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Introduction: The formal life-related objective of the M-2020 sample-collecting rover is to seek the signs of ancient life. The rover will not enter 'special regions' on Mars where Earth life may replicate or extant Martian life forms are likely to exist. Therefore, returned samples will not specifically be chosen for the purpose of discovering extant life unless something unexpected is encountered in the field. Regardless, the astrobiological community is highly interested investigating whether or not there is extant life in/on these samples.

Sampling: As far as we are aware, the proposed M-2020 mission landing sites lack distinguishing features that would favor one over another as an environment condunsive to the survival of extant life. Thus, for the purpose of this analysis, we assume that all samples collected by the M-2020 rover be selected for other reasons.

Investigations Required to Test for Extant Life:

So far, no detailed methods and procedures for the detection of extant extraterrestrial life forms have been defined. A draft protocol for the identification of biohazards in Martian samples was formulated in 2002 [1] and a workshop report about life detection in Martian samples was published in 2014 [2]. There are several approaches for assessing the presence of extant life, which are presented in the order of impotance and likelihood of success.

Physico-chemical analyses: This examination has some overlap with Objectives 1.2 & 1.3 (identify candidate biosignatures as evidence of extinct life) in that a subset of the biomarkers targeted these objectives may also speak to the presence of extant life. Specifically, groups of organic molecules that are unlikely to be formed abiotically but are rapidly degraded. Proteins and DNA-like genetic material are stable for thousands to millions of years [3, 4]—a short period in the context of the presence and evolution of life—and are thus a primary target of this objective. Both the presence and size of DNA molecules are of particular interest. In the absence of the repair machinery that exists in a living cell, DNA is damaged and fragmented [5,6]. Therefore, large intact DNA moleucles would be strong evidence of recent life.

Physio-chemical analyses should start with non-destructive and non-invasive methods and proceed towards more and more destructive methods. First insights can be obtaind using different microscopic methods such as Raman, UV-, IR-, and VIS spectroscopy. Besides aiding in detecting biosignatures, they will enable direct detection of cells and biofilms. More destructive techniques include electron microscopy, nano- and ToFSIMS as well as combinations of mass spectrometry and liquid or gas chromatography techniques. These methods enable the detection and identification of complex organic compounds and put them in the structural and compositional context of their sample matrix.

Genetic analysis: If life on Mars and Earth share a common origin and thus share DNA as genetic material, another approach to discovering extant life would be to use a genetic-based analyses. Metagenomics, the processes of isolating and sequencing all DNA from an environment, is the most viable option for this as it can be performed with trace amounts of DNA and does not require culturing. Low DNA-yield samples are susceptible to contamination, so scientific investigations must have sufficient resources to eliminate contamination as a possible explantion for the data.

Culture experiments: Success in cultivating organisms from Martian samples would be the ultimate proof of exant life. However, even on Earth we can only culture a few percent of all microbes from an environmental sample. The probability of finding the right cultivation conditions is negligible. Culture attempts are not recommended unless evidence of extant life is identified though other independent means.

References: [1] Rummel et al., 2002, NASA publication CP-2002-211842; [2] Kminek et al., 2014, Life Sciences in Space Research 2, 1-5; [3] Willerslev and Cooper, 2005, Proc Royal Soc B 272, 3-16; [4] Aerts et al., 2014, Life 4, 535-565; [5] Willerslev et al., 2004, Curr. Biol. R9-R10; [6] Dabney et al., 2013, Cold Spring Harb Perspect Biol 5, a012567.