ENGINEERING
AND SCIENCE
May 1967, Vol. XXX, No. 8

THE SEARCH FOR EXTRATERRESTRIAL LIFE

by William H. Pickering

It may be elusive, or subtle; it may be beyond the range of our early instruments; but if it is there, we will find it.

The Mariner-Mars project 1969 now under development is raising the curtain on the search for extraterrestrial life. The primary objective of the project is to make exploratory investigations of Mars which will set the basis for future experiments, particularly those relevant to the search for extraterrestrial life. Two spacecraft similar to Mariner, IV, which photographed Mars two years ago, will be flown. These spacecraft include no instruments designed to examine interplanetary space; the entire payload is planet-oriented. During the approach to Mars, a series of pictures of the whole planet will be taken. Then, at close range, a group of instruments will trace a path across the surface of Mars, collecting infrared and ultraviolet spectra, a temperature profile, and high- and medium-resolution pictures. The television format will contain 16 times as many elements as the Mariner IV picture format. And finally, the same radio occultation and celestial mechanics experiments as were performed on Mariner IV will again be conducted.

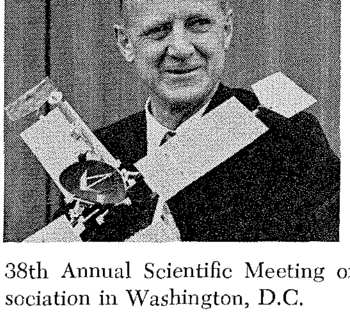
The search for extraterrestrial microbial life began, appropriately, with Louis Pasteur about a century ago. He used rigorous and new sterile techniques to drill out samples from the inside of the Orgueil meteorite and culture them in hopes of detecting biological activity. This meteorite, which fell in 1864, was the original carbonaceous chondrite, a stony meteorite containing a number of organic constituents. Pasteur found no extraterrestrial life forms in the meteorite. But he set an excellent example for modern researchers in careful techniques and the practice of avoiding contamination.

The likelihood of finding a highly advanced, intelligent life native to other planets of our solar system is not considered reasonable by responsible scientists. The search for extraterrestrial life, then, raises two questions: first, is there evidence of *any* life on our neighboring planets? Second, is there intelligence elsewhere in the universe, outside our solar system?

Because of the tremendous distances involved, the search for extraterrestrial intelligence is, at present, a communications matter. It is under study, in a limited sense, through such efforts as Project Ozma, which was established to listen with a sensitive radio telescope for any sort of intelligent radio signals from interstellar distances.

The search for life on a neighboring planet is of such universal interest that it is considered a major scientific goal of the space program.

One of the prime motivations in the search for life on the planets is related to the origin of life itself. Present-day biologists feel strongly that the life



As director of Caltech's Jet Propulsion Laboratory, William H. Pickering is involved in the development and supervision of space and satellite programs for the government. "The Search for Extraterrestrial Life" has been adapted from a speech given by Dr. Pickering on April 12 at the 38th Annual Scientific Meeting of the Aerospace Medical Association in Washington, D.C.

we know on earth began from a single primordial series of events. The life forms which fill our planet, from Arctic to Sahara to Amazon to city street, all flowed from a single source. Evidence for this is found in the genetic coding mechanism, which is common to all life forms so far studied, however different the genetic information coded. The fact that the same 21 amino acids serve as major building blocks in the construction of proteins for all terrestrial organisms is a second point. Third, is the fact that these amino acids are all left-handed stereo-isomers, and the sugars we earthly creatures use are right-handed. Apparently, we are all chemically trademarked, "Made on Earth."

We do not know whether terrestrial-type biology is universal. Another genetic mechanism or another set of amino acids might serve as well. We could, for example, postulate a life based on right-handed aminos and left-handed sugars.

If life forms of a different trademark were discovered on Mars, the implications to biology and medicine, and to all science and philosophy, would be staggering. These new life forms would be immediately recognizable as truly and originally extraterrestrial. The single primordial series of events on earth would clearly have been paralleled elsewhere. Comparison of the two forms would reveal a great deal about the fundamental nature, form, and function of life. And the fact that two such sequences could be completed in our small solar system would indicate a high probability for life generation and that the universe must be widely populated.

On the other hand, if such Martian life bore the same trademark as our own, this also would have interesting implications. It would first have to be clearly established that the life forms were not introduced to Mars by our own contaminated spacecraft equipment. For that reason, the policy of NASA is that all spacecraft and instruments which are expected to enter the atmosphere or land on the surface of another planet will be sterilized.

If these earth-type organisms are proven to be indigenous to Mars, it would then be necessary to reexamine the possibility that life began independently but identically on both earth and Mars or, as an alternative, the idea that the seeds of life were transported from world to world.

Another possibility is that we will find no life at all. But, considering the amazing variety and durability of life forms on earth, this is improbable. It may be elusive, or subtle. It may be beyond the range of our early instruments. But if it is there, we will find it.

In searching for extraterrestrial life, we are constrained to work at the limits of our knowledge of life. We define life generally in terms of the abilities of an organism to reproduce itself and to mutate. However, neither of these definitions provides a clear-cut criterion for the detection of life. Mutation can be studied only after life itself has been detected. Reproduction may be technologically difficult to prove. Experiments could be based on a number of attributes such as mobility or respiration, but biologists feel that a group of experiments will be necessary to determine unequivocally the presence of life on Mars.

Three classes of planetary missions are possible: flybys, orbiters, and soft-landers. From a flyby it is possible to obtain some surveillance while the spacecraft passes over the planet, lasting perhaps half an hour and coming as close as one or two thousand miles. This can be done in the visual, infrared, and ultraviolet portions of the spectrum. The spacecraft telemetry signal can be used, as in the case of Mariner IV, to gain information regarding the nature of the atmosphere.

The orbiter affords an opportunity for obtaining many high-resolution photographs of the planet and permits mapping of the surface topography and the investigation of seasonal changes. It can also aid in the selection of landing sites and in guiding landed spacecraft.

The soft-landed spacecraft will make the first direct contact with the surface. This spacecraft can examine the surface for the presence of biological specimens, the geological processes at work, and the local physical character of the environment.

A surface-roving vehicle, brought to the surface aboard a soft-lander, is capable of expanding area coverage and may become the most important instrument for the biological exploration of the planet.

The return of samples to earth for analysis is the most ambitious, sophisticated, and difficult variation of the planetary landing capsule. If manned landings are the climax of this series of missions, this task might well be left to the men. Some biologists feel that sample return may be the only way in which the question of life can be fully answered.

Human explorers could bring to the search the breadth of human senses, the speed of human reaction and judgment, and the deftness of human hands. In any robot operations at interplanetary distances, the communications time is many minutes each way. But men could also bring a variety of terrestrial life forms, so that extreme quarantine measures and guarantees will be necessary. And men cannot be written off as expendable, as can unmanned spacecraft.

There are a number of instrumental approaches to the search for extraterrestrial life. The first method is purely physical observation and measurement and is dominated by photographic and television systems.

The television mode used in the Ranger and Surveyor projects was similar to commercial television—the image was scanned off an electrostatic plate in several hundred lines. In Lunar Orbiter, the image was developed first on film and then electronically scanned in narrow strips. For Mariner IV, working at a distance of more than a hundred million miles, another format was used. The picture was divided into forty thousand elements. The brightness of each was converted into a number with zero representing white and 63 black. These numbers were then stored on a tape recorder and transmitted slowly but accurately back to earth, where they were reconstituted as pictures. These data were processed by a computer to remove noise and distortion, rectify the picture, increase the contrast, and perform other corrections.

Future spacecraft will carry television systems on such instruments as the telescope and the microscope and may transmit images obtained outside the visible spectrum. In addition, surveillance television will be used to observe any digging or sample-handling by the spacecraft.

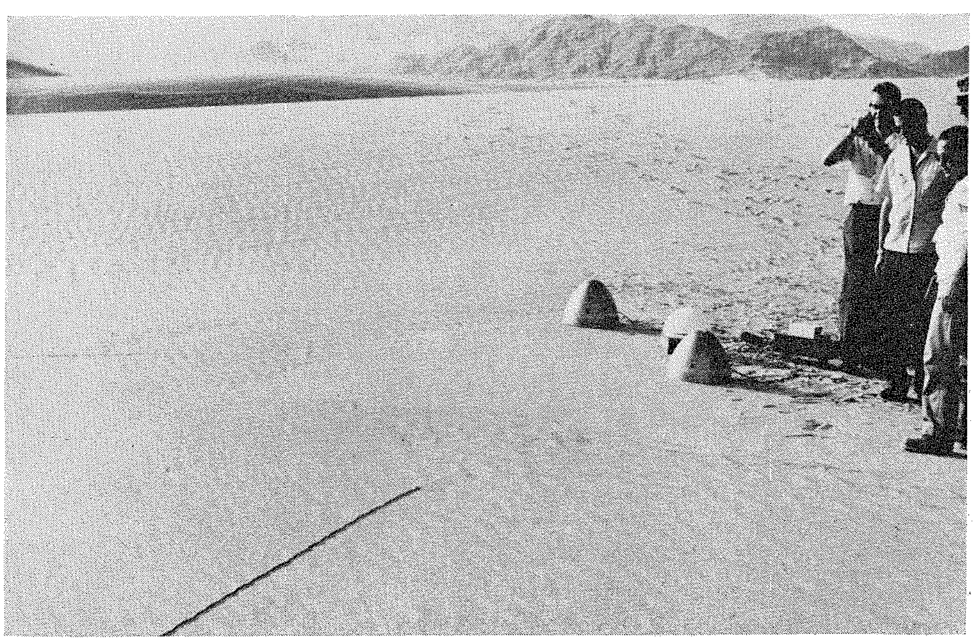
The second instrumentation approach is the chemical. Here the search is for compounds associated with life—biochemical constituents, products, and organic precursors. Periodic analyses might show changes in concentration or kind of organics caused by life processes.

An interesting member of this group of instruments is the gas chromatograph, of which a compact space-flight version is being developed. In this instrument a sample is heated to vaporize its organic constituents. These vapors are then forced through an absorption column with an inert gas medium. Each compound has its own distinct rate of passing through the column so that the various compounds in the sample are separated at the output and identified.

Probably the most interesting instrument approach to life detection is the biological. The activity of the living organism itself is the object of the search, not its chemical or physical effect on the environment. The advantage of this method is that a positive result is unmistakable. Its disadvantage is that the life form in the sample may be so selective in its metabolism that a positive indication cannot be observed.

The Gulliver experiment is an excellent example of the biological approach. In this device, a sticky string is propelled out on the planetary surface by a projectile and is reeled in like fishing line—covered, it is hoped, with local microbes. The string is cultured in a nutrient fluid with isotopically labeled molecules. Gases given off by the culture are tested for radioactivity. Any radioactivity found would indicate the presence of a metabolic product. As the organisms multiply, the signals would be increased. An exponential rate of increase would be interpreted as growth.

The biological experiment may also be combined or sequenced with other experiments. For instance, after an interval, the sample could be filtered and the microorganisms examined under the microscope. Or the remaining nutrient fluid could be analyzed to discover which constituents have been taken up. The sample could also be tested for polar-



The Gulliver instrument, designed to detect bacterial life, is tested on the sands of Death Valley. A sticky tape is propelled onto the land surface to "catch" local microbes. The tape is reeled in and examined for the presence of bacterial life. Gulliver will be an important device in the search for extraterrestrial life.

ized-light rotation to discover whether, for example, right-handed sugars are selectively removed.

There are, however, some limitations on this program of ways to search for extraterrestrial life in the solar system. They derive—except for the sterilization requirement already discussed—from inexorable laws of physics. They primarily concern energy, which affects both the schedule for conducting missions and the size of the spacecraft.

The schedule limitation is that, because of the relative positions of the earth, the sun, and the target planet, it is possible to launch an interplanetary flight only during a brief period approximately every two years. The interval between these launch periods is 18 months for flights to Venus and 25 months for flights to Mars. The length of the launch period depends on how small a spacecraft is to be launched with how powerful a rocket vehicle and on the particular launch geometry.

The size problem is simply that, under the best conditions, it takes a very, very large rocket to launch a very small spacecraft to a planet. The energy cost of flying to Mars is very high, and the rocket engineering cost of this energy is very high. For example, the quarter-ton Mariner IV with 41 pounds of scientific instruments was launched by the 138-ton Atlas/Agena rocket. The half-ton Mariner-Mars 1969 with 112 pounds of scientific instruments will use the 150-ton Atlas/Centaur. The Saturn V, which weighs more than 3,000 tons, could launch 20 to 25 tons of spacecraft to Mars. A ton of scientific instruments landed on the surface might reasonably result from such a launch.

The search for extraterrestrial life can be defined only by what it is looking for—not by what it finds. It is a characteristic of scientific work that, however closely you pursue the object of the search, other discoveries force themselves upon you. This search may find many objects. Some of the technology may draw on and stimulate medical technology and be able to hand back to medicine some new study tools. Another part will draw on communications, a technology already flourishing in conjunction with the space program. The many fields of knowledge and of application which may benefit from this search can only be guessed at.

Today we are starting the search for extraterrestrial life. Science is ready and eagerly awaiting the evidence. Technology is ready and preparing to obtain that evidence. The Mariner series of missions, designed to prepare the way for the search, is progressing well. The Voyager series, designed to land on the planet and take the first steps in the search itself, has begun. We stand on the threshold of new worlds. And we are not standing still.