

## **Astrobiology: Developing Non-Earth-Centric Methods of Life Detection**

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In order for life detection methods to be reliable in any type of environment, one must assume that all biota exhibit universal, measurable parameters which can be distinguished from a background. Such an assumption allows us to recognize the difference between life and non-life whether or not the candidate life is “as we know it” on Earth. Life detection from an astrobiologist’s perspective differs from that of a cancer researcher’s in that the former distinguishes life from a non-biological background and the latter distinguishes certain types of life such as cancer cells, for example, from a biological background. If our foundation assumption is correct, the same type of life detection protocol should be useful for both astrobiologist and pathologist because the defining features are the differences between sample and background.

Both types of interrogation proceed with the same stepwise line of inquiry:

1. What are we looking for?
2. How can we measure it?
3. Where should we look?
4. How will we know it when we find it?
5. What does it mean?

Two universal distinguishing features of life are chemical composition and structure, the structure being necessary to support the metabolic “machinery” of the biote. Once we know what type of biosignatures (i.e., chemical and structural) to look for, we can evaluate measurement methods. One must use complementary analytical tools in a particular order, proceeding from the least invasive rapid scan of a relatively large spatial region to a high-resolution probe of a smaller, well-defined area of interest. There are many factors which influence our ability to detect a biomarker against any given background whether biological, geological or technological in nature. Quantification and weighting of these factors is key to the appropriate integration of data from different scales and even different types of life detection probes.

We are developing a life detection protocol which employs several discrete probes which measure chemistry and/or structure of a sample differentiating between biological and geological components (Table 1). Ultraviolet fluorescence spectroscopy, deep ultraviolet (DUV) Raman spectroscopy, x-ray microscopy and x-ray spectroscopy are some examples of complementary techniques which are being used for the detection of biomarkers by the Astrobiology group at JPL. Both of the ultraviolet probes detect structure and, indirectly, chemical composition. The fluorescence technique provides a rapid assessment over a larger spatial extent than the DUV Raman probe, which, in turn, provides excellent discrimination between microbial and mineral signatures at a spatial

scale of a few microns. We have also been successful at discriminating different strains of bacteria within a common genus using DUV Raman spectroscopy. The x-ray probes yield detailed information on both chemistry (spectroscopy) and structure (microscopy) of a sample without destroying the rock which may surround it. The disadvantage of these methods is that they require a synchrotron x-ray source, which could not presently be miniaturized for a position on a spacecraft. The importance of these techniques, however, at least merits some thought with regard to how one might make a compact bright x-ray source for in situ sample analysis.

We believe that the integration of multiple data sets from these and other analytical tools will provide a high confidence level method for allowing us to make decisions regarding whether or not life is present in a sample of interest.

**Table 1**

<b>Chemical Signatures</b>	<b>Elemental Analysis</b>	<b>Structure Detection and Determination</b>
Mass Spectrometer Analyses	X-ray Spectroscopy	X-ray Microscopy
Deep Ultraviolet Raman Spectroscopy	Ion Probe Analyses	Computer-aided Tomography
Capillary Electrophoresis Fluorescence		