



First Life

Discovering the Connections between
Stars, Cells, and How Life Began

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DEFINING LIFE

An introduction to a book about the origins of life should at least try to define "life," but the fact is that no definition is generally accepted by biologists yet. Even the simplest microorganisms are extraordinarily complex, and dictionary-style definitions do not seem to encompass such complexity. However, in the next few years I think it is likely that someone will claim to have fabricated artificial life in the laboratory. To make that claim, he or she will need a satisfactory definition of life. Because life is a complex phenomenon, maybe the best we can do is to state a minimal set of properties that, taken together, exclude anything that is not alive. Here are the properties that I would include:

- Life is an evolving system of polymers synthesized by chemical reactions (metabolism) that take place in membrane-bounded compartments called cells.
- Polymers are very long molecules composed of subunits called monomers. The primary polymers of life are nucleic acids and proteins, often called biopolymers.

- Biopolymers are synthesized by linking together monomers—amino acids and nucleotides—using energy available in the environment. Polymer synthesis is the fundamental process leading to growth of a living system.
- Nucleic acids have a unique ability to store and transmit genetic information. Proteins called enzymes have a unique ability to act as catalysts that increase the rates of metabolic reactions.
- The genetic and catalytic polymers are in a cyclic feedback system in which information in the genetic polymers is used to direct the synthesis of the catalytic polymers, and the catalytic polymers take part in the synthesis of the genetic polymers.
- During growth, the cyclic system of polymers reproduces itself, and the cellular compartment divides.
- Reproduction is not perfect, so variations arise, resulting in differences between cells in a population.
- Because different cells have varying capacities to grow and survive in a given environment, individual cells undergo selection according to their ability to compete for nutrients and energy. As a result, populations of cells have the capacity for evolution.