Like many of his contemporaries, Darwin rejected the idea that putrefaction of preexisting organic compounds could lead to the appearance of organisms. Although he favored the possibility that life could appear by natural processes from simple inorganic compounds, his reluctance to discuss the issue resulted from his recognition that at the time it was not possible to undertake the experimental study of the emergence of life. As aptly summarized by David Deamer in *First Life*, we still do not know how life actually originated and what was the actual nature of the first living entities, but framing the problem within the evolutionary perspective provided by Darwin led to the development of a multidisciplinary research program that combines experimental simulations of the prebiotic environment with a wide range of observations that range from the presence of organic compounds in the interstellar medium, comets, and meteorites to the discovery of catalytic activities of RNA molecules. Equally important, as Deamer emphasizes in his book, the dramatic shift in the questions we ask today from those raised only a few decades ago are providing novel perspectives on the origin of the first organisms.

In November 1924, Alexander I Oparin published a small volume in Russian entitled *The Origin of Life*, which proposed that the first life forms were the outcome of a lengthy period of abiotic synthesis and accumulation of organic compounds that had led to the primitive soup. In a second book, Oparin went further and presented in 1936 a revised proposal, arguing for a highly reducing primitive milieu in which iron carbides of geological origin reacted with steam to form hydrocarbons. Oxidation of these hydrocarbons yielded alcohols, ketones, aldehydes, and so on, which then reacted with ammonia to form amines, amides, and ammonium salts. The resulting protein-like compounds and other molecules formed a dilute solution, where they aggregated to form colloidal systems from which the first heterotrophic microbes evolved. Following HG Bungenberg de Jong's ideas on the colloidal nature of protoplasm, Oparin suggested that the evolution of coacervates—droplets of organic macromolecules held together by different charges—formed in the primitive oceans led eventually to the first cells.

Oparin's second book was translated into English in 1938, but more than fifteen years went by before his ideas were tested under laboratory conditions. As Deamer writes, “[o]ne of the first atmospheric simulation experiments transformed origins of life research from speculation to solid experimental science. In the early 1950s, a young graduate student named Stanley Miller began his PhD research at the University of Chicago guided by Harold Urey” (p 66), adding...
Miller and Urey decided to make a chemical model of the primitive atmosphere of Earth. Urey knew that the outer planets were very high in hydrogen content, along with water, methane, and ammonia, and he reasoned that the Earth would have had a similar atmosphere just after it completed the process of planet formation. Taking this to heart, Miller decided to simulate these conditions in the laboratory by enclosing a mixture of gases in a large round flask. As a chemist, he knew that nothing would happen unless some form of energy was driving the reactions, so he chose to use an electrical spark to simulate lightning strikes ... The results were spectacular, and even today remain a touchstone for research on the origins of life. (p 66–67)

As discussed in First Life, during the past sixty years the laboratory simulations of the prebiotic earth have yielded many different molecules of biochemical significance under a wide range of environmental settings. We are far from understanding how the first cells evolved, but the empirical and analytical evidence suggests that prior to the origin of life the prebiotic environment was already endowed with many inorganic and organic catalysts, purines, and pyrimidines—the potential for template-directed polymerizations—and membrane-forming compounds, ingredients associated with the activity of cells.

Some were quick to realize the significance of membranes for the origin of life. A few months after Miller published the results of his experiment, the famous British geneticist and polymath JBS Haldane stated in a meeting of the Society for Experimental Biology in Cambridge that “[t]he long-chain polymers found in living organisms have ‘back-bones’ composed of phosphate [that is, nucleic acids], glycine, or pentose residues. The first seem to be the most catalytically active, and may be the most primitive. The critical event which may best be called the origin of life was the enclosure of several different self-reproducing polymers within a semipermeable membrane” (Haldane 1954:26).

However, it is sometimes forgotten that the results of the 1953 Miller-Urey experiment were published only a few weeks after the Watson and Crick double-helix model of DNA. It is difficult for contemporary scientists and students to understand in full the extraordinary impact that these two publications had on our understanding of the origin and nature of life. Molecular biology quickly became a blooming field and attracted some of the most brilliant scientific minds, leading to a rapid molecularization of our understanding of living phenomena.

Quite understandably, during the decades that followed, attempts to understand the origin of life were shaped, to a considerable extent, by the unraveling of the details of DNA replication and protein biosynthesis. Developments in molecular biology also led to some extreme reductionist approaches and to the idea that life depended on a single living molecule. In 1959 Hermann J Muller, the distinguished geneticist (and intellectual mentor of Carl Sagan), defended the idea that life emerged when a living DNA molecule was formed in the primitive earth and argued that

the most fundamental property distinguishing a living thing—and that can therefore be used to define life—is its ability to form copies of itself. We call this “reproduction”; but such copies must also include innovations—mutations—that distinguish a given living thing from its parents. ... Natural selection could not go on without the necessary basis of an ability or faculty of the material to copy not merely itself but its
variations. That, I think, is the heart of life, and such material, when it arose, is rightly called “living”. (Darwin and others 1959:71)

It is true that the multiple lines of evidence that support the possibility of an RNA World have reinforced a reductionist approach in the study of the emergence of life, but as Deamer underlines in his book, it is useful to put a healthy distance from the idea that living systems depend on one single molecule. Deamer argues instead in favor of the appearance of prebiotic cell-like vesicles made of lipids of abiotic origin, which may have accumulated on the primitive earth either due to endogenous syntheses or delivered during the collisions with meteorites or other similar primitive small bodies.

Such droplets, which are the modern version of Oparin’s coacervates, have been observed under laboratory conditions from certain fatty acids. As summarized by Deamer, experimental approaches to vesicle chemistry point to fatty acids as good candidates as the first amphiphilic protocellular constituents. Of course, any strong statement on the transition from abiotically synthesized organic matter into the first living entities is pure conjecture. Whether the earliest genetic polymers were enclosed within membranes is not yet clear, but as summarized in First Life, this is a very reasonable possibility.

The formation of membranes and lipidic vesicles under prebiotic conditions is highly plausible. Many examples of self-organizing physical systems that lead to highly ordered structures demonstrate that, in addition to natural selection, there are other mechanisms of ordered complexity that operate. The list includes lipidic molecules that exhibit self-assembly properties that lead to the formation of bilayers, micelles, and liposomes. As Deamer states, “Nothing holds the molecules together in the vesicle except a weak force called the hydrophobic effect. The same force is responsible for stabilizing the soap bubbles we play with as children and the lipid assemblies that form the membranes around every cell in the human body” (p 252). If the origin of life is seen as the evolutionary transition between the nonliving and the living, then it is easy to accept that complex systems of purely physical and chemical nature played a role in the emergence of life. It is true that some advocates of an early emergence of replicators consider the cell as a mere physical compartment for segregating polymers that show differential replicative abilities. However, biological membranes are not mere lipidic containers, but active players in bioenergetic transduction without which extant life could not exist. How they first appeared is still a major, open question.

Deamer has written a well-argued, deeply researched, and thought-provoking book on the origin of life. He is certainly well-qualified to discuss the subject; long before others, he was the first who spotted in contemporary times the significance of lipids and membranes in the origin of life. But First Life is neither dismayingly narrow nor unduly technical; its approach is engaging, accessible, and interdisciplinary. Based on his understanding of cell biology, the prebiotic environment, and the significance of Darwin’s intellectual inheritance, in this book he advocates an evolutionary approach as the key for understanding the essence of biological phenomena. His book is written as an enticing personal narrative, and ends with an epilogue that is a strong defense of the significance of science for individual and collective development.
REFERENCES

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