CSIR NET Life Science Unit 11

Origin of Life- Oparin-Haldane Hypothesis

In the early decades of the 20th century, Russian chemist Aleksandr I. Oparin (1924), and British scientist John B. S. Haldane (1929), independently envisaged that if the primitive atmosphere was reducing (as opposed to the oxygen-rich atmosphere of today), and if there was an appropriate source of energy, such as lightning or ultraviolet light from the sun, then a wide range of organic compounds might have formed.

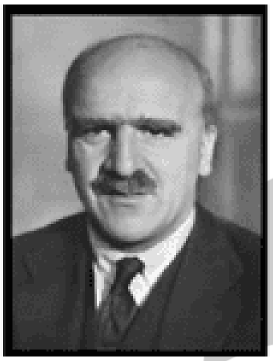

Figure 1. Aleksandr Ivanovitch Oparin (1894-1980) and John Burdon Sanderson Haldane (1892-1964)

Oparin hypothesized that the organic compounds might have undergone a reaction series resulting in simpler to more complex molecules. He proposed that the molecules formed colloidal aggregates, namely, coacervates, in an aqueous environment. These coacervates could absorb and assimilate organic compounds from the environment to utilise them, which resembles present-day metabolism. They would have evolved to different forms, eventually leading to the first lifeforms on the Earth.

Haldane coined the term prebiotic soup. Haldane's ideas about the origin of life were very similar to that of Oparin's. Haldane proposed that the primordial sea served as a vast chemical medium powered by solar energy. Since the atmosphere was oxygen (O_2) free, and the combination of carbon dioxide (CO_2), ammonia (NH_3) and ultraviolet (UV) radiations gave rise to an aggregate of organic compounds.

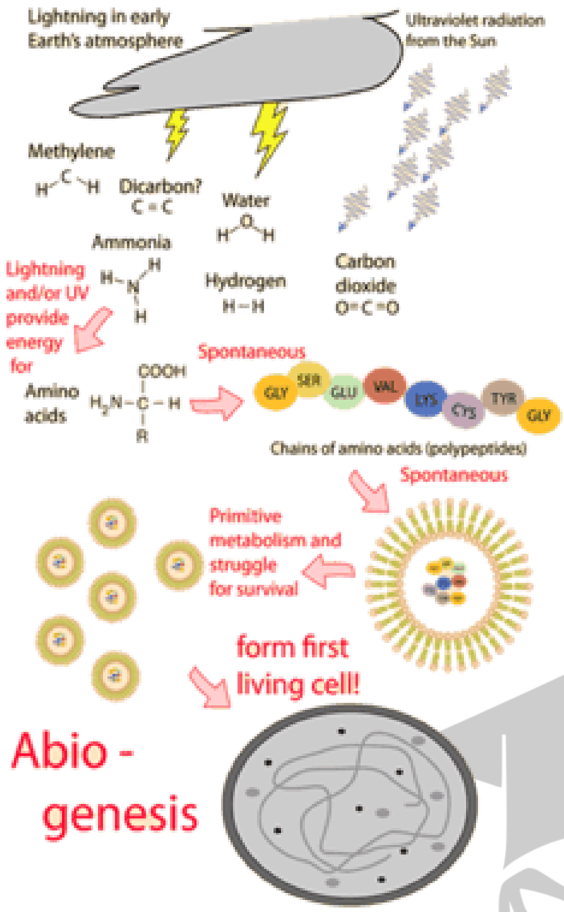

Figure 2. Oparin-Haldane hypothesis for Abiogenesis

The sea became a hot dilute soup containing large populations of organic compound monomers and polymers. Haldane proposed that groups of monomers and polymers acquired lipid membranes, and those further developments eventually led to the first living cells.

Miller-Urey Experiment

In 1953, Harold Urey and his student Stanley Miller test Oparin and Haldane's hypothesis. But, first, they tried to calculate the chemical constituents of the early Earth atmosphere. The basis of their experiment was that the early atmosphere was reducing. So they simulated early earth atmospheric conditions in a closed system that contained methane gas (CH_4), ammonia (NH_3), and hydrogen gas (H_2) in a 2:1:2 ratio with water vapours (H_2O) and a high temperature of 1073 K.

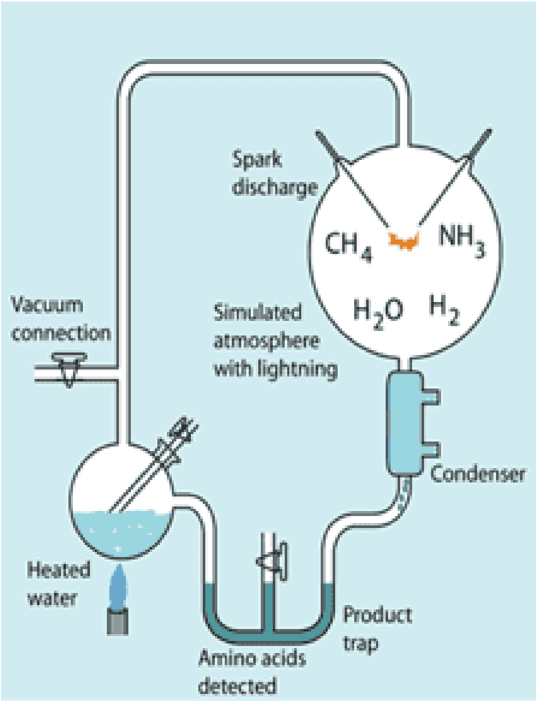

Figure 3. Spark discharge experiment of Stanley Miller

Miller carried out an experiment in which he passed a continuous spark discharge at 75,000 volts through a flask containing the gases identified by Urey along with water. Furthermore, this electrical current was run through the laboratory set up to simulate the catalytic source of lightning present in the early atmosphere.

After 18 days of circulating the mixture, Miller found that most of the ammonia and much of the methane had been consumed. The main gaseous products were carbon monoxide (CO) and nitrogen (N_2). In addition, there was an accumulation of dark material in the water. Few of the specific constituents of this could not be identified, but it was clear that the material included a large range of organic polymers. From the results of their experiment, they found that up to 15% of the carbon in the system was inorganic compounds that had formed in the system.

This conclusion proved that organic molecules could be formed from inorganic molecules in Earth's early atmosphere. In addition, out of the organic molecules produced, Miller and Urey showed that some of the organic compounds were amino acids necessary for living organisms. Analysis of the aqueous solution showed that the following had also been synthesized: 25 amino acids (the main ones being glycine, alanine and aspartic acid), several fatty acids, hydroxy acids and amide products.