

## The Search for Biosignatures and Their Relationship to Complex Societies

A biosignature denotes the presence of a substance or phenomenon that is indicative of life, past or present. Biosignature is a term defined in the context of the field of astrobiology and it represents evidence of life in the context of the system where it is being detected. More specifically, if this system is a planet or a moon, the biosignature represents the detection of chemical compounds on the surface or in the atmosphere (if it has an atmosphere) that are indicative of life on that planet or moon. For example, biosignatures can be chemical compounds, particularly organic compounds, visible macroscopic patterns, atmospheric gases.

The past couple of decades have seen an explosion in biosignature science, but currently only the Viking mission has been equipped to search for biosignatures in our solar system. Upcoming missions target the moons Europa and Titan for searches. One of Earth's biosignatures is the atmospheric composition of gases, particularly oxygen and methane in strong thermodynamic equilibrium, the surface reflectance of the vegetation in color red, and narrow-band, pulse modulated radio signs. These "signatures" together suggest an inhabited planet, but each signature by itself might be a "false positive" in confirming the presence of life.

Additional to how we understand the presence of life on Earth as a starting point for biosignature searches on exoplanets, there has been considerable work done in understanding "agnostic biosignature", or biosignatures that have very little in common with life on Earth. The agnostic biosignatures are based on a broader definition of life, based on processes and activities and not on specific molecular structures.

According to Merriam-Webster dictionary, this term was been first used in 1995 and for a while was synonymous with the term "biomarker". It was first used in connection with NASA's Strategy for Mars Exploration. While "biomarker" remains a term used in medicine and biology to identify specific substances and molecules, the term "biosignatures" has been mostly adopted by astrobiology and space sciences.

Aside from its' scientific implications, the term is important for our culture and society. Biosignatures research has a fundamental role in our understanding of the origin of life, in our quest to understand the universality or uniqueness of life on Earth, it has deep roots in our propensity for exploration beyond our planet and, most of all, in answering a deeply important question: *Are we alone?* The implications of finding biosignatures off Earth, in deep space, are staggering – they would expand our collective, social nature beyond our planetary home in Cosmos.

### *Additional Information*

- Textbook on Search for Life in the Universe:  
<https://www.nap.edu/read/25252/chapter/1>

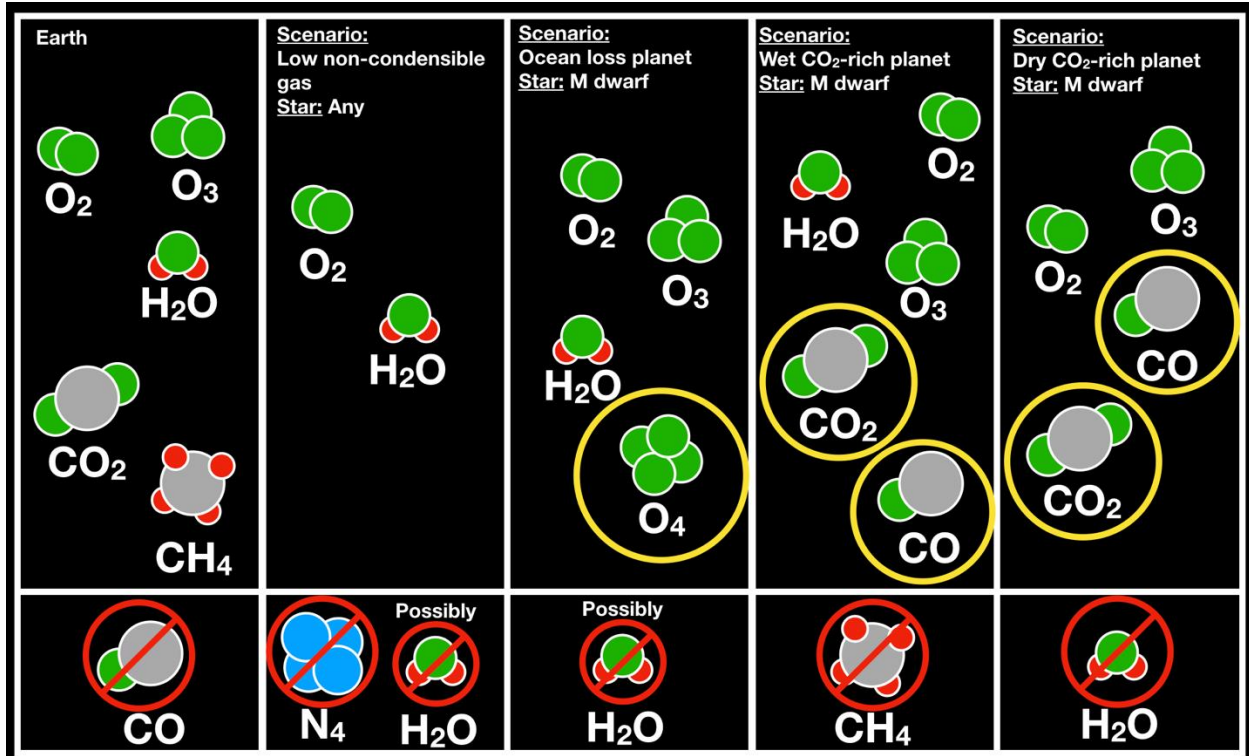


Figure 1. Cartoon adapted from Victoria Meadows' 2018 oxygen as a biosignature study.