicker regions in red, orange and white. The lowest recorded level was reached in October 1987.* Galileo *should help us better understand this process.*

Images: Goddard Space Flight Center, NASA



the furthest reaches of Earth's magnetotail (the tip of our planet's magnetosphere, blown into a teardrop shape by the solar wind). Since the spacecraft will fly right down the magnetotail during the first Earth encounter, Louis Frank, Principal Investigator of the plasma science (PLS) experiment, suggested that measurements with the fields and particles instruments could provide advance information useful for Japan's GEOTAIL mission, scheduled for the mid-1990s, and could thereby help refine GEOTAIL observational strategies.



We know from Earth-orbiting spacecraft that there is a tail of neutral-charge hydrogen blowing from the Earth in the anti-sunward direction. As explained by Joseph Ajello, member of the UVS Science Team, this tail is formed as fast-moving protons in the solar wind crash into slower-moving hydrogen atoms in the Earth's exosphere; the protons pick up electrons, thereby becoming neutral, as they continue onward to form the tail. Charles Hord, UVS Principal Investigator, proposed a UVS observation to measure and characterize the extent and nature of this hydrogen tail, thought to extend over half the distance to the Moon.

Airglow. Earth's atmosphere is alive with multicolored changing glows caused by the interaction of the Sun's ultraviolet radiation with electrically neutral components in our atmosphere. This interaction results in an ultraviolet fluorescence, or "airglow," from which we can learn more about the composition of our atmosphere. Coming in from deep space, *Galileo*'s UVS instrument will be looking for abundances of atomic hydrogen, atomic oxygen and molecular hydrogen gas.

Earth's Mass. Using *Galileo*'s radio, John Anderson, Team Leader for the Radio Science Celestial Mechanics Team, will be able to obtain the most accurate measurement yet by a spacecraft of the mass of the Earth. This super-refined measurement will improve our understanding of subtle perturbations acting on other bodies in the solar system; it will also aid in the design of future gravity-assist missions.

We owe our method for determining the mass of a planet to Isaac Newton, who showed that the acceleration of a small body, when acted on by the gravitational force of a larger body, is directly proportional to the mass of the larger body and inversely proportional to the square of the distance between them. Thus by determining *Galileo*'s acceleration and range, we can calculate the mass of the "larger body," Earth.

We'll determine the range by timing how long it takes radio waves, which travel at the speed of light, to go from the deep-space transmitter on Earth to *Galileo* and back to Earth. We'll determine *Galileo*'s rate of acceleration from the Doppler shift in the frequency of its radio transmissions: that is, as *Galileo* hurtles toward the Earth, the very stable frequency of its signal will seem to be slightly higher at our receiving station, in the same way that the pitch of a train whistle sounds higher to a person standing in the train station as the train approaches than it would if the train were at rest.

The Earth-Moon Movie. Finally, there is the movie. On the inbound trajectory, starting 40 days and approximately 30 million kilometers (20 million miles) from closest approach to Earth, *Galileo* will record several 8-hour segments of Earth rotating and the Moon orbiting past the Earth. At this range, the Earth and the Moon will appear as thin crescents in the blackness of space, and the Earth will be about 1/20th the size of the TV frame. These far-encounter photos will be only a taste of what is to come.

At closest approach (1,000 kilometers, or 600 miles, above Egypt at EGA1 and 300 kilometers, or 200 miles, above South Africa at EGA2) the Earth will more than fill the SSI camera's field of view. After closest approach, when lighting becomes favorable, we are planning a continuous movie of 5 days' rotation.

It expands the imagination to contemplate the effects a speeded-up movie of the Earth rotating on its axis, and the Moon orbiting past the Earth, might have on the people of our planet. Carl Sagan has said that "a continuous movie of the Earth, which begins with the Earth as a barely recognizable blue-white crescent, and ends, say, on the steps of the Lincoln Memorial, would be memorable beyond any motion picture ever taken by NASA."

NEAR-EARTH SCIENCE

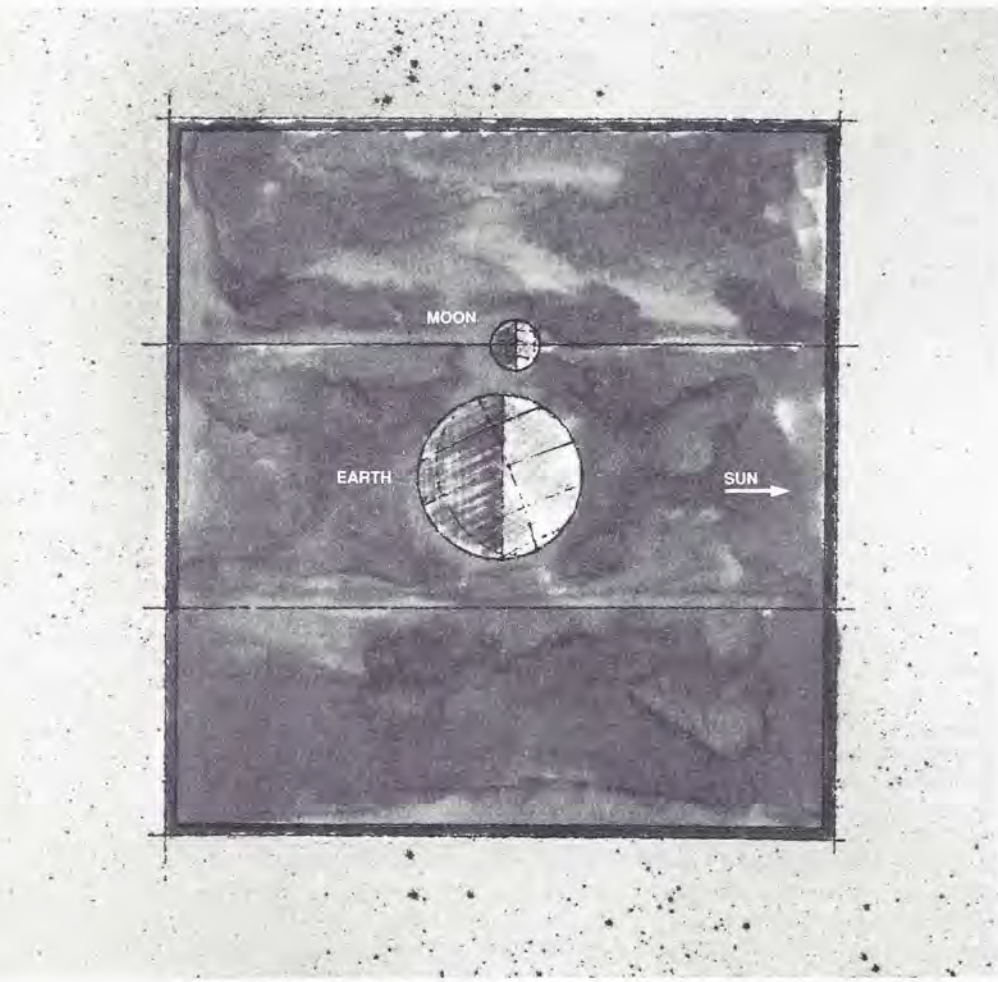
Comet Barrage? Louis Frank of the University of Iowa startled the scientific world a decade ago when he proposed, based on *Dynamics Explorer* data, that the inner solar system was being bombarded by small comets. According to Frank, now Principal Investigator of *Galileo*'s plasma science experiment, these comets have diameters of approximately 10 meters (30 feet) and a consistency like fluffy snowballs.

If the flux of small comets has been as great as suggested—raining down on the Earth at a rate of 10 million per year—the moisture introduced into the atmosphere over the last 4.6 billion years could account for the Earth's oceans. This possibility runs contrary to the accepted wisdom that our oceans derive from within the Earth or from a comet barrage that ended in our planet's earliest history.

Clayne Yeates, Science Manager of the *Galileo* Project, claims to have observed these small comets early in 1988 with the CCD telescope at the Kitt Peak National Observatory. If small comets have been streaming into the Earth-Moon system at the rate suggested by Frank, and apparently observed by Yeates, then we should find a large, tenuous, steady-state atmosphere of water vapor diffusing from the Moon. Such a water cloud would surround the Earth-Moon system with a huge hydrogen halo measurable by the UVS. We would also expect to find, as a result of dissociation of the water vapor, the relatively short-lived hydroxyl radical (OH), which can also be measured by the UVS.

An even higher priority observation in the search for evidence of small comets is the measurement of hydrogen as a function of distance from the Sun. The halo, if it exists, would cause hydrogen readings to increase as *Galileo* nears the Earth-Moon system to levels much greater than the background hydrogen constantly streaming through the solar system. Resolution of the comet question, which has inspired heated scientific debate, awaits *Galileo*'s first Earth encounter.

While the Earth has been studied from near-Earth space for many years, the *Galileo* Earth encounters are certain to offer a new perspective. Many months of careful consideration and analysis have gone into the observations and expectations discussed here. Yet we have every reason to believe there will be some surprises at the Earth encounters, and we will come to know our world, in a way, for the first time.



Galileo *mission planners are already designing spacecraft procedures that will produce the first "movie" of our Moon orbiting Earth. Over a period of 14 hours, the Moon will travel across the camera's field of view, which in this frame covers an area 48,000 kilometers (29,000 miles) across. At this point in* Galileo*'s journey, it and the Moon will be on the same side of Earth. In 1977, preceding* Galileo *to Jupiter,* Voyager 1 *took the only image of Earth and the Moon together.* *Illustration: S.A. Smith*

Theodore C. Clarke is Team Chief of the Galileo *Science Data Team. Fraser P. Fanale is Chairman of the* Galileo *Satellite Working Group.*

News & Reviews

by Clark R. Chapman

As *Voyager 2* sailed beyond Neptune for the stars, it left a legacy unrivaled by any previous spacecraft. Earlier missions have revealed intriguing worlds, comparatively near our own, but the richest discoveries about the diversity of moons and planets have been those of *Voyager*, two exquisitely instrumented probes that have completed a total of six encounters with the systems of Jupiter, Saturn, Uranus and Neptune.

As *Voyager* Project Scientist Ed Stone said at the August 29 press conference at the Jet Propulsion Laboratory (JPL), "Whenever you go someplace you haven't been before, there is always something waiting there to be discovered, something unexpected." Neptune did not disappoint.

Early this year *Voyager 2* found the Great Dark Spot, and it seemed that Neptune might be more like intricate Jupiter than like bland-faced Uranus, its nearest neighbor. Yet Neptune's aspect turned out to be entirely new. The Great Dark Spot sloshed around the planet, almost like a thing alive, and along with it went the white, cirrus-like "companion." *Voyager* atmospheric scientists struggled to find other spots that would last long enough to have their motions measured. Finally, beautiful pictures of cloud shadows, combined with detailed data from the remote-sensing instruments, provided a good view of the structure of Neptune's deep atmosphere. As *Voyager 2* went on its way, scientists remained perplexed as to how hundred-mile-an-hour winds could be sustained by the paltry energy Neptune receives from the Sun or the only slightly greater energy upwelling from the planet's interior.

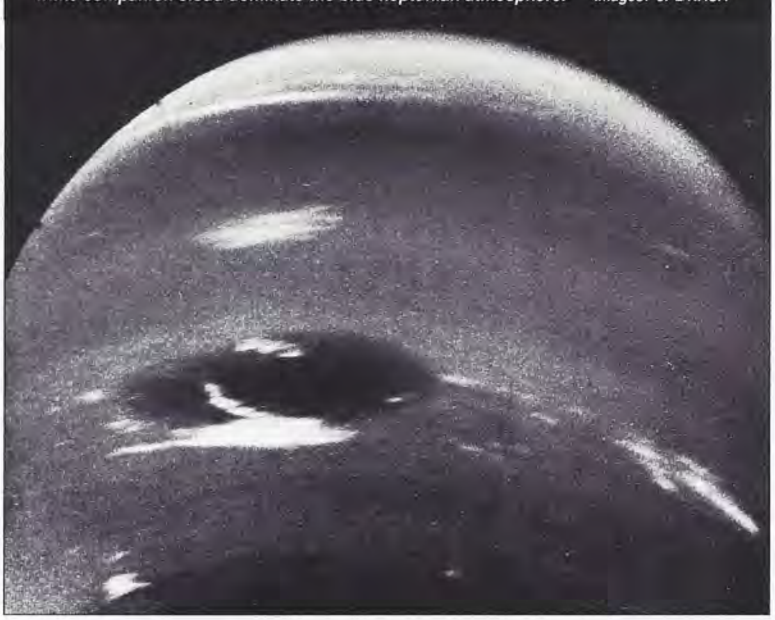
The star of the show on encounter night was certainly Triton. Scientists at JPL, Planetfest celebrants and people around the world saw stunning pictures of a gleaming pinkish-white (though dimly lit) world, where water ice behaves like rock, and frozen nitrogen and methane play a role that water and water ice do on Earth.

The possibility of ongoing eruptions of nitrogen-ice crystals, suggested by some darkish patches near the boundary of Triton's nitrogen ice cap, was the most exciting development during encounter. As Triton's southern hemisphere turns ever more sunward during its seasonal cycle, subsurface deposits of nitrogen may explode through "volcanic" vents, spraying the darker material dozens of miles downwind. Some *Voyager* scientists found it difficult to imagine that such icy-artesian volcanism was *not* occurring: *Voyager 2* detected clouds near some of the dark patches, suspended in Triton's exceedingly thin air (with only 1/1000th the surface pressure of the martian atmosphere). But in the best scientific tradition, *Voyager* scientists began the long process of rigorously studying all possible alternatives.

For now, we know what Neptune and Triton look like (and 1989 N1, too), but much more study is needed before we can confirm any of our first impressions and ideas. For example, is Triton a remnant planetesimal like those from which the cores of the gas-giant planets accreted? And, if Triton was captured into orbit around Neptune, why did its subsequent orbital evolution fail to disrupt the little, regular neptunian satellites discovered by *Voyager 2*?

With cratered moons, ring arcs, rings, ring sheets, auroras, a remarkably off-center and tipped magnetic field, and a fantastic set of data from 11 instruments (the radio science team alone had to deal with 992 pounds of magnetic tape), the scientific analysis is only beginning. Understanding will come eventually—and the excitement of discovery will return—in the comparison of all the finally reduced data in the months and years to come.

TOP: What are these dark spots marring Triton's icy surface? Voyager *scientists are sifting volumes of data for answers. BOTTOM: The Great Dark Spot and its bright white companion cloud dominate the blue neptunian atmosphere.* Images: JPL/NASA



Clark R. Chapman will provide an in-depth review of Voyager*'s Neptune encounter in a forthcoming issue.*

THE CASE FOR A MULTINATIONA

SOMEDAY A ROBOTIC ROVER WILL GATHER SAMPLES OF MARS THAT A ROCKET-LAUNCHED CRAFT WILL RETURN TO EARTH.
PAINTING: MICHAEL CARROLL

To continue the exploration of Mars we need a series of robotic missions, proposed as the Mars Surveyor Program. Elements of this program are being studied not only by the US and USSR but also by other countries and by the European Space Agency. However, these studies have been conducted in isolation from one another. They should be brought together in a coordinated multinational program.

Mars holds a unique place in the popular imagination. Mars was for a long time a favorite subject of science fiction because many supposed that its climate was benign and that it harbored intelligent life. These conjectures were rudely shattered by the *Mariner* and *Viking* missions, which discovered a barren planet with only a thin atmosphere. The *Viking* landers found no evidence of life or organic matter in the soil.

However, scientific interest in Mars has increased as we learn more about the planet. Analyses in recent years have concluded that the environment on early Mars may well have been conducive to the formation of life. Thus the search for evidence of early martian life has become an important exploration objective.

The continuing interest in the exploration of Mars is reflected in the planning and development of flight projects. Most recently the USSR sent an ambitious mission to the martian moon Phobos, though the mission failed before accomplishing the primary objective of placing landers on the surface of Phobos. The USSR is now developing a mission for 1994 that includes an orbiter, surface penetrators, miniature meteorological and seismological stations, and balloons that will be transported over the surface by winds. The US will launch *Mars Observer* in 1992 to study the planet's surface and atmosphere. Planning is under way in both countries for follow-on missions, ultimately to include piloted missions.

Human missions will be very cost-

L Mars Surveyor Program

BY D. G. REA, M. H. CARR AND M. K. CRAIG

ly and will require careful preparation. To make such missions worthwhile, we must select landing sites where the unique capabilities of human explorers will most likely result in major discoveries. These sites must be well characterized in advance to assure safe operations. Also, we need to test and prove technologies to make human flight to Mars possible.

Will We Find Life?

The fascination with Mars grows out of the possibility that some form of life may have existed there and the probability that humans will eventually go there. The *Viking* mission showed that indigenous, present-day life is unlikely.

The biology experiments failed to detect any evidence of biologic activity in the soil, and the gas chromatograph/mass spectrometer detected no complex organic molecules (despite sensitivities in the parts per billion range). Organic molecules in the martian soil are, apparently, destroyed by the combined action of the Sun's ultraviolet radiation and oxidizing constituents in the soil. The materials analyzed by the two *Viking* spacecraft are probably typical of much of the planet's surface, so most biologists have concluded that there is no life on Mars today.

Liquid water, which is universally regarded as an essential for life, cannot normally exist at the martian surface —temperatures are much too cold. The only places where liquid water might be found are local anomalies, such as volcanic hot springs. Even there, liquid water could survive only temporarily.

When Mars Was Like Earth

The prospects for life earlier in the planet's history were much brighter. When we look back in time to when life started, conditions on Mars and Earth may have been quite similar. Branching, waterworn valleys are common throughout Mars' most ancient terrains, where the heavy cratering dates back some 3.5 to 3.8 billion years. Since these valleys are far less common in younger terrain, we can infer that liquid water was abundant very early in Mars' history and that conditions then changed so that water became extremely scarce. One likely explanation is that Mars had a thick carbon-dioxide atmosphere long ago that kept surface temperatures relatively warm. But gradually the atmosphere thinned and temperatures fell as carbon dioxide reacted chemically with materials at the surface, forming carbonates.

When life on our planet began, the Earth was warm and water-rich, with an atmosphere abundant in carbon dioxide and nitrogen; it also had high rates of volcanism and meteorite impacts. The evidence suggests that all these conditions prevailed on Mars at the same time. Did life also get started on Mars? This is a fundamental question underlying the future of Mars exploration. It is also a question that can be readily answered, since water-strewn sediments should be common throughout the ancient terrains of Mars. Even if we don't find fossils, the sediments will retain chemical and physical evidence of any former biological activity.

Life Without Light?

Riverbeds are not the only places to search as we pursue some intriguing possibilities about what happened after conditions on Mars changed and the planet became more hostile to life. Recently, a class of organisms has been found on Earth whose life cycle does not depend on sunlight. These chemolithoautographs live in undersea hot springs by metabolizing sulfates, carbon dioxide and other locally available compounds. The nucleotide sequences on their RNA suggest that they are extremely primitive life forms.

If life did get started on Mars, could it have survived in volcanic hot springs, well below the surface, protected from the ultraviolet radiation and oxidizing surface conditions? Mars has been volcanically active throughout its history, and we know that volcanic systems are far more stable on Mars than on Earth. One aim of future Mars exploration should be to look for evidence of life in areas of past or present hydrothermal activity, to see if life was able to survive in these more hospitable locations.

Geology on a Grand Scale

Mars has plenty of science to offer apart from its possible biology. After Earth, it is the most diverse of all the planets geologically. Moreover, its observable record spans almost the whole of geologic time, unlike the mostly ancient record on the Moon and the relatively young record on the Earth.

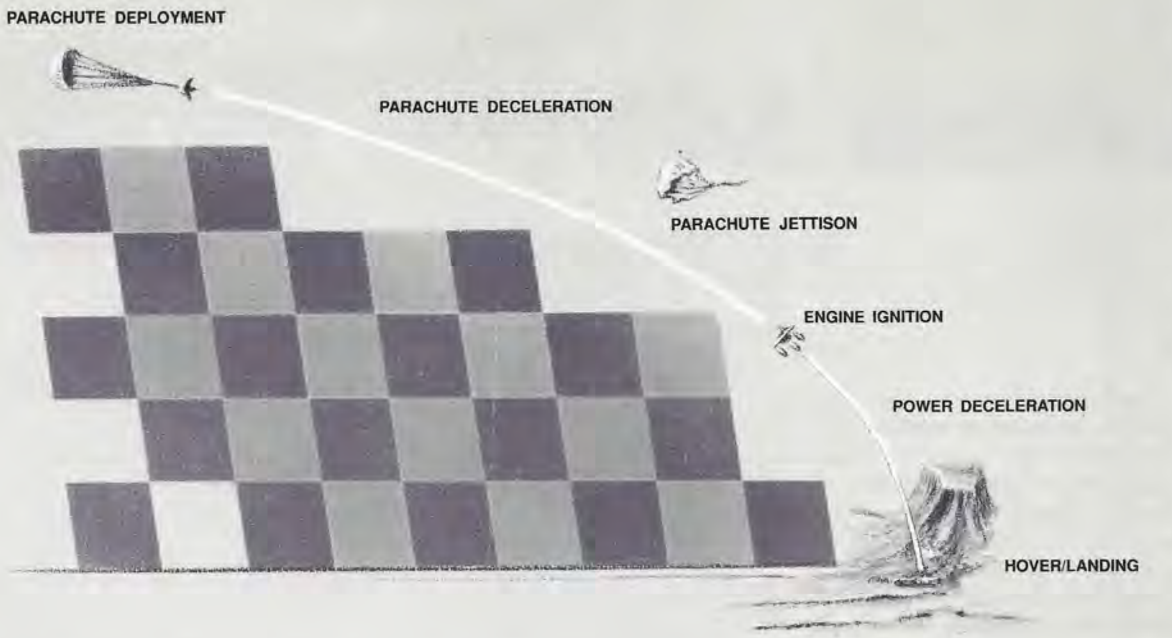
Almost every geologic process known on Earth has been at work on Mars, although under very different conditions. Mars has been shoved and shaped by a varied volcanic history; its features have undergone widespread deformation in response to regional and local stresses; and the surface has been carved by wind, water and ice.

The major geologic differences between Mars and Earth result from the absence of plate tectonics on Mars and the scarcity of liquid water through most of that planet's history. On Earth, the continent-size plates that make up the crust are in constant motion, causing mountain chains and ocean deeps to form at their boundaries. On Mars, the lack of such plate tectonics has resulted in the steady growth to enormous size of features such as volcanoes and canyons. Scarcity of running water has resulted in little erosion compared with that on Earth.

Thus, what we'll see as we explore Mars is a dramatic landscape—volcanoes, canyons, dry riverbeds, dune fields, regional upwarps, large impact craters—all on an unparalleled scale. These features will yield valuable clues as to how the planet formed, how its internal evolution differed from that of Earth and how climate conditions on the surface have evolved over time.

Martian Meteorology

Atmospheric science is another focus of interest on Mars. As on Earth, atmospheric circulation depends on a variety of seasonal factors, such as the winter/summer change in the angle of the Sun with respect to the equator, dimensions of the polar caps, and the amount and distribution of suspended dust. Directly examining the atmosphere of another planet will offer us new understanding



In one possible landing sequence for the Mars rover mission, a parachute will slow its entrance into Mars' thin atmosphere. An engine will ignite, further slowing the craft and enabling it to hover over the surface while searching for a safe landing site.
Illustration: S.A. Smith

of each of these factors, and will enable us to test circulation models over a much wider range of variables than is possible with terrestrial studies alone.

In addition, we'll have a close-up view of climatic changes caused by variations in Mars' obliquity (the tilt of a planet's equator from the Sun). On Earth, obliquity variations of only a few degrees are thought to have been a major cause of the ice ages. On Mars, the obliquity varies by as much as 20 degrees, and we may find proportionately larger effects.

Getting to Mars

Mars will be the first planet visited by humans, not only because of its great interest for us but also because of its accessibility.

It's not too far away, by solar system standards. The most energy-efficient trip would take about one year each way, but that time could be reduced significantly if we sent a spacecraft that used more energy.

Once we're there, Mars has the advantage of being relatively easy to explore, by humans or robots. The atmosphere is clear through most seasons, and conditions on the surface are benign compared with other planets. Average daily temperatures compare to arctic winters here on Earth, in marked contrast to the furnace-like temperatures on Venus.

Mars also has resources that could be used to support long expeditions. We could extract oxygen from the carbon dioxide in the atmosphere. Water ice, likely to be abundant at high latitudes, could be used by humans for drinking and food preparation and could also be used to grow food. We'll go to Mars first because no other planet combines easy access, a relatively hospitable surface and potential resources.

Mars Surveyor: Robot Scouts

A robotic Mars Surveyor Program should precede human exploration. Although our knowledge of Mars has expanded greatly in the space age, there is much we still need to know before we can design and implement human exploration missions. As noted previously, we need to select landing sites that hold promise for the discovery of evidence of early martian life.

As we decide where to land, we'll also have to decide how to land our spacecraft safely on the martian surface. The design demands (weight versus fuel) on a launch vehicle for human missions will be extreme. We can mitigate these demands considerably by making the most efficient use of the atmosphere of Mars in slowing the descent of our spacecraft. This technique, called aerocapture, will require a good understanding of the atmosphere at altitudes between 25 and 70 kilometers (15 and 40 miles), a range where increasing density is critical to stopping power. Without such knowledge, the aerocapture design will have to be based on the most conservative estimates, and the benefits (up to 50 percent of the spacecraft mass) will be diminished.

To design landing systems and human bases, we will need to understand surface hazards, including boulders, small craters, stream channels and dust fields that only appear to be solid. For extended human habitation we'll also need to search for martian resources that can be used over the long term for vehicular propulsion and maintaining the station. For example, experiments are in progress for separating carbon dioxide into carbon monoxide and oxygen, which could be used as rocket propellant. A key issue in the design of the life support system is the composition of the ubiquitous dust. If it has toxic properties, then extreme care must be taken to assure that it is not ingested by the astronauts. Even if it is non-toxic, the dust could pose a problem for mechanical joints and filters. Another important question is whether remains of martian life might contaminate Earth.

Acquiring all this information requires a combination of remote sensing, on-site observations and analysis of samples returned to Earth; these are the components of a Mars Surveyor Program.

Mars Surveyor: Robotic Rehearsals

A Mars Surveyor Program, in addition to gathering the advance information we need, will also demonstrate the technology critical for the safety and success of human exploration. Aerocapture, for example, should be tested and proved by robotic flights. Another key technique to develop is landing: that is, being able to avoid surface hazards and land within a few meters of a desired point.

Once on the martian surface, human explorers must be able to travel to sites of interest, which will require vehicles of some kind. Mobility techniques need to be demonstrated robotically before they are designed into systems on which humans depend. Robotic rovers will also be used to extend the range of exploration even further.

The demonstration phase of a Mars Surveyor Program should also encompass automated launch from Mars, autonomous rendezvous and docking in Mars orbit, and the handling and isolation of samples for return to Earth.

When humans go to Mars, they will need a supporting infrastructure: communications orbiters, imaging orbiters, robotic rovers, geophysical/meteorological stations and navigation aids. The Mars Surveyor Program, in the course of performing research and demonstrating technology, will provide opportunities to put some of the support equipment in place before humans arrive.

How Will We Manage?

Operations at Mars will pose a set of new problems in management. For example, the distance to Mars is going to affect communications, which in turn has wide-ranging consequences for mission control and planning. The greatest distance people have traveled to date is the Moon, with a round-trip time of about 3 seconds for radio signals. The corresponding time for Mars is as great as 44 minutes. For the safety of our human explorers, it is essential that we anticipate and become familiar with organizational problems never before encountered.

Thus the final but by no means least important justification of robotic missions is the management experience to be gained. Human exploration of Mars will probably be multinational and will involve two or more NASA centers. The total management organization will be, to say the least, complex. The Mars Surveyor Program will enable participants to develop and refine the management relationships and techniques that will eventually be used to support human exploration.

Multinational Rationale

Of the many reasons for making the Mars Surveyor Program a cooperative venture among several nations, the most obvious is cost. The two leading players in Mars exploration are the US and the USSR, and each country is experiencing budget pressures on its space programs. These pressures are not likely to ease for years, unless there is an unexpectedly sharp decrease in spending on defense.

Meanwhile, with the economic strength of Japan steadily increasing, and the economic unification of western Europe slated for 1992, two more potential partners will soon be in a position to assume major roles in space exploration. A pooling of resources in a joint program of exploration makes economic sense for all.

The multinational approach is equally convincing when viewed from the standpoint of world politics. Of necessity, banding together to explore Mars must have a positive influence on our ability to coexist peacefully on our own planet. The interdependence of spacefaring nations will be institutionalized as we mount the expedition, and it will demonstrate that similar cooperative relationships can and should exist in other areas of world society.

Interdependence will create major challenges, particularly in the early stages of a new endeavor. Confidence among the parties must be established; it cannot be assumed at the outset.

Some may balk at the transfer of technology, fearing that US computers, for example, might be adapted by the USSR to military uses. The flight systems comprising a Mars Surveyor Program can be designed and coordinated in a manner that minimizes such problems. In effect, we can design flight systems to be compatible but independent, so that the failure of one will not have a fatal effect on any other.

The physical interfaces need only involve the transfer of samples, the stacking of flight systems on board launch vehicles and the transport of one system by another. None of these is complex, and none requires technology transfer.

Space data systems will pose major challenges for a multinational endeavor. The flight systems will be built by two or more countries; telecommunications stations will be provided by several countries; and the ground systems and data analysis will be likewise shared. Thus uniform standards must be adopted so that the entire information system functions as an effective, coordinated whole. The standards developed by the Consultative Committee on Space Data Systems (CCSDS), an international body established in 1982, have been adopted by most of the world's space organizations. The USSR should become a member of CCSDS and adopt its standards.

In this discussion we have tried to show that our eventual exploration of Mars should begin with a robotic surveyor program prior to human flights and that a multinational approach is both desirable and feasible. The next step is a decision to initiate a study involving all interested countries, so that we may decide jointly on objectives, timetables and responsibilities.

The surface of Mars has been etched with scars cut by a complex geologic past. Volcanism, fractures and faults, wind and even running water have all left their traces. A roving robot explorer could teach us much about this fascinating planet. Image: JPL/NASA

In his speech commemorating the 20th anniversary of the *Apollo* Moon landing, President Bush directed Vice President Quayle "to lead the National Space Council in determining specifically what's needed for the next round of exploration—the necessary money, manpower and material—the feasibility of international cooperation . . ." The robotic program, an integral precursor to the human exploration phase, can function as a testing ground to develop and demonstrate international collaboration. This experience will be invaluable in the evolution of plans for the exploration of Mars by humans.

Donald G. Rea is Manager, Mars Rover Sample Return, Jet Propulsion Laboratory. Michael H. Carr is a Geologist at the US Geological Survey. Mark K. Craig is Deputy Manager, Mars Rover Sample Return, at NASA's Johnson Space Center.

The *Apollo* Anniversary

Excerpt from the Address by President George Bush

July 20, 1989

The *Apollo* astronauts left more than flags and footprints on the Moon. They also left some unfinished business. For even 20 years ago, we recognized that America's ultimate goal was not simply to go there and go back—but to go there and go on.

Mike Collins [*Apollo 11* astronaut] said it best: "The Moon is not a destination—it's a direction."

And space is the inescapable challenge to all the advanced nations of the Earth. And there's little question that, in the 21st century, humans will again leave their home planet for voyages of discovery and exploration. What was once improbable is now inevitable.

The time has come to look beyond brief encounters. We must commit ourselves anew to a sustained program of manned exploration of the solar system—and yes—the permanent settlement of space. We must commit ourselves to a future where Americans and citizens of all nations will live and work in space.

And today, yes, we are, the US is the richest nation on Earth—with the most powerful economy in the world. And our goal is nothing less than to establish the United States as the preeminent spacefaring nation.

From the voyages of Columbus to the Oregon Trail to the journey to the Moon itself, history proves that we have never lost by pressing the limits of our frontiers.

Indeed, earlier this month, one news magazine reported that *Apollo* paid down-to-Earth dividends—declaring that man's conquest of the Moon "would have been a bargain at twice the price." And they called *Apollo* "the best return on investment since Leonardo da Vinci bought himself a sketch pad."

In 1961, it took a crisis—the space race—to speed things up. Today we don't have a crisis. We have an opportunity.

To seize the opportunity, I'm not proposing a 10-year plan like *Apollo*. I'm proposing a long-range, continuing commitment.

First, for the coming decade—for the 1990s—Space Station *Freedom*, our critical next step in all our space endeavors.

And next—for the new century—back to the Moon. Back to the future. And this time, back to stay.

And then a journey into tomorrow, a journey to another planet—a manned mission to Mars.

Each mission should—and will—lay the groundwork for the next. And the pathway to the stars begins, as it did 20 years ago, with you—the American people. And it continues just up the street there—to the United States Congress—where the future of the space station and our future as a spacefaring nation will be decided.

And yes, we're at a crossroads. Hard decisions must be made now as we prepare to enter the next century.

As William Jennings Bryan said just before the last turn of the century: "Destiny is not a matter of chance, it is a matter of choice. It is not a thing to be waited for, it is a thing to be achieved."

And to those who may shirk from the challenges ahead or who doubt our chances of success, let me say this:

To this day, the only footprints on the Moon are American footprints. The only flag on the Moon is an American flag. And the know-how that accomplished these feats is American know-how. What Americans dream—Americans can do.

And 10 years from now—on the 30th anniversary of this extraordinary and astonishing flight—the way to honor the *Apollo* astronauts is not by calling them back to Washington for another round of tributes. It is to have Space Station *Freedom* up there, operational, and underway—a new bridge between the worlds—and an investment in the growth, prosperity and technological superiority of our nation.

And the space station will also serve as a stepping stone to the most important planet in the solar system—Planet Earth.

As I said in Europe just a few days ago, environmental destruction knows no borders. A major national and international initiative is needed to seek new solutions for ozone depletion, and global warming, and acid rain. And this initiative—Mission to Planet Earth—is a critical part of our space program. And it reminds us of what the astronauts remember as the most stirring sight of all. It wasn't the Moon or the stars, as I remember. It was the Earth—tiny, fragile, precious, blue orb—rising above the arid desert of Tranquility Base.

The space station is a first and necessary step for sustained manned exploration—one that we're pleased has been endorsed by Senator Glenn, and Neil Armstrong, and so many of the veteran astronauts we honor today. But it's only a first step.

And today I'm asking my right hand man, our able Vice President, Dan Quayle, to lead the National Space Council in determining specifically what's needed for the next round of exploration—the necessary money, manpower, and material—the feasibility of international cooperation—and develop realistic timetables, milestones along the way. The Space Council will report back to me as soon as possible with concrete recommendations to chart a new and continuing course to the Moon and Mars and beyond. . . .

In the decades ahead, we will follow the path of *Pioneer 10*. We will travel to neighboring stars, to new worlds, to discover the unknown. And it will not happen in my lifetime, and probably not during the lives of my children, but a dream to be realized by future generations must begin with this generation. We cannot take the next giant leap for mankind tomorrow unless we take a single step today. □

Consolidating the Presidential Initiative

BY CARL SAGAN AND LOUIS D. FRIEDMAN

President Bush, in his speech on the 20th anniversary of the *Apollo 11* landing on the Moon, stated his commitment to human exploration of Mars and the Moon as a goal for the US space program. For years we have been calling for presidential leadership in setting a goal for the US space program. We called for Mars, and President Bush's endorsement of that goal is welcome.

We are concerned about too-narrow political support for the President's goal. Unless its constituency can be broadened, this initiative may be strangled as it is being born. The natural and most effective means to broaden support is to implement the program cooperatively with other nations—especially the Soviet Union. The Mars program then becomes a constructive, long-term goal of the two superpowers and a symbol of their joint determination to end the Cold War. Such a program would then appeal to many who do not ordinarily support either military or civilian space activities.

Cooperation between the US and USSR can begin with slow steps, with adequate time for each nation to test the other's intentions and competence, and with minimal transfer of national-security technology.

Internationalizing the space program, if done intelligently, can also save a considerable amount of money. Cost sharing is an important way to meet the serious criticism of the Mars goal that is now being offered on fiscal grounds.

There is evidence that the American people are ready for cooperation with the Soviets in Mars exploration. A nationwide poll, conducted late last year by Market Opinion Research, asked: *If a joint US/Soviet manned mission to Mars could work, would you favor it?* Seventy-two percent answered yes. Only 31 percent endorsed US-only manned missions to Mars.

President Gorbachev, following The Planetary Society's lead, has on several occasions invited the US to join the USSR in robotic and in manned exploration of Mars. There has been no US reply. We believe the program needs to involve the Europeans, the Japanese and the Soviets from the beginning.

Far too little work has been done on international planning. NASA has spent several million dollars on studies of precursor missions, technology requirements, and manned missions, but all have been limited by one ground rule: no international cooperation. There have been no serious studies and, worse yet, no joint discussions on how to design joint missions.

If we make all studies of joint missions taboo and forbid joint planning, then we trap ourselves in a self-fulfilling prophecy: International missions cannot be considered in detail because no preparatory work has been done. Accordingly, there should be an immediate start on a joint study of Mars/Moon exploration by the US and the USSR. This study—which can be undertaken without long-term commitments from either side—should include consideration of cooperation in heavy-lift launch vehicles for peaceful space exploration.

An Exploration Scenario

1. Design of the US space station
Space Station *Freedom* has been proposed as a general-purpose, research and development facility for the US. Planning for the space station needs to be redirected to meet requirements in two key areas: assembly of interplanetary vehicles and life support for long-duration flight.

2. Robotic missions
In answer to President Bush's call for development of timetables, we urge consideration of the following as milestone missions.

1992 *Mars Observer.* A modest supplement to the current mission is needed to permit additional imaging data.
1994 Soviet orbiter/lander mission linked to *Mars Observer* through a telecommunications relay (current plan). Additional American participation is possible on the Mars Balloon component of the lander.
1995 US lunar geochemical mapping mission (*Lunar Observer*). We note that Japan, which has been developing a mission design, could be invited to play a complementary or leading role.
1996 US/USSR Mars orbiter/lander mission to establish a sensing/communications network (e.g., penetrators), with substantial European participation.
1997 US/USSR lunar network mission.
1998 Soviet rover mission, with US surface experiments.
2001, 2005 US/USSR Mars rover and sample-return missions.

3. Moon as stepping stone to Mars
We have been skeptical about the value of human missions to the Moon in a Mars program. Most testing and development can be done more cheaply in Earth orbit or even on Earth, if the goal is early readiness for human exploration of Mars. But NASA favors more cautious development. The NASA plan for simulating a round-trip Mars flight with a one-year stay in the space station, then three months on the Moon, followed by another year in the station, is innovative and, if internationalized, may have great merit.

4. First Mars mission with crews
If an American spacecraft and a Soviet spacecraft fly side by side to Mars on the first mission and rendezvous in Mars orbit, we'll have dramatic opportunities for cooperation. We can have cooperation without total integration.

One nation might be responsible for manned Mars orbiters, the other for manned Mars landers. Europe might construct the ascent vehicle, Japan a surface excursion module. There are many possibilities.

How closely integrated the Mars orbit, landing and surface exploration are would depend on political and technical experience in the next few years.

Construction of interplanetary vehicles could begin around 2004, with the first launch of a Mars mission with human crews by 2009.

Carl Sagan and Louis D. Friedman are The Planetary Society's president and executive director, respectively.

World Watch

by Louis D. Friedman

MOSCOW—The *Phobos* spacecraft failure has slowed neither *glasnost* nor preparation in the Soviet Union for future Mars exploration. The hitherto secret Lavochkin Space Center—where planetary spacecraft (*Mars, Venera, Luna, Lunakhod, Vega* and now *Phobos)* are designed, built and tested—was opened up this year. Lavochkin also houses Babakin Center, where the scientific missions are designed. On behalf of The Planetary Society, I was the first American visitor.

As a participant in the development of the Mars Balloon, The Planetary Society has a special interest in the *Mars '94* mission. We also have a recognized role as an informal ambassador to all space agencies, bringing them together for international cooperation in planetary exploration. Thus, as also happened five years ago during a visit to the Space Research Institute, I found I was able to talk with Soviet space officials unhampered by communication barriers.

Ronald Kremnev, Babakin Center Director, and Konstantin Pichkhadze, the Spacecraft Development Department leader, outlined a number of changes planned for the *Phobos* spacecraft. The changes are not fundamental to the design, according to these officials, but are significant and consistent with the criticism voiced recently by Bruce Murray and K. Gringauz in *The Planetary Report*.

Kremnev maintained that the basic design had been proven sound. All systems operated well, except for the attitude control on *Phobos 1*, which was shut off inadvertently by a human operator on Earth, and an unexplained power loss to the main onboard processor (computer) on *Phobos 2*. He said the planned software modifications would provide the resiliency needed for the spacecraft to survive failures of individual components.

The opening up of Babakin is very much in the spirit of other recommendations made by Murray and Gringauz, including openness in dealing with international science partners about mission design. The Soviet officials made it clear that my visit was not an isolated event. They had already admitted French *Mars '94* personnel and invited The Planetary Society to participate in forums about future international planetary exploration.

Mars '94 remains the next major mission priority for the Soviet Union, despite the failure to complete the *Phobos* mission. Decisions about what to do after 1994, and whether or not to repeat *Phobos* or do a lunar orbiter mission, are not expected until at least the end of 1989.

The *Mars '94* mission will not be officially approved until the end of the year because it is part of a ten-year plan Soviet space officials are still considering. The delay in the *Mars '94* official start is of some concern to Lavochkin personnel and to the international science team because adequate funds have not yet been released for work requiring long lead-times. However, officials at Lavochkin and at the Space Research Institute emphasized the near certainty of the *Mars '94* plan, including its centerpiece: the Balloon.

WASHINGTON—NASA has begun to study a *Mars Observer* for 1996. The objectives of the proposed 1996 mission, following the 1992 *Mars Observer* and the Soviet *Mars '94* missions, would focus on the atmosphere of the planet. Components under consideration include an orbiter to examine upper-atmosphere composition and several small meteorological stations on the surface. These stations could be supplied by an international team, including, perhaps, the Soviet Union. This would be the first Soviet participation on a US planetary spacecraft.

CAPE CANAVERAL—A small group in Florida has instituted an effort to stop the *Galileo* launch, scheduled for October, because of what they perceive to be too great a danger from its radioisotope thermo-electric generators (RTG). The RTGs, which supply electricity to spacecraft instruments and systems, use plutonium. Because of The Planetary Society's special credibility as an organization concerned about the environment as well as interested in planetary exploration, the Florida group has asked us to join with them in the attempt to delay the launch.

We declined. We very much support the launch of this important exploratory mission to Jupiter. First scheduled for 1982, *Galileo* has been delayed far too long now. If it doesn't go this year, we suspect it will never go.

We are sensitive to concerns about nuclear power in space. In 1987 *The Planetary Report* commissioned David Salisbury, former science reporter for the *Christian Science Monitor* and now working for the University of California, Santa Barbara, to research and write "Radiation Risk and Planetary Exploration: The RTG Controversy." Published in our May/June 1987 issue, his article did not draw conclusions but pointed out that even the worst-case risks are comparable to those judged acceptable in many ordinary technical and industrial activities.

The principal danger from plutonium occurs if it is ingested or inhaled as fine particles. On *Galileo* the plutonium is held within successive shields, and no plausible accident would release a significant amount into the environment as fine particles. The level of safety has been determined not just by theoretical analysis but by high-velocity impact tests and accident simulations.

In supporting the launch of *Galileo*, The Planetary Society stands with other prominent organizations concerned about nuclear dangers, including the Federation of American Scientists and the Committee to Bridge the Gap. Congressman George Brown (D-CA), who has led efforts to consider banning nuclear reactors in Earth orbit, also supports the *Galileo* launch.

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

liant minds is pointless and counterproductive, serving only to sour the public's attitude toward the space sciences.

There can be no denying the wealth of information returned by unmanned space probes. *Ranger* and *Surveyor* made the manned landings on the Moon possible. *Mariner, Viking, Pioneer* and *Voyager* have shown us new worlds ripe for exploration. Robots make exceptional trailblazers, but they are not the be all and end all of space exploration. Inevitably, humans will visit those worlds. Our present space program is laying the groundwork for those future expeditions.

Scientists and science fiction writers long dreamed of an establishment in Earth orbit that would provide a comfortable fraction of normal gravity and serve as a staging base for future space voyages. The Moon fills the bill perfectly, and may provide abundant materials for the construction of true space colonies.

It is entirely possible that the gold rush of the 21st century will be to the Moon. Let's not ignore our dusty little companion of the night just because we're a little bored with it.
KEVIN R. SOULE, *Bismarck, North Dakota*

"Funding Planetary Science," the discussion by Bob Brown in the March/April issue of *The Planetary Report*, contains very deep perspectives on the purposes and rationales for the pursuit of a vigorous forefront national program in planetary exploration and research. Indeed, many of his observations would apply equally to on-going national debates related to many other elements of the nation's technological and scientific enterprises. The article bears careful rereading and thoughtful reflection by all members of the Society.

I commend Bob for his forthright elucidation of his positions, and commend as well the Society for publishing his views.
L. J. LANZEROTTI, *Murray Hill, New Jersey*

The article "Funding Planetary Science—A National Perspective," by Robert A. Brown looks to me like the kind of writing that is meant to make the reader feel good but obscures the real issues. For example, he says, "Viewed broadly, our space exploration program is a brilliant servant of national policy, and it holds out ever-fresh opportunities to those who join it with realistic expectations." The word "brilliant" serves only to obscure the meaning and when it is eliminated, the meaning of the sentence becomes clear: "Exploration is a servant of policy; if you join it don't have high expectations, take what you get and don't complain."

Although I don't agree with it, the idea that science exists to serve political policy and that the government is best qualified to decide what's best for us is a perfectly tenable philosophy and Mr. Brown has every right to defend it. However, if we wish to have a meaningful dialogue among our many viewpoints and to come to a consensus on these issues, it is important that we speak plainly with one another. Mr. Brown's article seems designed to stifle communication rather than to foster it.
ED GUPPY, *Seattle, Washington*

According to the Society Notes column in the March /April *Planetary Report*, Planetary Society President Carl Sagan recently set the Society on a "Mission to Planet Earth." I full-heartedly agree that while we turn toward space, we must be ever-vigilant with the goings-on here on Earth. I hope The Planetary Society pursues this mission to the extent possible for the organization.

One problem on Earth is the sizable and quick elimination of woodlands. Much of this clearing is needless given this day and age's ability to recycle paper. As a first step toward our Society's mission to planet Earth, I suggest that we rid ourselves of the high gloss magazine we currently receive and instead turn toward a publication printed on recycled paper. Indeed, all Planetary Society mailings should be printed on paper that has been used before.
JOSEPH D. SIEGEL, *Hebron, Ohio*

I am writing in response to a news brief that appeared in the July/August issue of *The Planetary Report*. It calls to our attention Senator Albert Gore Jr.'s charge that Bush administration officials reworded and censored a report by Dr. James E. Hansen of NASA's Goddard Institute for Space Studies concerning global warming. I support Senator Gore and his attempt to expose this embarrassing incident that the administration placed on their shoulders as well as Dr. Hansen's. I recommend that all Planetary Society members support both Senator Gore and Dr. Hansen by complaining to their congressmen and to the President himself.
C. ATTENIESE, II, *Lynbrook, New York*

NEWS BRIEFS

(continued from page 3)

the unknown and that it makes this effort in the hope that something good will come of it.
—from the *Wall Street Journal*

Aden and Marjorie Meinel, a husband and wife team from the Jet Propulsion Laboratory, are designing a spacecraft to explore the Oort Zone, just outside our solar system. They've named the mission "TAU" for "thousand astronomical units," the distance the probe would travel.

At a speed of over 225,000 miles per hour, TAU would take 50 years to reach the inner Oort Cloud, sending back scientific data all along its journey.

"There are a lot of questions about the outer solar system we need to answer," says Aden Meinel. "For instance, are there a large number of objects in the Oort Zone and if so, where did they originate?"

TAU will also help astronomers precisely measure the distances to other stars, something they can't do from observatories on Earth. The Meinels believe the spacecraft may find undiscovered stars within a dozen or so light-years from our Sun.
—from *Final Frontier*

"It is one thing to fail in a competition when you do not have the ability or resources to win. America's history is not characterized by timidity. Our space program has been effective primarily through its boldness. Today's competitive global climate is no time for technocrats to stifle America's ingenuity. How will we explain to our children and grandchildren if we lose this one because we simply did not have the sense to move forward?"
—from G. A. Keyworth and Bruce Abell in *Science*

Questions & Answers

Something has puzzled me ever since I saw a series of photographs of Earth taken from the Moon by the **Apollo crew.** ***The series is called "Earthrise." If the Moon doesn't rotate, how is an earthrise possible?***
—Jon Siegfus, Norwalk, California

The Earthrise photos were taken from the *Apollo* spacecraft in orbit about the Moon. From that moving vantage point, Earth rose and set about every two hours. As seen by *Apollo* astronauts on the lunar surface, Earth did hover overhead permanently.
—JAMES D. BURKE, *Jet Propulsion Laboratory*

What methods are used for dating solar system objects and for determining their distances and diameters? How reliable are these methods?
—Brandon Hill, Cañon City, Colorado

If we can get a sample from a meteorite or a lunar rock, then radioactive dating can accurately and reliably measure the amounts of unstable uranium, thorium, potassium and rubidium isotopes along with their daughter products. From analyzing such samples as well as a variety of the oldest terrestrial rocks, we know that many of these objects solidified over 4 billion years ago in the solar system's earliest days.

However, for distant planets and their satellites where we have yet to get actual samples, we have to make do with a less reliable approach. Counting the density of impact craters provides insight into the relative ages of different regions of a body's surface, since the longer it has been exposed to infalling asteroids and comets (and their fragments) the more heavily cratered it will be. In some regions of the solar system, where the bombardment history is well established, this method can even give us a good guess at the absolute age as well.

Distances in the solar system are generally easy to calculate by observing a body's orbit, since the laws of motion in the vacuum of space are well known. For planets and asteroids that have been studied by radar, we can often calculate their distances to an accuracy of a few hundred meters even when these objects are hundreds of millions of kilometers away from us. Furthermore, with spacecraft carrying accurate radio tracking instruments to the outer planets, we can also study many of their satellite systems to a lesser, but still highly accurate, degree.

We've determined diameters for the inner planets, again to a few hundred meters, using radar signals transmitted from Earth (for Venus we also have data from a radar-equipped spacecraft that orbited that planet). By timing the round trip of radar signals from Earth to the target body over a long period, we get a fix on the body's trajectory, and thus its center of mass. We then measure the time it takes the radar signals to travel to the planet, bounce off its surface and return to Earth. By subtracting this time from the time it would have taken the signal to reach the center of mass, we determine the radius.

Another reliable way to measure sizes and shapes of objects in the solar system is to time how long a star remains hidden (occulted) as the object passes in front of it. This method works well even when the object is too small for its disk to be directly resolved from Earth. However, for a small object (like an asteroid) whose orbit is not precisely known, it may be difficult to find a suitably located star. We overcome this problem by calling on several observers spread out over a large area of the country. This approach also allows sampling of the target's shape. Since useful data can usually be obtained with only a pair of binoculars and patience, the participation of amateur astronomers is especially welcome.
—GORDON H. PETTINGILL, *Massachusetts Institute of Technology*

If Uranus is tipped on its side, how did we decide which pole was south and which was north?
—Kate Celeste, Van Nuys, California

There is some disagreement as to the proper nomenclature for Uranus' poles. The governing body for astronomical nomenclature, the International Astronomical Union (IAU), has established a convention that uses Earth as the reference: All poles above the ecliptic (the plane in which Earth orbits) are north poles, all poles below the ecliptic are south poles. Since the uranian pole currently illuminated by the Sun is tilted slightly (about eight degrees) below the plane of the ecliptic, it is designated the south pole by the IAU.

A second nomenclature used with regard to poles involves the so-called

From the orbiting Apollo 8 Earth appeared to rise over the Moon.
Photograph: Johnson Space Center, NASA

The rings of Saturn pass in front of the star 28 Sagittarii (see "Factinos").

Photograph: Dennis di Cicco and Leif Robinson

"rotational pole." If you imagine grasping the spin axis of a planet with your right hand in such a way that your fingers curl in the direction of the planet's rotation about its axis, then the rotational pole, by definition, is the one in the direction of your thumb.

These two styles of nomenclature come into conflict for two solar system planets: Uranus, whose rotation axis is tilted about 98 degrees with respect to the north pole of the ecliptic, and Venus, which rotates clockwise rather than counterclockwise. No end of confusion and inconsistency has been generated by the lack of agreement in the cases of Uranus and Venus.

The *Voyager* navigation team uses this "right-hand rule" and at Uranus referred to the pole currently facing the Sun as the north pole; the IAU steadfastly calls it the south pole.
—ANITA M. SOHUS, *Jet Propulsion Laboratory*

A couple of years ago I noticed that the pronunciation of Uranus had changed [to an accent on the first syllable as opposed to the second]. Why the change? Who initiated the alternate pronunciation?
—Michael Plog, Springfield, Illinois

Only the standard pronunciation of Uranus, with the accent on the first syllable, appears in pre-World War II reference books, such as the *Oxford English Dictionary* (1933), *Webster's Second International Dictionary* (1934) and *Century Cyclopedia of Names* (1889). However, the *New Century Cyclopedia of Names* (1954) and other postwar references give an alternate pronunciation, with the second syllable stressed. It may be that the alternative pronunciation, yer RAY nus, took hold by analogy with *uranium,* yer RAY nee um, which in the Atomic Age had become a household word.

Radio and television coverage of the *Voyager 2* flyby in 1986 did much to restore the preferred pronunciation, YER uh nus, which may account for your having noticed a change "a couple of years ago."

The German astronomer Johann Elert Bode was the first to suggest the name Uranus, after the god in Roman mythology who was the father of Saturn and the grandfather of Jupiter. Sir William Herschel, who discovered the planet in 1781, had called it the "Georgian" planet (George III being king of Great Britain at the time). For a while the planet was known as Herschel; by 1800 the name Uranus had become recognized internationally.
—KARL STULL, *Copy Editor*

Do other planets experience quakes?
—Susan J. Pearl, Quemado, New Mexico

Yes—*Apollo*'s seismometers registered thousands of small moonquakes. As for Mars, one of the two seismometers landed on Mars by *Viking* failed to uncage, and data from the other one were ambiguous because of thermal and wind effects on the spacecraft. But there is plenty of geomorphological evidence (faults, graben, volcanic flows, impact craters and landslides) to show that some planets and many satellites must have experienced quakes in the past—and Jupiter's actively volcanic moon, Io, is surely having them now.
—JAMES D. BURKE, *Jet Propulsion Laboratory*

FACTINOS

On July 2 and 3, scientists were treated to a once-in-a-lifetime chance to study Saturn from Earth. The planet crossed the line of sight to a star known as 28 Sagittarii, which enabled scientists to examine its intricate ring features in detail due to the star's brilliant "backlighting" effect. Scientists haven't had this good a look at Saturn since the *Voyagers* passed by in 1980 and 1981. Although 28 Sagittarii is barely visible to the naked eye, it is very bright in giant telescopes [and positively brilliant at near-infrared wavelengths].

When compared to *Voyager* data, these observations, will provide information on the longevity of features in the ring system and could give insight into how the rings formed and evolved.
—from Mount Wilson Institute

◇

Over the past year and a half the minor planet Chiron has been getting brighter than expected by astronomers. In fact, it has begun to behave like a comet. Using the four-meter telescope on Kitt Peak, astronomers Karen J. Meech and Michael Belton found that the extra brightness comes from an extended dust atmosphere, indicating that Chiron is a very large comet.

Always considered to be an oddball among asteroids, Chiron's orbit lies farther out in the solar system, between Jupiter and Saturn. It is about 180 kilometers (about 110 miles) in diameter, or ten to twenty times as large as Halley's Comet. The discovery of the dust atmosphere was made during an observational project to follow Halley's Comet into the distant reaches of the solar system.
—from the National Optical Astronomy *News*

◇

Extraterrestrial amino acids discovered at the Cretaceous-Tertiary boundary provide convincing evidence of the impact theory of mass extinction 65 million years ago, according to Jeffrey Bada of the Scripps Institution of Oceanography in San Diego. Dr. Bada reports that the compounds he discovered are extremely rare on Earth, but are among the major amino acids in carbon-containing meteorites and are likely to be found in comets and asteroids.

"The fact that we detect these compounds at the K-T boundary demonstrates that these organic molecules can get to Earth and be spread around during an impact," says Bada. "However, we have calculated, based on what we know so far about this one impact event, that the supply of organic compounds is far too low to be a source of life on Earth even if there were numerous impacts."
—from the Scripps Institution of Oceanography

SOCIETY *Notes*

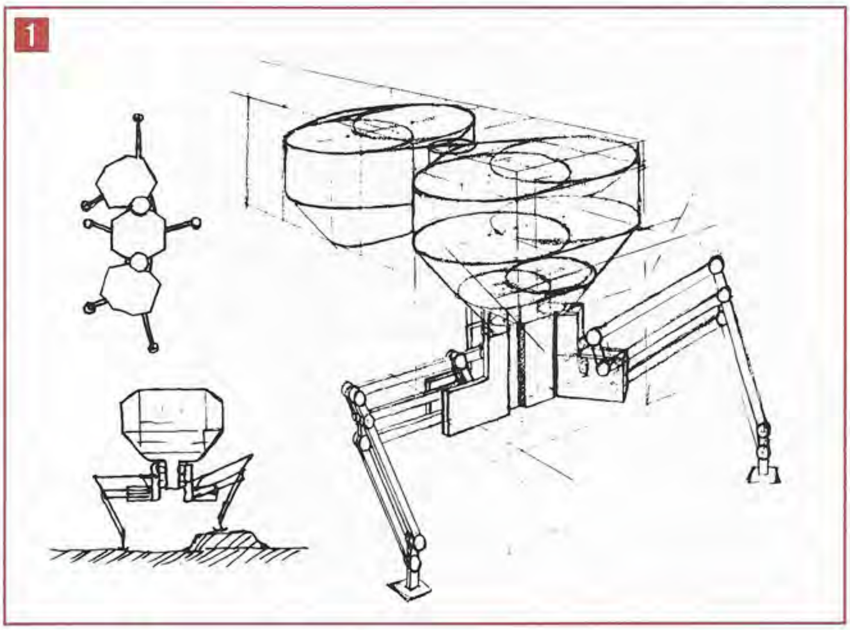
MARS ROVER CONTEST— AND THE WINNER IS . . .

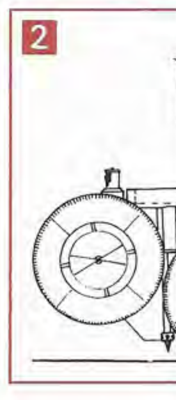
When we asked you to "Help Design a Mars Rover" (March/April 1989), the entries came rolling in (they also came creeping, crawling, bouncing on balloon tires, trudging on tracks) from around the world—from Mexico, Sweden, Argentina, Belgium, nearly all the provinces of Canada, and especially from Australia, where the broadcast media spread news of the contest.

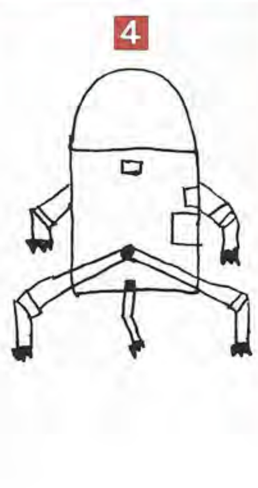
Teach the rover the ways of an Indian hunter/scout, suggested Robert D. Vickers Jr. of Marietta, Georgia. Other ideas earning special notice came from Ruth A. Veness of Coffs Harbour, New South Wales, Australia, who suggested adapting the technology of microsurgery to soil sample collection and analysis. Ron Gregory of Balcatta, Western Australia described a rover that scans the terrain for interesting targets by means of a camera hung from a balloon.

The winning entry came from John R. Kollar, Calgary, Alberta, Canada, who proposed a rover able to prioritize targets according to "interest points" calculated against "hazard points." To assign points, the rover evaluates an object by such characteristics as shape, color and similarity to objects already collected. Kollar's rover has six legs ("Insects have been very successful in this respect"), and it travels in groups of three, so that each rover can be observed by at least one other.

The winner's prize is a library of books about Mars. However, the real reward, as we see it, comes from having a lot of Planetary Society members involved in ground-level thinking about the challenges of planetary







1 John R. Kollar, winner of the Mars rover contest, acknowledges that the joints of his entomological design will require "a little engineering" to withstand dust and stresses.

2 A storm brace, visible between the first and second tires at the left, adds protection for the rover's seismic, sound, motion and heat sensors: Garry Lee Robinson Jr., Baltimore, Maryland

3 A bulldozer-type rover, with camera raised and drill poised at the rear, clears a path in the rocky martian terrain: unsigned entry

4 Resembling R2D2, this rover is equipped with a "green scope" for night vision, a heat sensor and a computer-synthesized voice: Amy Oshinsky, Thornwood, New York

5 The "Tsiolkovsky and Goddard" rover is from a children's book currently being developed about a US/USSR joint mission to Mars: Stephen Lee Howard, Belmont, North Carolina

6 A vacuum-actuated sampler is lowered at the right; not shown is an onboard air compressor for inflating a plastic dome, which serves as a sterilizable lab: unsigned entry

7 The JZ 2000 tank extends a sonic sensor to detect hazards and targets of interest: Fred Zagotti and Jim Johnson, Cincinnati, Ohio

8 Transmission of television images, adapting Soviet technology from the *Lunakhod* spacecraft, enables controllers on Earth to guide the rover toward objects of interest and away from hazards: Misha (Micky) Koshelev, Leningrad, USSR

9 A robot arm is one subsystem of a rover controlled by a personal computer (512K internal memory): Thomas M. West, Indianapolis, Indiana

10 Six rimless wheels, operating independently, have "shoes" at the spoke-ends to allow the rover to step over obstacles: Fr. Kenneth F. Connor Jr.

exploration. We have forwarded several of the most interesting designs to the Mars Rover Sample Return team at the Jet Propulsion Laboratory. When next we land on Mars, if the rover looks familiar, remember where you saw it first.
—Karl Stull, Copy Editor

MARS BALLOON UPDATE

Balloon races held July 23-29 in Vilnius, Lithuania gave a boost to development of the Mars Balloon component of the Soviet *Mars '94* mission, according to Slava Linkin, scientist with the USSR's Space Research Institute (IKI). Some 20 IKI specialists in engineering, modeling, meteorology and space science took part in 200 launches, acquiring experience with flight and design characteristics while 14 teams of sport balloonists from six nations competed.

Directing the event was Tom Heinsheimer, member of The Planetary Society design team for the Mars Balloon guide-rope.

Success at Vilnius led to approval for demonstration flights at IKI's Moscow headquarters and in Gorky Park. Film of the Gorky Park flight made the Moscow morning news. *—Susan Lendroth, Manager of Events and Communications*

ASAE INT'L AWARD

This year's International Achievement Award for mid-size associations was presented to The Planetary Society by the American Society of Association Executives at its 1989 meeting in Boston. Tim Lynch, Director of Programs and Development, accepted the honor for the Society, which was cited for an impressive increase in membership outside the US and Canada. We grew from fewer than 700 to more than 10,000 non-US/Canada members in a little more than a year, thanks to Tim's efforts and direction.
—Louis D. Friedman, Executive Director

HAAS AWARD

Jeff Beish has been honored as this year's winner of the Haas Award by the Association of Lunar and Planetary Observers (ALPO). The award, named for ALPO founder Walter H. Haas, recognizes outstanding contributions in observational planetary science.

Beish earned the distinction for his thousands of Mars observations and measurements over the last 15 years. He wrote the *Mars Observer's Handbook*, published by The Planetary Society, and served on our Science Advisory Council during Mars Watch '88. *—SL*

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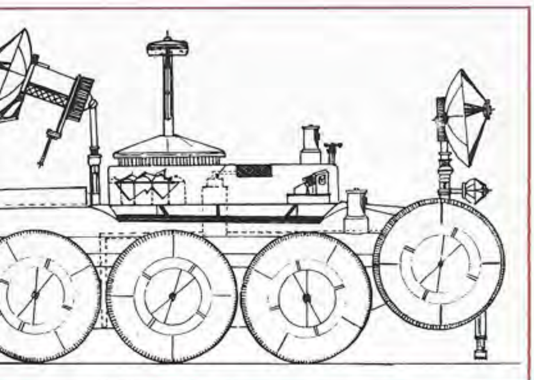

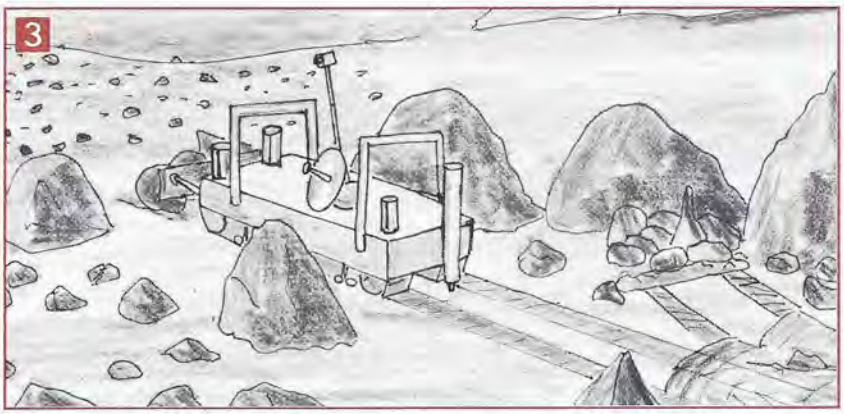

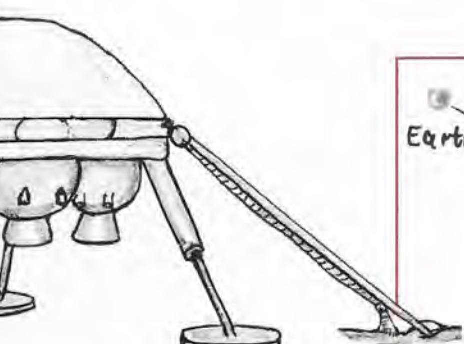

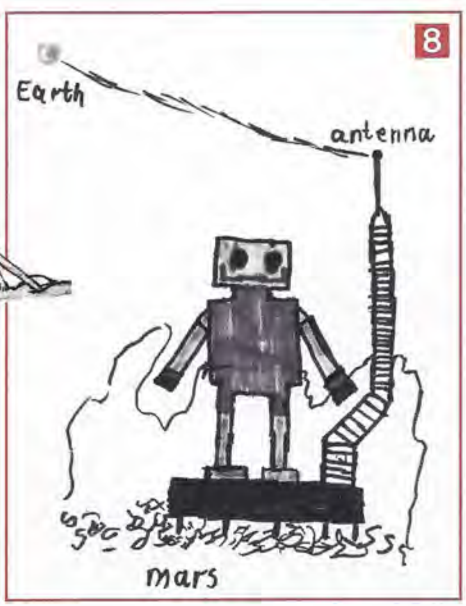

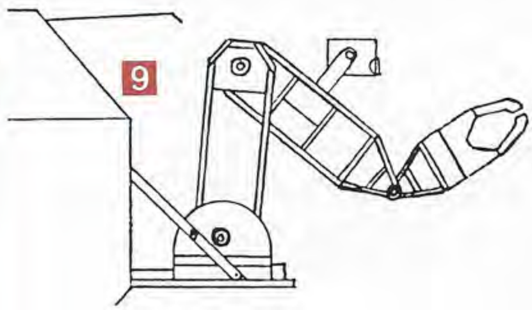

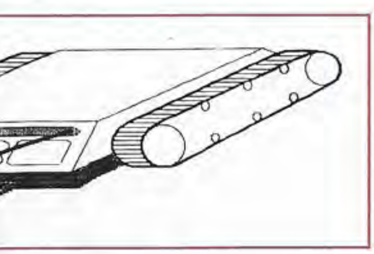

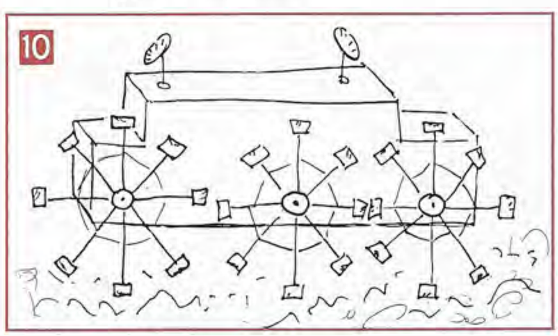

THE LEAD POOLS OF VENUS—This painting illustrates the fact that surface temperatures on Venus are hot enough to melt lead. Venus' atmosphere is so dense that its horizon appears to be refracted or bowl-shaped. This optical distortion also occurs on Earth when one looks up at the surface of the ocean from underneath.

Alan Gutierrez is a space artist who lives and works in Sedona, Arizona. His work has appeared on the covers of science fiction novels by Isaac Asimov, Gordon Dixon and Frederick Pohl, to name a few.

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