DOCUMENT RESUME

ED 124 428 SE 020 992

TITLE NASA Facts, The Viking Mission.
INSTITUTION National Aeronautics and Space Administration, Washington, D.C. Educational Programs Div.
REPORT NO NF-62/6-75
PUB DATE [76]
NOTE 13p.; Photographs may not reproduce well; Some small Print in charts
AVAILABLE FROM Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock No. 033-000-00622-5)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Aerospace Education; Aerospace Technology; *Astronomy; Earth Science; *Instructional Materials; Research; Science Education; *Scientific Research; *Secondary School Science; Space Sciences
IDENTIFIERS *Mars; Solar System; *Viking Mission

ABSTRACT
Presented is one of a series of publications of National Aeronautics and Space Administration (NASA) facts about the exploration of Mars. The Viking mission to Mars, consisting of two unmanned NASA spacecraft launched in August and September, 1975, is described. A description of the spacecraft and their paths is given. A diagram identifying the five phases of the mission to Mars is presented. A diagram of the lander spacecraft and the orbiter spacecraft with the lander attached in cruise mode is included. Descriptive and pictoral views of landing sites and photographs taken with a Viking lander camera show some of the aspects of the science experiments being completed. A life detection experiment is explained in detail. Three student-oriented projects are given as well as a suggested reading list. (EB)

NASA Facts
An Educational Publication of the National Aeronautics and Space Administration
One of a series of NASA Facts about the exploration of Mars.
NF-62/6-75

THE VIKING MISSION

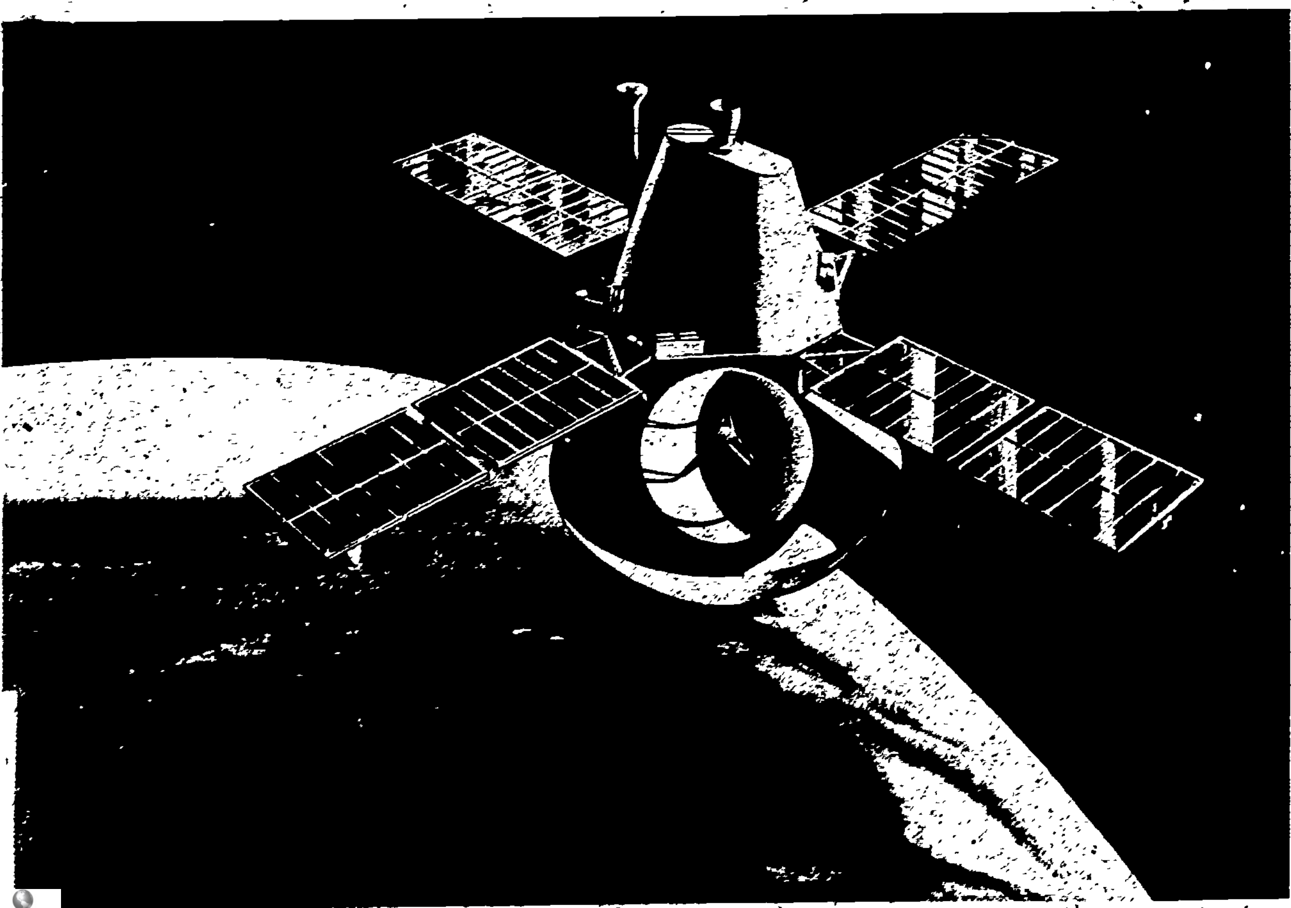
Mission to Land on Mars

The American bicentennial Viking mission to Mars consists of two unmanned NASA spacecraft launched in Aug. and Sept. 1975. When each spacecraft reaches Mars during the summer of 1976 it will go into orbit around the red planet and later dispatch a landing capsule to the Martian surface. Each lander and orbiter will carry a payload of scientific instruments aimed at two major scientific explorations of our neighbor world:

- Seek evidence of whether life exists now or has existed in the past on Mars.
- Obtain information to improve our understanding of how Earth developed as a planet able to support life and how we can better preserve and protect the environment of Earth.

If Viking detects life on Mars we might expect that among the hundred billion stars in the Galaxy, many of which have planets, there may be other solar systems that also have life and possibly have developed intelligent life forms.

The Viking spacecraft are designed to make three basic types of scientific observations of Mars. First, the orbiting spacecraft will continue with the detailed photo-



survey of the planet started by earlier Mariner spacecraft. Second, the nuclear-powered lander will search for forms of life on the surface. Third, both spacecraft will obtain information about the physical features and makeup of the planet and its atmosphere.

The orbiters and the landers will conduct their experiments to study surface geology and the internal structure of Mars, and to find out if Mars is still geologically alive. Orbiter and lander photographs will identify types of land forms, stratification, folds, joints, faults, rock types, erosion, sediments and soil, and will provide clues about mineral and chemical composition of the Martian surface. If marsquakes are recorded as expected, scientists might be able to determine if Mars has a core, a mantle, and a crust, as does the Earth. Thus they will be able to compare the internal structures of Earth, Moon, and Mars through actual seismic recordings.

The lander instruments will identify elements and minerals in the soil. Thermal mapping from orbit will search for ground frost and thermal hot spots that might indicate heat flow anomalies, such as volcanoes, where internal heat comes to the surface of the planet.

Viking's radio and radar systems will provide information that should improve our knowledge of Mars' size, mass, gravitational field, surface density, and electromagnetic properties, and atmospheric density and turbulence. The orbiters will also observe the formation and movement of clouds on Mars, watching the gross meteorology of the plant from orbit, while the landers sample ground-based weather at two positions on the planet's surface.

The Viking Project

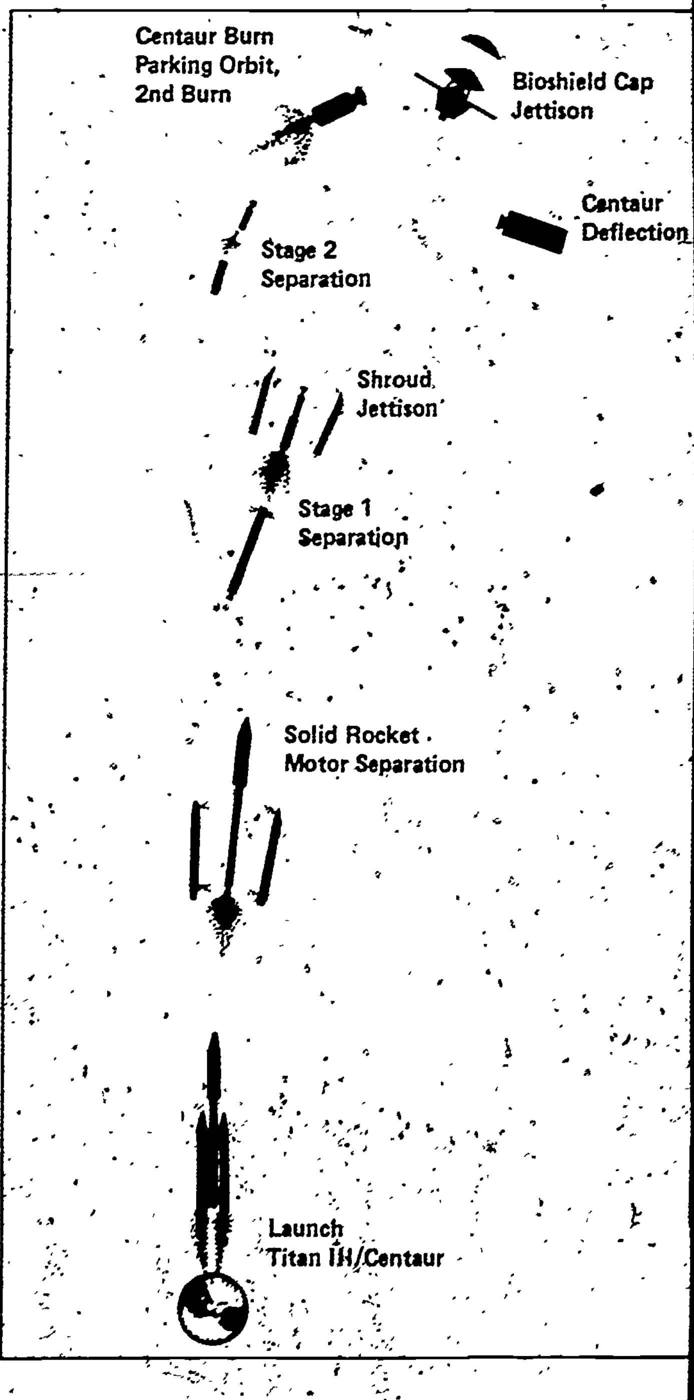
The Viking project, of the National Aeronautics and Space Administration is managed by the Langley Research Center at Hampton, Virginia. Martin Marietta Corporation designed and built the landers, is responsible for developing the science instruments, and builds the Titan III launch vehicle. NASA's Jet Propulsion Laboratory is responsible for building the orbiters and for providing the facilities for spacecraft tracking and for mission control Eighty scientists of the United States and other nations direct the scientific investigations of this project. They form thirteen science teams.

The Spacecraft and their Paths

Viking is the most complex space mission to be flown by NASA, since it requires the simultaneous operation of four sophisticated spacecraft around a distant planet, each of the spacecraft carrying out exacting scientific experiments on or about an alien world. It is the first American mission to land a spacecraft on another planet.

Each spacecraft travels through space for almost a year and arrives at Mars when the planet is on the opposite side of the Sun from the Earth, having traveled some 644 million kilometers (400 million mi.) to reach the Red Planet. At the rendezvous distance of 322 million kilometers (200 million mi.) radio signals traveling at 300,000 kilometers per second (186,000 mps) take 20 minutes to travel from the spacecraft to

The five phases of the Viking mission to Mars are identified on this diagram—Launch, Cruise, Orbit, Landing and Surface Operations. If the Viking spacecraft survive beyond solar conjunction in November 1976, there will be a sixth, extended, phase of Viking operations.



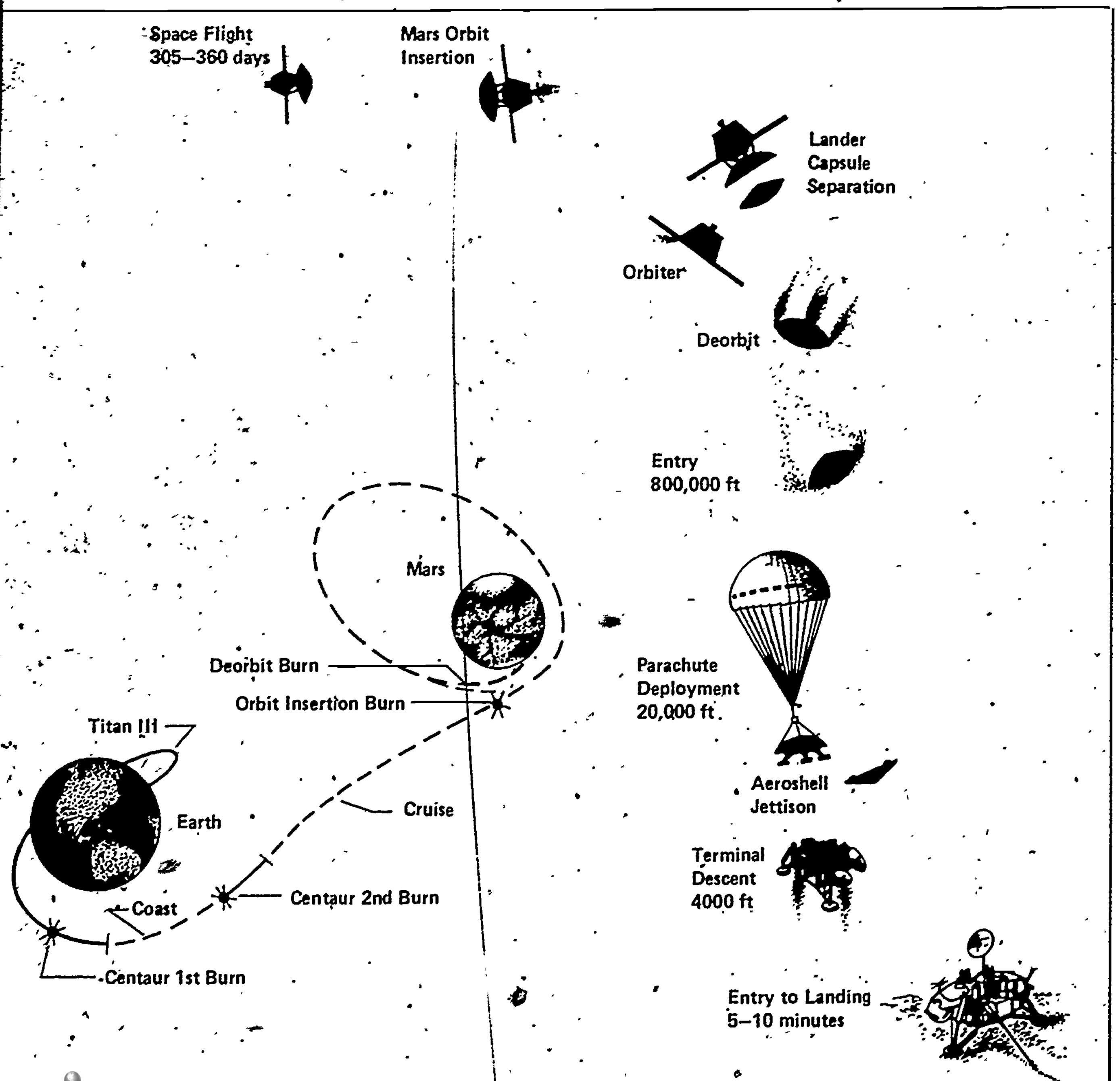
Earth, and commands to the spacecraft also take the same time to reach it from Earth.

The diagram shows the five major operations of the Viking mission. The launch phase is accomplished when the Titan III, Centaur launch vehicle lifts the spacecraft from the pad at the Air Force Eastern Test Range, Florida, and places it into orbit around the Earth. A short while later the rocket engines of Centaur again thrust and send the spacecraft into an elliptical solar orbit to carry it from Earth to Mars.

The cruise phase of Viking operations is a period of waiting on the long voyage to Mars, punctuated by some on-course corrections to the flight path to make sure that arrival is timed just right to enter the required orbit around Mars.

Next, when the spacecraft enters its elliptical path around Mars, the mission moves into the orbital phase of operations. Cameras aboard the orbiter photograph the landing sites, the orbit is adjusted as needed, and all is made ready for the descent of the landing capsule.

An entry phase follows in which the landing capsule goes through a series of complex sequential operations, deceleration from orbit by rocket braking, entry into the atmosphere and braking by atmospheric drag



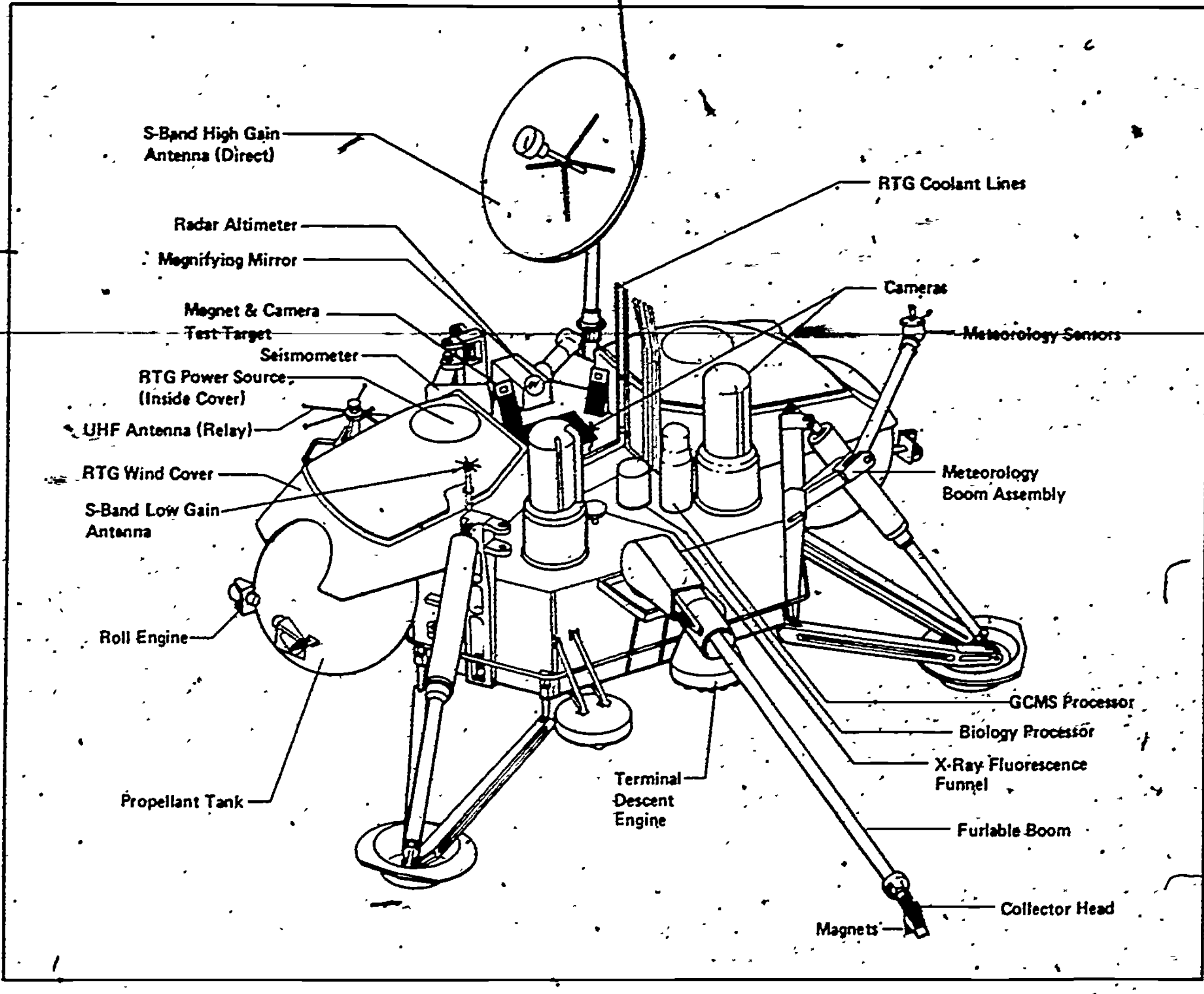


Diagram of the lander spacecraft of Project Viking.

on the enclosing aeroshell, opening of a parachute and further aerodynamic braking, and finally landing on the surface with the aid of rocket engines.

With the lander safely down, the mission enters its final landed phase in which scientific exploration of the Martian surface takes place.

The orbiter spacecraft is the larger of the two spacecraft components of the Viking system. The lander is contained within its own capsule and attached to the orbiter by a truss adapter. It remains quiescent during the long journey to Mars. The orbiter is a larger version of the Mariner spacecraft that explored Mars from flyby and orbit in earlier years. The arrangement of components is similar to Mariner, but Viking carries much larger propellant tanks and more powerful computers. Its camera system has been improved to permit taking of landing site pictures and relaying them to Earth much faster than would have been possible with the earlier Mariner spacecraft. The pictures are needed urgently for scientists to assess the [illegible]ce of landing sites.

The Viking orbiter is also equipped with a larger area of solar energy collecting cells to provide additional electrical power for the complex mission; a total of 620 watts. A large parabolic antenna is motor driven to point toward Earth and provide a tight communications beam that allows rapid transmission of data to the big antennas of the Deep Space Net located in California, Spain, and Australia.

The combination of orbiter and lander must be positioned correctly in orbit around Mars and pointed in the right direction when retro-rockets fire aboard the lander to separate it from the orbiter and send it on its way to the Martian surface.

The lander is a very special spacecraft. Since we do not want to contaminate Mars with Earth bacteria, the lander is sealed in a protective structure—a lightweight bioshield—and heated to a high temperature long enough for all bacteria to be destroyed. The lander remains in this bioshield until it leaves the Earth's atmosphere. Three small hydrazine engines in the lander capsule apply thrust to break from orbit and cause the lander to fall toward Mars. About two hours after separation, the lander encounters the Martian atmosphere and uses its aeroshell to protect it from the heat of entry into this atmosphere. This shell also slows the capsule down by dissipating energy into the atmosphere. When the lander is about 6200 meters (20,000 ft.) above the surface of Mars a parachute is deployed to slow the descent further. The aeroshell is blown off and falls away from the slowly descending lander. At about 1200 meters (4000 ft.) above the surface, the rocket engines of the lander ignite and brake the fall further, ultimately bringing the spacecraft softly to rest on the surface of Mars. As soon as the footpads touch down, the rocket engines are turned off. For these maneuvers the lander has to be a very complex spacecraft able to perform them all automatically. But once it is down on the surface its operations change to a highly sophisticated machine for exploring the surface of Mars. Now it sets on three spindly legs, its instruments whirring, its dish-shaped antenna pointed skyward, its two cameras turning and blinking as they build up detailed strip pictures of the Martian panorama.

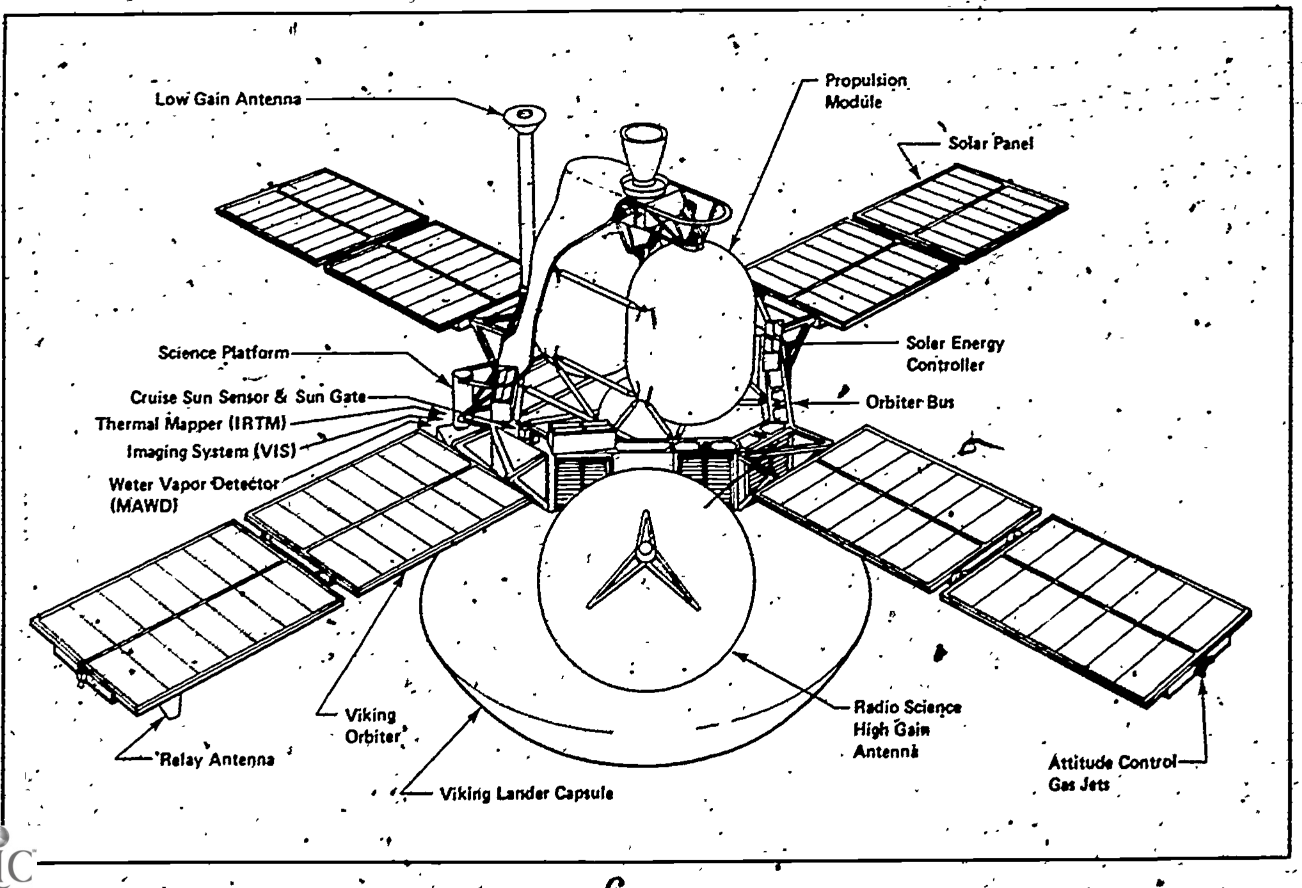
On top of the lander at either side are two radioisotope-powered electricity generators for its power needs. And stretching out in front, between the two camera turrets, is a long arm which scoops up samples of Martian soil and deposits them into the maw of the machine like some strange animal scooping up food. The soil samples are not, however, food for this Earth monster invading the Red Planet. They are samples for complex mini-laboratories inside the lander, there to be analyzed and bathed in nutrients to see if any Martian life within them can be cultivated into activity that will reveal its presence.

For several weeks after touchdown each lander will gather samples, take photographs, record weather conditions, and analyze the atmosphere of the Red Planet. All the while the orbiters aloft will be keeping watch on their offspring below, accepting their data and relaying it back to Earth.

But gradually and inexorably the motion of Earth and Mars will carry Mars behind the Sun as seen from Earth and communication will be broken during November 1976. Before this happens, the landers will be placed into hibernation. When the planet emerges again from behind the Sun, the landers can be brought out of hibernation and continue their experiments on the surface of Mars.

This would be an extended mission since the nominal Viking mission ends at the time of solar conjunction. In recent years all NASA spacecraft have survived their nominal missions and continued into extended missions, and Viking is expected to do the same.

Diagram of the orbiter spacecraft of Project Viking with lander attached in cruise mode.



The lander spacecraft on the surface of Mars searches for evidence of Martian life; it samples the soil and the atmosphere, and photographs the surrounding area.

Where the Vikings will land on Mars

Following months of study by a panel of geologists and other scientists, four sites were selected on Mars for the landing of the two Viking spacecraft. These sites were selected on the basis that they must be geologically different to provide two types of Martian surface sampling, must provide unobstructed areas for meteorology, and be at low altitude where atmospheric pressure is greatest and there would be a chance of liquid water. Additionally the sites were chosen on 'river' deltas and not too widely separated so that the two Viking landers can make seismographic observations of the same marsquakes.

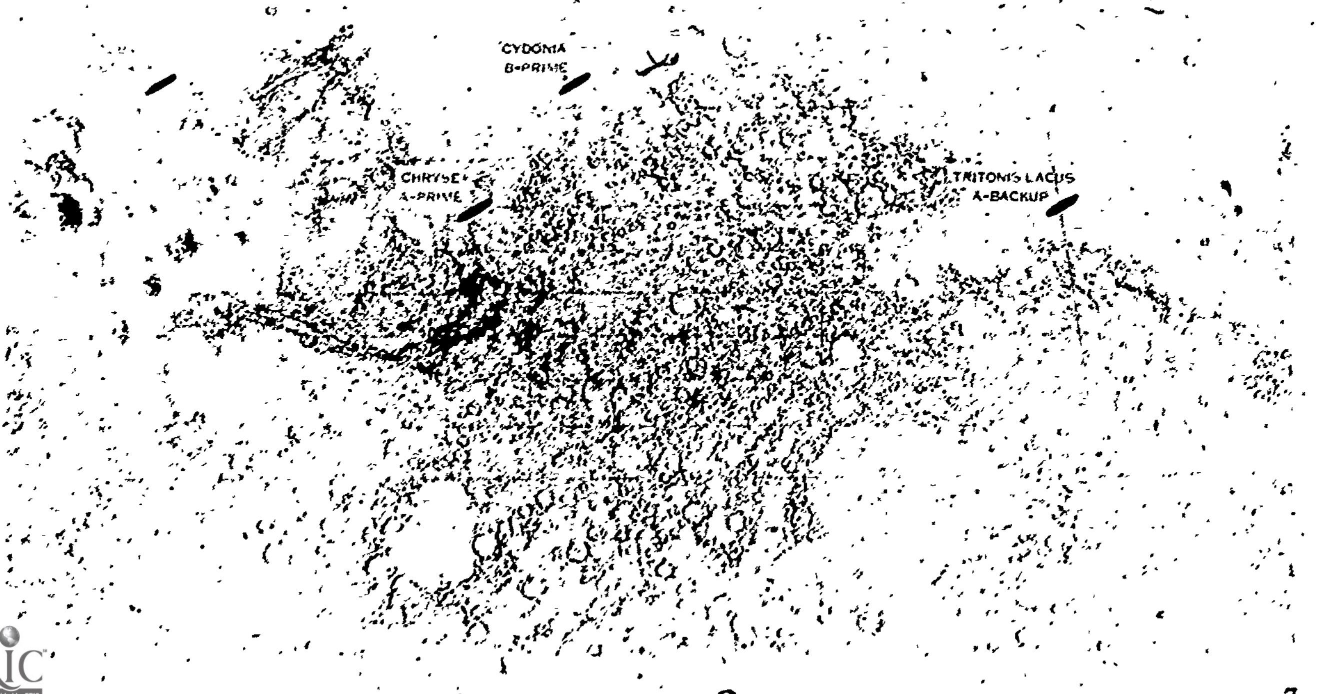
In addition, the sites had to be between 25 degrees south latitude and 75 degrees north latitude at locations where there would be only gentle slopes with no large protuberances and no surface rocks, and where winds might blow at less than 70 meters per second (220 f.p.s.).

The first Viking will be aimed for a landing site at 19.5 degrees north latitude and 34 degrees west longitude, in a region of Mars called Chryse. This is prime site A. Chryse means "land of gold," and relates in ancient Greece to a golden land in the far east. In mythology Chryse was a priest of Apollo whose daughter was seized in the battle of Troy and given to Agamemnon, only to be returned after Apollo struck the Greek camp with a plague.

The southern half of the Chryse area consists mostly of deeply dissected plateaus, possibly deposited from volcanoes. But much material from this area seems to have been swept northward along well-defined channels to a low area of only slight relief where it is intended to land the Viking lander. Scientists believe that the surface at this site is nearly everywhere partially covered by dust deposits transported by the wind. There may also be material washed from the canyons and interspersed with the dust layers. The wind-driven deposits may consist of sand dunes, each hundreds of meters across and covered with tiny ripples. The channel deposits might consist of slightly rolling hills with small channels and low sandbanks, each perhaps tens of meters wide. This site is within a region where water may have flowed in copious quantities in the past.

Landing sites chosen for the two Viking spacecraft. Each consists of a prime site and a backup site as shown on this map of the planet. Close-ups of each landing site are shown above and left. Prime A in Chryse and Prime B in Cydonia. The long ellipses signify the areas in which the Vikings might land.

Viking landing sites.



The second Viking will be targeted to land farther north in an area called Cydonia, a flat stretch of the northern basin plains where water may be available even today. Cydonia is the name of a town in Crete which, in turn, is named for Kydon, the son of the greatest king of Crete, Minos.

The landing site area consists of smooth and mottled rolling plains—possibly flows of basalt covered by wind-borne debris, volcanic dust, and water-borne sediments. The site is located on the eastern side of the Mare Acidalium where the plains units of the Martian northern lowlands abut the higher equatorial plateaus and hills. There may be volcanic cones and lava flows in the area, as well as the wind-borne and water-borne debris.

There is a band around Mars between latitudes 40 and 55 degrees north at which some parts of the surface are depressed like the floor of some ancient dried up ocean. In this band liquid water may be present for about two or three weeks during each northern spring. Thus life might flourish for a brief period here each Martian year, taking up its water from the Martian soil as permafrost melts into liquid. To a single bacterium a drop of water is as good as an ocean. This second landing site, known as prime site B, is located in this band at 44.3 degrees north latitude and 10 degrees west longitude.

Both prime sites have backup sites to be used if the first sites are rejected following close observations from orbit before the actual landings. The backup to site A is in a region known as Tritonis Lacus at 20 degrees north latitude and 252 degrees west longitude. The site B backup is in the region of Alba at 44.2 degrees north latitude and 110 degrees west longitude. All the sites are thus in a variety of plains in the northern lowlands comparable to the Earth's ocean floor basins, close to the margins of the Martian continents The A sites are where the highlands drained, so samples there should provide regional highland material. The B sites are on ocean floor sediments. This combination gives the best possibilities for fossil and present water and best samples to test current theories about the evolution of Mars.

The Science Experiments — Orbiters

Each orbiter carries two television cameras which at closest approach to Mars on each orbit (periapsis) will provide pictures of the surface sufficiently detailed to reveal an object the size of a football stadium. A major effort will be to check the landing sites chosen for the Viking landers before these landers are sent down from orbit to the Martian surface.

Scientists on Earth will interpret the pictures geologically to try to ensure that the exact landing sites chosen will be in a relatively flat area rather than in hilly or rough country. The orbiter will also be alert for local dust storms that might be developing before the lander is sent from orbit to the surface. Such a storm, while it is not expected to put the lander out of action when it reaches the surface, could be damaging during the lander's descent.

With the lander safely down, the orbiter's cameras will then be used for routine mapping of Mars to supplement the pictures returned by Mariner 9 in 1971 and look for significant changes on Mars since that date.

As far as is known at present, life must have water for its survival. Consequently, in searching for life on Mars, landing at sites where water might be in the liquid state is very important. The orbiter will carry an atmospheric water detector that will scan the selected landing sites to see if there are concentrations of water vapor in the atmosphere above them. After the lander is safely down, this instrument will look at other regions of Mars to map their water vapor characteristics.

Since life, too, on cold Mars might be predisposed to seek warm spots on the generally inhospitable planet, a search will be made from orbit for warmer regions in the vicinity of the landing sites. The instrument uses infrared measuring devices at various wavelengths able to detect small areas of Mars that are as little as one degree hotter or colder than their surroundings.

The Science Experiments — Landers

Most of the science instruments are carried in the landers, which will not only sample the surface but also

make direct measurements of the Martian atmosphere on the way down to the surface.

Some atmospheric measurements have been made previously by Soviet spacecraft entering the atmosphere of Mars, and by both U.S. and Soviet orbiting and flyby spacecraft. The surprise to scientists was that the atmosphere of Mars is very deficient in nitrogen compared with that of Earth. Some of the Soviet experiments imply that there might be quantities of another inert gas such as argon; as much as one-third of the Martian atmosphere.

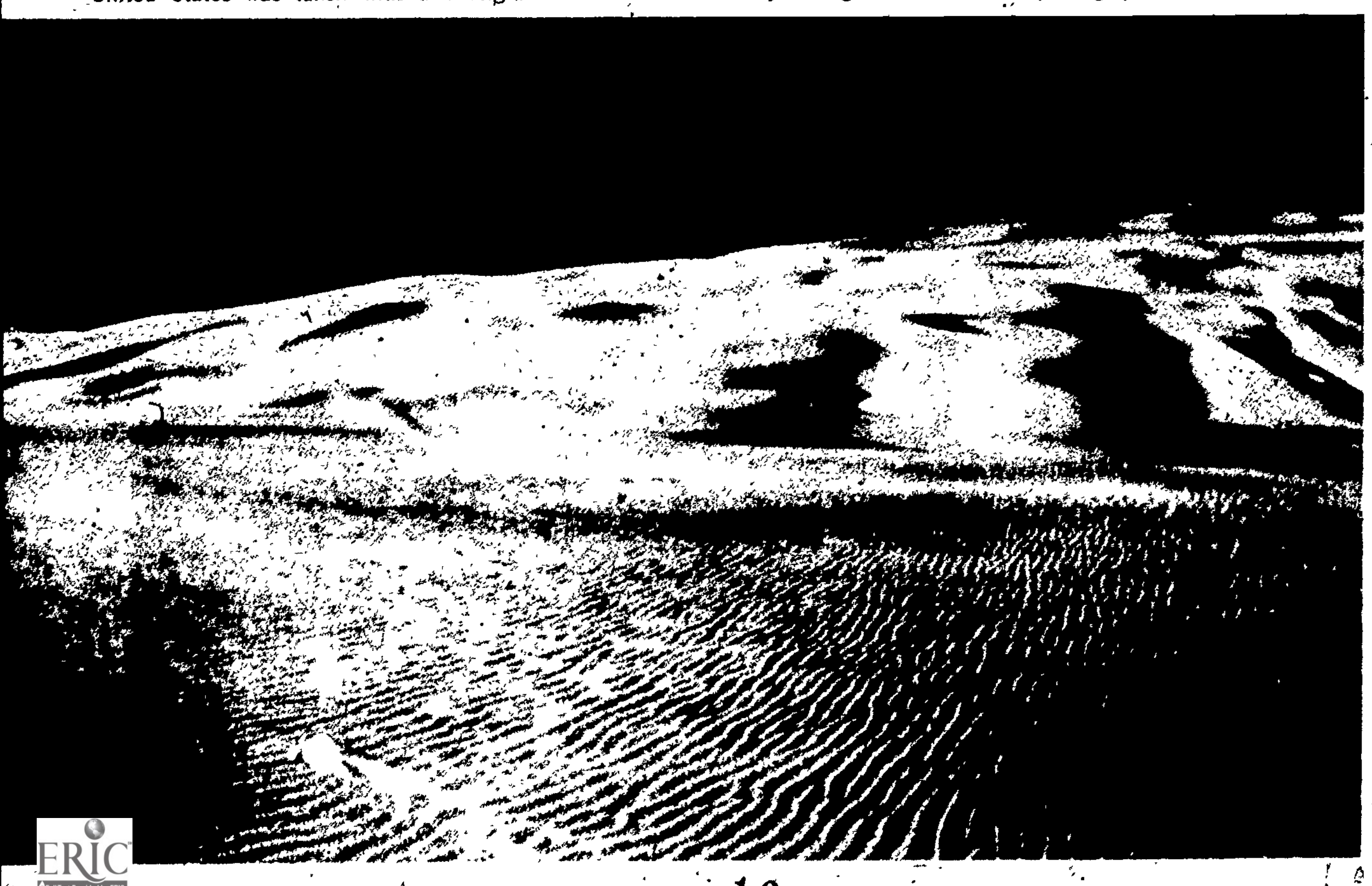
Two entry experiments will be made by the lander. The first is for the highest regions of the atmosphere known as the ionosphere, where atmospheric molecules lose electrons under the influence of solar radiation, and become ionized. Earlier Mariners passed radio waves through the upper atmosphere of Mars and detected this ionosphere at a height of about 130 kilometers (81 mi.). The Viking landers will use an instrument called a retarding potential analyzer which measures the concentration and charge of ions and the concentration of electrons in the ionosphere as they flow across the instrument's wire grids. Charged particles of different energies and electrical charges are filtered and measured.

But the gases in the atmosphere of Mars are mostly un-ionized, i.e. electrically neutral. A separate instrument is carried to determine the identities and concentrations of the uncharged atmospheric gases. This instrument is a mass spectrometer which must rapidly analyze the gases flowing through it as the aeroshell of the lander pushes through the atmosphere. Every five seconds the instrument will search through a range of atomic particles including hydrogen (atomic mass 1) and carbon dioxide (atomic mass 44). This range includes those other gases expected in the Mars atmosphere.

The physical characteristics of the Martian atmosphere will also be measured during the landing phase by several other sensors carried on the aeroshell and the lander itself. Measurements will be made of how quickly the atmosphere slows down the lander. The pressure and temperature of the atmosphere at various heights will be measured along the landing track.

But the main science experiments begin when the lander has safely reached the dry, dusty surface of Mars. Two cameras, mounted on extensions above the upper surface of the lander, will take 360 degree panoramic views of the landing site. The two cameras permit three-dimensional (stereo) views of the surface of Mars. These cameras are the facsimile type which use nodding mirrors to make a picture by scanning the scene to be photographed in a series of very narrow vertical strips. Each camera requires 20 minutes to scan a full scene; so a rapidly moving object would not be photographed on Mars. However, the cameras do not require a lens (that might be scoured by Martian dust storms) and

This photograph of sand dunes in a western desert of the United States was taken with a Viking lander camera. It shows the type of detail that is expected to be revealed by Viking when it returns photographs from Mars in 1976.



they show objects in sharp focus from close to the lander to the far horizon. They are adapted to take photographs in black and white, full color, and infrared. A picture of terrestrial sand dunes taken with one of these cameras shows the tremendous detail expected to be revealed on the Martian landscape.

The pictures of Mars will provide geologists with information to help interpret what has been happening on Mars since the water flowed in the ancient channels perhaps hundreds of thousands of years ago. Water-worn debris might be revealed that will confirm flows of surface water. The cameras will also reveal any vegetation that might be growing on the surface. Note that Martian plants could be brown or black since they might use other sunlight absorbers than the chlorophyl that gives the green color to Earth's plants. Views of the footpads of Viking resting on the Martian dust will allow scientists to determine the strength of the Martian soil and possibly its composition.

Suppose you could stand on the dusty landscape of Mars on July 4, 1976, beneath the dark blue sky with its feathery wisps of high cirrus clouds. In the broad valley where mountains of soil were spread evenly in past ages by water deluging from the equatorial canyonlands you might see a distant dust devil whirling across the sand dunes. And squatting on the Martian soil would be the Viking lander moving its mechanical appendages. The faint whirr of electric motors would struggle through the thin cold air as a slender arm extends in front of the lander and carefully scoops up a sample of soil in its mechanical claw. The arm then retracts and drops the sample into round openings in the top of the lander.

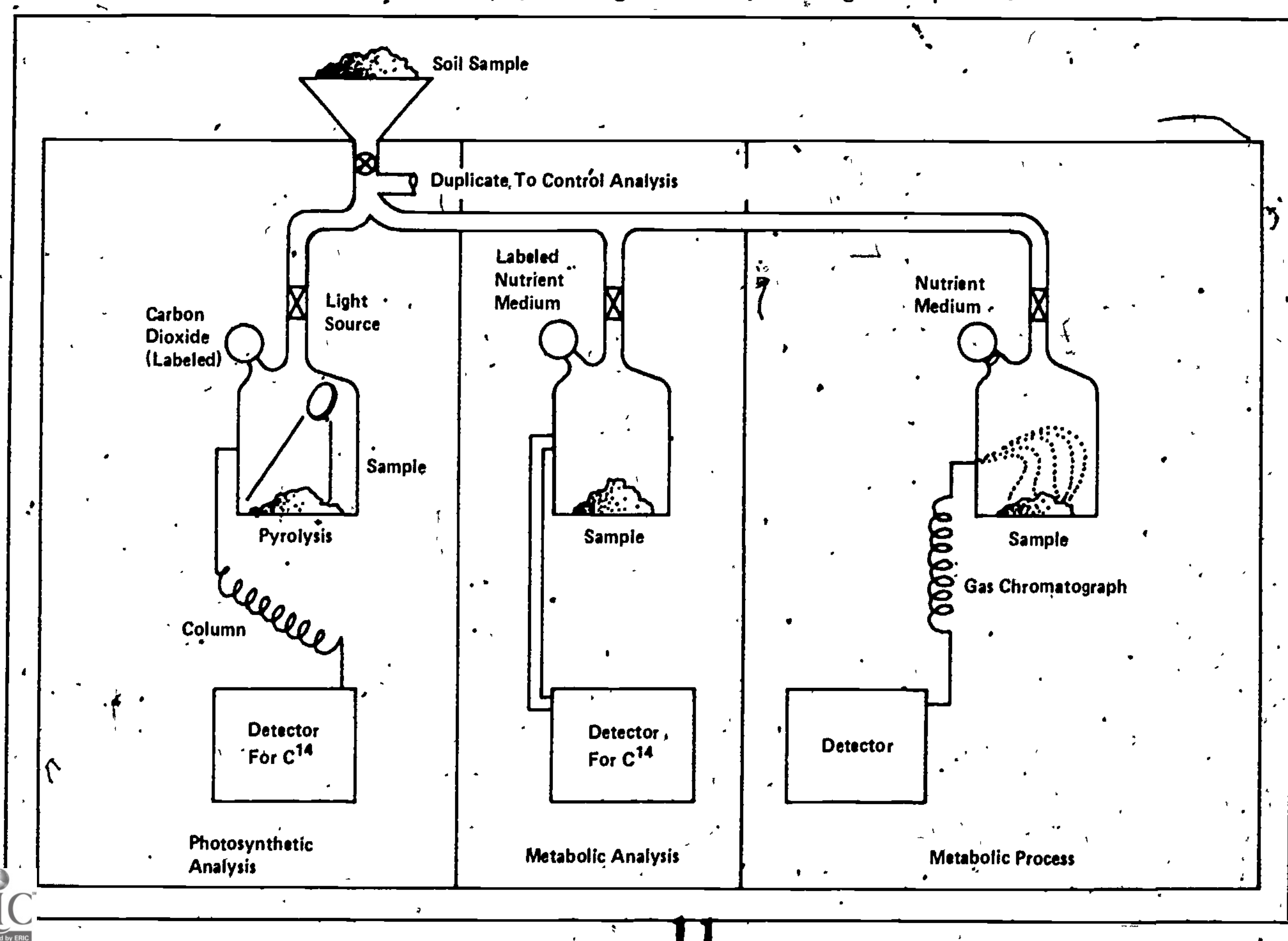
The search for life on Mars will have started. The lander carries three major life detection experiments which test for photosynthesis (the basic process of terrestrial plant life), for metabolic activity (consumption of nutrients), and for respiration (interchange of gases with the atmosphere).

In an instrument occupying a single cubic foot of volume, each lander packs the equivalent of three automated biochemical laboratories, a computer, ovens, radioactivity counters, a sunlamp, and a gas chromatograph. It has 43 miniature valves to control flow of gas and nutrients, 40 temperature control devices, 22,000 transistors, and 18,000 other electronic parts.

A simple drawing of the biology package is shown. The first experiment deals with photosynthesis, the basic process by which plants apply energy from the Sun to assimilate carbon from the atmosphere

Biology experiment

This diagram shows the three life detection experiments that Viking will make on the surface of Mars; a) checking for photosynthesis; b) checking for conversion of nutrients, and c) checking for respiration.



and use it with hydrogen from water to produce organic molecules. Oxygen from the water is emitted by the living system as a waste product. It is believed that the Earth's atmosphere became oxygen-enriched by this process.

On Viking a quarter of one cubic centimeter of Martian soil is placed into a container in which the Martian atmosphere has been changed to include carbon monoxide and carbon dioxide made from radioactive carbon-14. For several days the sample is bathed in light simulating Martian sunlight. A living organism in the soil would be expected to assimilate carbon, some of which would be the radioactive isotope. Then the remaining gases in the chamber are flushed from the sample to remove all the remaining carbon-14, and the sample is immediately heated to 625°C (1155°F). Organic materials are changed into gases that are passed into a device that detects for the presence of any carbon-14. Detection of this radioactive isotope will indicate that something in the soil, most probably a living organism, has extracted the carbon-14 from the atmosphere. The second experiment places about twice as much Martian soil in a tube and moistens it with a nutrient fluid labeled with carbon-14. The sample then stands for about two weeks at a temperature of about 10°C (50°F). If there are any microorganisms in the sample they would be expected to consume the nutrient and later release gases containing the carbon as a waste product. If a detector finds carbon-14 in the gas from around the sample the conclusion would be that a living system exists on Mars able to absorb nutrients from a fluid and exude carbon dioxide as a waste material. Many Earth life forms, including people, do just that. People eat food rich in carbon (see this carbon if you overcook food in a skillet until it blackens), extract energy by changing the complex molecules containing the carbon into simpler molecules, and exhale carbon dioxide as a waste product.

The third biological experiment carried by the Viking lander operates on the basis that living creatures must alter their environment as they live, breathe, eat, and reproduce. Soil which has been moistened by water rich in nutrients is incubated for close to two weeks in a sealed cup. Periodically the gas surrounding the soil sample is withdrawn and passed through an instrument known as a gas chromatograph. Thus any changes to the atmosphere surrounding the soil sample are detected; for example if methane and carbon dioxide have been developed by a microorganism.

But should all these instruments fail to detect life, this will not mean that there is no life on Mars. The landers might have been set down in barren places. Or Martian life might not even be detected by these Viking instruments which are based upon what we know about how Earth life operates biologically.

Besides looking for life, Viking will analyze the surface materials of Mars. A soil sample will be bombarded with X-rays which cause the soil atoms to fluoresce by emitting other X-rays characteristic of the different elements present in the sample. This experiment only tells what elements are present in the soil and their concentrations, not how they are compounded into molecular substances. But a good understanding of the surface materials may be obtained by camera observations of how the claw-like sampler scoops up the soil and how the landing legs disturb this soil. A magnet on the scoop will also reveal the presence of magnetic materials in the Martian soil.

The presence of large volcanoes on Mars raises the question of whether they are still active. Volcanoes on Earth often lie dormant for centuries. But dormant volcanoes can still give rise to marsquakes. Each Viking lander carries a seismometer to detect such quakes and search for evidence of a Martian core. The seismometer would also detect the footsteps of a large animal passing by the lander!

Another group of the lander's instruments will record Martian weather as weather stations do on Earth. Pressure, temperature and wind velocity will be recorded. The atmosphere will also be analyzed for its composition by means of a mass-spectrometer. It will determine how the atmosphere changes each day for many Martian days. Then the instrument will be used in conjunction with an oven that will roast soil samples so that they give off in sequence gases that can be recognized as originating from organic molecules.

The next booklet in this series describes the sequence in which these experiments will be made in orbit and on Mars during the mission of the two Viking spacecraft—the orbiters and the landers.

STUDENT PROJECTS

Project One—Role Playing

You are the leader of the Martian community. By monitoring Earth TV, even though you do not understand Earth languages, you have seen that Viking is coming to your planet and what it will do; i.e. photographs from orbit, photographs from the surface, life detection, seismometry. You and your subjects, the class, must decide if and how you will make yourselves known to the Earthmen through their spacecraft's instruments. If you decide YES, what will you do to communicate with Earth through Viking? Design a message to Earthmen from your civilization, remembering that Earthmen cannot read your language and may not even understand your symbology. For example, an arrowhead on Earth is a symbol of directions and was developed as a result of man's early use of bows and arrows, something unknown on Mars.

If you decide NO, how will you try to fool Viking?

Project Two

You are a scientist at Viking Mission Control in California and on one of the pictures returned from the lander you see a group of curious creatures standing still and examining the lander. They were not on the previous picture and have vanished on the next picture. You see them in color and in stereo or 3D. You have to inform the U.S. President about this amazing discovery. Write your report describing what you see in the picture, what you think it implies; recommend what should be done and point out the possible dangers or benefits to humanity from discovering this life form on Mars.

Project Three

Experimental detection of life by an optical technique. Use the following equipment

- Lime water, $Ca(OH)_2$
- A test tube
- A simple photoelectric lightmeter
- A soil sample with and without organic material.

Method: Place the lime water in the test tube and take a reading of the light meter against the tube with a fairly constant light source, a north-facing window for example. Next insert a good amount of the soil sample. Watch how the presence of any organism that gives off carbon dioxide will cause a shift in the clarity of the water and register on the light meter.

Suggest how you might modify an experiment such as this for use on Mars. Compare this experiment with those in Viking that detect the production of carbon dioxide by living organisms. List the advantages and disadvantages of the various methods.

SUGGESTED READING

Viking, Mission to Mars

W. R. Corliss, NASA SP-334, 1974, U.S. Govt. Printing Office Stock Number 3300-0561

Progress Report on Project Viking

R. N. Watts, Jr., *Sky and Telescope*, v.44, n.5, November 1972, pp. 302-303

The Search for Life on Mars

K. F. Weaver, *National Geographic Magazine*, v.143, n.2, February 1973, pp. 264-265

Where the U.S. Will Land on Mars

E. Driscoll, *Science News*, v.103, n.17, 28 April 1973, pp. 273-274

How We'll Search for Life on Mars

G. Soffen, and J. S. Martin, *Popular Science*, February 1971.

The Viking Mission to Mars

various authors, *Icarus*, v.16, n.1, February 1972, entire issue.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402
Stock Number 033-000-00622-5

☆U.S. GOVERNMENT PRINTING OFFICE : 1976 O—579-910