# BIOSIGNATURES OF PAST LIFE ARE ALSO RELEVANT TO THE SEARCH FOR EXTANT LIFE.

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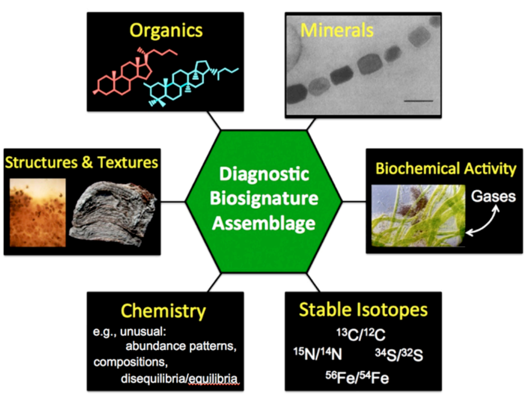
**Introduction:** A biosignature (a "definitive biosignature" or DBS) is an object, substance pattern and/or process whose origin requires a biological agent [1]. A potential biosignature (PBS) is a feature that *might* have a biological origin and thus compels investigators to gather more data before determining 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. Habitable planetary environments create nonbiological features that can mimic biosignatures, so these environments must be characterized to the extent necessary to confirm the presence of DBS. Environments also must have allowed biosignatures to be preserved and to remain amenable to detection [2].

**Relevance to Extant Life:** Biosignatures that can indicate past life are also relevant to the search for extant life. They do not require extant life to be present at the time and place of sample acquisition. If the origin of a biosignature can be confirmed to be geologically recent then it could indicate that life still exists somewhere. This scenario applies if, for example, the biosignature was delivered from a habitable environment elsewhere. Or the biosignature might have been created at the sample site under a geologically recent environment that was more habitable than it is today.




**Carbon compounds:** Organic 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 sub-picomole 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).

**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.

**References:** [1] Des Marais et al., (2008) *Astrobiology 8,* 715-730. [2] Summons R. E. et al. (2011) *Astrobiology 11,* 157-181. [3] Mars 2020 SDT (2013) *http://mepag.jpl.nasa.gov/reports/MEP/Mars_2020_SDT_Report_Final.pdf.* [4] Franz H. B. (2017) *Nature Geoscience, DOI:10.1038/NGE03002.* [5] Williford et al. (2015) *Geobiology, DOI:10.1111/gbi.12163.* [6] Hazen R. et al. (2008) *Amer. Mineral. 93,* 1693-1720. [7] Schopf J. W. (1983) Earth's Earliest Biosphere, Princeton Univ. Press Princeton, NJ.