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A CONCEPTUAL MODEL OF AN EXOBIOLOGY ROBOTICS LABORATORY TO SEARCH FOR LIFE ON MARTIAN WATER

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INTRODUCTION

Liquid water is generally believed to be a prerequisite for life (3,12). Our Triple Point of Water (Mars conditions) experimental results suggest that liquid is feasible on the Martian surface (4). Footage from the Mars Orbiter Camera (MOC) had revealed signs of ancient flood plains, lakes, rivers, channels, ponds and seepage, and Mars Global Surveyor (MGS) photos also suggest recent water activity (11). Since water is possibly present on the surface, a robotics laboratory is proposed to search for life forms in Martian water by cultivation with various media and detection of life forms by microscopy.

Past methods included Lederberg's " Multivator Robotics Laboratory" to detect phosphatase by fluorescence (1,2,6,18), Merek and Oyama's Dual Chamber method and Vishniac's "Wolf Trap" to detect turbidity and pH changes as a result of growth. Lederberg proposed the use of Vidicon for microscopy. However, these past methods were not space-qualified (5). Levin proposed Chirality experiments to differentiate Martian microbes from terrestrial species (17). Deamer proposed nanotechnology to detect non-specific long chain polymers (ssDNA and ssRNA)(24).

Results from the Viking experiments on Mars were inconclusive (1) because the presence of superoxides may have precluded biological activities. Perhaps a direct approach using cultivation with peroxidase to neutralize superoxides, accompanied by microscopy may provide definitive answers to the question of life on Mars.

Accordingly, this conceptual model is proposed to challenge the University of California at Berkeley academic community, scientific and technological companies to make this project feasible, space qualified and accepted by NASA for future Mars exobiology experiments.

The robotics laboratory employs an automated rotating carousel system with vials containing various defined media formulations for growth of bacteria and observation of biological activities by microscopy. The automated testing technology has been in use for over two decades by clinical, chemistry, biochemistry and radiological laboratories and only requires miniaturization and adaptation for testing under Martian conditions. A separate system is required for collection and preservation of water samples to prevent sublimation and freezing prior to preparation for inoculation in the robotics laboratory. The system will be adequately insulated, heated and fitted

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with a vacuum pump to preserve water in liquid form for testing.

The defined media formulations targeting bacteria belonging to Archea, Eubacteria and extremophiles are found in Standard Methods, Difco and Baltimore Biological Laboratories manuals (7,8,9) and elsewhere. Since peroxides and superoxides were believed to exist on Martian soil, peroxidase enzymes will be incorporated into media to neutralize their toxic effects.

Preliminary evaluations of the robotics laboratory's performance, will utilize recent deep terrestrial isolates such as Bacillus infernus (12), classified as an aerobic in Bergey's Manual, but found to be the first anaerobic species. Other isolates to be used for evaluation tests under Martian conditions include deep ground water pseudomonads and other fastidious extremophilic bacteria.

The computerized experimental program commences with the inoculation of water samples into culture vials. Periodically, each vial is observed by microscopy and the results are stored in the data memory bank for transmission to Earth via the Mars Orbiter. Several microscopy systems are currently being considered and discussed below (10,11,20,21,22,23).

DISCUSSION

The belief that bacteria is present in Martian water is based on the premise that water seeks its lowest level (Life follows Water) and bacteria which may have existed as long as three billion years ago may follow the course of water movement (18). It is conceivable that bacteria may have the adaptive capability to survive under Martian conditions.

The rationale for employing the cultivation method is that detection of bacteria, few in numbers, may be missed by microscopy. However, exponential growth of bacteria in large numbers will facilitate its detection. For example: Under 1000 X magnification with a light microscope, the presence of one bacterium per field represents approximately a million cells/mL; if bacteria are present in much smaller numbers, they may escape microscopic detection. Consequently, cultivation of a few bacteria will result in billions of cells for observation. In addition, cultivation and microscopy will permit observation for growth, morphology, motility, activity and mode of reproduction.

The presence of superoxides in Martian soil presents a problem, because some terrestrial bacteria, in addition to Martian bacteria, may have produced peroxidase to neutralize the toxic effects of superoxides, but as a precaution, peroxidase will be augmented in the media to address this obstacle.

Image translation in microscopy continues to be a major challenge; however, several systems are being considered to address the complexities involved in data transmission: Landis fixed focus microscope (10), Edmund Scientific Industrial Optics systems (11); Confocal Microscope (23), Scanning Probe Microscope (SPM), and the newly developed Atomic Force Microscope (AFM), which can operate in a liquid environment to examine cellular structures with magnifications of 25 to 10,000,000 X (20,21,22). Consequently AFM shows promise for high-resolution microscopy.

The use of the Robotics Laboratory also ensures personnel safety. If Martian microbes are found to be opportunistic pathogens by molecular biological methods, human exposure to contaminants will be prevented and public health problems will be averted for manned missions (13).

CONCLUSIONS

A conceptual model of a robotics laboratory was constructed to challenge the academic and scientific communities and the space technology to develop a feasible prototype that will search for, and detect, life on Mars. The method employs cultivation and microscopy to accomplish its objectives.

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