

Isn't the origin of life highly improbable?



Introduction

It would be difficult to give a short answer to this complex question. From all we know about the state of the Earth 3 to 4 billion years ago and what we know about the complexity of the building blocks of life — DNA, RNA, amino acids, sugars — no entirely plausible hypothesis for the spontaneous origin of life has been found. Because the topic does not have as many potentially useful applications as other areas of science, less research has traditionally been performed in this area. However, scientists are currently approaching this challenge from a number of different perspectives.¹ The fact that there is no answer today does not mean there will be no answer tomorrow. Though an explanation for the origin of life is currently elusive, this does not mean divine intervention is the only possible explanation. There are many unexplained natural phenomena; the origin of life is simply a particularly compelling example of an unsolved mystery we would like to understand.

Clarifications

In discussions about the origin of life, an important first step is clarifying what is meant by life. The

first forms of life on Earth were probably very different from what we would call life today. It may be tempting to think of life as anything containing the DNA double helix seen in many life forms today. However, the main property required for early life is self-replication. The earliest self-replicating systems could have been made out of DNA, RNA or some other basic building blocks. The key feature of such systems would have to be the ability to gather chemicals from the local environment and make copies of themselves. All life on Earth contains carbon as an essential elemental building block.² Carbon is the simplest element capable of forming the remarkably complex molecules that are so prevalent in life forms. Therefore, it is likely carbon was involved from the beginning. Compounds containing carbon are generally categorized as organic; and exploring the natural mechanisms that create complex organic compounds is a main focus in research on the origins of life.

It is also important to keep in mind the age of the Earth. The Earth is approximately 4.5 billion years old. All evidence suggests that the Earth was inhospitable to life for the first 700 million years, largely because it was so hot. However, the Earth gradually cooled, and 4 billion years ago it became more hospitable. Within little more than 100 million years, the first single-cell life forms appeared.³ Where did these organisms come from? And what were their capabilities? Although we do not know the path that led to these early bacterial forms, it seems likely DNA had emerged as the information molecule by this time. Microbiologist and physicist Carl R. Woese suggests there was a considerable amount of lateral gene transfer among the first forms of bacteria called archaeobacteria.⁴ Lateral gene transfer, which is the movement of genes from one bacterium to another, would have enabled the exchange of genetic material, and it would therefore expedite the process of diversification of biological function acted upon by natural selection. How these first organisms ever developed in the first place is the topic of the following discussion.

The Miller-Urey Experiment

Charles Darwin is often credited for the original “warm little pond” hypothesis, which proposes life may have formed from a combination of inorganic compounds and energy.⁵ Soviet biochemist Aleksandr Ivanovich Oparin revisited this idea and proposed life formed in an environment that lacked oxygen but was energized by sunlight.⁶ These kinds of ideas are the basis of much research of life’s origins, including the famous Miller-Urey experiment.

In 1953 at the University of Chicago, Stanley Miller and Harold Urey tackled the problem of the origin of life by reproducing the conditions they believed to be present on the primitive Earth when life originated. By zapping a mixture of water and inorganic compounds with electricity, they produced organic compounds including amino acids, the building blocks of protein.⁷ This result

catalyzed further experiments — and at least to some, it appeared that the solution to life’s mystery was about to unfold.

A subsequent discovery by Joan Oro at the University of Houston, published in 1961, demonstrated that an essential component of DNA — adenine — as well as several amino acids could be formed by heating the inorganic compound hydrogen cyanide in water-ammonia.⁸ Though this work potentially contributed useful pieces to the puzzle,⁹ Miller-Urey type experiments have fallen short of providing a full answer to how life originated. It’s one thing to have organic compounds present, it’s quite another to have them form a self-replicating system.

Recently, these initial results were revisited with more sensitive methods. Researchers discovered additional amino acids and other building blocks formed during the Miller-Urey experiments that they originally had not realized.¹⁰ Miller continued a variety of experiments to pin down life’s origins and, though the mystery remained unsolved, members of his lab discovered amino acids and other building blocks for life can also form from inorganic compounds in extremely cold environments.¹¹

How Life Came Together

Explanations of how the amino acids, nucleotides and sugars were formed, how they assembled in the form of DNA and RNA, and then how these building blocks of life came to replicate themselves and acquire the enzymes to facilitate this process, are all still speculative. Many interesting ideas are being researched, however, including the deep sea vent theory,¹² radioactive beach theory¹³ and crystal or clay theory.¹⁴ Another opinion, held by Francis Crick and others, is that the only explanation for life on Earth is that it came from another planet.¹⁵ However, this type of explanation only pushes the question farther back: How did this extraterrestrial life originate? A compelling explanation of the origin of life here on Earth has not yet emerged.

Evolutionary theories of how life originated fall in two main camps: the gene first hypothesis and the metabolism first hypothesis. The gene first hypothesis currently focuses on RNA rather than DNA, as certain RNA molecules have shown the ability to function as enzymes, suggesting RNA could have both carried information and copied itself. From this point of view, RNA preceded both DNA and protein synthesis. On the other hand, the metabolism first hypothesis argues the molecules of prebiotic materials formed chemical cycles and networks of chemical reactions that gave rise to primitive metabolic systems. These metabolic systems existed before RNA and provided the environment for RNA replication to later emerge. Despite the exploration of numerous avenues of research, both theories currently lack conclusive evidence. While researchers have recently

generated self-replicating RNA from prebiotic molecules in the laboratory,¹⁶ it is difficult to understand how RNA — a notoriously unstable polymer — could have supported self-replicating systems in the hostile chemical and thermal environment of early planet Earth.

Conclusion

The study of life's origins is an exciting area of research. The jury is still out on how life first emerged. A simple response would be to give a God-of-the-gaps explanation: that some supernatural force, namely God, must have intervened to bring life into being.

But consider the timeline of these scientific quandaries. Life on this Earth appeared approximately 3.85 billion years ago, yet serious scientific study of its origins began just 60 years ago. A convincing scientific explanation may still emerge in the next 50 years. Though the origin of life could certainly have resulted from God's direct intervention, it is dangerously presumptuous to conclude the origin of life is beyond discovery in the scientific realm simply because we do not currently have a convincing scientific explanation. Although the origin of life is certainly a genuine scientific mystery, this is not the place for thoughtful people to wager their faith. All that has happened in the history of life has happened in response to God's creation command ([John 1:3](#)). Furthermore, God is immanent in creation, upholding the natural laws. [Colossians 1:17](#) tells us, "He is before all things, and in him all things hold together." What we do not know at this point is the extent to which God may have intervened supernaturally in the history of life. Some believe that the creation command was carried out through the natural laws which have been continuously upheld by the ongoing presence of God in creation. Others believe that since the God of the Bible and the God we experience in our lives intervenes in supernatural ways at times, that this would also likely have been true in the history of life itself. Neither of these views are inconsistent with scientific findings. The important thing is that in the BioLogos view, God's sustaining creative presence undergirds all of life's history from the beginning to the present.

Finally, as a purely technical matter, the theory of evolution does not propose an explanation to the question of the origin of life at all. The theory of evolution becomes relevant only after life has already begun.

Consulted Experts:

The BioLogos Foundation is grateful for the assistance of [Darrel Falk](#) in drafting this response.

Notes

1. Two examples of research groups working on the topic are: Gerald Joyce at Scripps Research Institute (The Joyce Laboratory, <http://www.scripps.edu/mb/joyce/> (accessed 12/20/08)) and Jack Szostak with the Origins of Life initiative at Harvard University (The Origins of Life Initiative, <http://www.harvardscience.harvard.edu/directory/programs/origins-life-initiative> (accessed 12/20/08)). Other recent publications on the subject include Robert M. Hazen, *Genesis: The Scientific Quest for Life's Origins* (Washington, D.C.: Joseph Henry Press, 2005), and Andrew H. Knoll *Life on a Young Planet: The First Three Billion Years of Evolution on Earth* (New Jersey: Princeton University Press, 2003).
2. It has hypothesized that silicon may be an alternative to carbon, as it is structurally similar to Carbon with a half filled outer shell and four free electrons, but as of yet it has not been shown to be a viable alternative because of differences in the way it reacts to other molecules. See, for example, Raymond Dessy, "Could Silicon be the Basis for Alien Life Forms, just as Carbon in on Earth?" *Scientific American* (1998), <http://www.sciam.com/article.cfm?id=0004212F-7B73-1C72-9EB7809EC588F2D7> (accessed 12/28/08).
3. Heinrich D. Holland, "Evidence for Life on Earth More Than 3850 Million Years Ago," *Science* 275, no. 3 (1997): 38-39.
4. Carl Woese, "The Universal Ancestor," *Proceedings of the National Academy of Sciences* 95, no. 12 (1998): 6854-9. See also W. Ford Doolittle, "Uprooting the Tree of Life," *Scientific American* 282, no. 2 (2000): 90.
5. Francis Darwin, ed., *The Life and Letters of Charles Darwin, Including an Autobiographical Chapter* (London: John Murray, 1887), 3:18. Available online at Darwin Online, "The Complete Works of Charles Darwin Online," Darwin Online, <http://darwin-online.org.uk/content/frameset?viewtype=text&itemID=F1452.3&pageseq=1> (accessed 12/28/08).
6. Aleksandr I. Oparin, *The Origin of Life* (New York: Dover, 1952).
7. Stanley L. Miller, "A Production of Amino Acids under Possible Primitive Earth Conditions," *Science* 117 (1953): 528-9.
8. Joan Oro, "Mechanism of synthesis of adenine from hydrogen cyanide under possible primitive Earth conditions," *Nature* 191 (1961): 1193-4.
9. Michael P. Robertson and Stanley L. Miller, "An Efficient Prebiotic Synthesis of Cytosine and Uracil," *Nature* 375 (1995): 772-4.
10. Adam P. Johnson et al., "The Miller Volcanic Spark Discharge Experiment," *Science* 322, no. 5900 (2008): 404.
11. Douglas Fox, "[Did Life Evolve in Ice?](http://discovermagazine.com/2008/feb/did-life-evolve-in-ice/article_view?b_start:int=0&-C=)" *Discover Magazine* (2008), http://discovermagazine.com/2008/feb/did-life-evolve-in-ice/article_view?b_start:int=0&-C= (accessed 12/20/08), and M. Levy et al, "Prebiotic Synthesis of Adenine and Amino Acids

- under Europa-like Conditions," *Icarus* 145, no. 2 (2000): 609–13.
12. W. Martin and M.J. Russell M.J, "On the Origins of Cells: A Hypothesis for the Evolutionary Transitions from Abiotic Geochemistry to Chemoautotrophic Prokaryotes, and from Prokaryotes to Nucleated Cells," *Philosophical Transactions of the Royal Society: Biological Sciences* 358 (2003): 59-85, and Jianghai Li and Timothy M. Kusky, "World's Largest Known Precambrian Fossil Black Smoker Chimneys and Associated Microbial Vent Communities, North China: Implications for Early Life," *Godwana Research* 12 (2007): 84-100.
 13. Adam, Zachary, "Actinides and Life's Origins," *Astrobiology* 7, no. 6 (2007): 852–872.
 14. Martin M. Hanczyc, Shelly M. Fujikawa and Jack W. Szostak, "Experimental Models of Primitive Cellular Compartments: Encapsulation, Growth, and Division," *Science* 302, no. 5654 (2003): 618-622.
 15. Francis Crick, *Life Itself: Its Origin and Nature* (New York: Simon and Schuster, 1981).
 16. Carl Zimmer, "On the Origin of Life on Earth," *Science* 323 (2009), <http://www.sciencemag.org/cgi/reprint/323/5911/198.pdf>.

Further Reading

Books

- Hazen, Robert M. *Genesis: The Scientific Quest for Life's Origins*. Washington, D.C.: Joseph Henry Press, 2005.
- Knoll, Andrew H. *Life on a Young Planet: The First Three Billion Years of Evolution on Earth*. New Jersey: Princeton University Press, 2003.