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Search Strategies for Organic Bio-Signatures in Extraterrestrial Samples

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The search for organic molecules that indicate the existence of extinct or extant life in extraterrestrial samples involves many of the same potential problems (such as interference from mineral matrices) that occur in analyses of terrestrial biomarkers. In addition, there are problems unique to the search for extraterrestrial bio-signatures. These include selection criteria for target compounds, very low concentrations of target compounds, and extremely limited amounts of sample material. These problems will occur with both laboratory analysis of returned samples and *in situ* analysis onboard lander or rover spacecraft.

Our current knowledge base for development of techniques and protocols for extraterrestrial bio-signature searches comes in large part from the analysis of organic compounds in meteorites. These include carbonaceous chondrites as well as meteorites from Mars. Several classes of organic compounds have been identified in carbonaceous chondrites, including biologically relevant molecules such as amino acids, purines, pyrimidines, and vesicle-forming compounds. These relatively organic-rich meteorites have provided insight into the problems associated with extraction and separation of multiple classes of compounds from small samples. Organic analysis of Martian meteorites has so far been limited to those classes of compounds for which extremely sensitive detection and identification techniques exist, due to the limited amounts of meteoritic material available. One of these classes, polycyclic aromatic hydrocarbons (PAHs), is only associated with biology in rare and uniquely terrestrial circumstances. The other class of compounds, amino acids, is intimately associated with biology on Earth, but also has known extraterrestrial abiotic sources. In the case of amino acids and other chiral molecules, enantiomeric ratios can be used to help distinguish biological from non-biological sources.

Convincing identifications of bio-signatures in extraterrestrial samples will only be possible if multiple classes of biomarker compounds are detected. The concentration profiles of these compounds can then be combined into a multidimensional data set, and patterns in this data set can be discerned using multivariate statistical techniques. Biological compounds that are not traditionally used as biomarkers (e.g. osmolytes, pigments) should be examined for their potential as extraterrestrial bio-signatures. Increases in sensitivity and adaptability of analytical techniques for many types of bio-organic compounds will be necessary before we have the capability to collect such a multi-dimensional data set from an extraterrestrial sample that may contain evidence of life.

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