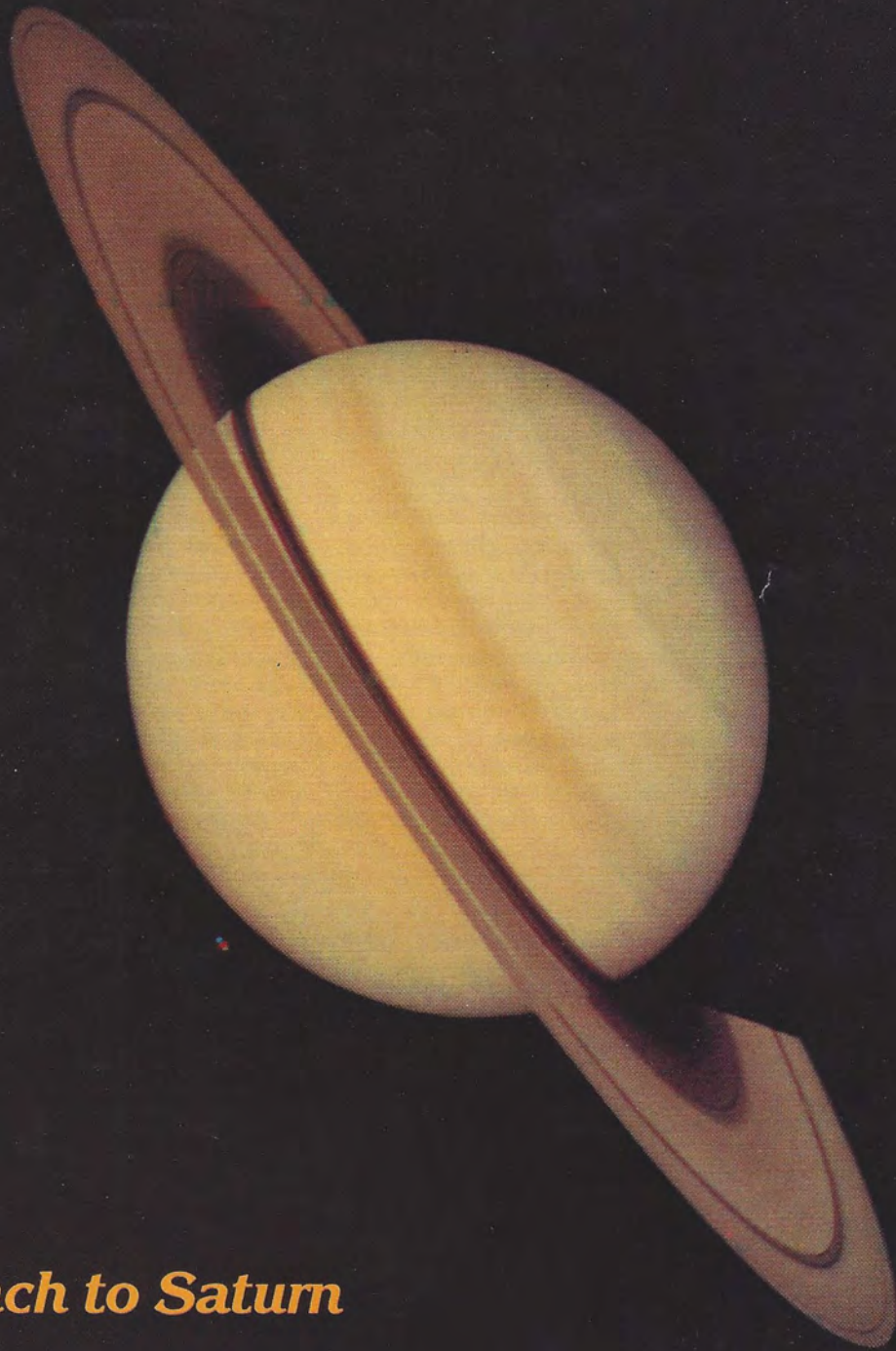


The **PLANETARY REPORT**

Volume I Number 1

December 1980 / January 1981



Approach to Saturn

A Publication of

THE PLANETARY SOCIETY



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The Planetary Report is published six times yearly at the editorial offices of The Planetary Society, 116 S. Euclid Avenue, Pasadena, CA 91101. Mail memberships, correspondence, address changes and adjustments to The Planetary Society, P.O. Box 3599, Pasadena, CA 91103. Copyright © 1980 by The Planetary Society.

Cover Photograph: The last picture from Voyager 1's approach to Saturn in which the entire planet and ring system can be seen in a single frame. As the spacecraft moves closer to the planet, it will view successively smaller areas with increasing detail.

PHOTO: JPL/NASA

Space Exploration — Is It Worth The Cost? by Bruce Murray

We have come to the culmination of an extraordinary era in our exploration of the solar system. In the last four years we have seen pictures of Mars returned from the spacecraft *Viking*, and of Jupiter and Saturn from *Voyager*. Sophisticated chemical and biological tests were carried out over many months on the surface of Mars. Six of our spacecraft conducted atmospheric experiments on Venus. This properly has been hailed as an unprecedented triumph of science and technology which could presage still another era of exploration beyond limits considered possible only a few years ago.

We have been fortunate to live at that singular period in human history when we were the first able to reach out from our ancestral home to investigate, like a growing child, our solar system environment. We were able to do so because we have lived in the most advanced technological society the world has known; one that has freely chosen, thus far, to lead that exploratory process for all humanity, present and future. The world has joined with us, the American public, in sharing the sense of wonder and excitement at the space discoveries of the last two decades.

No one questions the scientific potential of the space exploration program. But budgetary limits now threaten the demise of the undertaking — already slowed by Congressional action, and lack of it. The question is being asked: is the program worth the cost? By one obvious measurement the price is high — between \$200 million and \$1,000 million dollars per mission. Spread over time, the total space science budget in NASA — covering astronomy as well as planetary science — runs about \$550 million per year, about 10% of the total NASA budget, or about one-tenth of one percent of the total federal budget. The answer to whether the costs are too high depends, of course, upon the priorities assigned by those who make the budget and appropriate the funds.

It is not possible to assign precise dollar values to a program without precedent. But it can be shown that new knowledge and discovery has resulted in new benefits, new understandings, and new awareness that helps us in our daily life, perhaps more so than many specific "application" projects. For example, it was scientists studying planetary atmospheres who first discovered the possible breakdown in the ozone layer due to aerosols, and the possible danger of a global atmospheric greenhouse heating effect due to the continual addition of carbon dioxide from the burning of fossil fuels and the destruction of forests.

Our understanding of climatology, still in its infancy, has increased significantly as a result of the comparative study of the planets. Planetary experiments and measurements help us understand the processes that influence our own weather. Leading scientists in my field, geology and geophysics, have analyzed the internal structure of Mars, Venus and the Moon, and studied the craters and other land forms on terrestrial planets and satellites; knowledge of comparative planetology improves our understanding of the structure, historical development and dynamics of our own planet Earth.

Last year's exciting *Voyager* encounter with the Sun's principal companion, Jupiter, and its mini-solar system, was a microcosm of the entire space exploration effort. To the layman, the flow patterns in the Jovian atmosphere resemble an abstract painting from God; these pictures had an obvious impact on the American and world public. Scientists, studying these flow patterns, for the first time could observe closely a rapidly rotating planet and examine the meteorological developments in a heavy atmosphere on a short time scale; this provided new insights into the effects of rotational dynamics on the flow of storms and weather systems.

Discovery of the first active volcano on another planet, Io, the nearest large moon of Jupiter, came about in the classic fashion — almost by accident. One of the mission navigators looking

(continued on page 15)

The Adventure of The Planets

by Carl Sagan

For all of human history the planets were wandering lights in the night sky, moving against the background of the more distant constellations in complex, although regular, paths. The planets stirred our ancestors, provoked their curiosity, encouraged mathematics and accurate record keeping. Through the work of Johannes Kepler and Isaac Newton, understanding planetary motion led to the development of modern physics and, in a very real sense, opened the modern age of science and technology. In the last 18 years — ever since the encounter of the *Mariner 2* spacecraft with Venus — every one of those wandering lights has been visited by space vehicles from Earth; every one has revealed itself to be a world in its own right very different from our own. We humans have landed exquisite robot spacecraft on Mars and Venus and orbited both planets. We have flown by Mercury, Jupiter and Saturn. We have discovered the broiling surface of Venus, the windswept valleys of Mars, the sulfur rivers of Io, the great polychrome storm systems of Jupiter. We have discovered new moons, new ring systems, puzzling markings, enigmatic pyramids and have searched for life. Never again will the planets be mere wandering points of light. Because of the effort of the last two decades they will forever after be worlds crying out for exploration and discovery.

And yet the pace of planetary exploration has slackened ominously. After the *Voyager* encounters with the Saturn system in November, 1980 and August, 1981, there will be a period of more than four years in which no new images are returned from the planets by any United States spacecraft. The Soviet Union also shows signs of slowing its once vigorous program of space vehicle exploration of the Moon, Venus and Mars — although it is still spending probably two or three times more per year on such enterprises as the United States. If we back off from the enterprise of the planets, we will be losing on many different levels simultaneously. By examining other worlds — their weather, their climate, their geology, their organic chemistry, the possibility of life — we calibrate our own world. We learn better how to understand and control the Earth. Planetary exploration is an activity involving high technology which has many important applications to the national and global economy — robotics and computer systems being two of many examples. It uses aerospace technology in an enterprise which harms no one, which is a credit to our nation, our species and our epoch. And planetary exploration is an adventure of historic proportions. A thousand years from now, when the causes of contemporary political disputes will be as obscure as the origin of the War of the Austrian Succession is to us now, our age will be remembered because this was the moment when we first set sail for the planets and the stars.

These arguments are widely accepted. And yet when a specific planetary mission is being considered by the Executive Office of the President or by the appropriate Congressional Committees, planetary scientists hear another story. We are told that it is expensive — although a vigorous program of unmanned planetary exploration would cost about a tenth of a percent of the federal budget; the *Voyager* spacecraft, when they are finished with their explorations, will have cost about a penny a world for every inhabitant of the planet Earth. But mainly we are told that, although the arguments for planetary exploration are widely understood in government, they are not supported by the people. We are told that spending money on planetary exploration — on the discovery of where we are, who we are, what our history and fate may be — is unpopular, that it is a political liability to support such ventures. I can remem-



LEFT TO RIGHT: BRUCE MURRAY, CARL SAGAN, LOUIS FRIEDMAN

ber a Congressman telling me that the only letters he had received in support of the *Galileo* exploration of Jupiter were sent by people too young to vote.

And yet there is evidence of enormous support and enthusiasm for the exploration of the planets. We can see it in the popularity of motion pictures and television programs on planetary themes; in the topics discussed in the burgeoning set of science fact magazines, and in the success with which books on this subject have recently been greeted. In puzzling over this apparent paradox, it became clear to me and a number of my colleagues that the solution would be a non-profit, tax-exempt, public membership organization devoted to the exploration of the planets and related themes — particularly the search for planets around other stars and the quest for extraterrestrial intelligence. If such an organization had a substantial membership, its mere existence would counter the argument that planetary exploration is unpopular. And so Dr. Bruce Murray, the director of Caltech's Jet Propulsion Laboratory and I, with a number of colleagues and friends, have established The Planetary Society. The membership of its Advisory Board is not only very distinguished but very broadly based. We believe that many sectors of our society would be willing to support us. We hope to be able to put planetary scientists in touch with their local supporters. With the contributions we have received — some of them anonymous — we have been able to mount a very encouraging sample direct mailing to test the interest of the American public. If we are as successful as at least some experts think we are likely to be, we may be able to accomplish not only our initial goal of demonstrating a base of popular support for planetary exploration; but also to provide some carefully targeted funds for the stimulation of critical activities — for example, in planetary mapping and in the radio search for extraterrestrial intelligence. We can be contacted at P.O. Box 3599, Pasadena, California, 91103. [Like many proposed interstellar radio messages, the Post Office Box number is the product of two prime numbers, 59 and 61.] □

The Mysteries of Saturn

by David Morrison

In our own lifetime we have had the extraordinary privilege of witnessing a series of explorations into the unknown that will rank alongside the great terrestrial discoveries. Millions of us participated vicariously in the landings on the Moon ten years ago, and more recently in the *Viking* landings on Mars and the *Voyager* flybys of Jupiter and its satellite system.

Now, in the fall of 1980, we have again anticipated the thrill of discovering new worlds as *Voyager 1* moves on across vast distances to begin the exploration of Saturn. In this splendid system of planet, rings and satellites there is as much potential for new and remarkable findings as there was in *Voyager's* encounters with Jupiter in 1979 — perhaps even more so, since we start out knowing less of this great planet than we did of Jupiter and its moons before the spacecraft began its flyby. By the end of the year the far-seeing eyes of *Voyager* will have brought us a new vision of a remarkable, and until now, mysterious planetary system.

The planet Saturn is, like Jupiter, a giant gas ball composed primarily of hydrogen and helium. Although Saturn is both smaller and cooler than Jupiter, we have not generally anticipated that it should be much different. But even before *Voyager*, a few significant differences were being noted. Perhaps the most fundamental concerns the internal heat source of Saturn.

We have found from Earth-based and *Pioneer* spacecraft infrared measurements that Jupiter emits more energy than it receives from the Sun, and it is widely believed that this energy is primordial, representing a slow leakage of heat generated in the formation of the planet. Saturn also has a hot interior, but surprisingly this energy source is greater than that of Jupiter. It seems quite clear that primordial heat of formation is not enough to explain Saturn's brightness, indicating some fundamental differences in the interiors of the two planets. Another mystery of Saturn's interior concerns its magnetic field, which probably arises from a rotating core. *Pioneer 10* and *11* found that the magnetic field was oriented around the axis of rotation — much more so than for other planets measured. Saturn may have a lot to tell us about the mechanism of formation of planetary magnetism.

Seen from above, the atmosphere of Saturn lacks the dynamism apparent in the fantastic colors and turbulence of Jupiter. We suspect, however, that these differences may

be only superficial. Underneath, both planets should have similar atmospheric dynamics, but on Saturn, a deep haze blots much of the action from our view, at least that afforded by Earth-based telescopes. *Voyager*, with its increased resolution, is already beginning to penetrate the haze of Saturn. It is anyone's guess just how Saturn's clouds will look as we get closer and closer views.

Saturn is unique among the planets in its brilliant ring system composed of billions of icy moonlets. The darker, narrower rings of Jupiter and Uranus are tiny, inconspicuous things by comparison. One of the primary objectives of *Voyager* is a better understanding of the rings of Saturn. As the pictures improve, ever more complex structure is appearing and perhaps near *Voyager's* closest approach it will be possible to distinguish the largest individual moonlets within the rings. The recent discovery of new satellites skirting the edges of both the Jupiter and Saturn rings hints at a complex interplay between rings and satellites that was not suspected a few years ago.

Saturn possesses a fine system of satellites, as varied and exciting as the moons of Jupiter. The largest, Titan, is the largest satellite in the solar system — nearly as large as the planet Mars. Titan also has the unique distinction of being the only satellite with a major atmosphere and clouds. The surface pressure on this satellite is thought to be larger than that of Mars and its clouds may be as opaque as those of Venus. *Voyager 1* is targeted for an extremely close flyby of Titan on November 11, just a few thousand kilometers above the cloud tops. One of the outstanding questions is whether it will be possible to glimpse the surface through breaks in the clouds.

The dozen or so other satellites of Saturn are primarily icy objects — perhaps composed of nearly pure water ice. We have never before seen a pure icy planetary body, so we do not have any idea what to expect. The best views from *Voyager 1* will be of Rhea, with fine detail visible down to objects 2 kilometers across. Another satellite that excites *Voyager* scientists is Iapetus, which has its leading hemisphere (the one in the direction of its orbital motion) covered with a dark material quite unlike the bright white ice of its trailing hemisphere. And there is excellent prospect of discovering many new small satellites, especially near the outer edge of the ring.

The one thing we can expect with confidence from the *Voyager* Saturn encounters is to be surprised. A whole new system of planet, rings and satellites lies there, waiting to be discovered. Only once will humanity ever be able to get a *first* good look at the Saturn system — and that opportunity begins in November, 1980.

Professor David Morrison, of the University of Hawaii, is a member of the Voyager Imaging Team and President of the Division of Planetary Sciences of the American Astronomical Society.

More Than Meets The Eye

by Torrance Johnson

Pictures of Saturn were taken by the *Voyager 1* spacecraft early in the "observatory phase" of the mission from a range of about 107 million kilometers; they have a resolution [an ability to discriminate fine detail] of about 2,000 kilometers.

The pictures shown here illustrate two of the many ways imaging scientists use the color sensitivity of the TV vidicon cameras aboard the spacecraft. The camera takes successive black and white images through a series of color filters. There are five of these available for the narrow angle (1,500mm focal length) lens – ultraviolet, violet, blue, green and orange – covering the spectral range in wavelengths of light from 3500Å to 7000Å [where an Ångstrom is one hundred millionth of a centimeter].

In order to produce the "natural" color photograph shown on this page the blue, green and orange images are used to control the brightness of the three primary colors, blue, green and red, in creating a color negative. These three *Voyager* filters approximate the color response of the human eye and the resulting picture is close to what a space tourist would actually see or be able to photograph with ordinary color film.

Since the camera sees further than the human eye into the ultraviolet range, it is possible to use the same basic technique to produce "false" color pictures for special purposes. The colorfully striped picture of Saturn is one type of false color image found useful by scientists. It was produced by allowing the ultraviolet image to control blue intensity, the violet image the green and the orange image the red. Thus, areas on Saturn which are bright in the ultraviolet range appear blue in this picture.

This type of false color image is particularly useful in studying the high-altitude, smog-like hazes in Saturn's atmosphere. The blue belt just north of the equator is a region which is relatively clear; Rayleigh scattering [the process by which small particles scatter short wavelengths of light preferentially – this is the same process that makes Earth's sky blue] reflects more ultraviolet light from the atmosphere. The bright blue areas near the edge of the planet and in the southern hemisphere will also allow atmospheric scientists to study the height and distribution of these hazes.

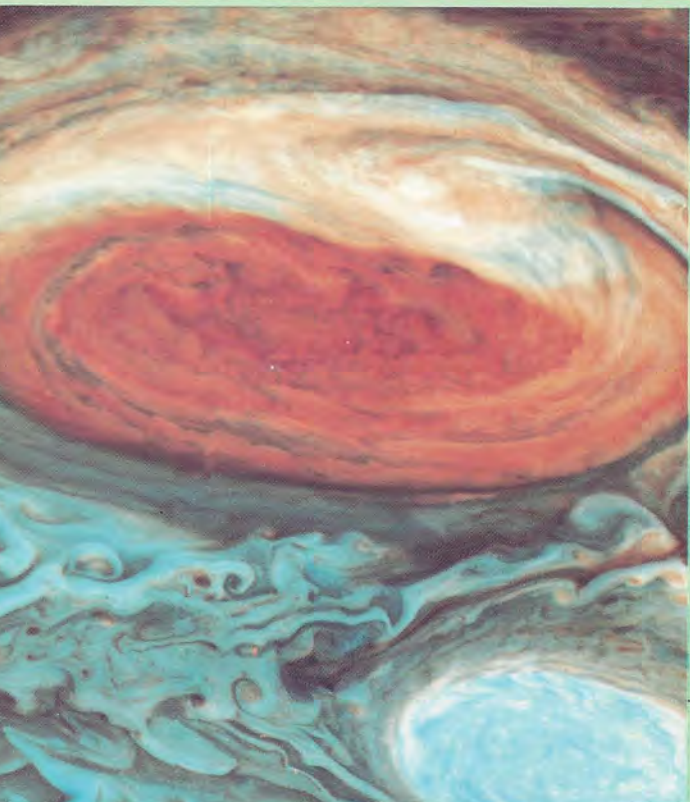
Many other types of false color displays can be produced from spacecraft images. These techniques are being used routinely to study the Earth using *Landsat* data, and are important tools in analyzing images of Mars, the Moon, Jupiter and the Galilean satellites.

The other picture on this page, showing the Great Red Spot, an atmospheric image sent back from Jupiter by *Voyager*, was produced by use of the "natural" color filters – blue, green and orange – but has had the contrast in each color enhanced to produce another type of "false" color image. This treatment shows many subtle differences in the colors of Jupiter's clouds which cannot be seen in the "natural" color version.

Dr. Torrance Johnson, of the Jet Propulsion Laboratory, is Project Scientist for the Galileo Project and a member of the Voyager Imaging Team.



PHOTOS: JPL/NASA



Voyager Scientific Investigations

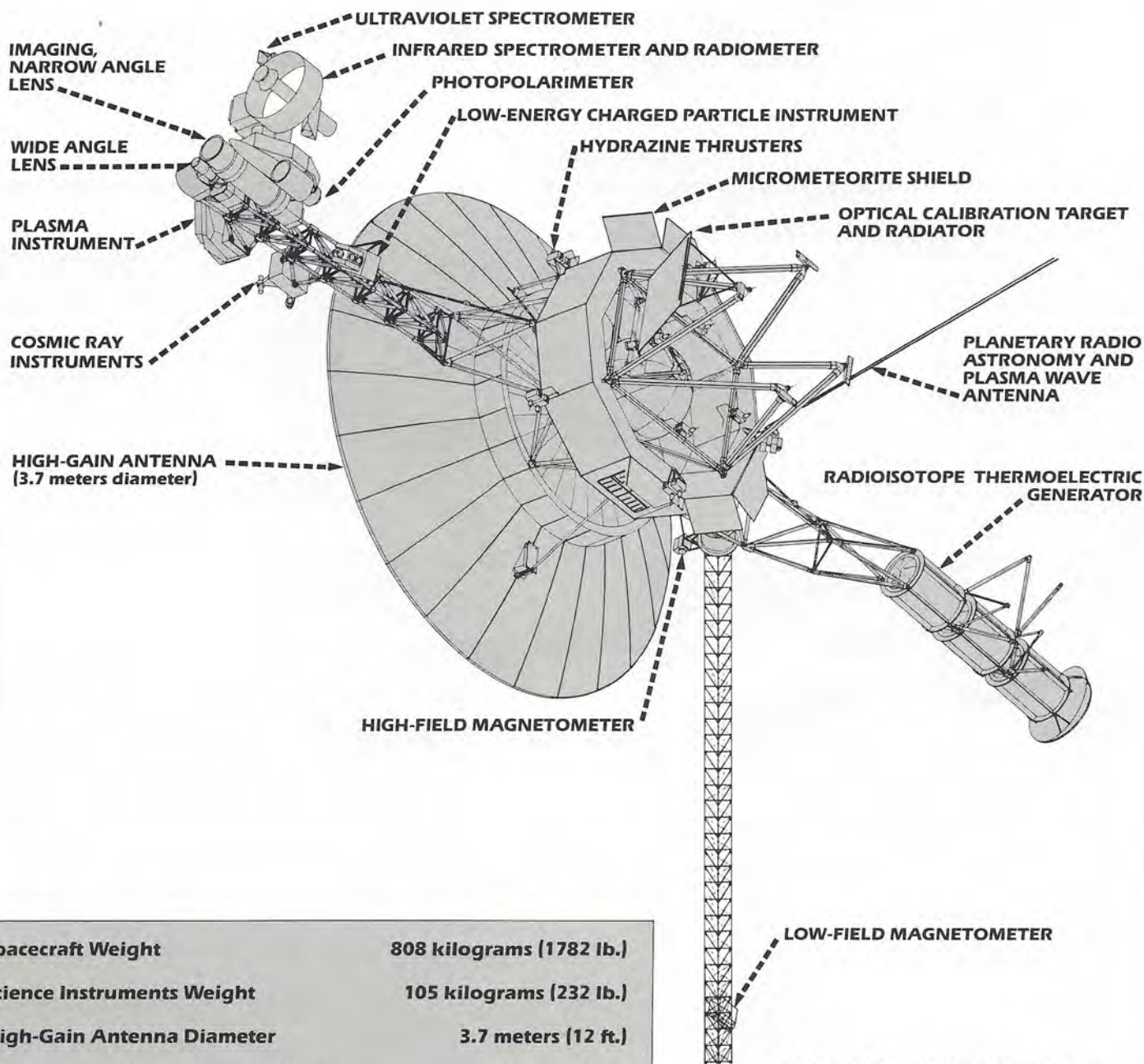
THE SCIENTIFIC INVESTIGATIONS of the *Voyager* mission are multipurpose and most are intended to obtain data in a variety of environments. For example, the ultraviolet spectrometer is oriented toward planetary and satellite atmospheres and toward studies of interplanetary and interstellar hydrogen and helium. The magnetic fields experiments examine the magnetospheres of the planets and search for the transition between solar and galactic regions. Thus, it is difficult to separate "planetary" from "interplanetary" instruments and experiments. There is, however, another way of grouping: the optical scanners, mounted on the spacecraft's scan platform, have narrow fields of view and must be accurately pointed. They collect radiant energy (light, for example) from their targets and create images or spectral information that permit scientists to understand the physical form or chemical composition of the planets and satellites.

Experiments in this group include the image-science instruments (the cameras), the infrared interferometer-spectrometer and radiometer, the ultraviolet spectrom-

eter, and the photopolarimeter. A second family of experiments senses magnetic fields and fluxes of charged particles as the spacecraft passes through them. These instruments, fixed to the body of the spacecraft, have various fields of view; their data taken together provide information on planetary magnetic fields and trapped radiation zones (and indirectly, on interior structures), on Sun-planet and planet-satellite interactions, and on cosmic rays and the outer reaches of the solar plasma. These experiments are the plasma, low-energy charged particles, cosmic ray, and magnetic-fields investigations. A third family of experiments consists of the planetary radio astronomy and the plasma-wave experiments, whose long antennas listen to radio emissions from Jupiter and measure waves in the plasma surrounding the planets. A radio experiment uses S-band and X-band radio links between the spacecraft and Earth to gather information on planetary and satellite ionospheres and atmospheres, and spacecraft tracking data to chart gravitational fields that affect *Voyager's* course.

Experiment	Principal Investigator	Primary Measurements
Cosmic Ray Investigation	R.E. Vogt, <i>California Institute of Technology</i>	Energy spectra and isotopic composition of cosmic ray particles and energetic particles in outer planetary magnetospheres.
Imaging Science	Team Leader, Bradford Smith, <i>University of Arizona</i>	Imaging of planets and satellites at resolutions and phase angles not possible from Earth. Atmospheric dynamics and surface structures.
Infrared Interferometer Spectrometer	Rudolf Hanel, <i>Goddard Space Flight Center</i>	Energy balance of planets. Atmospheric composition and temperature fields. Composition and physical characteristics of satellite surfaces and Saturn's rings.
Low-Energy Charged Particles Investigation	S.M. Krimigis, <i>Johns Hopkins University, Applied Physics Laboratory</i>	Energy spectra and isotopic composition of low-energy charged particles in planetary magnetospheres and interplanetary space.
Magnetometer	Norman Ness, <i>Goddard Space Flight Center</i>	Planetary and interplanetary magnetic fields.
Photopolarimeter	Charles Lillie, <i>University of Colorado</i>	Methane, ammonia, molecular hydrogen, and aerosols in atmospheres. Composition and physical characteristics of satellite surfaces and Saturn's rings.
Planetary Radio Astronomy	James Warwick, <i>University of Colorado</i>	Planetary radio emissions and plasma resonances in planetary magnetospheres.
Plasma Investigation	Herbert Bridge, <i>Massachusetts Institute of Technology</i>	Energy spectra of solar-wind electrons and ions, low-energy charged particles in planetary environments, and ionized interstellar hydrogen.
Plasma Wave Investigation	Frederick L. Scarf, <i>TRW Systems Group</i>	Dynamics of planetary magnetospheres and satellite perturbation phenomena associated with charged particle-plasma wave interactions. Determination of electron density.
Radio Science	Team Leader, Von R. Eshleman, <i>Stanford University</i>	Physical properties of atmospheres and ionospheres. Planet and satellite masses, densities, and gravity fields. Structure of Saturn's rings.
Ultraviolet Spectrometer	A. Lyle Broadfoot, <i>Kitt Peak National Observatory</i>	Atmospheric composition including hydrogen to helium ratio. Thermal structure of upper atmospheres. Hydrogen and helium in interplanetary and interstellar space.

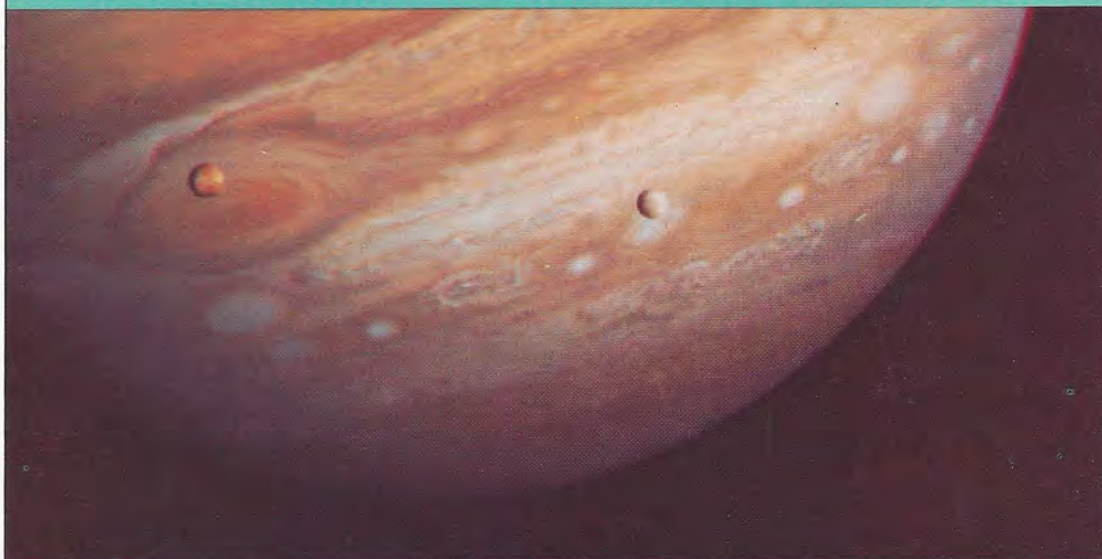
Voyager Spacecraft Features



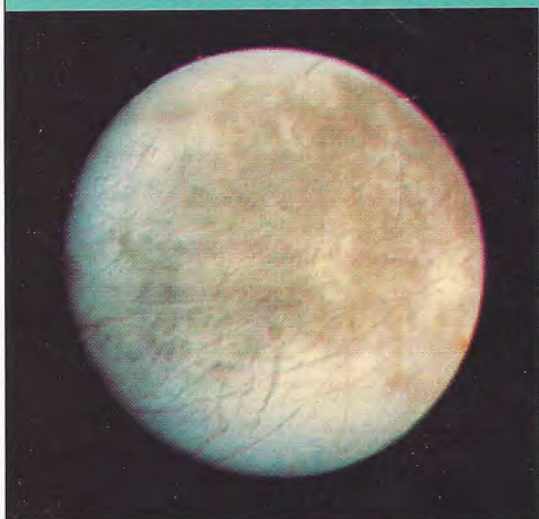
(SPACECRAFT SHOWN WITHOUT THERMAL BLANKETS FOR CLARITY)

Spacecraft Weight	808 kilograms (1782 lb.)
Science Instruments Weight	105 kilograms (232 lb.)
High-Gain Antenna Diameter	3.7 meters (12 ft.)
Radioisotope Thermoelectric Generator (RTG) Power (at Saturn)	approx. 400 Watts
Data Storage Capability	538 million bits
Rate of Data Returned to Earth at Jupiter	115,200 bits per second
at Saturn	44,800 bits per second

THE VOYAGER 1 ENCOUNTER WITH JUPITER



Jupiter and two of its satellites (Io, left, and Europa, right) were photographed on February 13, 1979. Jupiter is about 20 million kilometers (12.4 million miles) from the spacecraft. At this resolution (about 400 kilometers or 250 miles) there is evidence of circular motion in Jupiter's atmosphere. While the dominant large-scale motions are west to east, small-scale movement includes eddy-like circulation within and between the bands.



The resolution of this picture of Europa taken in the afternoon of March 4, 1979, from a distance of about 2 million kilometers (1.2 million miles) is about the best obtained by Voyager 1. The most unusual features are the systems of long linear structures that cross the surface in various directions. They may be fractures or faults which have disrupted the surface.



This picture of Callisto was taken on March 6, 1979, at a distance of 350,000 kilometers (217,000 miles). Surface features about 7 kilometers (4 miles) across are shown. Smaller than Ganymede (about the size of the planet Mercury), Callisto is apparently composed of a mixture of ice and rock. Far more craters appear on the surface of Callisto than that of Ganymede, leading scientists to believe that Callisto is the oldest of the Galilean satellites, possibly dating back to the final accretional stages of planet formation 4 to 4.5 billion years ago.

A WEALTH OF NEW KNOWLEDGE OF JUPITER, five of its moons and the magnetic and radiation environment of the Jovian system was obtained during the first several months of 1979 by *Voyager 1*. Eleven science teams had the monumental task of analyzing the data and correlating their findings. Some major scientific discoveries apparent in *Voyager's* spectacular photographs are the thin ring of particles around Jupiter, the swirling turbulence of the planet's weather system, superbolts of lightning crackling in the atmosphere and towering volcanic eruptions on the satellite Io. The pictures on this and the facing page are a small sample of the thousands of images acquired by *Voyager 1*.



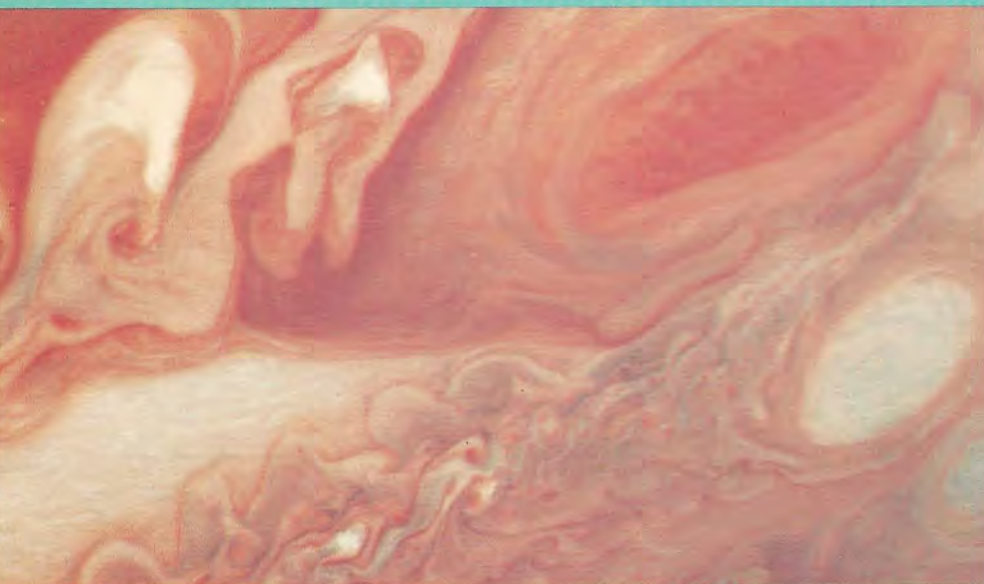
Artist's conception of the ring of Jupiter.



Io is shown here in a picture taken on March 4, 1979, from a distance of 862,000 kilometers (500,000 miles). Circular features are seen that later were proved to be of volcanic origin. Irregular depressions indicate that surface modification has taken place.



This image of Io was acquired on March 4 at a distance of about 490,000 kilometers (294,000 miles). An enormous volcanic explosion is seen silhouetted against dark space over Io's bright limb. This is the first currently active volcanism identified on solar system bodies other than planet Earth. Io appears to be far more active volcanically than Earth.



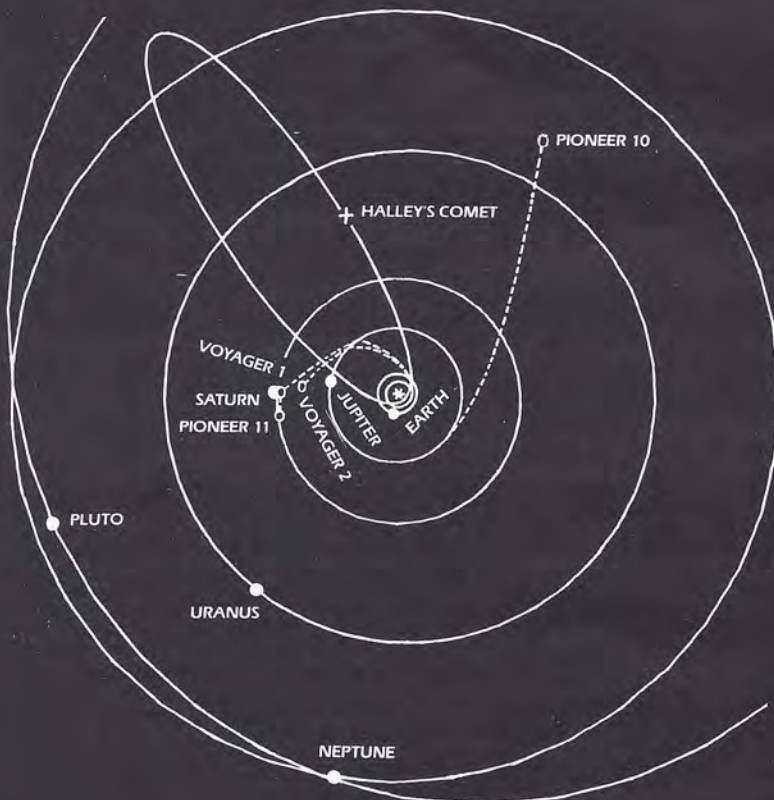
Jupiter was photographed by Voyager 1 on March 1, 1979, at a distance of 5 million kilometers (3 million miles). This picture shows Jupiter's Great Red Spot (upper right) and the turbulent region immediately to the west.

TEXT AND PHOTOS: COURTESY JPL/NASA

Calendar of Events

PLANETARY POSITIONS

Shown here are the positions of the planets and the currently active spacecraft in the outer solar system for October, 1980. The orbit of Halley's Comet, which comes into the inner solar system in late 1985, is also shown, since it will be a target of at least two missions. The Voyager spacecraft, on approach to Saturn, are evident (Voyager 2 arrives in August, 1981), as are the Pioneer spacecraft. Note that Pioneer 10 is now rapidly exiting the solar system, but that Pioneer 11 has yet to get relatively far from Saturn even though its encounter was one year ago. Saturn's orbital period is nearly 30 years, so that in one year it travels only 12° in its orbit. Halley's highly-elliptical orbit has a period of 76 years, and most of the time (except when it nears the Sun) it moves imperceptibly over a one-year period. Halley's Comet orbits the Sun in a direction opposite to that of the planets — clockwise, looking down on the solar system from the North.



December 1–26

5:55 a.m. weekdays:
Knowledge-Space
New York, WNBC (Channel 4).

December 7, 14, 21

Cosmos: A Personal Voyage
by Carl Sagan.
Check your local Public Broadcasting
Service for time of broadcast.

December 8–12

AMERICAN GEOPHYSICAL UNION
FALL MEETING,
San Francisco, California.
*Symposia: Voyager Results
from Saturn*,
Dec. 11, morning and afternoon,
El Dorado Room,
Jack Tar Hotel.
Full program in *Eos*,
Vol. 61, No. 46, Nov. 11, 1980.

December 13

Geminid meteor shower.

December 21

Winter Solstice and Full Moon.

December 22

Ursid meteor shower.

January 3–8, 1981

AMERICAN ASSOCIATION FOR
THE ADVANCEMENT OF SCIENCE,
Toronto, Canada.
*Symposium of Exploration of
the Solar System*
(Tobias Owen, David Morrison,
Bradford Smith, Harold Masursky).
Jan. 5, 2:30 p.m., Sheraton Centre Hotel,
Full program in *Science*,
Vol. 210, No. 4467, Oct. 17, 1980.

To list items, send them to:

Bonny Lee Michaelson
The Planetary Society Calendar
P.O. Box 3761
Beverly Hills, California 90212

WASHINGTON WATCH

by Louis Friedman

Action on the NASA budget begins when NASA submits its request to the Office of Management and Budget (OMB) of the Executive Office of the President in September of each year. Following lengthy consideration, and with the advice of the Science Advisor's office, the President's budget is completed in early January and submitted to Congress on January 20. In the next issue of *The Planetary Report* we will discuss OMB and Executive Office action. This issue we consider Congressional action.

Congressional action on the NASA Program involves three processes—authorization, appropriation and budget—in each of the two Houses of Congress. Theoretically, authorization establishes program content, appropriation sets funding levels and budget provides a total constraint consistent with overall federal expenditures. In fact, distinctions are blurred; all three processes interact and each heavily influence program content. Here is a summary of this year's action on the NASA budget for the Fiscal Year 1981—the budget period beginning in October, 1981—as it pertains to planetary exploration and the search for extraterrestrial life.

Authorization

Both House and Senate passed a bill which kept intact the President's request and added some items. *Galileo* [see glossary below] and International Solar Polar Mission (ISPM) were continued and a two percent real growth item for supporting research and technology and data analysis was included. Gamma Ray Observatory, the only new space science start requested, was approved. Twelve million dollars was added to the President's recommendation for the Solar Electric Propulsion Stage (SEPS), a space transportation program. This was much less than would be required to accomplish the Halley/Tempel 2 Rendezvous Mission. Authorizing committees (House Science and Technology, and Senate Commerce, Science and Transportation) specifically decoupled the SEPS from a mission start.

Appropriations

It was confusion on the Hill over the NASA budget and appropriations have not yet been finally approved. A "continuing resolution" passed just one week before the beginning of the fiscal year enabled temporary appropriations for NASA but did not permit any new starts. The House Appropriations Subcommittee dealing with NASA attempted to delete funds for ISPM in the 1980 budget supplement for NASA. The Chairman of the House Science and Technology Committee suc-

cessfully challenged the Subcommittee's authority to cancel the program. This saved ISPM. Subsequently, in a dispute with NASA over greater Congressional control over reprogramming authority, the House Appropriations Committee passed a zero NASA Research and Development budget, which covered all NASA programs. The actual level will be set in a House-Senate Conference. In addition, the Committee agreed to a two percent cut for all agencies under the Subcommittee's jurisdiction—Housing and Urban Development, the National Science Foundation, the Environmental Protection Agency and NASA.

The Senate Appropriations Committee approved most of the requested programs and the twelve million dollars for SEPS. But it also adopted the two percent cut. Congress went into recess without final action on the budget. The House and Senate Committees must go into conference next, before final action can be taken.

If all of this sounds confused—it is!

Budget

A year ago the Senate Budget Committee staff suggested NASA's budget be cut by cancelling or deferring *Galileo*. After much debate this was rejected by the Committee. At the first budget resolution in March, no attack on the program was made, but during the preparations for the second budget resolution in July, there was a suggestion that *Galileo* and Space Telescope be delayed or even cancelled. The Committee, in response to strong counterarguments, refused.

The Senate Budget Committee debate, the attempt in the House to cancel ISPM and earlier attacks on *Galileo* and *Pioneer*

Venus rallied public support for the space program. Although there was no organized effort and no central leadership, many of the principals in Congress received scores of letters and telegrams objecting to the budget cuts. Communications came from persons associated with the L-5 Society, *Omni*, the American Institute of Aeronautics and Astronautics (AIAA), the Division for Planetary Science of the American Astronomical Society, universities and the space industry.

Public Opinion

Time magazine, in its October 20, 1980 cover story on Carl Sagan and the Public Broadcasting Service program *Cosmos*, reported: "Many people pressed loudly and insistently for more attention to earthly problems. NASA is still suffering budgetary blues from this outcry. Indeed, only last week the space agency's beleaguered boss, Robert Frosch, announced he was quitting, reportedly because of lack of financial support...."

"In a turnabout as sudden as some of the scene shifts in *Cosmos*, ennui has turned into enthusiasm. Public curiosity about science, if not financial support of it, seems to be skyrocketing. Some signs: *The New York Times* has created a special weekly section to report the news of science, and other newspapers have expanded their science staffs and coverage. Some half a dozen new mass-market science magazines have been launched...."

Louis Friedman, Planetary Society Executive Director, spent one year as a Congressional Fellow with the Senate Committee on Commerce, Science and Transportation.

Glossary of Missions Discussed in "Washington Watch"

Galileo: The Jupiter orbiter and probe mission to be launched in 1985 by the Space Shuttle. The mission involves both an orbiter, which will make many passages by the Galilean satellites of Jupiter, and a probe which will enter and sample the giant planet's atmosphere.

ISPM: The International Solar Polar Mission being conducted in cooperation with the European Space Agency. Two spacecraft will be launched, one to fly over the Sun, the other under it.

SEPS: The Solar Electric Propulsion Stage, a low-thrust continuous propulsion system for deep space missions. It uses solar energy collected by solar cells to heat and ionize a plasma. The

expulsion of those ions creates the thrust to move the spacecraft.

Halley/Tempel 2: A proposed mission utilizing Solar Electric Propulsion (SEPS) that would involve a United States spacecraft flying in formation with Comet Tempel 2 after deploying a European probe into Halley's Comet. Because this mission needed SEPS and SEPS was not included in the President's budget last year, this opportunity was lost. But a Halley's Comet fly-through without the Tempel 2 rendezvous is still possible.

Gamma Ray Observatory: An Earth-orbiting telescope mission that has been proposed by the Administration for a new start.

The Last Pictures From VIKING Orbiter I

by James A. Cutts and Karl R. Blasius

On Aug. 7, 1980 the *Viking Orbiter I* spacecraft terminated its mission after 1489 orbits around Mars. This mission lasted more than sixteen times the nominal 90-day orbital lifetime and the orbiter succumbed, as did its sister ship *Viking Orbiter II*, to the exhaustion of attitude control propellant [the gas which permits the spacecraft to point to a particular place] and not to mechanical or electronic failure.

Viking Orbiter I ended its mission as it began it—photographing the channel systems which were the focus of the first landing of a spacecraft on Mars. Some of the last images cover the Maja Vallis channel system near the *Viking Lander I* (VL-1) site at unprecedented resolution. However, these data have not been completely processed into quality photographs; they will be discussed in a future issue of *The Planetary Report*. Presented and discussed here is the Mangala Vallis channel system—1500 kilometers southwest of the Olympus Mons shield volcano and one-third of the way around the equatorial girth of Mars from the *Viking Lander I* site.

Fig. 1: Prior to *Viking Orbiter I*, Mangala Vallis was recognized as the larger and easternmost of the two sinuous valley systems extending approximately 350 kilometers north-south from 9° S to 4° S near 151° W longitude near the center of this mosaic of pictures. The "source area" was identified as a hummocky area consisting of a complex of small channels and scars lying near the southern end of Mangala Vallis and its "subsidiary" unnamed sister channel.

These images taken midway through *Viking Orbiter I*'s mission first revealed that this description of channels in this area is quite incomplete. They clearly show that north-south oriented flow-features extend 600 kilometers farther upstream, apparently originating at a massive fissure system called *Memnonia Fossae*. More remarkably, another west-north-westerly trending channel system, comparable in size to Mangala Vallis, intersects the north-south trending channel almost at right angles. Also revealed in this image is a sparsely cratered deposit that has encroached upon the mouths of all these channels from the north after the flow processes terminated. [Lightly cratered areas are believed to be of more recent origin than heavily cratered regions.] Remnants of these later deposits may also partially fill the narrow channels.

This is a mosaic of images prepared by the U.S. Geological Survey from imaging data acquired on orbits 637 and 639 of *Viking Orbiter I* and resolution is between 130 and 300 meters per pixel. [All spacecraft pictures, like newspaper photos, are composed of many dots; each dot is a picture element, or pixel.]

Fig. 1

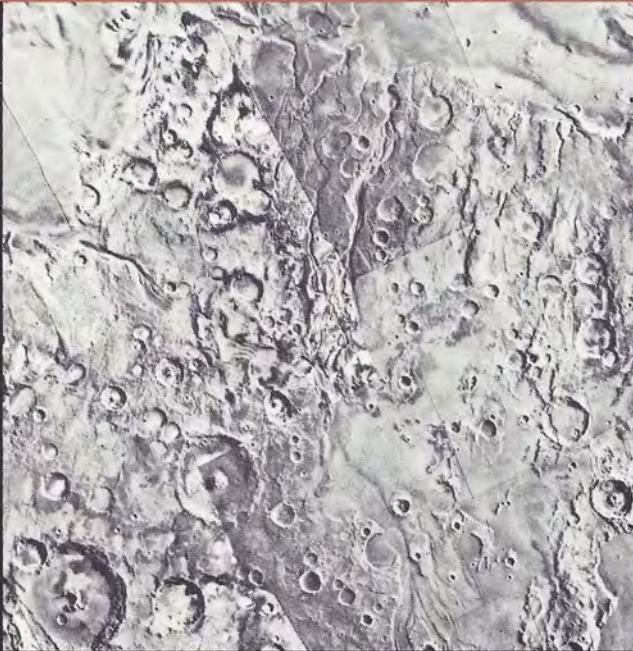


Fig. 2

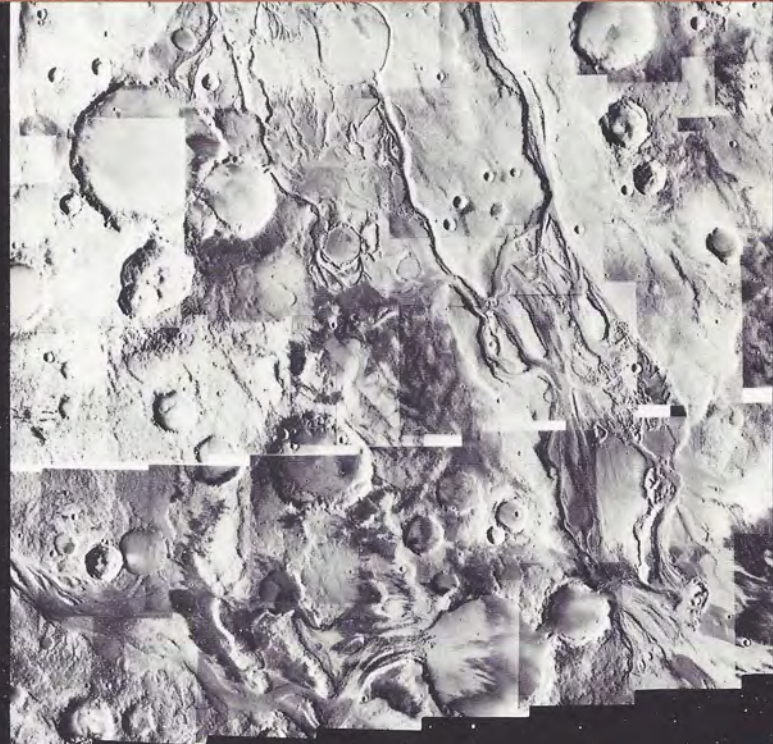


Fig. 2: This mosaic of the Mangala Vallis region was taken by Viking Orbiter 1 on three successive days, June 19, 20, 21, 1980. Resolution is 40 meters per 1 pixel; this is between 4 and 8 times better than the earlier images (Fig. 1).

The complex of small channels and erosional scars at right center was believed, from Mariner 9 images, to be the source of Mangala Vallis. We can now see that it is only a broad basin that interrupts a pattern of flow extending from further south. The sinuous, flat-floored valley that extends to the top of the mosaic is Mangala Vallis proper; to the left is the subsidiary and somewhat narrower unnamed channel. The massive new channel first discovered in the Viking Orbiter pictures extends across the bottom of the mosaic almost at right angles to these two. Why did these channels cascade away from one spot in such different directions? What is the source of the flow? These questions are currently a mystery but information contained in high resolution pictures such as these may provide an answer.

Fig. 3: This is a single frame from the mosaic of Fig. 2 providing a high resolution view of part of the complex of small valleys, plateaus and depressions which may have once been the source of water which formed the valley known as Mangala Vallis and is now seen to be traversed by flow features originating from further south. The broad swath of parallel grooves seen on the left part of the frame bears a strong resemblance to flow features of Chryse basin (the Viking 1 landing site). The circular depression at right center is typical

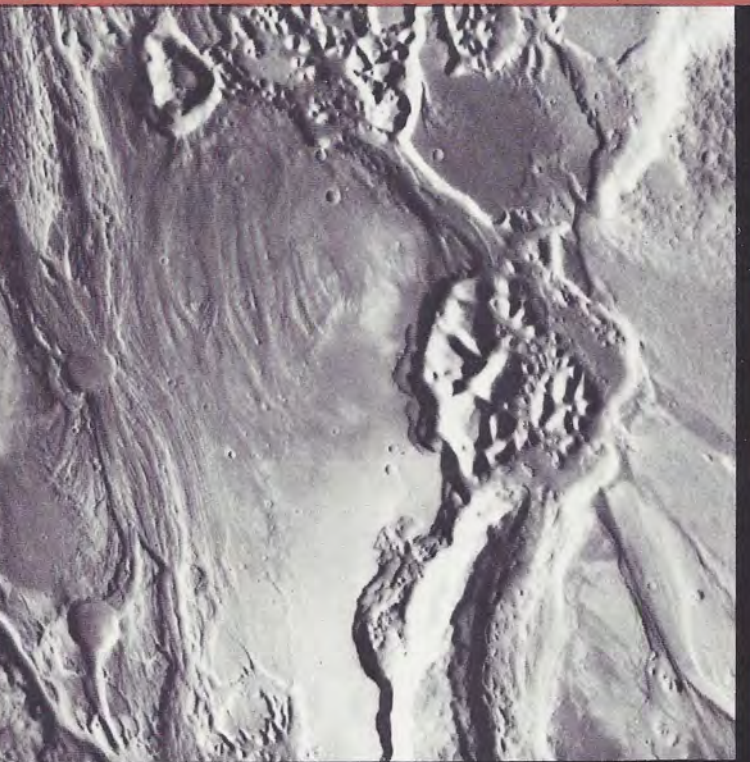
of features produced by collapse and rock disintegration elsewhere on Mars.

Fig. 4: This remarkable view of the margin of the southern cratered upland approximately 300 kilometers west of the mouth of Mangala Vallis reveals youthful deposits encroaching on the ancient upland from the west. These materials, more than a kilometer thick in places, form a virtually crater-free surface. Whether they are of volcanic or wind-blown origin is unknown but they are certainly much younger than channels of the Mangala Vallis region. The continuation of the westerly trending channel of Fig. 2 can be seen near the bottom right of the mosaic. Dark and bright streaks and splotches are thought to be fine particles blown by the wind and therefore wind direction indicators. A dark plume extending west of the mouth of the channel suggests that the channel controls the flow of the present winds as well as the fluids that coursed down it in earlier times. An interesting mix of flow directions can be perceived in the channel bedforms, the eolian scour markings on the younger deposits, and the dark streaks formed by recent winds.

Investigations of the relationships between these phenomena will assist scientists in unravelling the history of the sculpture of the Martian surface by flows.

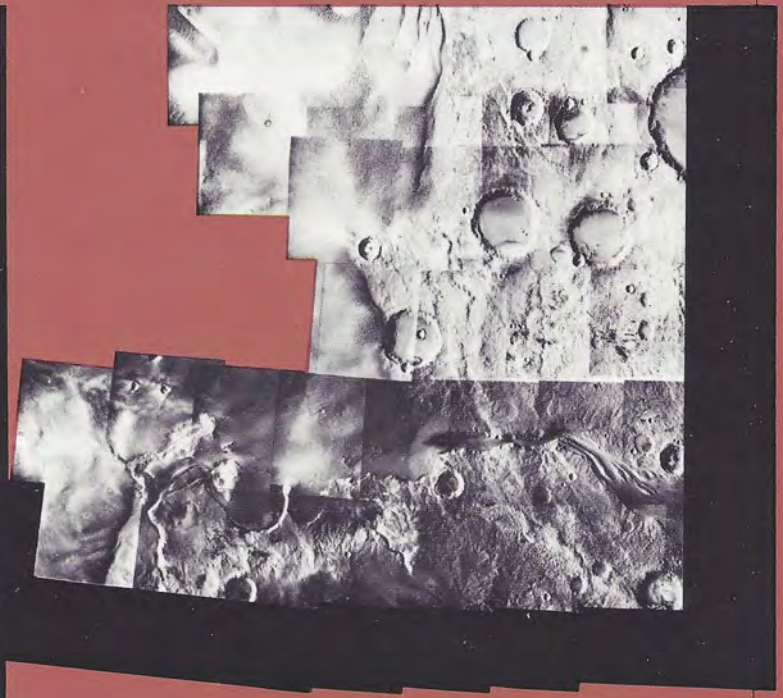
Viking Imaging Team investigators, James A. Cutts and Karl R. Blasius are associated with the Planetary Science Institute, Science Applications, Inc., Pasadena.

Fig. 3



PHOTOS: JPL/NASA

Fig. 4



News & Reviews

by Clark R. Chapman

This is the first publication of "News & Reviews," reporting on some of the latest scientific results of the planetary program, as contained in technical journals and popular magazines. Many of these magazines are available in local libraries (e.g., *Astronomy*, *Sky and Telescope*, *Star and Sky*, *Science 80*, *Mercury*, *Scientific American*, *Science*, and *Nature*) while others may be found only in libraries of major universities (*Icarus*, *Eos*, *Journal of Geophysical Research*, *Astrophysical Journal* and *Astronomical Journal*).

Our emphasis will be on planetary topics. Planetary research usually is only beginning when the daily press loses interest after reporting a spectacular encounter. Many lasting concepts in science develop only after years of rigorous, creative analysis of data gathered in space exploration. Therefore, articles that present a synthesis of the interdisciplinary threads of research are particularly noteworthy. But I also will call attention to new discoveries and concepts reported at scientific meetings. I hope to keep readers of *The Planetary Report* posted on rapidly changing perspectives about our niche in the galaxy, and guide them to articles where they can find definitive summaries.

Four New Worlds

In my view, the most remarkable feat of the planetary program has been *Voyager's* revelation of four fascinating new worlds: Io, Europa, Ganymede, and Callisto. These satellites of Jupiter had been studied through telescopes for centuries. Modern researchers, both observational and theoretical, had correctly inferred their gross properties. But the beautiful, richly detailed *Voyager* portraits of these planet-sized bodies exhibited geological and geophysical traits and processes beyond our imaginations.

David Morrison, an astronomer who studied the Galilean satellites before *Voyager* and became a member of the *Voyager* Imaging Team, has written an excellent, profusely illustrated popular summary of the findings on these "Four New Worlds" in the September issue of *Astronomy* magazine. His article is accompanied by maps and colorful pictures of each body. [An article by Dr. Morrison appears on page 4 in this issue of *The Planetary Report*.]

Callisto is the most densely cratered body now known in the solar system. Ganymede, crisscrossed by weird grooved terrain, shows evidence of motions in its icy crust; perhaps they are partly analogous to the continental plate tectonics [movement of the Earth's land masses] dominant in our own planet's geological history. Europa is smooth as a billiard ball but covered with mysterious stripes. The innermost world, Io, is the most active terrestrial body in the solar system, with volcanic eruptions that put Mt. St. Helens to shame. Some *Voyager* scientists speculate that Io may have an underground ocean of liquid sulfur, crusted over with a solid sulfur surface. In this model sulfur dioxide will exist as a liquid at some shallow depth within the sulfur crust. Eruptions continuously spew sulfurous compounds into the vacuum around Io, which mostly fall back to Io's surface as sulfur dioxide snow.

Mapping Venus

A far different technology has gradually unveiled the geological character of another world much closer to home, but long shrouded from our view by its thick atmosphere and clouds. Huge earth-based radar telescopes, combined with an unheralded small radar antenna still orbiting Venus aboard *Pioneer Venus 1*, have given us maps of that world, as described in the August issue of *Scientific American*. Authors Gordon Pettengill, Donald Campbell, and Harold Masursky describe how Venus differs from both the Earth and Mars. The immense Ishtar plateau is the one true continent on Venus. It is capped by an eleven-kilometer-high mountain named Maxwell, possibly a giant volcano. There are two other regions of complex geography on the otherwise smooth-surfaced world. The radar maps published in *Scientific American* raise many more questions that they answer about crustal processes on Venus. They highlight the importance of obtaining more detailed maps, as the proposed Venus Orbiting Imaging Radar (VOIR) could do later in this decade.

Evolutionary Theory

An intriguing question about evolution of life on Earth concerns occasional mass extinctions of life forms (such as the dinosaurs) recorded in the fossil record. A new view is developing that such extinctions may be due to the havoc created by gigantic asteroidal impacts on the Earth. Several scientists have examined clays at the boundary between the Cretaceous and Tertiary geological periods (65 million years ago) using techniques developed for identifying meteorites. Minute quantities of certain rare metals measured in the clays have abundances much like those found in such extraterrestrial material as meteorites, but very different from abundances typical in rocks from the Earth's crust (R. Ganapathy, *Science* for August 22, 1980).

Nobel-prize winning physicist Luis Alvarez and his colleagues Walter Alvarez, Frank Asaro and Helen Michel have written a long, technical, but readable article in the June 6th issue of *Science* describing their hypothesis for the demise of dinosaurs. They believe that the collision of a ten-kilometer asteroid with Earth 65 million years ago was the source of the extraterrestrial rare metals and responsible for changes in climate, the food chain and ecological niches that "did in" the dinosaurs. Other scientists have written their own perspectives on this problem in *Eos*, *Nature*, and other magazines during the past few months.

Jovian 'Weather'

The *Voyager* pictures of Jupiter's swirling clouds are beautiful and dramatic. But an understanding of Jupiter's fluid motions will take much analytical effort for years to come. The *Voyager* data will be augmented by new data from the *Galileo* mission in the late 1980's. But planetary meteorologists are making some progress in identifying the nature of Jovian "weather." Staff writer Richard Kerr of *Science* magazine has posed the question in the September 12th issue as to whether Jupiter's atmosphere behaves more like the Earth's (which is driven by solar energy) or a star's (which is driven by internally generated heat). The brief article summarizes ideas of several theoreticians and anticipates possible comparisons with Saturn that may be possible soon when the first *Voyager* arrives at that planet.

Clark Chapman, of the Planetary Science Institute in Tucson, Arizona, is a member of the Galileo Project Imaging Team. His primary research interests are asteroids and small bodies.

Society Notes

When Carl Sagan and Bruce Murray asked me to join with them in promoting a popular membership organization devoted to advancing the cause of space exploration, I wasn't sure whether I faced the prospect of ending my professional career in aerospace, or revitalizing it. The question was whether a "constituency" existed to support the continuation of the great programs that have brought so many break-throughs in recent years — and, if so, how it could be enlisted.

The appearance of Volume 1, Number 1 of *The Planetary Report* provides the answer. The distinguished members of the Advisory Board (listed on page 2) greeted the proposed Society with enthusiasm, scores of professional colleagues offered active assistance, and individuals and foundations came forward with seed money. Thousands have joined the Society since it was announced a few months ago — and our general membership mailing is just now going out.

Articles about the founding of the Planetary Society appeared in *Omni*, *Astronomy*, *Star and Sky*, *Science*, *Sky and Telescope*, *Science 80*, and the *Aerospace Daily*. Beyond the professional publications, there have been news stories in the general press, and the officers of the Society have provided dozens of interviews for the broadcast media, including *The Tonight Show*. This has generated a mail response from persons in every section of the nation and from abroad, and the flow has been increasing steadily since we began mailing our special membership brochure.

So we are confident that the Society is thriving and will provide a tangible answer to those who doubt the depth and breadth of public interest in space exploration — and the willingness of taxpaying citizens to continue to support the programs that have produced the spectacular results of the last decade. Our goal is an expanded membership; and to attract and maintain it we are initiating programs that

should allow every interested person to have a role in the great adventure that lies ahead.

The Society's officers and their associates have an active role in many of the programs the Society's members will help stimulate — further Mars exploration, solar sailing, asteroid missions. Drs. Sagan and Murray are working actively to stimulate efforts toward a more active program in the Search for Extraterrestrial Intelligence. The Society is deeply interested in the Venus Orbital Imaging Radar and Halley's Comet programs and in NASA's completion of *Galileo* and the Space Telescope.

Our purpose is to keep the members of the Society up to date on all these developments — through *The Planetary Report* and through the organization of lectures, programs and seminars across the country.

So, welcome aboard — and please pass along directly to me any ideas, suggestions, or queries relating to the Society and its future.

Dr. Louis Friedman

Executive Director, The Planetary Society
P.O. Box 3599, Pasadena, CA 91103

Afterword

I cannot properly thank the many people, otherwise uncredited, who helped initiate the Society and this newsletter. But I must especially thank those who made key donations which enabled us to get started — Joseph W. Drown, Larry Niven, Isaac Asimov, Michel Halbouty, Charles Brush for the Explorer's Club and a very special anonymous donor. John Gardner and Barney Oliver of our Advisory Board have been a great help. In addition, I would like to thank Jon Lomborg and Brown, the artists who generously designed our logo.

Space Exploration

(continued from page 2)

at the picture for a totally different reason noted a small speck at the edge of the Io limb. Further analysis is producing significant additions to our scientific knowledge. In observing Ganymede we found the only place outside the earth where lateral displacement faults exist, a Jovian San Andreas fault probably reflecting ancient convection in the interior of that moon. Further studies may reveal much about how these internal processes work and could improve the prospect that we eventually will be able to predict earthquakes and control their effects on the surface of our planet.

Voyager's exploration of Jupiter and its current exploration of the Saturnian system is the culmination of a continuous lunar and planetary exploration program beginning nearly two decades ago. Each year since 1964 we have received new images of another celestial body. Now the United States faces a hiatus in new planetary encounters of nearly five years. This

means a halt in the acquisition of new scientific knowledge and the slowing of the associated technological development of space vehicles. Here the great advances of the last twenty years have produced many practical applications in propulsion, sensors, digital communications, computers, data processing, image processing, robotics, guidance, and automatic control and space navigation. These technological advances have had a profound impact in such fields as transportation, housing, medicine and health care, factory management, plant process control, energy, and environmental control. Can this kind of development be done in more direct ways? Perhaps, but there is bound to be a significant loss of the impetus that comes of bringing together scientists and technologists in a broad-gauge common effort. It seems to be a characteristic of a forward-looking society that its vision is outward, that it is driven not by mere problem-solving but by the need to *understand* the processes that allow us to open up new frontiers. At a cost of

less than one-half of one percent of the federal budget we have been able, year after year, to lead the world in the most visible new technologies. The flights to the Moon, Mars and Jupiter have been catalysts for advances which touch the whole of human society.

What we do in space is a reflection of how our society chooses to invest its resources; creative space exploration projects a positive commentary on our self-image. Engaging the talents of our scientific and technological community in an effort that produces achievements of lasting historical importance is in the highest tradition of western civilization. The possibility of continued expansion of human knowledge is at hand. We must reckon the cost of continuing the program against the cost of slowing or abandoning it. I have no doubt as to the outcome of that calculation.

Bruce Murray, Director of the Jet Propulsion Laboratory at the California Institute of Technology, is Vice President of The Planetary Society.



EXPLORING A MARTIAN CHANNEL— One of the most surprising discoveries about Mars came in 1971–72 when the Mariner 9 orbiter first photographed riverbed-like channels on this arid planet. Pre-Mariner work had indicated that Mars is too dry and has too little air pressure to allow extensive liquid water activity. Yet, despite an initial flurry of alternative theories, most planetary geologists have concluded that the Martian channels were cut by flowing water at some time in the geologic past. Recent results, including those of Viking, indicate much Martian water is frozen in underground permafrost, frozen in polar ice caps, and chemically bound in the soil. Whether this water was released in occasional floods by local underground heating (Martian “Yellowstone parks”) or by some profound variations in ancient global Martian climates is a continuing Martian mystery with ramifications for our understanding of Earth’s climatic evolution.

Planetary Society member William K. Hartmann painted this imaginary scene from life (with suitable sky color modification!) in a tributary arroyo in Death Valley. A noted planetary scientist in his own right, Dr. Hartmann, a co-investigator on the Mariner 9 mission, comments that we have yet to see closeups of the most interesting scenery on Mars, because the Viking landing sites were chosen for smoothness. Here, he envisions a party of future geologists searching at first hand for clues about the origin and history of the channels. (Painting © 1979 William K. Hartmann)

William K. Hartmann is the author of *Moons and Planets*, published by Wadsworth Publishing Co. of Belmont, California. He is a scientist with The Planetary Science Institute in Tucson, Arizona.

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