Three Dimensional Optical and Chemical Imagery of Precambrian Microscopic Fossils

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Throughout biologic history, microbe-level life has been ubiquitous, abundant, metabolically diverse, and for the earliest (Precambrian) seven-eighths of geological time, biotically predominant. The search for life elsewhere in the solar system has therefore centered on detection of microbe-level living systems -- whether ancient or extant -- with the microbe-dominated world of the Precambrian being the best analogue we know. Solution to problems posed by the Precambrian fossil record may thus be key to the detection of ancient life on other worlds.

Perhaps foremost among such problems is the difficulty of unambiguously distinguishing true biologic remnants from nonbiologic (e.g., mineralic) look-alikes. This problem can be addressed by demonstrating in objects claimed to be microscopic fossils a one-to-one correlation, in three dimensions and at a micron scale, of preservable "biological morphology" with geochemically altered "biological chemistry." Two non-destructive, non-intrusive techniques, both new to astrobiology, meet this need:
(1) Confocal laser optical microscopy provides means to image in three dimensions the visible characteristics of organic-walled microscopic fossils *in situ*; and
(2) Laser-Raman spectroscopic imagery provides means to map, *in situ* and in three dimensions, the distribution of the carbonaceous matter that comprises such fossils.

Used in tandem, these techniques for the first time provide means to assess the optically discernable cellular morphology and chemical-structural composition of ancient fossil microbes, a major breakthrough in Precambrian paleobiology of obvious relevance to future analyses of any "life-like" microscopic objects detected in extraterrestrial materials.