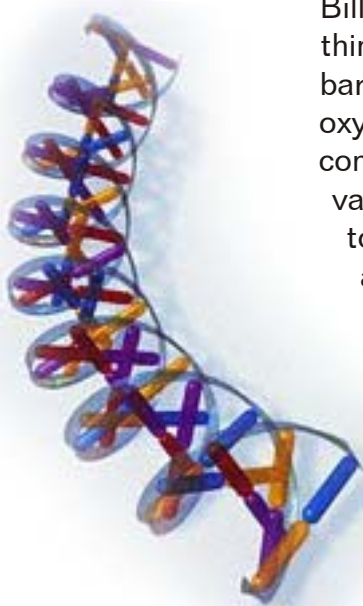




Origins of Life

Chemosynthesis

<http://library.thinkquest.org/C003763/index.php?page=origin04>



Billions of years ago, the planet Earth was a world destitute of living things. There was no flora, no fauna; the Earth was completely barren of life. Instead of having an atmosphere rich in nitrogen and oxygen as it is today, the atmosphere on primitive Earth was composed primarily of methane, ammonia, hydrogen gas and water vapor. The lack of a protective ozone layer resulted in high exposure to UV light and radiation. Earth was also extremely volcanically active in the past and was continuously outgassing chemicals into the atmosphere. Even the oceans of Earth were a 'primordial soup' of chemicals such as ammonia, phosphorus, nitrogen and carbon. Generally, the world was not a hospitable place back then, at least not according to human standards.

How did the Earth metamorphose from the lifeless planet described above to the world teeming with living organisms that we live on today? How could complex life have originated from non-living chemical elements? These are difficult questions to answer (unless time travel is somehow brought into the equation), but scientists have developed a theory that describes how the very first microscopic life on primitive Earth could have evolved as a result of a series of chemical reactions. This theory is called chemosynthesis, and it describes the chemical evolution of cellular life.



Images courtesy of AltaVista Images



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The process of chemosynthesis can be divided into a series of six stages which lead to the origin of the first living cell...

1

The first phase of chemosynthesis is when random molecules in the atmosphere of primitive earth form simple organic molecules with energy provided by UV light, radiation and other energy sources. The first organic molecules thought to have formed in this phase were hydrocarbon chains, which are composed solely of hydrogen atoms bonded to carbon atoms. Hydrocarbons provided the foundation framework for the formation of more complex organic molecules such as simple amino acids (when, when linked together, form proteins) and carbohydrates (which are very simple sugars). These simple molecules are thought to have accumulated in the ocean, a hypothesis strongly supported by research conducted by Stanley Miller.

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In the third phase, these macromolecules are organized into bodies with definite shape, unity and properties which resemble those of living things. The important event in this phase is the development of aggregates of molecules called coacervates. Coacervates, which are small, membrane-bound sphericals, are theorized to have been the early ancestors of cells. They share a few important characteristics of modern cells in that they have a boundary, they reproduce by dividing by fission, they grow by accumulating additional molecules and they undergo simple metabolism in the form of controlled internal chemical reactions.

The fourth phase is marked by the appearance of nucleic acids. These nucleic acids began to control the reproductive process and directed the internal activities of the coacervates. This stage of chemosynthesis is characterized by the improvement in the organization of the coacervates and it marks the first appearance of true living things. Life has arisen!

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The fifth phase shows the beginning of evolutionary development. Natural selection could now come into operation through genetic control by nucleic acids and those organisms that could use energy most efficiently could reproduce more rapidly.

Finally, the sixth and last phase of chemosynthesis is marked by the appearance of autotrophic bacteria. These organisms were self-sufficient and could directly synthesize nutrients with energy provided by the sun. This appearance of autotrophic cells marked the beginning of a balance in the living world that exists even today.

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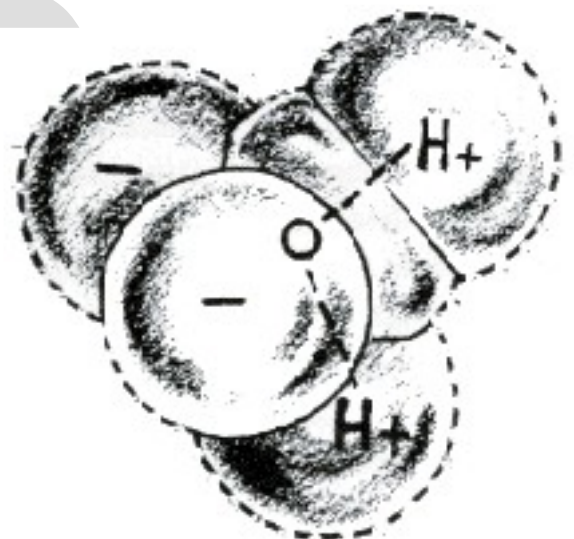
Problems with the chemosynthetic theory

Like all theories, the chemosynthetic theory for the origin of cellular life is a speculative explanation based upon thought and observation. And, like most theories, the chemosynthetic theory is not perfect. There are two main difficulties with the chemosynthetic theory. The first difficulty is the described transition from chaos to organization - how did a bunch of chemical elements transform into organized and living forms? It is very difficult to imagine that a random system could produce such an organized and complex structure as the eukaryotic cell. The second difficulty is the

appearance of enzymes. How did enzymes come into existence? Enzymes are biological catalysts which reduce the amount of energy needed to initiate a chemical reaction. They are structures that are extremely task-specific. Did the enzyme appear before or after the task appeared? This question is somewhat like the "what came first, the chicken or the egg?" dilemma. As with any theory about the origin of life, the chemosynthetic theory is basically impossible to conclusively prove. However, despite its known imperfections, it is the most rational and available explanation for the evidence at hand.

Why the chemosynthetic theory makes sense

The chemosynthetic theory implies that the development of life is probable wherever the proper physical and chemical conditions are in place. It also implies that all life on Earth evolved from a common cellular ancestor. There are a number of molecular similarities between all life forms that indicate that all life did indeed evolve from a single ancestor. One thing that supports this is that the molecules of living organisms are rich in hydrogen-containing carbon compounds, indicating that there was no free oxygen on primitive Earth. Another proof is the fact that DNA and RNA are the genetic bases of all life forms on Earth. Also, ATP is the universal energy currency of all living organisms, suggesting a common origin of metabolism. These molecular 'proofs' help support the chemosynthetic theory, making it the most widely accepted scientific theory for the chemical origin of cellular life.



Sketch of a water molecule