THE CASE FOR LIFE EXISTING OUTSIDE OF OUR BIOSPHERE:
Techniques for identifying molecular structures

RICCARDO SIDNEY GATTA
The International Center for Genetic Engineering and Biotechnology New Delhi, India

There is no fundamental difference between a living organism and lifeless matter. The complex combination of manifestations and properties so characteristic of life must have arisen in the process of the evolution of matter. *A.I. Oparin*

In order to identify life outside of a terrestrial paradigm we examine the Jovian moon, Europa as a potential source for biological material. The selection of biological targets is based on an investigation of convergent evolution as a universal precept in eukaryote development (Chela-Flores, 1998). Analytical techniques have benefited from multi-disciplinary efforts that have led to the creation of the first functional microscopic-scale laboratories that can perform a concerted series of "hyphenated" functions. Devices contained within a specialised Europan lander (Naganuma and Uematsu, 1998) will have the ability to gather samples, screen for promising biosignatures, and present sufficient data to accurately determine the characteristics of the samples. Application of these "labs-on-a-chip" (Wang *et al.*, 2001) holds great promise in the search for life out of our own biosphere. The question of whether life exists elsewhere in the universe needs to be pertinent to the novel search paradigms afforded by missions to other potential planets. Data inferring presence of liquid water under ice cover on the Jovian moon Europa has made it a candidate for being a possible source of extra-terrestrial life (Reynolds *et al.*, 1987). In the event of a rare opportunity for the direct sampling of the Europan surface and sub-surface (Chyba and Philips, 2002), we should examine whether life could be present in some form that has not evolved on Earth. Target and search criteria should be addressed as to whether evolution is a universal prerogative, or simply a terrestrial artifact. A search based on assays suitable for determining whether convergent evolution is a universally valid paradigm should also be open to the possibility of identifying higher organisms (Chela-Flores, 1998). Evolutionary classification of life gained a solid basis when Carl Woese propounded a novel method (Woese, 1987), using contemporary technology, that identifies those characteristics of organisms that could indicate evolutionary progress. It is necessary to identify aspects that are conserved enough in order to identify, yet are variable enough to allow an evolutionary development to be observed. This would imply an "earth-centric" approach (Conrad and Nealson, 2001) to the search for life in the universe and presupposes evolutionary criteria to be universally valid. The model of convergent evolution raises pertinent questions (Doolittle, 1994), as different organisms often develop similar traits, that can be explained in a variety of manners. In order to evidence the level of similarity, a common method is to create a battery of analytical probes that are known to conjugate with a previously identified analyte, and that can signal the level of interaction in a quantifiable manner. Interactions that have been evaluated in the known biosphere can be extrapolated to an unknown, but believed to be isolated, biosphere (Caetano-Anolles, 2003). In the case of a non earth-centric search for life, the method for evaluation must be de-coupled from what is considered to be life in our biosphere or in any habitability zone (Sagan, 1964). Life as an unknown target can still be identified and quantified according to consideration of its inextricable properties (Cleland and Chyba, 2002). An inherently earth-centric point of view of any earth-bound observer can be deconstructed in order to identify basic characteristics necessary for alternative forms of life to exist. Basic elements that can present emergent properties, such as topology and chirality (Bonner, 1995) could be identified and interpreted, though it may be some time before we obtain the knowledge necessary to prove the biogenicity of a purported biogenic signature, or at least that it has not been formed abiotically. Observable energy disequilibria may be an indication of the existence of life, suggesting a form of energy transduction such as in metabolism/catabolism (Bhattacherjee and Chela-Flores, 2003), or for replication at either molecular or cellular levels. In order to obtain sufficient data, micro-scale (chip based) devices permit most automated multistep assays (Anderson *et al.*, 2000) derived from bench-top systems with advantages of speed, cost, portability, and reduced energy/solvent consumption. Studies of mechanosynthesis of molecular machine systems will enable the development and production of a wide range of micro-components (Drexler, 1994). Attention must be paid to any influence that the analytical techniques may have on the sample under analysis, as positive results in the search for life in the universe will surely have far-reaching effects on life and society in our own biosphere.

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