Mind the gap: from the primitive soup to the root of universal phylogenetic trees

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Laboratory experiments have shown how easy it is to produce a variety of organic compounds, including biochemically important monomers, under plausible cosmic and geochemical conditions. This discoveries support the proposals by Oparin and Haldane of a heterotrophic of the origin of life, which assumed that the first life forms had resulted from a process of evolution that started with the abiotic synthesis of organic compounds. The robust nature of these reactions has been demonstrated by the finding that organic compounds are highly ubiquitous, as shown by their presence in carbon-rich meteorites, cometary spectra, and interstellar clouds where star and planetary formation is taking place. Experimental results achieved so far with the FeS/H_2S combination in reducing N_2 and CO are consistent with a heterotrophic origin of life that acknowledges the role of sulfur-rich minerals and other catalysts in the synthesis and accumulation of organic compounds.

The remarkable coincidence between the monomeric constituents of living organisms and those synthesized in Miller-type experiments appears to be too striking to be fortuitous. However, how the ubiquitous nucleic acid-based genetic system of extant life may have originated from such a mixture is one of the major unsolved problems in contemporary biology. The discovery of catalytically active RNA molecules provided considerable credibility to prior suggestions that the first living entities were largely based on ribozymes, in an early stage called the RNA world. There is convincing evidence suggesting that the genetic code and protein synthesis first evolved in such an RNA world, but at the time being the hiatus between the primitive soup and the RNA world is discouragingly enormous, and the problem of how RNA came into being remains an open one. Bioinformatics and comparative genomics provide important insights into some very early stages of biological evolution, including significant insights into early duplication events and the nature of the last common ancestor, but it is difficult to see how their applicability can be extended beyond a threshold that corresponds to a period in which protein biosynthesis was already in operation, i.e., the RNA/protein world. They are also not applicable to the origin of life itself, since all possible intermediates that may have once existed have long since vanished. Given the huge gap in the current descriptions of the evolutionary transition between the prebiotic synthesis of biochemical compounds and the last common ancestor of all extant living beings, it may be naive to attempt to describe the origin of life and the nature of the first living systems based on molecular cladistics.