STRATEGIES AND RECOMMENDATIONS FOR THE SEARCH FOR EXTANT LIFE.

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Introduction: The discovery of life on Mars would revolutionize science. Mars life would yield insight into the universal properties of living systems and the rules governing its formation, establishment, and evolution. One purpose of upcoming missions to Mars is to search for evidence of extant life. To accomplish this goal, it will be necessary to establish recommendations guiding investigative strategies. An open question is whether sufficient analytic capacity can be delivered to Mars to detect life *in situ* or whether the only credible path is to return samples to Earth. Since we cannot predict with any accuracy the form life might take, the answer to this question depends the methods necessary to account for variables in potential forms.

Life detection strategies: In early 2018, the International Mars Sample Return Objectives and Samples Team (iMOST) described the value of returning samples to Earth and outlined investigative strategies to assay for evidence of extant life [1]. One aim was to identify a suite of methods that encompass a broad definition of life. Since detecting and characterizing life in extreme environments is a common goal in extreme environments on Earth, proposed methods were modeled on terrestrial methods (Fig. 1). These methods fall into three broad categories:

(1) Identify and characterize molecules that are diagnostic of organisms that are either alive, or were recently alive. Molecules to target are low-stability molecules such as ATP, phosphoenolpyruvate, chiral amino acids, and nucleic acids. If Mars and Earth life share a common ancestor, nucleic acids would be the genetic material of Mars life. This would enable detection and characterization through methods such as metagenomics.

(2) Detect evidence for metabolism and respiration. In this strategy, samples would be incubated with 'heavy'-isotope-labeled substrates using various combinations of deuterated water, ^{13}C- or ^{15}N-labeled substrates, and other stable isotope labeled substrates. Unlike the Viking mission, substrates would encompass a variety of metabolic strategies not limited to heterotrophic growth.

(3) Perform growth experiments to determine whether organisms are capable of reproduction in culture experiments. Success in cultivation would be the ultimate proof of extant life. To maximize the possibility of growing life, growth conditions would simulate the martian environment as closely as possible.

Conclusions and future directions: The sobering reality is that an *in situ* mission can only handle equipment and sample preparation in one small component of the rover. While the rover has limited capacity to house analytical equipment and perform multi-step sample preparation procedures, returned samples can be analyzed in a wide range of Earth's most sophisticated laboratories. Returning samples would provide a logical and systematic way of approaching the problem. A primary goal of this conference is to critically evaluate life-detecting methods, identify which are critical to the objective of detecting evidence for life, and to determine what would need to be done in possible upcoming missions (e.g. sample return, multiple return missions, expeditions to environment that might support life).

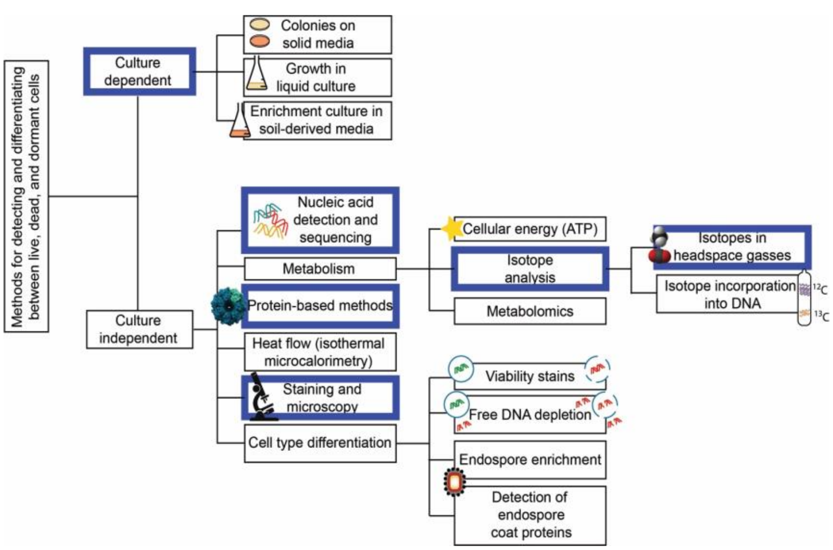

Figure 1: Common methods for detecting and differentiating between live, dead, and dormant cells in terrestrial samples. A subset of investigations recommended for initial investigations into Mars return samples are outlined in bold. Adapted from Emerson et al (2017) [2].

References: iMOST (2018), The Potential Science and Engineering Value of Samples Delivered to Earth by Mars Sample Return,. https://mepag.jpl.nasa.gov/reports.cfm. [2] Emerson J.B. et al (2017) *Microbiome*, *5*, 86.