First Life: Discovering the Connections between Stars, Cells, and How Life Began.

Author: Wickramasinghe, Chandra

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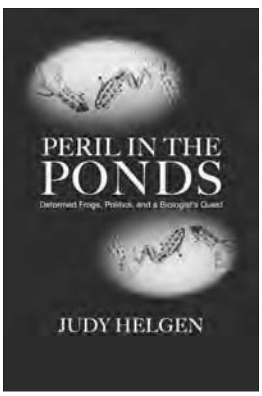
It is clear that Helgen held tenaciously to the goal of keeping the project funded and moving forward, and her commitment to her work was critical to bringing so much attention to the issue. Less clear is the portrayal of the MPCA (now her former employer) as an unwilling partner in her work. At every turn in the book, funds are threatened, her position is in jeopardy, or the project is destined to be taken from her control and ruined. She repeatedly implies that the people behind these actions may have dark motives. But this is not investigative reporting, and readers are left only with the author's vague sense of conspiracy with little to support it. Whatever the facts, few readers will conclude that the system worked well in this case.



So, what is the bottom line? Perhaps the largest lesson lies with what is still not evident: However sophisticated our approaches, developing an understanding of the causes of certain types of environmental threats will take a great deal of time and effort. Commonly, when an environmental problem emerges, we can readily discern the cause and figure out what we would need to do to remedy the issue. Acid rain offers one clear example. The symptom led us to the cause and to the range of possible solutions (Likens and Bormann 1974). It is with increasing frequency, however, that we are encountering environmental issues that we simply do not understand. Initially, we may not even know how to study them or when we have reached false conclusions about their causes (Sessions 1996, Lannoo 2008). Deformed frogs are a great case in point—one that deserves our attention, regardless of how much we may care about the fate of frogs themselves.

In reflecting on Helgen's story, I kept asking myself what kind of response would have been mounted were the deformities afflicting humans instead of frogs. As Helgen notes in the book, whatever was causing the maladies to frogs could potentially represent a threat to the health of other species, including humans. (At one point, Minnesota families living near ponds with deformed frogs were being supplied with bottled drinking water against just such a possibility.) Undoubtedly, millions of dollars and hundreds of researchers would have been involved—and yet, it might have taken years to work out what was happening. It is not so surprising, then, that the very few who have worked on the issue have not produced a definitive understanding of deformed frogs. Helgen deserves great credit for her accomplishments under the circumstances and for bringing the issue back under our scrutiny.

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DAVID K. SKELLY

David K. Skelly (david.skelly@yale.edu) is a professor of ecology and associate dean at the School of Forestry and Environmental Studies at Yale University, in New Haven, Connecticut. He recently coauthored a publication for the journal Ecology Letters *(2010 13: 60–67) entitled "An examination of amphibian sensitivity to environmental contaminants: Are amphibians poor canaries?"*

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SIMULATION OF EARTH-BASED THEORY WITH LIFELESS RESULTS

First Life: Discovering the Connections between Stars, Cells, and How Life Began. David Deamer. University of California Press, 2012. 286 pp., illus. $24.95 (ISBN 9780520274457 paper).

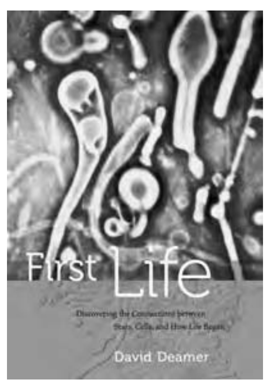
First Life: Discovering the Connections between Stars, Cells, and How Life Began is an eloquent exposition of what can be described as the "conventional wisdom" on Earth-based theories of the origin of life. Author David Deamer, professor of biomolecular engineering and research professor of chemistry and biochemistry at the University of California, Santa Cruz, is a preeminent leader in the field and tells his personal story of discovery in a unique and absorbing way. The text is sprinkled throughout with interesting anecdotes of how leading figures in the field of biochemistry influenced the author and his scientific career, thus driving home the fact that science is an intensely human pursuit. The topics covered in the book's 15 chapters span a wide range, from meteorites and biochemical pathways to evolution and the prospects for synthetic life, but Deamer keeps well within the bounds of consensus and convention throughout the book. Cultural constraints dating back to pre-Copernican times have tended to restrict origin-of-life investigations to within an Earth-centered framework; *First Life* is no exception.

The functioning of a living system depends on thousands of chemical reactions taking place within a membrane-bound cellular structure. Such reactions, grouped into metabolic pathways, have the ability to harness chemical energy from the surrounding medium in a series of very small steps: transporting small molecules into cells, building biopolymers of various sorts, and ultimately making copies of themselves while possessing a capacity to evolve. Batteries of enzymes, composed of chains of amino acids, play a crucial role as catalysts precisely controlling the rates of chemical reactions. Without enzymes, there could be no life.

Since the twentieth century, the most important metabolic pathways in biology have been unraveling (e.g., the carbon dioxide cycle in plants), and a number of Nobel Prizes have been awarded for such groundbreaking discoveries. However, even if we possessed a complete knowledge of all the metabolic pathways in biology, we would not come any closer to understanding the processes by which the simplest living system emerged. The prebiotic models discussed in *First Life* (e.g., the clay world, the iron–sulphur world, the RNA world) are all possible intermediate genetic systems that possess a lower level of complexity, but where such systems may have operated remains unspecified. Terrestrial venues for the origin of life have been explored in the book as the sites of choice, although all such venues are grossly inadequate, in my view, to overcome the enormous hurdles of improbability that are involved.

In present-day biology, the information contained in enzymes—the arrangements of amino acids into folded chains—is crucial for life, and this information is transmitted by way of the coded ordering of nucleotides in DNA. In a hypothetical RNA world that may have predated the DNA protein world, RNA is posited to serve a dual role as both enzyme and genetic transmitter. If a few ribozymes are regarded as precursors to all life, one could attempt to make an estimate of the probability of the assembly of a simple ribozyme composed of 300 bases, as is done on page 216 of the book. This probability turns out to be 1 in 4^{300}, which is equivalent to 1 in 10^{180}, which, as Deamer admits, can hardly be supposed to happen even once in the entire 13.7-billion-year history of the universe.

Deamer describes his ambitious laboratory setup to attempt a simulation of the origin of life by making trillions of half-micron-size cellular compartments by adding water to dry lipids in a flask. To this, he adds a solution of small peptides and nucleic acids in the hope that, among the trillion or so cellular compartments and a vast array of biological monomer combinations, a proto-living system will be found. The failure to witness any trend whatsoever toward the emergence of a living system is attributed to the infinitesimal scale of the laboratory system when it is compared with the terrestrial setting in which life is thought to have arisen. Yet, if we move from the laboratory flask to the oceans of the Earth, we gain in volume only a factor of about 10^{20}, and in time, from weeks in the laboratory to half a billion years, the gain is an additional factor of 10^{10}. In the probability calculation for the single ribozyme, we therefore gain a factor of 10^{30} in all, which reduces the improbability factor given by Deamer from 1 in 10^{180} to 1 in 10^{150}.



On this basis, it is very difficult to avoid the conclusion that the emergence of the first evolvable cellular life form was a unique event in the cosmos. If this did indeed happen on Earth for the first time, it must be regarded as a near-miraculous event that could not be repeated elsewhere, let alone in any laboratory simulation of the process. To overcome improbabilities on the scale that is involved here, it stands to reason that one would gain immensely by going for the biggest system available—manifestly, the universe as a whole.

The only astronomical connection with the problem of the origin of life that is endorsed by Deamer is his acknowledgment of Sir Fred Hoyle's groundbreaking contribution to our understanding of how the chemical element carbon—the element of life—is synthesized in stars. Hoyle and I took the astronomical connection much further in the mid-1970s, when we proposed that organic molecules resembling biochemicals were distributed everywhere in the galaxy and, moreover, that such molecules were most plausibly the product of life itself—the detritus of life. Comparisons of astronomical infrared spectra with organic polymers and biomaterial were made by us well ahead of those made by the investigators at NASA's Ames Research Center, to whom the author gives credit in his book. In fact, the first proposal of organic polymers in interstellar grains was published in *Nature* between 1974 and 1977 (Wickramasinghe 1974, Hoyle and Wickramasinghe 1977a, 1977b, Wickramasinghe et al. 1977).

Deamer's cavalier dismissal of panspermia is to be regretted in view of the growing evidence that microbial life is exceedingly robust and that interplanetary panspermia is inevitable. The arena of life is thereby extended across the entire solar system, and much grander settings for Deamer's laboratory simulations can be envisaged.

The argument that panspermia must be rejected because it merely transfers the problem of origin from Earth to another setting is by no means scientific. The question of whether life started *de novo* on Earth or was introduced from the wider universe is a fully scientific question that merits investigation and one that is open to testing and verification. The invocation of Occam's razor to exclude a discussion of such matters is unfortunate and merely an excuse for keeping scientific discussion within the strict bounds of what is considered *de rigueur*. It is strikingly reminiscent of the restrictions that stifled science in the Middle Ages.

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Ultraviolet and infrared spectral signatures that could be regarded as having a connection with biology are present everywhere in the universe—in the solar system, in the most distant galaxies, up to distances exceeding 8 billion light years (Wickramasinghe 2010). The amount of such organic material in our galaxy alone totals nearly one third of all the carbon in interstellar space. The possibility that all this organic material is the result of prebiotic chemical evolution is mere wishful thinking. Whenever similar spectroscopic features are found on Earth (e.g., polycyclic aromatic hydrocarbon features), we attribute them to degradation products of biology, yet we refrain from adopting this same logic on a cosmic scale—the argument being that life outside Earth is an extraordinary claim for which extraordinary evidence is called for. On the contrary, Deamer's confinement of life to Earth is an extraordinary claim, particularly in view of the dynamic pathways available for interstellar and interplanetary transfers and the survival properties of bacteria that have been identified and documented.

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CHANDRA WICKRAMASINGHE

Chandra Wickramasinghe (ncwick@gmail.com) is director of the Buckingham Centre for Astrobiology at the University of Buckingham, in the United Kingdom. He is the coauthor of the recent work Comets And the Origin of Life *(World Scientific).*

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