Mars in Focus

Wild winds, dry deserts, vast volcanoes and a promising past

BY JONATHAN EBERHART

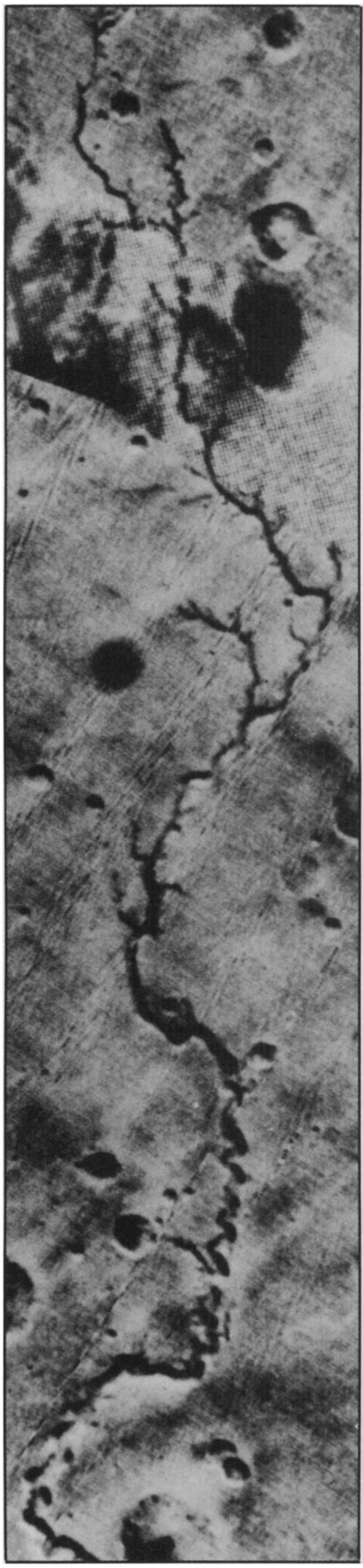
It's noteworthy that one of the most important aspects of the study of what Mars is like is the question of what it *used* to be like. It's to be expected that planetologists would want to study the past as well as the present, of course, but in the case of Mars, there seems to be particular reason to ask. And like most of the ruddy world's mysteries, the answer involves water.

Mars, for the most part, is dry. Minute quantities of water vapor have been detected in its atmosphere, and larger amounts are believed to be chemically bound in the rocks and perhaps frozen beneath the surface as permafrost. But there are certainly no seas or ponds, and even a transitory trickling streamlet would be a big surprise. Yet consider the evidence.

Much of the planet is covered with thousands of winding channels, complete with tributary furrows, deltas and a host of other compelling visual evidence that they were created by substantial flows of . . . what? As Carl Sagan puts it, "No alternative liquid besides running water has been proposed which is reasonable for the physical conditions of Mars." The longest channels are more than 1,000 kilometers long, and most of them twist sinuously around for all the world like terrestrial erosion ditches. The tributaries run the right direction and slope correctly to be inflow channels, teardrop-shaped plateaus in the channels have their pointed ends aimed "downstream" like proper former islands, and scientists will be hard-pressed to explain the braided silt patterns as other than the deposits of ancient streams.

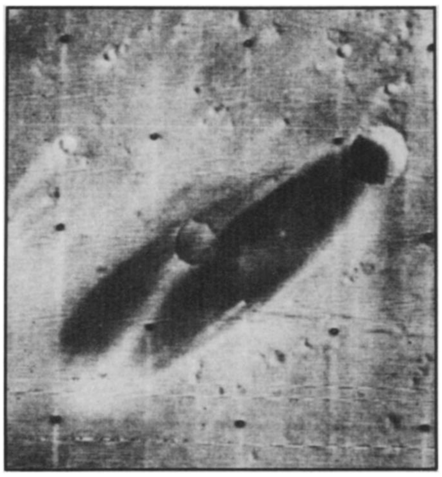
So where is the water? On most of the planet, a lakeful would boil away to nothing with only the minuscule atmospheric surface pressure of Mars to hold it in place—if it didn't freeze solid first or get absorbed by the parched, rocky soil. The one thing it wouldn't do is flow around cutting river beds.

At least not today. But once upon a time, hundreds of thousands of years ago, or millions, or *tens* of millions, the situation may have been different. If estimates of large quantities of argon in the atmosphere prove correct, it would be strong evidence that the Martian atmosphere used to be much thicker than it is now. The partial pressure of the one percent of argon in the earth's atmosphere is greater than the total pressure of the whole atmosphere



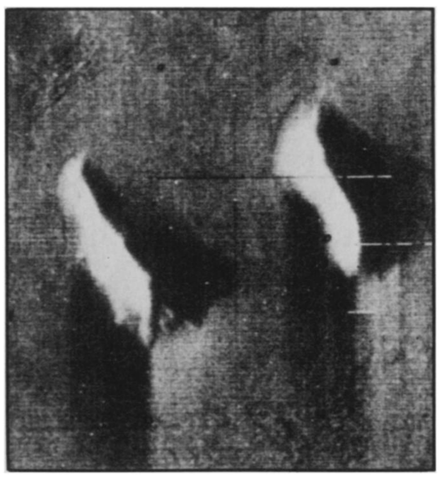
All photographs: Mariner 9/NASA

Bed of possible early Martian river.



Dark, windblown plume extends 140 km.

Dune field shows complex wind effects.



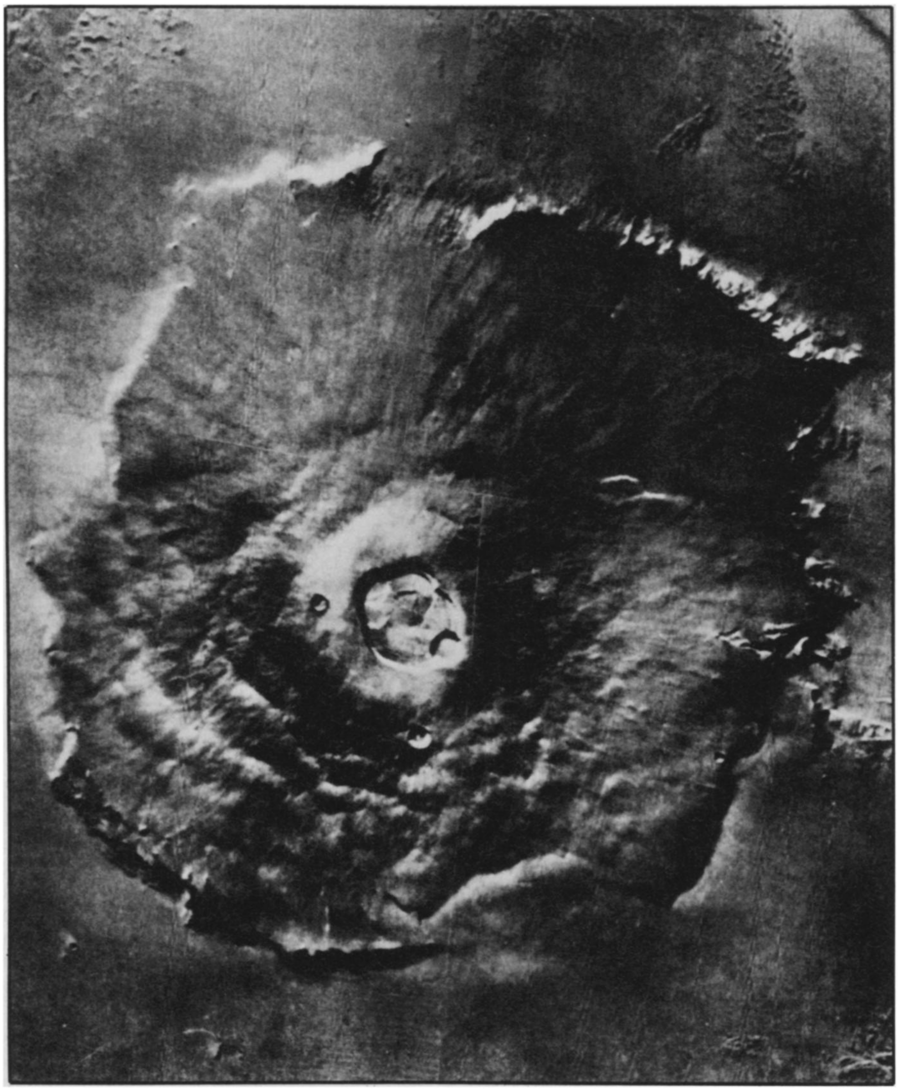
Pyramids, 1 km high, left by erosion.

Dark lines are ledges, revealing laminar layers near south pole.

A TALE OF TWO PLANETS

	Mars	Earth
Mean equatorial diameter	*6,795 km (0.533)	12,756.28 km
Volume	*1.632 x 10^{11} km^3 (0.15)	1.082 x 10^{12} km^3
Mass	*6.418 x 10^{23} kg (0.10744)	5.9733 x 10^{24} kg
Mean density	*3.945 g/cm^3 (0.715)	5.517 g/cm^3
Dynamic oblateness	*0.00524	0.00335
Escape velocity	*5.02 km/sec (0.45)	11.18 km/sec
Surface gravity at equator	*371 cm/sec^2 (0.379)	979 cm/sec^2
Mean distance from sun	227,943,996 km	149,599,000 km
Max. distance from sun	249,229,407 km	152,104,783 km
Min. distance from sun	206,658,586 km	147,093,217 km
Orbital eccentricity	0.09338	0.01675
Mean orbital velocity	*24.2 km/sec	29.8 km/sec
Sidereal period	686.98 earth days (1.88)	365.257 days
Period of rotation	*24 hr 37 min 22.7 sec	23 hr 56 min 4.1 sec
Orb. inclination to ecliptic	1°50′59″	0°
Equatorial incl. to orbit	*25°12′	23°27′
Visual geometric albedo	.16	
Mean bolometric albedo	.26	.30±.025 approx.
Surface temperature range	148° to 310° K, calculated (−193° to 98°F)	
Surface atmospheric pressure	2.8-10.3 mb	314-1061 mb
Average surface atm. pres.	5.5 mb, 0.077 lbs/in^2	1016 mb, 14.696 lbs/in^2

*includes Mariner 9 data
(Figures in parentheses are Mars:Earth ratios)



Olympus Mons volcano is 500 km across, 29 km high, biggest known in solar system.

of Mars, and it is reasonable to assume that other gases besides argon were released from the early Martian interior. Yet argon may constitute as much as a third of the Martian atmosphere, so a lot of other gases could be expected to have disappeared, perhaps escaping into space from the weak Martian gravity. Another possibility is that much of the early atmosphere is frozen into the polar caps (argon is too heavy to escape and its freezing point too low for either fate). It has been estimated that the caps could contain enough material to raise the atmospheric pressure to that of today's earth, roughly a hundred-fold increase. "If we find that the polar cap is carbon dioxide the year around," says Viking meteorology team leader Seymour L. Hess of Florida State University, "and if we can estimate how much frozen carbon dioxide exists there, then we may know that Mars once could have had a warm, thick, wet atmosphere."

A thicker atmosphere and flowing water would have meant a Mars almost unrecognizably different from the present one. Balmier temperatures, milder winds, probably fluffy clouds and a light blue sky—an almost healthy environment, one might dare to hope, for life.

Mars, then, seems to be gritting its way through a long winter, a vicious ice age that has apparently wrought far more radical changes than any comparable known epoch on earth. And just as important, at least by earthly experience, is that ice ages can be expected to end. Maybe there's a better Mars to come. "Might we," asks Sagan, "be able at some future time to prod Mars into returning to its pleasant

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past environment and—if there is no indigenous life—hosting immigrants from the distant planet earth?''

Mars also changes in short time-scales. The Mariner 9 spacecraft saw features appear and disappear within weeks. Even Antoniadi, as long ago as 1930, reported that the eastern edge of Syrtis Major—the most prominent feature, seen from earth, on the entire planet—shifted substantially from year to year. Light and dark streaks come and go; even the polar caps grow and shrink by the Martian seasons. (The behavior of the caps suggests to some researchers that there may be major seasonal changes in the density, and perhaps composition, of the atmosphere.) Many of the surface changes, notably including the alterations in the ''classical'' features once associated with artificial canals, reflect the vast clouds of dust moved around by the awesome Martian winds, a transport mechanism that is all the more surprising in view of the thin atmosphere. Another factor may be that the orbit of Mars is considerably less round than that of the earth: The planet's aphelion is more than 20 percent farther from the sun than its perihelion, compared to a difference of less than four percent for the earth.

The result is a bleak planet, but with one fascinating plus: weather. It is also a comparative planetologist's dream. (''If it didn't exist,'' says one researcher, ''we would have had to invent it.'') The reason is that it forms obliging sequences with other nearby bodies to the earth:

The moon is a dead world, untouched by wind or water and marked only by meteorite impacts and its own internal thrashings. The earth, on the other hand, is so weather-ridden that meteorologists can barely understand the phenomena that are obliterating the geophysicists' subject matter. Mars is right in the middle. It preserves so many craters that it keeps being described as ''moonlike,'' while still managing to provide clouds, winds, duststorms, even a weak ionosphere to hold down the physicochemical changes caused by the bombardment of the solar wind. ''Really,'' says Hess ''trying to understand the earth's atmosphere can be compared to trying to understand a manic depressive paranoid who has schizophrenic tendencies. But when numerical studies are developed with a good observed data base on a simpler atmosphere such as Mars, one would expect that we would get a better feeling for what is important on earth.''

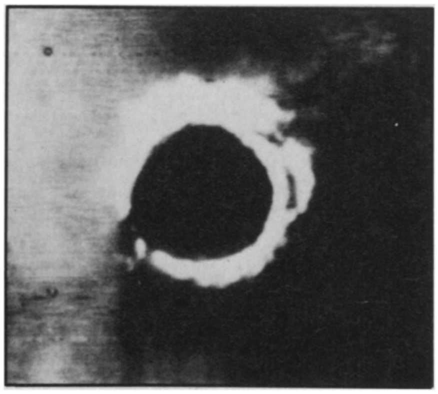
The surface, then, is so visible that geophysicists have been able to make relatively fine-toothed suppositions about it. One such is the possibility (SN: 4/10/76, p. 228) that the apparent dome-like structure of the uplands in the region known as Tharsis is sustained by some heat source (such as radioactive minerals) that is still cooking. The promise of active internal heat sources is an exciting one, both because it suggests that scientists have a chance to study a still-evolving planet and because thermally produced seismic activity might give Viking's seismometers some good, strong shocks with which to analyze the Martian interior.

Mars also forms a nice grouping with the earth and Venus. The thick, boiling soup that is the atmosphere of Venus is probably the most souped-up planetary heat engine that earthly space probes have any chance of exploring. The nearby sun heats the top, Venus itself heats the bottom, but so dense is the atmosphere that the radiative response time—the time required for the effects of added heat to be averaged out—is measured in weeks. For earth, it is mere days. And on Mars, with just enough ''air'' to help with the transporting but far too little to offer anything but token resistance, it takes only hours. It is this rapid heat transport, in fact, which gives birth to the violent winds.

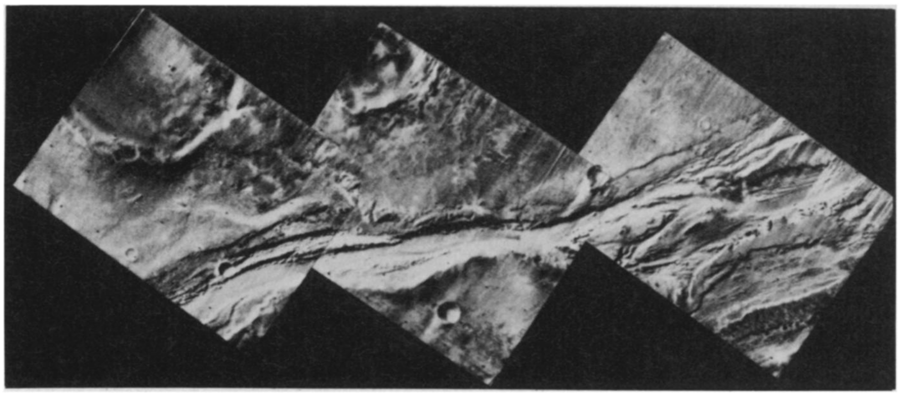
Mars is a world of marvels. It has a volcano the size of Rhode Island, a canyon that could span the United States, improbably precise craters-within-craters and a host of other exotic features. ''One warning,'' says Thomas A. Mutch of Brown University, leader of the Viking lander imaging team. ''Rocks can be faceted by the wind to have highly polished faces so that to look at them one would swear that they were artifacts of some civilization.''

But if there is one favorite description of Mars, it is ''the red planet.'' The prevailing explanation is that the soil is rich in the mineral hematite, oxidized iron. Hematite is nonmagnetic, and Viking's instruments are capable of both spotting the iron and checking its magnetism. If that is the answer, says Princeton's Robert B. Hargraves, in charge of Viking's magnet, ''it encourages the suspicion that an atmospheric evolutionary process has taken place in which at one time quite a bit of water was present, and that it dissociated into hydrogen and oxygen atoms, and that the hydrogen escaped from the planet and the oxygen got locked up in oxidizing surface materials.'' It all comes back to water.

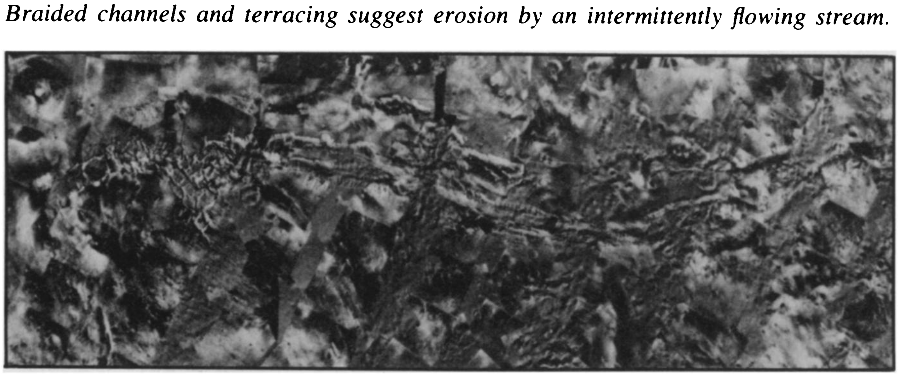
More answers have been provided about Mars in the last decade than in all the previous centuries, but new questions keep cropping up. ''We didn't know about penicillin,'' says Richard S. Young, vice chairman of the huge Viking science steering committee, ''until Fleming accidentally discovered it. . . . You don't always find what you are looking for, but you almost always find something of value.'' □



Bright ring may be water ice, since temperature at the time might have been enough to evaporate frozen CO_2.

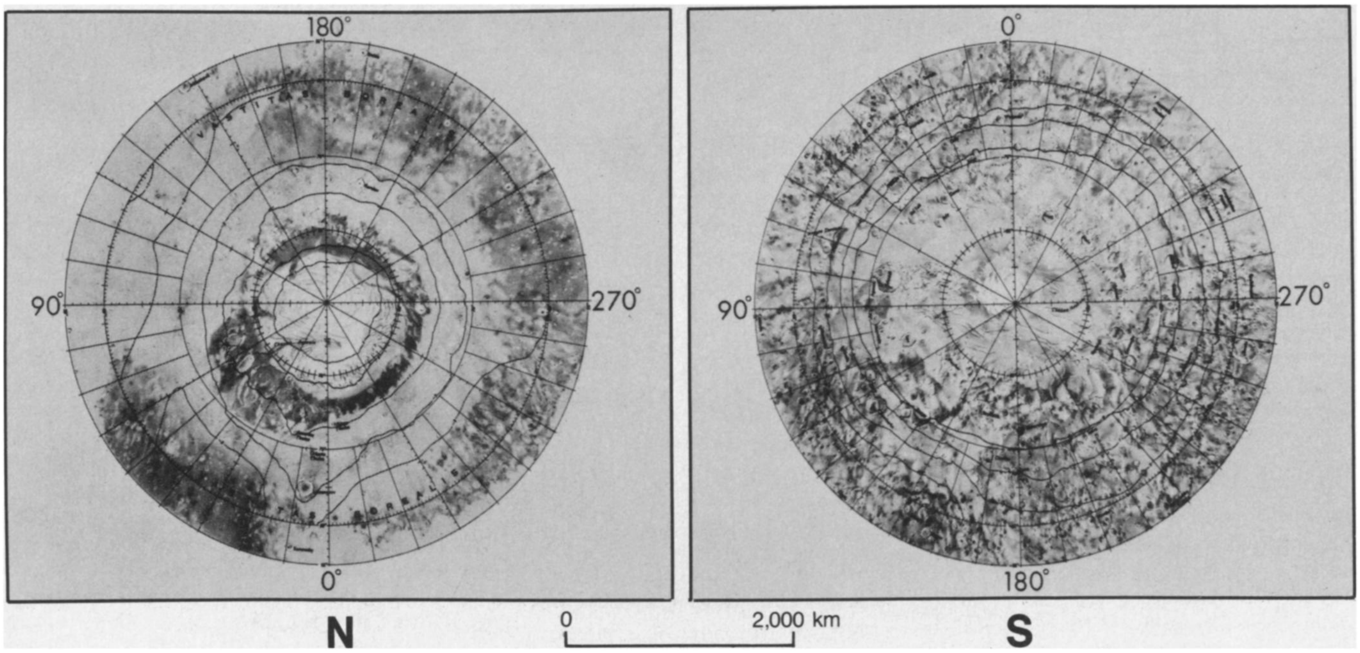


Braided channels and terracing suggest erosion by an intermittently flowing stream.



Valles Marineris canyon network, 4,000 km long and 6 km deep, would span U.S.

The Martian Poles



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COMMUNICATION WITH EXTRATERRESTRIAL INTELLIGENCE (CETI)—Carl Sagan, Ed.—MIT Pr, 1975, 428 p., photographs, diagrams, paper, $6.95. Reprint (1973), scientists discuss the possibilities of life on other planets, interstellar communication.

COSMIC CONNECTION: An Extraterrestrial Perspective—Carl Sagan and Jerome Agel—Doubleday, 1973, 274 p., photographs, drawings, $7.95. An entertaining exploration of the basic concepts used to evaluate the investigation of extraterrestrial intelligence.

EXPLORING MARS—Roy A. Gallant—Doubleday, 1968, rev. ed., 61 p., illus. by Lowell Hess, (gr. 7-9), $4.95.

EXTRATERRESTRIAL INTELLIGENCE: The First Encounter—James L. Christian, Ed.—Prometheus Bks, 1976, 250 p. (approx.), $12.95; paper, $4.95. To be published in July. Original essays consider the consequences to man's view of himself and his world when the first proven contact with beings from another planet will be achieved.

THE GALACTIC CLUB: Intelligent Life in Outer Space—Ronald N. Bracewell—Freeman (Scribner), 1975, 141 p., illustrations, $6.95. An astrophysicist discusses the possible sources, methods, purposes and implications of the first intelligent communication from extraterrestrial beings.

INTELLIGENT LIFE IN SPACE—Frank D. Drake—Macmillan, 1967, 120 p., illus., $4.50. A general survey on a more elementary level describing the early work on extraterrestrial intelligence.

INTELLIGENT LIFE IN THE UNIVERSE—I. S. Shklovskii and Carl Sagan—Holden-Day, 1966, 509 p., illus. part color, $6.95. The major pioneering work of Shklovskii illuminated by the embellishments of Carl Sagan.

MARS—Patrick Moore and Charles A. Cross—Crown, 1973, 10x13, 48 p., color and b&w photographs, drawings, maps, $8.95. A pioneering work, this atlas shows in 30 mosaic maps the features of the four quadrants and two poles of Mars, prepared from more than 1500 individual Mariner 9 photographs.

MARS AND THE MIND OF MAN—Ray Bradbury, et al.—Har-Row, 1973, 143 p., illus., $8.95. Panel discussion held in November '71 at California Institute of Technology, R. Bradbury, A. C. Clarke, B. Murray, C. Sagan and W. Sullivan; with afterthoughts written after October '72.

The following books are not *available through* SCIENCE NEWS, *but can be ordered directly from the U.S. Government Printing Office, Washington, D.C. 20402.*

MARS AS VIEWED BY MARINER 9—H. Masursky, B.A. Smith and the other members of the Mariner 9 television team and the planetology program principal investigators—GPO, 1974, 225 p., photographs, maps, $8.15. The definitive, pre-Viking photographic Mars atlas, with myriad photos of canyons, volcanoes, channels, wind-shaped features, clouds and other phenomena, including a section on comparisons of Mars with earth and earth's moon.

THE NEW MARS: The Discoveries of Mariner 9—W.K. Hartmann and O. Raper—GPO, 1974, 179 p., photographs (some color), maps, diagrams, $8.75. A wide-ranging, readable discussion of Mars, prepared with help from the entire Mariner 9 science experiment team, including Mariner imagery as well as laboratory studies, artists' concepts, many detail and inset views and ample text.