SEEKING THE SIGNS OF LIFE: ASSESSING THE PRESENCE OF BIOSIGNATURES IN THE RETURNED SAMPLE SUITE.

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Introduction: A biosignature (a "definitive biosignature" or DBS) is an object, substance and/or pattern whose origin specifically requires a biological agent [1]. One category of DBS are complex organic molecules and/or structures whose formation and abundances relative to other compounds are virtually unachievable in the absence of life. A potential biosignature (PBS) is an object, substance and/or pattern that might have a biological origin and thus compels investigators to gather more data before reaching a conclusion as to the presence or absence of life. The usefulness of a PBS is determined not only by the probability that life created it but also by the improbability that nonbiological processes produced it. Because habitable planetary environments create nonbiological features that can mimic biosignatures, these environments must be characterized to the extent necessary to provide a context that is essential for confirming the presence of DBS. Environmental conditions [2] also must have allowed biosignatures to be preserved and amenable to detection. Categories of biosignatures and their measurement requirements are indicated below.

Carbon compounds: Carbon compounds constitute the chemical framework of living systems due in part to their enormous molecular diversity and chemical versatility. But life utilizes only a relatively small number of compounds that meet its requirements for functionality and efficiency. These compounds can be distinguished by measuring their particular molecular structures, relative abundances and molecular weight distributions [2,3]. Potentially diagnostic compounds include certain normal and branched alkanes, fatty acids, porphyrins, hopanes, steranes, amino acids, and other heteroatomic (N-, O-, P-, and S-bearing) compounds. Measurements should be able to detect subpicomole quantities and distinguish between terrestrial contaminants and any components indigenous to Mars.

Patterns of stable isotopic abundances: Biochemical processes can affect the stable isotopic compositions of reactants and products in ways that differ from those caused by nonbiological processes. Such differences form a basis for distinguishing between biosignatures and products of other processes. Stable isotopic compositions (e.g., of C, H, N, O and S) should be measured in individual compounds or minerals in the context of known isotopic reservoirs to seek patterns inconsistent with abiotic processes [4,5].

Minerals: Biological activity has greatly expanded the known repertoire of minerals on Earth, in part by creating chemical conditions for their stability that would not exist otherwise [6]. Measurements should detect and map the spatial arrangement of minerals that, on Earth, are compositionally and morphologically associated with biological activity or catalytic activity (e.g., Fe-oxides, C- and S-bearing minerals) relative to rock textures and the presence of organic carbon.

Morphologies (objects and fabrics): Microbial cells have characteristic size and shape distributions [7]. Microbial biofilms can alter sedimentary fabrics and physical properties [7]. Measurements should seek microscale or macroscale rock or mineral fabrics and structures that are consistent with formation or fossilization of biological entities and inconsistent with chemical or abiotic processes. Mineral surfaces and interiors should be imaged to search for physical evidence of metabolic activity (e.g., pits and trails), especially where associated with redox gradients.

Preservation and degradation: Deposits should be sought that are particularly conducive to biosignature preservation, e.g., phosphates, carbonates, sulfates, and phyllosilicates [2]. Samples least altered by oxidation, heating and radiation are preferred.

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