A YEAR IN THE LIFE OF MARS

By DANIEL PENDICK

Mars Observer may resolve long-standing mysteries about the Red Planet

Humans have journeyed to Mars for generations. Jetting to the Red Planet on high-octane imagination, novelists have spun tales of parched Martian cities, bug-eyed monsters, and an ancient race of canal builders.

Eventually, technology began to replace daydreams as the route to Mars. In 1964, the Mariner 4 space probe revealed the planet's true face: barren, heavily cratered, bereft of breathable air – and clearly uninhabited by the tentacled warriors and inscrutable aliens described in science-fiction stories of previous decades.

Other U.S. spacecraft followed the trail blazed by Mariner 4, culminating in 1976 with the triumphant touchdown of two robot laboratories called the Viking Landers. After a series of largely unsuccessful Soviet attempts to explore Mars, Russian space scientists in 1988 sent a pair of probes to Phobos, one of the Red Planet's two moons. These ill-fated missions were cut short by technical snafus and operator errors.

Now, for the first time in 17 years, a U.S. spacecraft is again hurtling toward Mars (SN: 9/19/92, p.181). The Mars Observer will reach its destination on Aug. 24. After a three-month respite, during which the craft will gradually assume a circular, nearly pole-crossing orbit, mission controllers will turn on the orbiting observatory's instruments. At that moment – more than 13 years after the radio transmitter of the last surviving Viking robot went silent – NASA's network of giant ground-based antennas will once again hear the drone of scientific data from a U.S. visitor to Mars.

Mars Observer will probe the planet's surface and atmosphere for at least an entire Martian year, or 687 Earth days. If the craft's batteries and control rockets hold out, the mission could continue to the turn of the century. The information beamed home to Earth – pouring in from space fast enough to fill a computer's 120-megabyte hard drive every day – will offer planetary scientists the most comprehensive portrait of the Red Planet to date, says project scientist Arden L. Albee of the California Institute of Technology in Pasadena.

Scientists are far better prepared to explore the Red Planet now than they were in the early 1960s, when some Mars enthusiasts still hoped to find shallow lakes and vegetation there. Indeed, 114 veteran Mars scientists published a scientific magnum opus on the Red Planet last year, a 1,498-page behemoth appropriately titled *Mars* (1992, University of Arizona Press). Yet despite the impressive body of observation, theory, and experiment this book represents, a number of important questions about the planet remain unanswered.

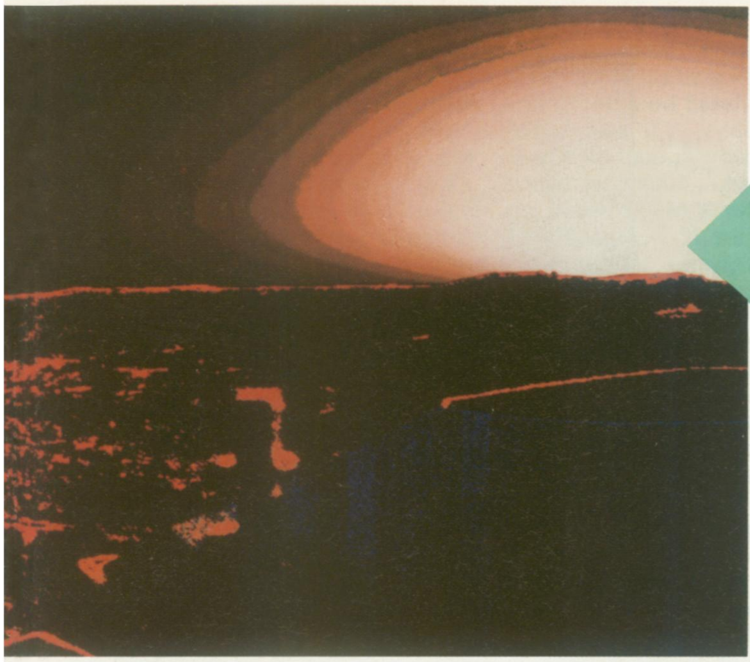
Naturally, there are as many big questions about Mars as there are planetary scientists. But a few come up more frequently than others. What processes have sculpted the planet's surface and interior? How does chemical composition vary across the surface? Does Mars have active volcanoes and a magnetic field? To what extent do dust storms affect the weather and climate? How much water is locked up in the Martian soil and atmosphere? And perhaps most intriguing, did Mars ever have an Earth-like climate capable of nurturing life?

While Mars Observer won't clear up all these mysteries, it will at least offer a way to test some of the prevailing explanations for Martian weather, climate, and geology. "With the data from Mariner and Viking, we have [tentative] answers for a lot of the big questions about Mars, but those answers are built upon one data set," says Albee. "It's like doing a weather prediction based on last week's weather, but you don't have another week's weather to check it against."

In all likelihood, Mars Observer will slay some beautiful old theories with ugly new facts, to paraphrase the words of 19th-century biologist Thomas H. Huxley. One likely victim will be computer models of the Martian atmosphere, says planetary scientist James B. Pollack of NASA's Ames Research Center in Mountain View, Calif.

Pollack has spent much of the past 20 years helping to create a global circulation model (GCM) for Mars. Built on a foundation of Mariner and Viking observations, his GCM rests on mathematical simulations of the physical processes that drive weather phenomena – the movement of high- and low-pressure systems, for example.

Mars GCMs predict what the average weather conditions should be on the planet at particular locations and times



NASA/JPL

Computer-enhanced image of Martian sunset taken Aug. 20, 1976, by Viking Lander 1.

of the year. For example, before the Viking Landers descended from orbit, Pollack and his colleagues used a GCM to predict the wind conditions on the plains of Chryse (pronounced CRY-see) and Utopia, where the robot laboratories touched down.

Planetary scientists are eager to test their GCMs against Mars Observer's harvest of new data. "In science you never believe a model entirely," says Pollack. "You always want to put it to as many tests as possible." It's very likely, he says, that Mars Observer will turn up unforeseen mismatches between observed Martian weather and the GCM predictions. "I'd almost be disappointed if it didn't."

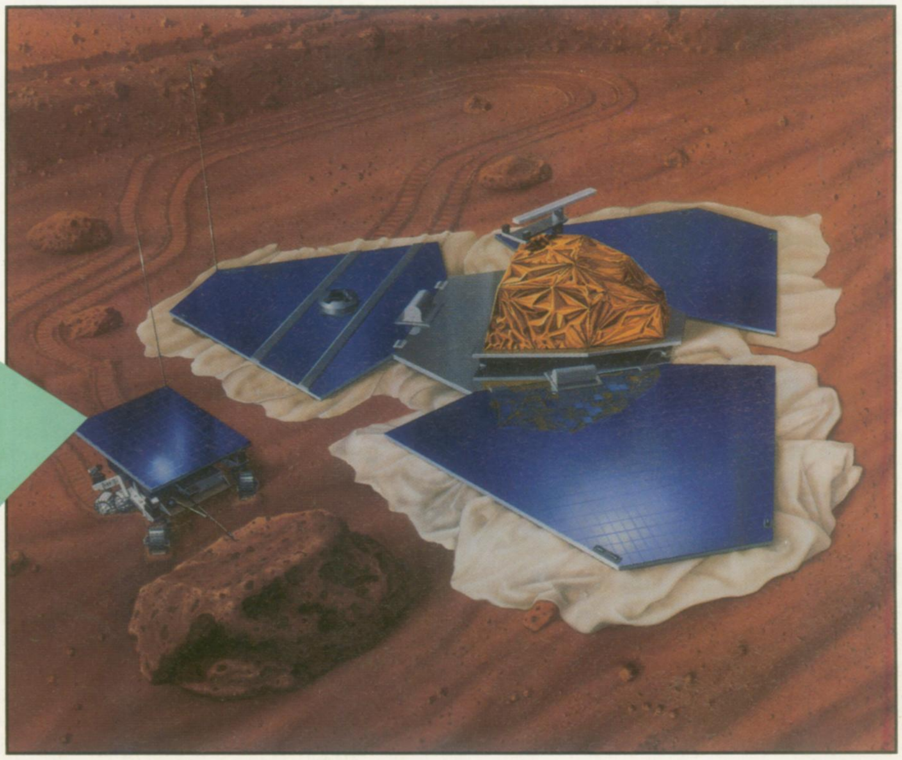
Mars Observer — whose main body consists of a rectangular box the size of a large office desk with scientific instruments bolted to its underbelly — will reach its destination well equipped to continue the work of past explorers. The power of its instruments, says Albee, stems from their synergistic nature: Various sensors and instruments will probe the Martian surface and atmosphere in different regions of the electromagnetic spectrum, returning different kinds of information about the same target areas. "No single instrument does everything," Albee says. "The combination is designed to help us understand a whole host of things."

The orbiting observatory carries gamma-ray detectors to identify the various elements that make up Mars' red-tinted soil. The craft will also use radio beams and infrared sensors to study weather systems, dust storms, and currents of water vapor as they flow through the planet's thin, carbon dioxide atmosphere. Mars Observer will search for a magnetic field or evidence of now-extinct magnetism preserved in Martian surface rock. Mission scientists will also map the planet's gravitational field and create precise topographical maps of its fractured, wind-carved surface.

And Mars Observer's pole-crossing orbital path offers some important advantages over past missions. Completing an orbit every 118 minutes as the planet spins beneath it, the craft will achieve uniform, global coverage of the surface every 26 days. In contrast, the Viking Orbiters circled the girth of Mars like a pair of extra moons, building up a patchwork of images captured at different times during the year and under varying lighting conditions.

Mars Observer will also send home a "nightly newscast" of the entire atmosphere, similar to the satellite images of Earth's weather systems shown during television news, Albee says. These daily snapshots may permit planetary scientists to observe the birth and growth of giant dust storms, which play an important role in Martian weather (see sidebar, p.106).

For this global photo shoot, Mars Observer carries two kinds of cameras. One captures wide swaths of the planet's surface in moderate detail, enabling researchers to see features as small as 250 meters across. The other camera scans



NASA/JPL

NASA's planned Mars Environmental Survey (MESUR) mission will consist of a series of simple landers carrying instruments to study the interior and exterior of Mars. Due to arrive on the planet before the turn of the century, MESUR Pathfinder — the first lander — will carry an autonomous rover equipped with a camera and other instruments.

DUST PLANET

On parched Mars, dust rules the skies. Whirlwinds driven by solar heating periodically carry vast amounts of dust high into the atmosphere. These dust storms can last for weeks and often blanket large regions of the planet's surface.

Martian dust storms have intrigued planetary scientists for decades. The genesis of this interest traces back to a frustrating moment during the Mariner 9 mission. As the space probe reached its destination on Nov. 13, 1971, mission controllers back on Earth realized that a global dust storm, packing winds of up to 300 miles per hour, had engulfed Mars. Mariner 9 circled the planet for three months while the storm raged.

This global dust storm made a strong impression on astronomers, says Richard W. Zurek of the Jet Propulsion Laboratory in Pasadena, Calif. "People really understood and realized that [Martian] dust storms weren't just a local phenomenon," he says. In addition, Mariner 9's instruments showed that the storm had lofted enough dust into the skies to affect the atmosphere's temperature and global circulation, Zurek says.

After this global disturbance, astronomers observed several other large dust storms. This convinced many that dust storms arise frequently on Mars and can play an important role in Martian weather, says Zurek. Take, for example, the carbon dioxide cycle. In the depths of a Martian winter, as much as 25 percent of the atmosphere freezes, forming dry-ice crystals at the poles. In computer models, "dust loading" affects the amount of carbon dioxide that solidifies, Zurek explains.

Zurek hopes Mars Observer will improve scientific understanding of this process and answer other basic questions about the Martian atmosphere. "It will give us a complete picture, for one Mars year, of the atmosphere and how it varies with the seasons," he explains. "In previous observations, we've not had continuous, global coverage of the planet. You got a snapshot of something that happened [in the atmosphere] and you didn't get to see it again."

More fundamentally, planetary scientists would like to know how dust storms arise in the first place. The largest storms, which can literally encircle the globe, seem to begin locally, grow to regional scale, and then coalesce into planet-spanning monsters visible from Earth.

Zurek emphasizes the difference between "planet-encircling" and "global" dust storms. The latter type covers the entire planet and has been observed only once, in 1971. In contrast, a planet-encircling storm need only form a continuous band, however narrow, around Mars.

Mars Observer may witness the birth of such a storm between February and August 1994. In these months, the southern hemisphere undergoes spring and summer as Mars passes through its perihelion – the point in its eccentric, egg-shaped orbit when the planet comes closest to the sun. Historically, the largest Martian dust storms have arisen in the southern hemisphere around this time.

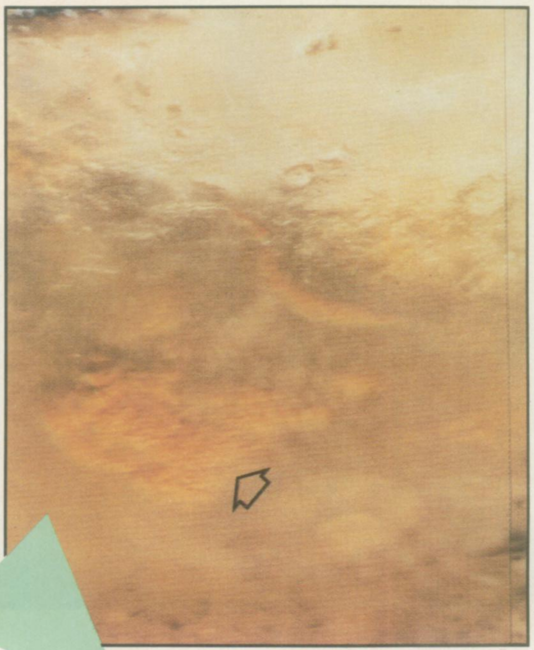
A handful of theories attempt to explain how the more intense solar heating of Mars' southern spring and summer gives birth to large dust storms. But neither humans nor their robotic space probes have ever watched such a storm from beginning to end. Mars Observer's cameras and other instruments may fill this observation gap.

Yet there's no guarantee that a large dust storm will even appear this coming Martian year, according to a statistical study by Zurek and Leonard J. Martin of Lowell Observatory in Flagstaff, Ariz. Zurek and Martin have surveyed a century's worth of telescopic and spacecraft observations to determine just how often earthlings have witnessed planet-encircling storms on Mars.

The researchers searched the records for times when conditions were favorable for viewing dust storms on the surface of Mars. Their findings led them to conclude that astronomers have a one-in-three chance of seeing a true planetary-scale storm in any given Martian year (equivalent to 687 Earth days). Zurek and Martin describe their work in the Feb. 25 JOURNAL OF GEOPHYSICAL RESEARCH.

Thus, chance will determine whether Mars Observer witnesses the rise and decline of a planet-engulfing dust storm. "Our past experience suggests that we can't predict very well what kind of year we're going to have," says Zurek.

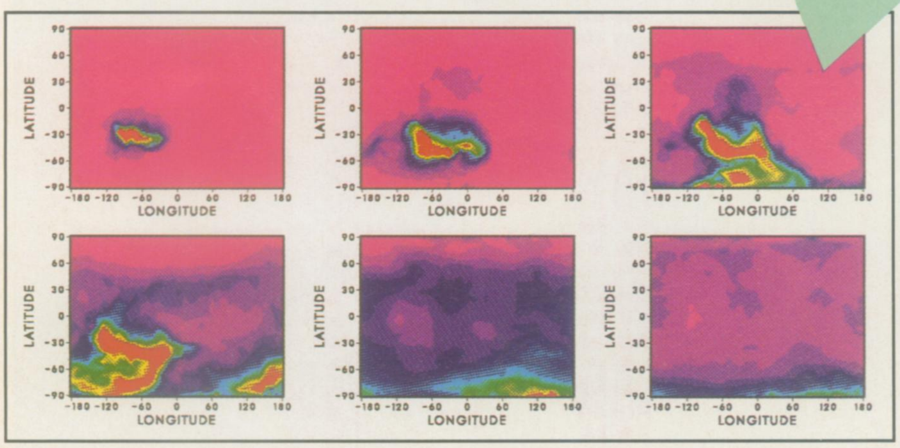
– D. Pendick



NASA/JPL

Arrow indicates dust storm, 300 kilometers wide, on the surface of Mars. Photographed in 1977 by Viking Orbiter 2, this is the first color image of a Martian dust storm snapped by an orbiting spacecraft. Relatively small, local storms like this can grow to enormous proportions during the dust-storm season.

These six images show the rise and decline of a global dust storm on Mars, as simulated by a computer model developed at NASA's Ames Research Center. Red indicates regions of highest dust density; magenta regions are relatively free of dust.



Pollack/NASA

narrower strips but in much greater detail. Together, the cameras will complete the visual exploration of Mars begun by the Viking Orbiters, which achieved detailed mapping of only 15 percent of the planet's surface.

Mission scientists will use the high-resolution camera selectively to map potentially important surface features, such as ancient stream channels. This sharp-eyed instrument can distinguish objects as small as 1.4 meters across – about the size of a Viking Lander.

With the high-resolution camera, mission scientists will be able to detect changes in the appearance of the soil caused by permafrost, says Albee. On Earth, permafrost creates distinctive patterns that are visible from space. If the same is true on Mars, scientists could use the high-resolution camera to measure how far the Martian permafrost–thought to be a major repository of water in Martian soil – extends from the poles.

This kind of measurement can help resolve a long-standing puzzle: Where's all the water that once carved huge channels in the surface of Mars? Is it locked up in the soil, or did it somehow escape into space?

"We assume there's a lot of water tied up," says Albee, "but we don't really know that yet."

What about the most provocative of the big questions about Mars: Could it have supported life in the distant past? To some extent, this is the wrong question to ask Mars Observer, whose instruments and experiments are designed to document a year in the life of the planet as it exists today, not as it was 2 billion years ago. But Pollack thinks the present is a good place to begin a scientific journey into the past. "You have to understand the present before you can hope to understand the past," he says. "And in that sense, I think Mars Observer will do a first-rate job."

Mars Observer's focus on the present will leave the mysteries of Martian history for future missions to solve. But Mars will not lack for such visits over the next decade. The space agencies of Russia, Japan, the European Community, and the United States have all announced plans to send orbiters, landers, surface crawlers, and other robotic probes to Mars in coming years.

In many ways, says Pollack, Mars Observer will serve as a reconnaissance mission that will scope out interesting sites for future exploration. For example, its instruments might detect areas rich in carbonates – possibly the mineral remnant of ancient lakebeds (SN: 6/5/93, p.357). A lander or robot space buggy could then explore such a place up close.

Russian space scientists will spearhead the coming robot invasion of the Red Planet. In 1994, they plan to launch a craft that will deploy surface probes and landers. In 1996, researchers from Russia and France will watch over a second mission that will deploy additional robot explorers on the surface.

NASA's proposed Mars Environmental Survey (MESUR) will include a network of a dozen or more landers. These squat, automated laboratories will monitor the local weather, sample the soil, measure seismic rumblings, and possibly let loose a pack of desktop-sized robot crawlers. NASA hopes to launch MESUR Pathfinder, the first lander in the network, in 1996.

When this next clutch of robot explorers awakens on the surface of Mars, scientists will get a much clearer and more comprehensive portrait of the planet's current state, and that could provide clues to what Mars looked like in the distant past.

Such knowledge may also enrich our understanding of other planets in the solar system, says Albee.

"If you look at Mars, Venus, and Earth, the sizes are not too different and they're not too far apart in the solar system," he explains. "The challenge is to understand why these three planets, which should be a lot alike, differ in some very significant ways." □