

four Maxwell equations, the continuity equation, the Lorentz force expression, Newton's second law of motion and the inverse square law of gravitation.) Professional physicists know how uncommon it is for even advanced-level textbooks (as opposed to specialized monographs) to appear as references in papers reporting on current research. How extraordinary, then, must a book at the undergraduate level be to merit numerous such citations? This reviewer can think of at least two different examples of this sort in the FLP. The first is figures 41-6 in Vol.2, captioned "Flow past a cylinder for various Reynolds numbers". Evidently such a clearly delineated set of sketches is not too common even in the specialized hydrodynamical literature! The second is the beautiful little chapter on irreversibility in Vol.1 (Ch.46, entitled 'Ratchet and pawl'). The analysis of the hypothetical device described in this chapter has attracted considerable attention in recent years. These are but a few instances of the remarkable clarity of focus on the real issues, sometimes bordering on prescience, that is characteristic of the FLP. As Feynman himself said in relation to

the FLP, "...I've always been trying to improve the method of understanding everything...There was always a certain pleasure in discovering for myself actually that I could understand many more things than I thought I could from the elementary point of view. I would use these explanations (in the lectures)." James Gleick ends his biography of Feynman with the words, "An imprint remained: what he knew; how he knew". *The Feynman Lectures on Physics* are an important and memorable part of that imprint.

### Suggested reading

R P Feynman. Preface, FLP.

M Kac. *Enigmas of Chance*. Harper & Row, New York. 1985.

J Mehra. *The Beat of a Different Drum — The Life and Science of Richard Feynman*. Clarendon, Oxford. 1993.

R B Leighton. Foreword, FLP.

R P Feynman in *Interviews and Conversations with J. Mehra*. 1988. Quoted in Ref.3, Ch.22

J S Rigden. *Am. J. Phys.* 52: 303. 1984.

J Gleick. *Genius — Richard Feynman and Modern Physics*. Rupa, Calcutta. 1992.

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## "Odd, Watson - Very Odd!"

### The Chemical Evolution Model Revisited

S Mahadevan



*Seven Clues to the Origin of Life -*

*A Scientific Detective Story*

A G Cairns-Smith

Cambridge University Press,

Cambridge, 1985

pp. xii + 131. Rs.195.

The origin of life on earth, as described in most standard text books, has seemingly two contradictory aspects. Most authors start by describing the classic experiments of Redi, Spallanzani and Louis Pasteur that disproved the theory of spontaneous origin of life forms from inanimate matter, leading to the conclusion that life can arise only from pre-existing life. This automatically leads to the question as to how it arose in the first place. Here, one

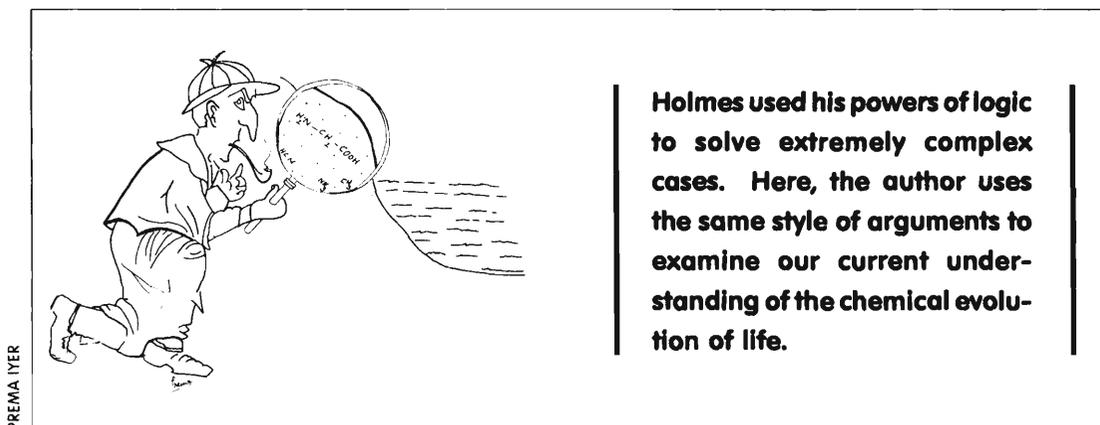
has to back track and seriously reconsider evolution of life forms from the pre-biotic, i.e. non-living environment. This is taken in stride and the experiments of Miller are described. The ultimate conclusion drawn is that chemical evolution gave us the primitive life forms and biological evolution, mediated by natural selection, gave us the varied life forms seen today. This is accepted today by most biologists, in many cases for want of a better theory.

In this context, Cairns-Smith's extremely readable book, *Seven Clues to the Origin of Life: A Scientific Detective Story* offers a serious re-examination of our ideas of chemical evolution. The book is written for the lay-person with no training in biological sciences. In spite of this, it is fun reading for any one interested in biology, particularly students and teachers, as well as fans of Sherlock Holmes, for the author depends heavily on the methods of the illustrious fictional detective created by Sir Arthur Conan Doyle. Holmes used his powers of logic to solve extremely complex cases. Here, the author uses

the same style of arguments to examine our current understanding of the chemical evolution of life.

As the author states in the introductory chapter itself, no one doubts that evolution has occurred. What he questions is the commonly believed role attributed to chemical evolution. As the title suggests, the arguments are presented in the form of seven clues which point to the inadequacies of the chemical evolution model as it is understood conventionally.

The introductory chapter examines the various possible models proposed for the origin of life. Was it the result of natural events or supernatural intervention? Based on available evidence, the likely conclusion is that life originated on earth due to natural causes 3-4 billion years ago. He compares our position to that of Sherlock Holmes starting his famous case of *The Hound of the Baskervilles*. We have to exhaust all other possibilities before falling back on the supernatural. The following chap-



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ters take us through our present concepts of information transfer in biological systems and the interrelation between various biological processes. The result of this exercise is the appreciation that biological systems that exist today are extraordinarily complex, consisting of interlocking components that can function only in a mutually dependent manner. Armed with our current knowledge about the molecular architecture of living beings, we can go back to the initial question as to how it all started. In the author's view, the explanation given in terms of chemical evolution is far from satisfactory. After leading us through a garden path initially, the theory leads us to an insurmountable cliff-face.

The major problem with the chemical evolutionary theory, according to the author, is the fact that it fails to explain the interdependent nature of the different components of the living system. The basic molecular processes such as DNA replication, transcription, and translation are multicomponent systems that are closely tied to each other. It is almost unimaginable that they evolved independently and came together in a miraculous fashion. It is also equally unlikely that they evolved simultaneously. The problem is similar to building an arch without a scaffolding. The stones of an arch cannot be assembled one at a time without a support as the whole structure will collapse. Similarly, in the absence of a 'scaffold', the interlocking components of the biological system cannot evolve independently. But then, where is the supporting structure? This argument is a bit weak as it

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applies not only to the molecular aspect of evolution, but also to biological evolution. Therefore, by the same argument, the transformation of a single cell to a complex organism with interacting components is not likely to happen in the absence of a scaffold.

The disparity between the available experimental evidence for the synthesis of organic molecules in the prebiotic soup under harsh geological conditions and the complexity of the final products of evolution, according to the author, is simply too vast and takes a giant leap of imagination to go from one to the other. The organic synthesis of DNA, RNA, and proteins involves dehydration and their synthesis in an aqueous environment is next to impossible in the absence of catalysts. Thus it is difficult to picture the direct evolution of the entire ensemble of biopolymers and the biochemical cycles. These arguments are pre-



sented lucidly in the following chapters.

In the absence of the direct evolution of organic biopolymers from the prebiotic soup, what other possibilities can one consider? The author suggests the clue provided by the rope. The fibres that make the rope need not run through the entire length of the rope as long as they can be interconnected. The same way, newer organisms carrying more efficient genes can be generated sequentially like the fibres of the rope. The rope symbolises the continuum of life forms as they gradually evolved, one giving way to another as new genes were created replacing old ones. (Strangely, ropes found at the scene of crime gave valuable clues to Sherlock Holmes also. At least in two cases, they helped him in the identification of the criminal.)

But then where is the scaffolding? Where are the catalysts? Where are the secluded chambers where the primitive information molecules that were evolving could be isolated from the vagaries of the environment? The way the author reads the clues, the answers have to come from inorganic rather than organic molecules. Crystals can be the primitive carriers of information. With their ability for self assembly, they can be reproduced relatively easily. With their layers of closely stacked atoms, they can offer a matrix for chemical reactions, thus playing the role of a primitive catalyst. With polarised surfaces, they can also act as a primitive biomembrane. The primary organisms based on minerals could gradually lead to the formation of sec-

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ondary organisms based on organic chemicals. Because of their inherent efficiency, they could gradually replace the primary organisms in a genetic takeover. The scaffolding was probably destroyed in the course of time.

What could be the inorganic molecule that is best suited for such a challenging task? Well, like any reviewer of detective stories, I do not want to name the 'culprit'. The author's choice is quite original and plausible. However, one gets the feeling of an anticlimax at the end of the book. Expecting an ending similar to the logical manner in which Sherlock Holmes would summarise his case, one is presented with the flair of Hercule Poirot who is known to present his culprits dramatically without sharing with the reader the evidence that led him to his remarkable results. But despite this limitation, the book is thoroughly readable, as it promotes a healthy irreverence to many closely held beliefs of 'molecular evolutionists'. In a culture like ours which takes the printed word as the gospel truth, questioning of "holy cows" is definitely recommended. As Holmes would say, "The game is afoot, Watson!"

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