

A Comparative Study of Methods for Detecting Extraterrestrial Life (microorganism) in the Solar System Exploration

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We present a comparative study of the methods used in the search for extraterrestrial microorganism life, including a summary table where different life-detection techniques can be easily compared as an aid to mission and instrument design aimed at life detection. This is an extension of previous study, where detection techniques for a series of target characteristics and molecules that could constitute a positive life detection were evaluated. This comparison has been extended with a particular consideration to sources of false positives, the causes of negative detection, the results of detection techniques when presented regarding terrestrial life, and additional science objectives that could be achieved outside the primary aim of detecting life. These additions address both the scientific and programmatic side of exploration mission design, where a successful proposal must demonstrate probable outcomes and be able to return valuable results even if no life is found. The applicability of the life detection techniques is considered for Earth life, Earth-independent life (life emerging independently from that on Earth,) and Earth-kin life (sharing a common ancestor with life on Earth), and techniques effective in detecting Earth life should also be useful in the detection of Earth-kin life. However, their applicability is not guaranteed for Earth-independent life. As found in our previous study, there exists no realistic single detection method that can conclusively determine the discovery of extraterrestrial life, and no method is superior to all others. In this study, we further consider combinations of detection techniques and identify imaging as a valuable addition to molecule detection methods, even in cases where there is insufficient resolution to observe the detailed morphology of a microbial cell. The search for extraterrestrial life is further divided into a survey-and-detection and analysis-and-conclusion step. These steps benefit from different detection techniques, but imaging is necessary for both parts.

Keywords: extraterrestrial life, microorganism, detection, method, systematic comparative study