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AN UNAMBIGUOUS MARTIAN LIFE DETECTION EXPERIMENT

Gilbert V. Levin
Biospherics Incorporated

A simple, robotic method to provide an *unambiguous* determination of extant life in the Martian surface or subsurface material is presented. It cannot render a false positive, nor mistake a chemical response for a biological one.

Not since the landing of Viking has interest in life on Mars reached the current level. The finding (1) of possible biochemicals and microbial fossils in meteorites attributed to Mars has provided incentive for many new scientific investigations. Similar inclusions have recently been found (2) in non-Martian meteorites. The latter have rekindled interest in earlier reports (3,4) of meteorites containing "organized elements." Exquisite techniques are being developed (5) to examine and analyze these minute inclusions, and to distinguish them from possible terrestrial contaminants.

Intensive efforts are underway in a number of laboratories to develop reliable biomarkers for use in examining meteorites in laboratories, in return Mars samples, and in robotic missions to Mars and other celestial bodies. Chemical, biochemical, genetic mapping, physical, optical, computer recognition of morphological attributes, and laser ablation and sniffing techniques, along with their appropriate instrumentation, are under development. These techniques are focused on the detection and study of fossilized cellular remains. Other efforts are aiming at drilling to depths where lenses of liquid water with live microorganisms may exist. However, none of these biomarker recognition methods can distinguish living organisms from dead ones.

Recent developments have resuscitated the possibility that live microorganisms might be indigenous on the surface of Mars. Living microorganisms recovered (6) from permanent ice in which they extract minute quantities of liquid water have provided a good model for Mars, since frozen water deposits were often seen on the surface by Viking. An analysis (7) of the dynamics of the Martian atmosphere made possible by Pathfinder data shows that liquid water is most likely present diurnally on the Martian surface. The calculated amounts are sufficient to sustain soil microorganisms on Earth.

The new life detection method is based on the legacy of the Mars Viking Labeled Release (LR) experiment (8), which, itself, is gaining renewed attention in view of the recent discoveries on Earth and Mars cited above. In addition, the salient arguments against the LR findings have been answered: 1. theories that H_2O_2 caused the LR results have been negated by recently reported (9) direct observations which established an upper limit of $2x10^{-3}$ precipitable μm of H_2O_2 for Mars (this miniscule amount, were it present, could not have produced the LR results); 2. the failure of the Viking GCMS (10) to detect organic matter on Mars, often cited as proof against the presence of microorganisms, has been contravened by the finding (11) of fully metabolizing microorganisms in permafrost in which no organic carbon was detected by GCMS.

The enhanced LR experiment exploits the fact that all known life forms make and utilize L-amino acids and D-carbohydrates preferentially over the respective stereoisomers. On the other hand, no natural chemical reactions can distinguish between stereoisomers. Therefore, any strong response by an unknown agent to one isomer of an administered compound over its stereoisomer constitutes indisputable proof that the agent producing the reaction is biological. A modified, miniaturized LR instrument can administer L- and D-isomers of amino acids and carbohydrates individually to discrete portions of the same soil sample. A stereospecific response would be proof of life. Should stereospecificity be found, and should it be the same as that of terrestrial life, a possible relationship between the two life forms would be indicated. Should the stereospecificity differ from that of Earth life, an independent origin of life forms would have been established. A variety of thermal controls on replicate samples could determine the thermal sensitivity of any life forms found, and would also serve as a redundant verification of the biological result.

Using new technology, the LR instrument can be simplified and miniaturized. It can be deployed on the planetary surface, or, placed in penetrators, can sample at depth. The instrument can be lodged in a cocoon and the entire assembly heat-sterilized before being mated to the spacecraft. Upon landing, the cocoon door would pop open and, in the same motion, the instrument would be ejected beyond the contamination zone of the lander, thereby eliminating the high cost of spacecraft sterilization. Two-way radio communication between the instrument and the lander would provide for instructions and data exchange.

It is recommended that this simple, small, easily and cheaply developed instrument be flown on the next Mars mission and on missions to other candidate life-bearing bodies.

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