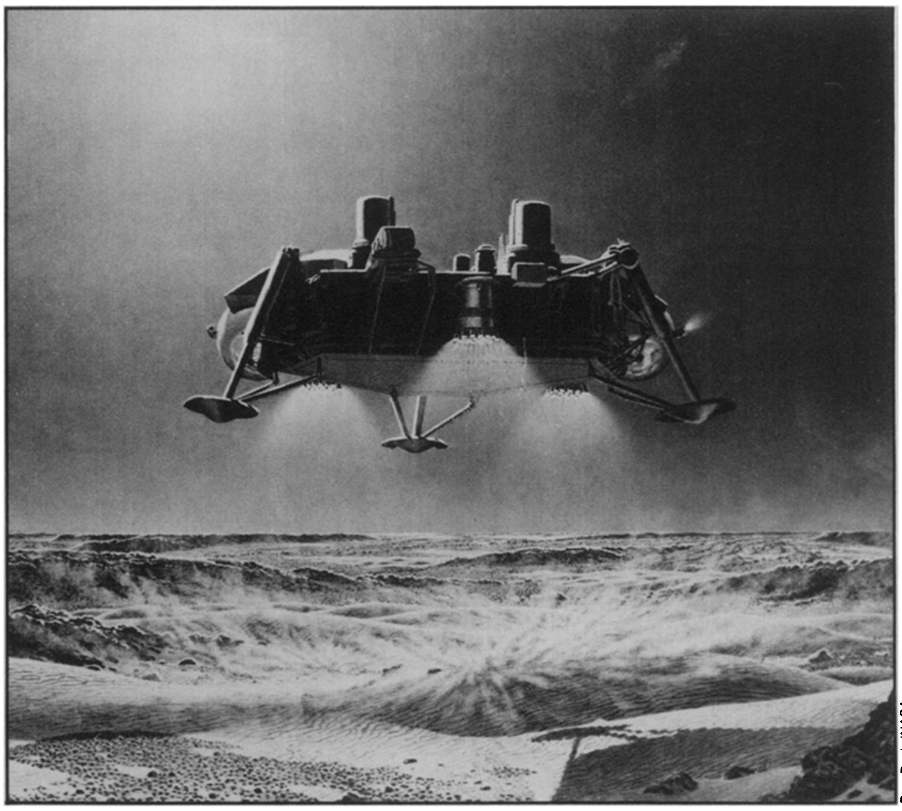
THE ROAD TO MARS

Departure is imminent for the most comprehensive look yet at another planet—and perhaps at what lives there

BY JONATHAN EBERHART



Don Davis/NASA

July 4, 1976: Viking lander 1 descends the last few feet to the Martian surface.

Mars. With the exception of the earth, no other body in the heavens, including the sun, has so drawn the thoughts of humankind. Philosophers and scientists, authors and dreamers, rationalists and fantasists, all have felt its pull, all have succumbed to its mysterious attraction. Spacecraft sent there in recent years have dispelled legends and added reams of sound, ordered data, yet the charisma of Mars remains.

The reason is life. For all the centuries of astronomical observations, for all the photos transmitted by Mariner 9 and its robot cohorts, conspicuous for the absence of canals, cities, domes or flying saucer bases, the tantalizing possibility remains. And now, this very month, a billion-dollar program called Viking takes flight to look for the Martians themselves, or at least the microscopic members of their biological family tree.

The search for life is not the only goal, of course. There are numerous others, from studying the rocks to charting the weather. The National Aeronautics and Space Administration, in fact, is living with a public-relations nightmare that if life is not found, the huge investment will seem to be for naught. But the lure of the Martians is all-pervasive. "Without exception," says Gerald A. Soffen, chairman of the prestigious 70-member science steering group that is guiding the elaborate Viking effort, "the Viking scientist has in one way or another been enticed by the question of biology, whether he was a biologist or not."

But why? Surely not as evidence that earthlings could move in and colonize the place. The Viking scientists are too, well, scientific to be seduced by such a promise in the forseeable future. "Even if the population of the earth, facing doom, decided to transport itself to another planet," says vice-chairman Richard S. Young, "you would have a big fight to decide who are the 400 people who get to go, because that is about the amount you would get there if you applied the gross national product of the whole world to the task."

Far more relevant—and, one suspects, far more deep-seated—is the desire to know that We Are Not Alone. There are countless prophecies of religions toppling, philosophers committing suicide and the entire concept that Carl Sagan calls "geochauvinism" being turned inside-out, so great are the emotional and psychological stakes in answering that fundamental question. Such cataclysms may never occur; fascination will triumph over fear. But what other issue can hold such portent?

There are, to be sure, many more "conventional" reasons for planetary research such as Viking's. "We may have the opportunity to probe natural laboratories that are undergoing the type of evolution that almost certainly must have occurred on Earth nearly four billion years ago," says Young. "Thus even the planets where most of us think there is not much likelihood of finding life are almost certain to be repositories of data that still are very relevant to the processes that influence earth, both historically and today."

Among such planets, Mars heads the known list. And Project Viking is in keeping with that stature. Viking is not one spacecraft, but four—two that will orbit the planet and two landers that will be detached from the orbiters and descend to the surface. The first orbiter/lander

Seeking the micro-Martians

The development and construction of the instruments that will make the first search for life on another planet cost $50 million, 10 percent more than an entire Saturn S-1B rocket and half as much as the entire Mariner 10 Venus-Mercury program. At TRW Systems' Applied Technology Division in Redondo Beach, Calif., 550 people worked full time on the project for half a decade, with another 450 part-time scientists, engineers, trouble-shooters and consultants. The technical obstacles were so great—polishing the inside of tubing only 0.003 inches in diameter, for example, or shrinking an entire gas chromatograph to the size and shape of a doughnut—that as recently as last year, NASA officials were wondering if the whole package would have to be left behind. Before the project team was able to get the job done, says a TRW official, it had "advanced the state of the art in 39 separate areas."

The 35-pound "biology instrument" aboard each Viking lander is actually three separate experiments, each compressed into a cylinder about the size of a 16-ounce can of peaches, and together, even with a laboratory's worth of ancillary equipment, taking up less than a cubic foot. Their work will not begin until eight days after the landers have touched down on the Martian surface, during which time Viking scientists will use the cameras and other instruments aboard to study the terrain, evaluate the disturbance caused by the landing, check out the condition of the experiments and pick a good spot to dig.

At last the spacecraft's telescoping scoop will reach out, pick up a small quantity of soil, reach back up "over its shoulder" and drop the precious sample into a hopper atop the biology instrument. After passing through a 1-millimeter screen to eliminate chunks too large for the system, the sample will land in a disk full of cups, like a round muffin tin, which will distribute measured amounts to the three experiments.

In the mid-1960's, potential experiment candidates were numerous, ranging from microscopes and microphones ("Maybe we'll hear them scratching," goes one reported sarcasm of the time) to full-scale robot laboratories far beyond the capabilities of Viking. By 1968, however, says TRW project scientist Frederick S. Brown, a NASA life sciences advisory committee had winnowed the field down to a basic selection based to varying degrees on the assumption of organic (carbon-based) life. ("Without some such assumption," says a NASA microbiologist, "your options would be infinite and your odds would be lousy.")

• The carbon assimilation or pyrolitic release experiment, according to its mentor, Norman Horowitz of California Institute of Technology, is the one that most closely duplicates the Martian environment. It seeks life that functions by photosynthesis or chemotrophy, converting carbon dioxide (main constituent of the Martian atmosphere) to organic matter. A 0.25-cc soil sample is left to incubate inside the experiment for five days, exposed to normal Martian air plus carbon dioxide and carbon monoxide "labeled" with radioactive carbon 14, and illuminated by the artificial sunlight of a xenon arc lamp filtered to remove potentially sterilizing ultraviolet rays. After the incubation period, the chamber is flushed with high-pressure helium to remove any carbon 14 that has not been ingested, after which the soil is heated to vaporize whatever organic material may be present. The resulting vapors are then routed past a carbon 14 detector to reveal how much has been taken in by possible microorganisms. The experiment can, and probably will, be repeated four times.

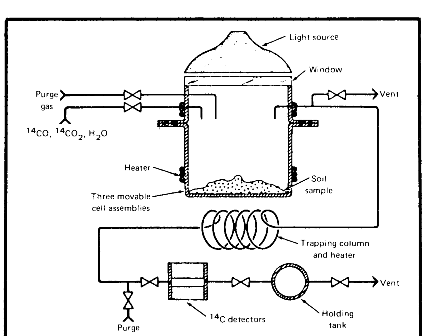
• The labeled-release experiment takes what amounts to the opposite approach. A 0.5-cc soil sample is moistened with 0.1 cc of a nutrient containing carbon 14 and incubated for up to 11 days. The assumption here is that any microorganism that functions by metabolism will take in the labeled nutrient and give off detectably labeled gaseous carbon products such as $^{14}CO_2$, ^{14}CO or $^{14}CH_4$ (methane). Measured every 16 minutes, the experiment will be read out once a day for a team headed by Gilbert Levin of Biospherics, Inc., of Rockville, Md., and can also be run four times.

• The experiment that, in a sense, makes the fewest assumptions about what Martian life must be like is a gas-exchange device. It is also, in principle, the simplest, although it is the one that embodies that ultra-miniaturized gas chromatograph. There are no labeled gases or nutrients—the experiment simply incubates its sample for up to 12 days, periodically checking the enclosed atmosphere for traces of metabolically produced molecular hydrogen, molecular nitrogen, molecular oxygen, methane or carbon dioxide. Vance Oyama of NASA's Ames Research Center in California is in charge of the device, which runs four times and could detect *you* if you were small enough merely to sit in it and be alive.

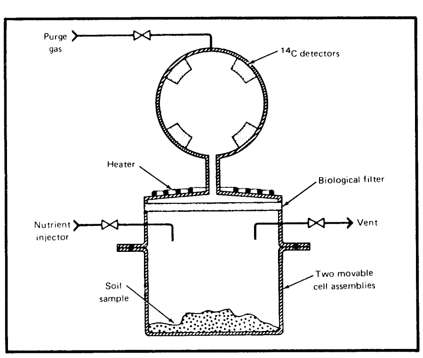
None of the experiments, of course, are really that simple. Eliminating ambiguities will require study, consultation and data from other experiments. "Dead" lunar soil, for example, points out Oyama, can produce hydrogen release and CO_2 uptake in the gas exchange experiment. In that particular case, one has to realize that the heat of meteor impacts on the moon would have both destroyed organic matter and reduced iron oxides to iron, with the gas reaction caused by the addition of water vapor to the pure iron. Since similar impact heating probably took place on Mars, and since only pure iron could produce the same gas reaction, that reaction in the Viking experiment could mean not that there is life, but that there was never enough water to reoxidize the iron.

Thus, a lot more is involved than simply reading out the numbers—but a lot more is at stake.

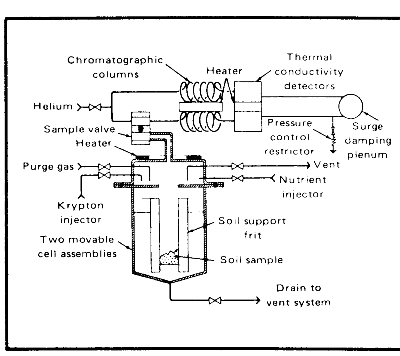
—J.E.



Carbon assimilation experiment.



Labeled-release experiment.



NASA

Gas-exchange experiment.

combination, known as Viking 1, is scheduled to take off from Florida's Kennedy Space Center on Aug. 11, followed on Aug. 21 by Viking 2. Viking 1 should settle into its Martian orbit about June 18, 1976, with its companion due to arrive about Aug. 7.

The landing sites have been long chosen (SN: 4/28/73, p. 273), selected from a preliminary list of 22 according to an elaborate set of specifications with the aid of data ranging from earth-based radar studies to photos taken by Mariner 9. (Viking officials point with pride to the fact that subsequent research on Mars has only served to confirm their choices.) First, the chosen sites had to be low in elevation (they are, respectively, 16,000 and 19,000 feet below the mean Martian surface) to provide a more dense atmosphere for safety in landing and increased chances of finding liquid water. The terrifying and unpredictable Martian winds, which have been known at speeds up to 200 miles per hour, had to be avoided, which was made possible thanks to wind-induced streaking visible on Mariner 9 photos. To prevent the landers' tipping over, slopes had to be less than 19 degrees. Neither thick dust layers nor large expanses of bare rock were permissible, the dust because the landers might sink through it and the rock because of difficulties in sampling the surface.

Finally, they had to be geologically interesting. The Viking 1 site, at 19.5 degrees north latitude and 34 degrees west longitude, is in a region known as Chryse, where scientists are interested in material apparently washed out from the northeast end of a vast, 2,500-mile-long rift system called Valles Marineris. Tributaries of this rift system resemble dry river beds, which may mean that the landing site is a drainage area rich in deposits of a variety of surface materials. Viking 2 is targeted at 44.3 degrees north latitude and 10 degrees west longitude, in an area called Cydonia, on the southernmost fringes of the Martian north polar hood, again a possible site for moisture. At 7.8 millibars of atmospheric pressure, the Cydonia site is above the 6.1-millibar limit that Viking researchers believe to be the minimum required for liquid water to exist on Mars. The two sites are about 1,000 miles apart.

Before the landers begin their respective descents, however, scientists and flight controllers guiding the mission from the Jet Propulsion Laboratory in Pasadena, Calif., will use the color cameras aboard the orbiters to check out the landing sites for safety and interest. At least 10 days is planned for such scrutiny, and probably more (in part because it has been deemed a nice bit of Bicentennialism for Viking 1 to touch down on July 4). Just in case, there are backup sites: for Viking 1 at Tritonis Lacus (20 degrees north, 252 degrees west) and for Viking 2 at Alba (44.2 degrees north, 110 degrees west).

The work of the orbiters will go far beyond mere site-checking, however. The cameras will record large-scale features around the landing sites for correlation with data from the landers, as well as map virtually the entire planet and monitor light-scattering, dust storms and other aspects of the atmosphere. Infrared heat-mapping devices will plot variations in the surface temperature, atmosphere and any possible condensation features such as frost or clouds. With all the interest in—and possible significance of—water on Mars, it is no surprise that the remaining device is a water-vapor mapper to chart the distribution of vapor in the atmosphere, as well as the atmospheric pressure at which it is found.

For all the complexities of the orbiters built at JPL, the really demanding spacecraft have been the landers, designed and built at Martin Marietta Aerospace in Denver, which was also responsible for integrating the overall Viking project. Designed to last at least 90 days each on the surface, each lander is a six-sided, three-legged boxlike structure, somewhat resembling an even more complicated lunar module without the astronaut-carrying cockpit on top. Launched from earth within a contamination-resistant "bioshield" (jettisoned in space), the landers descend most of the way from orbit inside an inner covering called an "aeroshell," which slows the craft down from more than 10,000 miles per hour to a predicted 670. At about 21,000 feet the aeroshell is jettisoned and a single huge parachute takes over, handling the task down to 4,000 feet where three braking rockets are ignited. The rockets were redesigned from their original single-nozzle configuration into three clusters of 18 nozzles each, which in tests have physically disturbed the surface below to a depth of only a few millimeters. The landers will be able to communicate directly with earth, as well as use the orbiters as communications-relay satellites.

The landers will begin their scientific tasks while they are still above the Martian atmosphere, some 4 minutes 55 seconds before reaching the ground. A mass spectrometer, retarding potential analyzer and other instruments and sensors will be used in a complex, interactive study of the atmosphere, including density, pressure and temperature profiles, composition measurements and even wind effects, using air admitted through slits in the aeroshell. Besides learning about the Martian environment, researchers hope to find out from ion and electron energies and distributions how Mars affects the passage of the solar wind.

With the landers on the ground at last, the really busy part of the mission will begin. So complex will the full-scale scientific program become that JPL is adding six more floors to a formerly two-story building to hold all the personnel involved.

There will be cameras, of course, capable of black and white, color and infrared photography, and even stereo. The cameras can change their focus and swing from the ground around the spacecraft up to 40 degrees above the horizontal for meteorological studies. The two cameras on each lander can be used together as a rangefinder to measure sizes and distances of various features.

The biology instrument (see box) will be the center of interest for many, but the experiments are such that it may be as long as three months or more before definitive conclusions are possible. And there is the frustrating realization that even if neither instrument finds life, that will be no proof that the planet is barren.

Organic components in both the soil and the near-surface atmosphere will be analyzed by a gas chromatograph mass spectrometer, which will receive its sample from the same 10-foot, retractable scoop that feeds the biology instrument. The scoop can dig trenches with 30 pounds of force, backhoe with 20 pounds and lift five pounds. Besides holding up samples to the cameras, it can be used to reposition a four-power magnifying mirror so that the cameras can see areas directly beneath the lander body. It also carries magnets and a small brush, for use in studying the magnetic and adhesive properties of the soil. The GCMS will study the soil first, then the atmosphere (a reversal from the original plan), in case excess amounts of argon in the atmosphere "clog" the instrument's ion pump (SN: 6/21/75, p. 398).

An X-ray fluorescence spectrometer will analyze metals, silicates and other inorganic components in the soil, while effects such as the disturbance of the descent engines and the recoil of the lander's shock-absorbing legs will aid the study of physical properties. A seismometer will "listen" for signs of activity within the planet, aiming not only at whether Mars is still tectonically active, but at developing a model of the planet's structure, including whether Mars has a distinct crust and core and whether its mantle resembles that of earth. A miniature weather station will keep running track of Martian meteorology, with the hope of valuable insight into how surprisingly active dust movements on Mars are possible in an atmosphere with a surface pressure less than one-hundredth that of earth.

"I predict," says Gerald Soffen, "that in the first week or two after a successful Viking landing, we will learn more about Mars than in any other single period of man's history."

And if there is life . . . where is the limit? □

Early next summer, shortly before the first Viking orbiter arrives at Mars, SCIENCE NEWS plans to devote a special issue to Mars and Viking.