The mystery of life

by George T. Javor

Probing the secret of life leads to an all-wise Creator.

The study of living matter is at the center of all current scientific efforts. Recent triumphs include the cloning of Dolly the sheep and acquisition of the complete sequence of three billion nucleotides of the human chromosomes.[1] But strangely, life itself is not the object of much study. Scientists seem to take the existence of life for granted. It is difficult to find any extended discussion on the essence of life in currently available monographs or textbooks. These publications explain well how living matter is put together and how its components function. But such information is not enough to explain life because the constituents of living matter themselves are lifeless.

Suppose we take apart the living matter, and then recombine the isolated components. The work will yield an impressive collection of inert substances—but not life. So far, science has not created living matter in the laboratory. Is this because living matter contains one or more components that cannot be supplied by the chemist? The answer, as developed in this article, will suggest an important point regarding the origin of life.

What is the origin of life?

More than 100 years ago Louis Pasteur and others proved the folly of abiogenesis—the spontaneous transformation of non-living matter into living organisms. Biologists now simply say, "life comes only from life." Nevertheless, scientists generally accept the concept that life developed abiologically on a primordial Earth. By doing so, they conveniently assert that conditions on a "primordial world" were conducive to generate life spontaneously.

Others theorize that perhaps life was imported to Earth from outer space. But while Earth is covered with millions of different species of organisms, there is no evidence of life anywhere in the solar system. And beyond it, there is three and a half light years of empty space until the nearest star, the Alpha Centaury.

The last logical option for the origin of life is creation by a supernatural Creator. But science, in its attempt to explain everything by natural laws, rejects the creation option as being outside the scientific realm.

Life not a tangible entity

Life is not a tangible entity. It cannot be put into a jar or handled. We only see "life" in association with unique kinds of matter that have the capacity to grow and divide into replicas, are able to respond to various external stimuli, and utilize light or chemical energy to accomplish all of these things.[2]

The term *life* has different meanings, depending on whether it refers to an organism, an organ, or a cell. Human organs may continue to live after a person's death if, within a certain time, they are transplanted into another living person. Survival of a transplanted liver, kidney, or heart means something quite different from human "life." Furthermore, the life of each organ depends on the vitality of its cells.

All manifestations of life depend on living cells, the most fundamental units of living matter. When a live cell is taken apart, a collection of very complex, but lifeless sub-cellular structures remain: membranes, nuclei, mitochondria, ribosomes, etc.

Is there an unbroken continuum between living and non-living matter, as some would assert? If so, the question of the origin of life becomes moot. Moving from one state to the other would be similar to other chemical transformations. Examples of organisms that supposedly bridge the chasm between living and non-living include viruses, prions, mycoplasmas, rickettsiae, and clamidiae.

In fact, viruses and prions are biologically active but non-living entities. The term "live virus" is a misnomer, even though a virus is a biologically active agent that infects living cells. Prions are unique proteins that have the capacity to alter the structures of other proteins.[3] The newly changed proteins in turn acquire prion-type activity, creating a domino effect of protein alteration. This property of prions renders them infectious. For reproduction, prions, like viruses, need living cells.

Rickettsiae, chlamidiae, and mycoplasmas, on the other hand, are among the smallest known living organisms. The first two have serious metabolic deficiencies, and can only exist as obligate intracellular parasites. There is a wide gap between living and non-living matter. *This is best reflected in our inability to bring life to non-living matter in the laboratory.*

The composition of living matter

Structurally, living matter is composed of a combination of water and of large, fragile, *lifeless* molecules, proteins, polysaccharides, nucleic acids, and lipids. Table 1 lists the gross chemical composition of a typical bacterial cell, *Escherichia coli.*

Water serves as the medium in which all chemical changes occur. Proteins and lipids are the principal structural components of cells. Proteins also control all chemical changes. Without chemical changes, life cannot exist. How proteins interact with chemical changes is central to understanding the chemical basis of life.

The structure of proteins: An analogy from language

Proteins come in thousands of different forms, each with unique chemical and physical properties. This diversity is due to their size: Each protein can contain hundreds of amino acids, and there are 20 different amino acids. What each protein is capable of doing depends on the order in which its amino acids are linked. To understand this feature of biology, consider the analogy of written language.

In any language, the meaning of words depends on the sequences of letters. In English, for example, we have 26 letters. Out of these we make words. An estimated 500,000 different combinations of letters are recognized as meaningful words. With some effort, we could produce another 500,000 or more nonsensical combinations. Similarly, the millions of different proteins represent but a tiny fraction of all possible combinations of amino acids.[4]

When words are misspelled, their meaning is garbled or lost. Likewise, for proteins to function properly, their amino acids must follow one another in the correct order. The results of alterations in the amino acid sequence can be drastic. The oxygen-carrying protein in blood, hemoglobin, is built from four chains of more than 140 amino acids each. In sickle cell anemia, an inherited disease, an altered amino acid occurs in the sixth position of a specific sequence of 146. This change causes distortion of the red blood cells, resulting in anemia and many other problems.

Genetic information and amino acid sequences

How does the protein-building apparatus know the correct amino acid sequences for each of the thousands of proteins? The chromosomes of each cell are libraries filled with just such information. Each volume in this library is a gene. When the cell needs a particular protein, it activates the protein's gene and synthesis begins. The details of this process can be found in any current biology or biochemistry textbook. Here it is sufficient to note that more than 100 separate chemical events have to occur for protein synthesis to happen.

All manifestations of life depend on chemical changes. These changes happen when atomic clusters (molecules) gain, lose, or rearrange atoms. A class of proteins, enzymes, bind specific molecules and facilitate their chemical transformations. In *E. coli*, there are about 3,000 different types of enzymes, facilitating 3,000 different chemical changes.

Enzymes speed up reactions enormously. This could be a huge problem,

Table 1

Components of *Escherichia coli* Cells

Component	Percent of total weigh	Number of molecules per cell	Number of different kinds of molecules
Water	70	24.3 billion	1
Proteins	15	2.4 million	4,000 approx.
Nucleic acids	7	255 thousand	660
Polysaccharides	3	1.4 million	3
Lipids	2	22 million	50-100
Metabolic intermediates	2	many millions	800
Minerals	1	many millions	10-30

because once the reaction is completed, its end point—known as equilibrium—is reached and no further chemical changes occur. Because life depends on chemical changes, when all reactions reach their end points, the cell dies.

Amazingly, in living matter *none of the reactions ever reach equilibrium*. This is so, because the chemical transformations are *interlinked*, so that the product of one chemical change forms the starting substance of the next. If biological molecules were represented by capital letters of the alphabet, a typical sequence of chemical conversions would look like Figure 1.

Figure 1

$$A \xrightarrow{\text{enzyme 1}} B \xrightarrow{\text{enzyme 2}} C \xrightarrow{\text{enzyme 3}} D \xrightarrow{\text{enzyme 4}} E \xrightarrow{\text{enzyme 5}} F$$

Such a sequence, or "biochemical pathway," resembles a factory assembly line. The end product of this particular pathway, substance F, is utilized by the cell, therefore it does not accumulate. In living matter, every one of the millions of molecules (Table 1) is kept track of. Any shortage or excess immediately results in adjustment in the rates of chemical transformations.

Figure 2 shows that in a live cell matter is organized into successively more complex hierarchies. The arrows represent biochemical pathways, leading from simple to complex substances. The interdependence among cellular components in the vertical direction parallels the logical relationships of written language among letters, words, and sentences all the way to the level of a book.

However, the degree of tolerance for errors is much smaller in biology. Misspelled words, garbled sentences, or missing paragraphs may not render a document useless. But given the tight functional interdependence of its components, cells would be in big trouble if they lack a full complement of parts.

There is horizontal complementation among cell components as well. For example, proteins cannot be manufactured without assistance from nucleic acids, and nucleic acids cannot be made without proteins. From a chemical evolutionary perspective, this problem resembles the classic "chicken and egg" problem. (See Figure 2.)

Each biosynthetic pathway feeds into successively more complex levels of organization of matter. Every pathway is regulated so that its output is appropriate for the needs of the cell. The life of the cell depends on the harmonious and nearly simultaneous operation of its many components. During balanced growth, a steady state exists; that is, there are only minimal perturbations in the flux of matter through the pathways. Since none of the reactions is permitted to reach its end point, *each of the*

Figure 2

Organization of Matter in the Cell

Level number	Components				An analogy
1. Precursors	Carbon dioxide, water, ammonia				1. Letters
↓	↙	↓	↓	↘	↓
2. Building blocks	Amino acids	Monosaccharides	Nucleotides	Fatty acids + glycerol	2. Words
↓	↓	↓	↓	↓	↓
3. Polymers	Proteins	Polysaccharides	Nucleic acids	Lipids	3. Sentences
↓	↘	↓	↓	↙	↓
4. Supramolecular assemblies	Enzyme complexes, ribosomes, etc.				4. Paragraphs
↓	↓				↓
5. Organelles	Membranes, nuclei, mitochondria, etc.				5. Chapters
↓	↓				↓
6. Cell	Cell				6. Book

thousands of inter-linked chemical reactions is in a non-equilibrium, steady state.

Chemical evolutionary efforts

If there are forces in nature that bring about life, we should search diligently to discover and harness them. If abiogenesis is possible, it could be harnessed to restore dead cells, organs, and even organisms to life. Who would argue that creating living matter, or reversing death, would not be humanity's most significant scientific achievement?

However, the history of biochemistry suggests that this is unlikely. In the 1920s, when Oparin and Haldane first proposed that life originated spontaneously on a primordial Earth, biochemistry was in its infancy. The concep itself was an elaboration of Darwin's idea that life arose in some warm pond.[5] The first metabolic pathway was described only in the 1930s. The structure and function of the genetic material began to be understood in the 1950s. The first amino acid sequence of a protein, insulin, was mapped in 1955 and the first nucleotide sequence of the chromosome of a living organism was published in 1995.

As the chemical basis of life began to be understood better, it turned out to be far more complex than originally imagined and the early abiogenetic suggestions should have been reconsidered. Instead, science embarked on a half a century long journey to demonstrate experimentally the plausibility of spontaneous abiogenesis.

The first experiments suggesting the plausibility of chemical evolution were done by Stanley Miller, who in 1953 reported the synthesis of amino acids and other organic substances under simulated primordial conditions.[6] Subsequently a sub-discipline emerged, which provided laboratory evidence of the production of 19 of 20 amino acids, and four or five nitrogenous bases needed for nucleic acid synthesis, monosaccharides, and fatty acids, all under varying hypothetical primordial conditions.[7] All of these substances are the components from which the large biopolymers are made, projecting the possibility of the primordial production of biopolymers.

However, actually demonstrating the linking of building blocks into chains of polymers could not be accomplished. Every link between building-block type substances requires the removal of water. This is next to impossible in the aqueous environment of the hypothetical primordial oceans. Furthermore, the sequences in which amino acids are strung together in proteins, or nucleotides in nucleic acids, are what determine the function of these biopolymers. Outside of living matter, there are no known mechanisms to ensure meaningful, reproducible sequences in proteins or nucleic acids.

Under simulated primordial conditions protein-like matter has been made by heating powders of amino acids to high temperatures. However, these "protenoids" were amino acids randomly linked by unnatural bonds[8] and have little resemblance to actual proteins.

Nucleotides, the building blocks of nucleic acids, have not yet been synthesized under simulated primordial conditions. This is a formidable task, which requires attaching a purine or pyrimidine base to a sugar and that to a phosphate. The challenge here is not only the removal of water, but that these three components may be linked together in dozens of different ways. All combinations but one are biologically irrelevant. Needless to say, nucleic acids have not been synthesized.

But this has not stopped many scientists from postulating that the earliest living cells contained primarily ribonucleic acids. This "RNA world" hypothesis gained popularity after it was discovered that certain RNA molecules had catalytic activities. Until then, it was believed that catalysis was the exclusive province of proteins.

Even though it is not possible to make biologically useful biopolymers under simulated primordial conditions, we can obtain them from once-living cells. Mixing these isolated biopolymers shortcuts chemical evolution, making it possible to test whether life will start from such a mixture. But in such preparations everything is at equilibrium. Since life happens only when all chemical events within the cell are in a state of non-equilibrium, the best that can be accomplished by this method is the assembly of dead cells.

How to make living matter

We know exactly how to create living matter: First, design and synthesize a few thousand different molecular machines that are capable of converting simple substances, commonly available in the environment, into complex biopolymers. Second, make sure that such devices are capable of precise self-reproduction. Third, ensure that these units can sense their environment and adjust to any changes in it. Then it is only a matter of starting hundreds of biochemical pathways simultaneously, maintaining the non-equilibrium status of each chemical conversion by ensuring availability of a continuous supply of raw starting materials, and providing for the efficient removal of waste substances.

A minimum requirement to create such complex biological devices is an absolute familiarity with matter on the atomic and molecular level. You will also need to have great ideas regarding the uses to be made of these complex living machines, hopefully in proportion with the effort expanded in creating them. Fashioning living cells requires absolute control over every molecule, large and small. This is a capacity that science does not have. Chemists can manipulate large numbers of molecules from one form into another, but they cannot transport selected molecules across membranes to reverse conditions of equilibria. This is why we cannot reverse death.

So how did life originate on Earth? This article has revealed the great discrepancy between the biochemistry of living matter and of the claims of those who would explain its origins by spontaneous abiogenesis. Fifty years of biochemical research has shown unequivocally that under any conditions, spontaneous abiogenesis is an impossibility. It is only a matter of time before the edifice called "chemical evolution" will collapse under the weight of facts.

For the believer in the Creation account of the Bible, the assertion that only the Creator can make life is not an argument for the "God of the gaps". We have a pretty good idea of what it takes to create life, only we cannot do it. It is an affirmation that life cannot exist apart from God. Indeed, life itself becomes an evidence for an all-wise Creator who chose to create life and share it with us.

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Notes and references

1. S. Lander and 253 others, "Initial sequencing and analysis of the human genome," *Nature* 409 (2001):2001. See also J. C. Vent and 267 others, "The sequence of the human genome," *Science*: 291(2001):1304.
2. Such an analysis of life may seem too materialistic to many who perceive that the Bible teaches a different view of lifestyle—one which does not insist that it be associated with matter. While there may well exist larger realities of life inaccessible to us, so far as science is concerned, we experience life on Earth only in association with matter.
   The Bible supports the notion that life as we know it on Earth is associated with matter. Says Genesis 2:7: "The Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul"(KJV). A combination of the breath of life and the dust of the ground gave rise to the living person. Similarly, a person dies when "his breath goeth forth, he returneth to his earth; in that very day his thoughts perish" (Psalm 146:4, KJV). The "return to earth" marks the end point of human existence. While one can speculate on the meaning of the "breath of life" and of the person's "breath," it is clear that life as experienced on Earth does not continue after death. The Bible does not mention anything about a disembodied form of life. To embrace the material basis of life on Earth, therefore, does not make one a materialist.
3. S. B. Prusiner, "Prion Diseases and the BSF Crisis," *Science* 278 (1997): 245.
4. The number of possible different sequences for a 100 amino acid-long protein is 1.2×100^{130}, or 12 followed by 129 zeros!
5. F. Darwin, *The Life and Letters of Charles Darwin* (New York: D. Appleton, 1887), II: 202. Letter written in 1871.
6. S. L. Miller, "A Production of Amino Acids Under Possible Primitive Earth Conditions," *Science* 117 (1953): 528.
7. C. B. Thaxton, W. L. Bradley, and R. L. Olsen, *The Mystery of Life's Origins* (New York: Philosophical Library, 1984), p. 38.
8. S. W. Fox and K. Dose, *Molecular Evolution and the Origins of Life* (New York: Marcel Dekker Publishing Co., 1977), second edition.