Martian Life: The Odds and the Oddities

Life on Mars is a long shot, but earthbound biologists are in a no-lose position

BY JANET L. HOPSON

Popular Victorian culture passed on to us the *H.M.S. Pinafore*, the incandescent lamp and a dying race of intelligent Martians. Percival Lowell's solemn pronouncements on Martian canals ignited the 19th century public imagination—an imagination later fanned to mass hysteria by H.G. Wells's *War of the Worlds* and W.R. Hearst's audacious headlines in 72-point bold. Hearst is said at one point to have cabled a well-known astronomer, "Wire collect immediately 500 words on whether there is life on Mars." The scientist wired back 250 repetitions of "Nobody knows, nobody knows, nobody knows. . . ."

Lamp technology has by now progressed from bulbs to lasers, and light operetta has surrendered forever to TV situation comedy. But scientific agnosticism remains an immutable force. Nearly a century's data on the Red Planet—in large part more reliable than Lowell's failed perceptions—leaves us on the verge of a Viking touchdown with one clear consensus about life on Mars: in Carl Sagan's words, "Nobody knows."

It is also clear, nevertheless, that biologists will get their first real crack at an answer this summer when the spidery Viking landers set down in Chryse and Cydonia. The chances are fairly slim, many scientists think, of seeing "Life on Mars!" in 72-point bold this summer. (They have, of course, dreamed up a scientifically sound collection of Martian creatures, just in case.) But biologists are in a no-lose position if the landers transmit any chemical data successfully. Even if no signs of life appear, they stand to gain their first real perspective on terrestrial biochemistry, life origins and evolution.

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Just as life here evolved and adapted to earth's physical environment, Lowell's belief in canal builders reflected the Victorian view of the Martian physical environment. Sophisticated space hardware, telescopes and spectrometric devices have by now retired that old construct of an earthlike Mars and with it, the superficial "evidences" of life—the canals, the vegetation, the Martian moon Phobos as a hollow, launched satellite.

The preoccupation with life on Mars, though, has not died out. The fact that Mars is a dynamic planet with winds, a complex surface, possibly recent volcanization and sinuous channels—apparent dry river beds through which liquid may have formerly flowed—could also mean that life has a tenuous foothold. This is particularly true if one considers the spectrum of creative approaches with which life conquers earth's harshest niches.

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For years, NASA has financed the study of life under extreme conditions. Such studies reveal the spectrum of survival approaches to be broad and life here to be tough, not timid. Organisms can live at the bottom of ocean trenches, crushed by extreme pressures. Organisms can live in pickling salt solutions and strong acids, in nearly boiling water and in snow. Certain bacteria can even survive for long periods under simulated Martian conditions. Martian organisms would certainly be even better adapted to Mars, and might, therefore, thrive in the red soil.

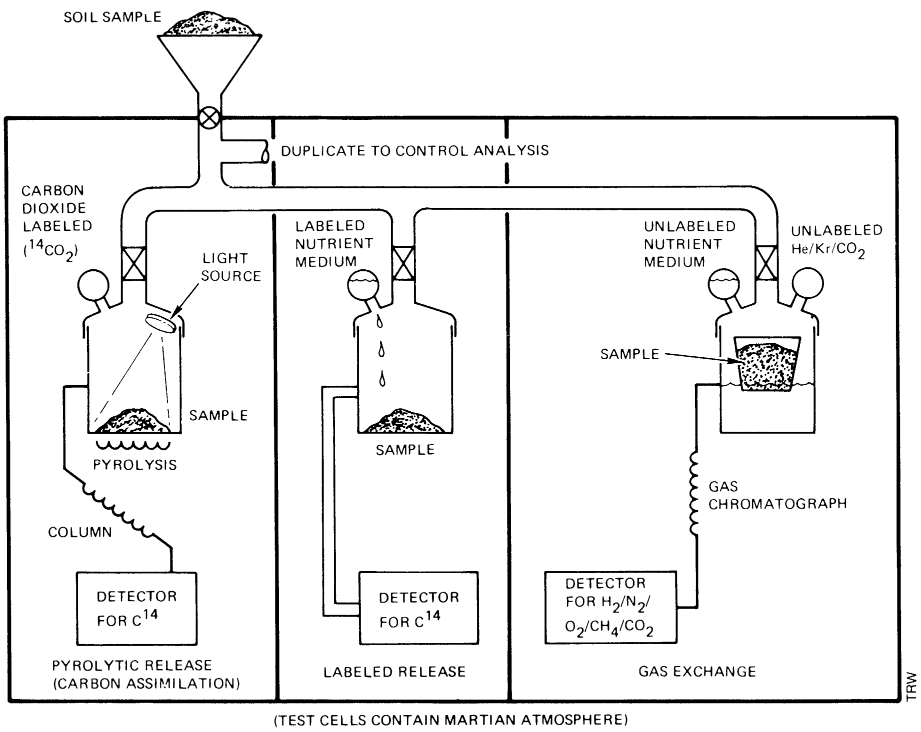
The observer of current Martiana finds a range of projected life forms from simple biochemical systems to "macrobes," all based on the sophisticated construct of the Martian environment and a trust in the ingenuity of life systems. Cornell University astronomer Carl Sagan, for example, and Stanford geneticist Joshua Lederberg, offer four possible classes of Martian organisms in the July ICARUS.

The four classes are based on the strictest environmental limitations. Availability of water is the most stringent of them, since water will exist mainly as ice or water vapor under Martian atmospheric pressures and temperatures. Low temperatures are the second major controlling factor. Class I organisms are the most earthlike and would require high temperatures and high water availability. Such creatures might flourish only when liquid water is present in the river beds or in the soil itself.

The second class could withstand low temperatures but would require more water. These might thrive only at night when temperatures are low but humidity rises, and water vapor is more available. Class III organisms are unknown on earth—those which would need high temperatures but little water. Sagan and Lederberg point out, however, that mechanisms for concentrating rare materials—water in this case—are common in earth creatures.

Class IV life would be the most exotic by earth standards—organisms that thrive on cold temperatures and little water. These organisms would have to concentrate both heat and water somehow, but such needs might also make them the most interesting. "There may be a strong selection pressure," the authors suggest, "for Class IV organisms to have large dimensions." Large organisms have a low surface-to-volume ratio, thus radiate less heat and, at least on earth, show greater adaptability. Sagan and Lederberg, fond, apparently, of coining phrases, propose that some Class III and IV organisms might be "petrophages" (rock-eaters) that get their water and minerals from rocks or "crystophages" (ice-eaters) that tap the permafrost.

A third environmental constraint—strong ultraviolet light penetration—might lead to more modifications: Martian genetic material that is not damaged by UV light, efficient repair of UV damage, or UV shields like insect exoskeletons.

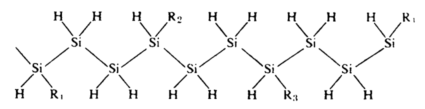


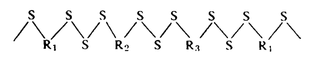
Biology experiments 1 and 2 test for carbon-based life; 3 tests some noncarbon gases.

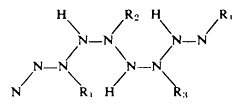
Artists working with NASA Viking project chief Gerald Soffen on the 1974 NASA movie "Mars—the Search Begins," have given form to petrophages, crystophages and UV-shielded creatures (see illustrations on next page). "As a biologist," Soffen says, "I can't tell whether these are hopelessly ridiculous or not. I told the artist, 'Be as far out as you want.' But the drawings are, of course, based on Mars's environment."

Although the subject is not so visually interesting, biologists are as excited by the potential biochemistry of Martian life as they are by clever stabs at weird morphologies. Biochemistry on earth is based on carbon, but innovative biochemists have for years proposed alternative biochemical systems based on sulfur for example, and nitrogen and silicon. Biochemist L.J. Henderson, in 1913, made the observation that those atoms "used" most often in terrestrial biochemistry (C,H,O,N,P,S) are also some of those found most abundantly in the terrestrial environment. Might it not be reasonable, therefore, to expect the same pattern in extraterrestrial biochemical systems?

On Mars, for example, the low temperatures and the lack of water for molecular exchange might bring carbon-based biochemical reactions to a standstill. Some believe that alternative biochemistries, such as the following, might be more suited to a Martian environment:







But, says Caltech biologist Norman Horowitz, an exotic biochemistry based on silicon, for example, is "basically a comic-book idea." Although silicon is abundant on earth and may be so on Mars, he says, it is not suited to forming the large, complex molecules we associate with life. "The unique attribute of living matter from which all of its other remarkable features derive," he wrote several years ago, "is its capacity for self-duplication with mutation." These attributes, in turn, depend on carbon and its ability to form large, complex molecules which can store energy and genetic information.

It in fact appears, Horowitz says, that carbon is *uniquely* qualified among the chemical elements for building complex yet stable life structures. Discovering a radically different biochemistry on Mars—if we can recognize it as *bio*chemistry in the first place—would, he says, give evidence for the separate origin of an alien life form, unrelated to the origin of earth life.

With such a broad spectrum of projected Martian macrobes—from bacteria to petrophages—and the caveat, as well, about exotic biochemistry, one begins to wonder whether the Viking scientists are guilty of blatant geochauvinism and over-conservative experimental design. Have they not stacked the deck in favor of detecting carbon-based biochemistry? Have they built assumptions into their experiments based totally on the peculiarities of terrestrial life?

Two of the three Viking lander biology experiments, after all, will measure labeled carbon (C-14). The Pyrolytic Release experiment monitors the uptake of radioactive carbon, and the Labeled Release experiment monitors the release of carbon-containing gases. Both experiments assume that carbon is important, if not central, to Martian biochemistry. Only the Gas Exchange experiment and the landers' cameras make no such assumptions about carbon.

That third experiment will monitor a number of gases (H_2, N_2, O_2, CH_4, CO_2) that may be released during Martian life processes. And the cameras will scan the ground and surrounding terrain for fossils, footprints and larger organisms. But even these, although free of carbon chauvinism, incorporate other assumptions: that life on Mars, for example, will take up chemicals and give off gases as do earth organisms; that Mars has tiny soil organisms similar to earth bacteria; that larger organisms, in the case of the cameras, could be distinguished from rocks or would move as we know it, or, to be outrageous, would choose in the first place to be photographed!

"You can construct scenarios," says biologist Frederick S. Brown, "that we can't refute and that the Viking couldn't correct for. We will all clearly admit that." Brown is Viking project scientist for TRW, Inc., the engineering firm that designed the landers' compact biology instruments. "In fact," he says, "I can give you two more: Our instruments never get below 5°C. If soil organisms there didn't function above that temperature, we couldn't detect them. And the cameras don't have lights. Life on Mars could turn out to be nocturnal." Or, as Sagan pointedly observes: "The experiments might show up negative while organisms are placidly munching the zirconium paint on the outside of the lander."

But Brown maintains that the Viking experiments are *not* geochauvinistic and are not designed modestly with limited expectations. Testing for soil organisms, rather than furry balls or green tentacles, first of all, does not represent moderation. The landers, were they to set down anywhere on earth, from the Mojave to the Antarctic, would detect soil microbes "just as alive—and alive in the same biochemical ways—as a human brain cell."

And the geochauvinism argument is faulty too, Brown says. "We are all bound by our understanding of earth life. That is inevitable. But, after decades of investigation, we have no reason to think life—life anywhere—would evolve with anything but carbon biochemistry. It would beat out other less complex and adaptable biochemical systems on an evo-

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lutionary level."

He further cites the reasonably uniform cosmic abundance of the elements, and notes that microwave searches of outer space have detected aldehydes, nitrites, substituted acetylenes and other organic bits from which a wide array of amino acids, proteins, carbon-sugars and nucleotide base pairs can be built with relative ease.

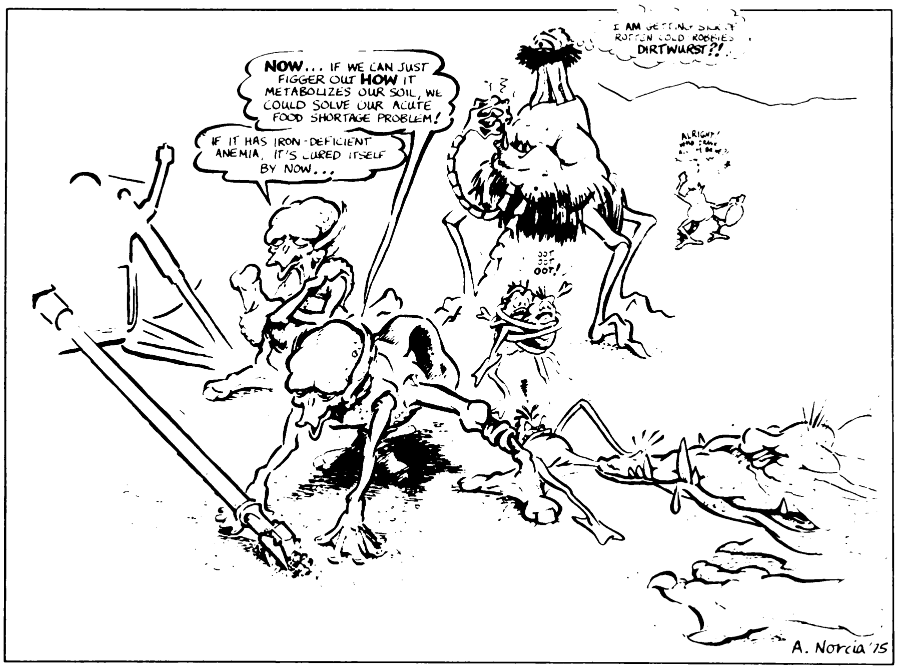
This attachment to carbon is ultimately responsible for the poor odds many Viking scientists lay on finding Martian life. "We took a poll of the scientists involved in the biology experiments," Brown says, "and got odds of from 10 to 1 to a million to one against finding life." If Martian biochemistry were carbon-based, he says, then it might have taken a somewhat earthlike evolutionary course.

"Yet earth life had at least half a billion years to evolve in abundant water. Many of us don't believe that there was liquid water on Mars long enough for carbon-based life to have evolved." But then again, he says, maybe it did. . . .

It is not optimism (nor pessimism, certainly) about the outcome that sustains the search for life on Mars, Horowitz wrote from Caltech in 1966. It is, rather, "the immense importance that such a discovery would have. The search for life on Mars is like buying a ticket on the sweepstakes in which the chance of winning is low but the prize to be won is very high." Among those prizes might be an answer to the question, "Did life originate solely on earth?"

A second finding of life in the same solar system would support the notion that life evolves from necessity when the starting materials are present, and is not just a highly improbable series of chance collisions and unlikely syntheses. It would support, too, the notion that life, perhaps intelligent life, is common in the universe. A second finding of carbon-based life in the same solar system, moreover, would support substantially the hypothesis that life is indeed a property of the carbon atom. We could suddenly find ourselves related, if not in image, at least in biochemistry, to all the organisms in the universe.

A finding, on the other hand, of life based on a different biochemical system would argue for a separate origin of life on Mars. "A single example of such an exotic life form," Horowitz says, "would revolutionize our knowledge of the origin of life."



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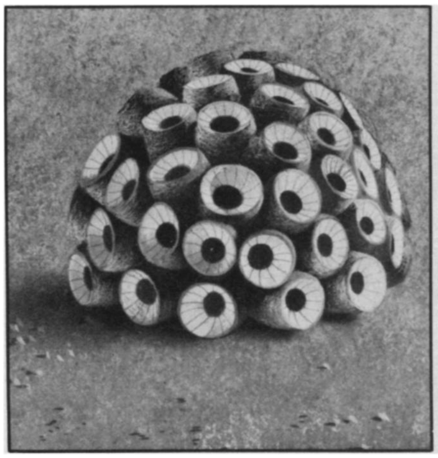
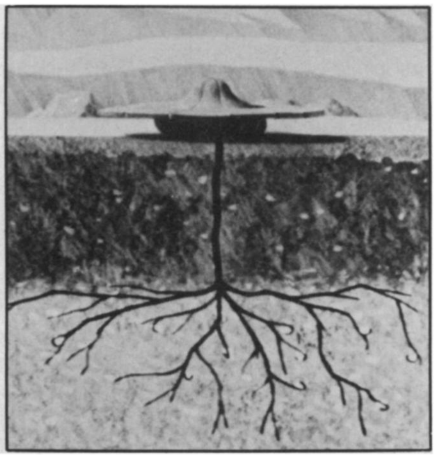
But even completely negative findings—no Martian life, carbon-based or otherwise—would have positive impacts. We would have, Sagan says, "the classic scientific situation, the experiment and the control." Somewhere in the differences between Mars and Earth might lie the clues to why life evolved here and not there.

These potential answers for such profoundly important biological questions, added to Viking's technical achievements and the data it will radio back on the Martian environment, make the mission, in Sagan's words, "an epochal event in human history." And while there isn't a chance, even after this mission, of repressing scientific agnosticism, there is at least the chance to change "Nobody knows" to "Science now knows." □





Illustrations: JPL

Menagerie of projected Martian life forms: Creature with UV-light shield (top left), permafrost eater (right) and rock eater.