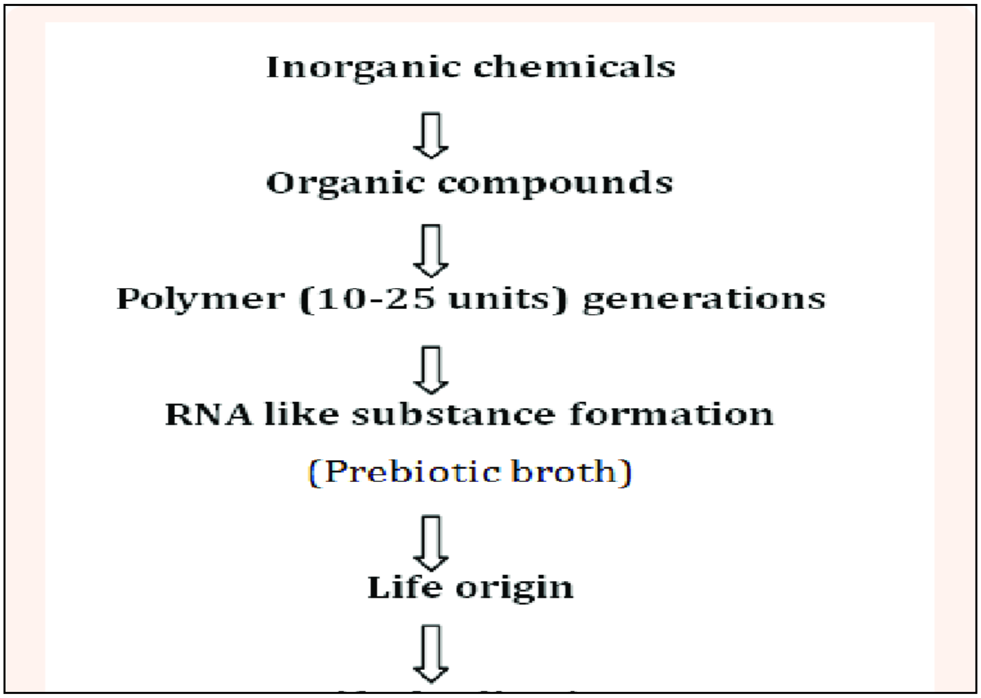
# Evolution: History of life:

The evolution of life has preoccupied humans since the dawn of civilization and has led to a wide range of creation myths involving superhuman agents. The ancient Greek were the first to seek a scientific explanation and proposed spontaneous generation as a path for the emergence of complex organic forms from simpler inorganic matter. With the rise of European science after the middle Ages, biologists gradually refuted this hypothesis, showing instead a seemingly unbridgeable gulf between life and inanimate matter ("omne vivum ex vivo"). At the same time, however, chemists gradually proved the validity of chemical principles across all matter, living and dead, leading them from the synthesis of an organic substance from inorganic precursors (urea) to the establishment of organic chemistry and biochemistry as scientific disciplines.

Although it is possible life may have begun on an ancient world whose chemistry was entirely different from Earth, there is nonetheless no evidence to support the belief that life on Earth originated from non-life. The first evidence against spontaneous generation came in 1668 from Francesco Redi, who demonstrated that no maggots appeared in meat when flies were prevented from laying eggs. Until Redi's experiments, it was generally held that life had spontaneous beginning. As per the then prevailing popular belief, maggots were spontaneously generated from rotten meat and garbage, and flies came from the chemicals secreted by decaying meat. In 1861, Louis Pasteur too performed a series of experiments wherein he showed that organisms such as bacteria and fungi do not spontaneously appear in sterile, nutrient-rich organic soup.

Charles Darwin was the first to advocate that "life could have arisen through chemistry in some warm little pond, with all sorts of ammonia and phosphoric salts, light, heat, electricity, etc. present". For much of the 20th century, origin of life research centered on Darwin's hypothesis to elucidate how, without supernatural intervention, spontaneous interaction of the relatively simple molecules dissolved in the lakes or ocean of the prebiotic world could have yielded life's last common ancestor. In 1920s, Alexander I. Oparin in Russia and in J.B.S. Haldane in England revived ideas of spontaneous generation suggesting that the presence of atmospheric oxygen prevented chain of events that would lead to the evolution of life. As early as 1929, Haldane had drawn attention to experiments in which ultraviolet radiation had been seen to encourage build-up of organic compounds from a mixture of water, carbon dioxide and ammonia (Haldane 1947). Oparin argued that a "primeval soup" of organic molecules could be created in oxygen-less atmosphere, through the action of sunlight (Oparin 1957). Oparin and Haldane thus proposed that the atmosphere of the young Earth, like that of outer (Jovian) planets, was deprived of oxygen or contained very little oxygen($O_2$ ), and was rich in hydrogen ($H_2$ ) and other chemical compounds such as methane

($CH_4$ ) and ammonia ($NH_3$ ). Inspired by the ideas of Darwin, Oparin, and Haldane, the duo of Stanley Miller and Harold Urey performed experiments in 1953 (Fig. 1) under simulated conditions resembling those then thought to have existed shortly after the Earth first accreted from the primordial solar nebula, thus heralding era of experimental prebiotic (non-living) chemistry. Their experiments demonstrated that amino acids and other molecules important to life could be generated from simple compounds assumed to have been present on the primitive Earth.




Schematic diagram of: Origin of life

In a self-contained apparatus, Miller and Urey created a reducing atmosphere (devoid of oxygen) that consisted of water vapour, methane, ammonia, and hydrogen above a ‘mock ocean’ of water. For this, they set up a flask of water to represent the ocean, connected to another flask of gases through which they passed electrical discharge to represent lightning After just two days, they analyzed the contents of the ‘mock ocean’. Miller observed that as much as 10-15% of carbon in the system was converted into a relatively small number of identifiable organic compounds, and up to 2% of carbon went into making amino acids of the kinds that serve as constituents of proteins. This last discovery was particularly exciting, as it suggested that the amino acids - basic building components of life would have been abundant on the primitive planet. Miller’s experiments produced a cocktail of 22 amino acids and other molecules like purines and pyrimidines, and sugars and lipids associated with living cells. According to Miller and Urey, these substances would have been washed into the Earth’s early oceans, where they developed into the first living cells. 'Glycine' (NH2CH2COOH) was the most abundant amino acid resulting from this experiment, and similar other experiments conducted subsequently. The above experiments showed that some of the basic organic monomers (such as amino acids), which form the polymeric building blocks of a modern life, can be formed spontaneously. Ironically, simple organic molecules are always a long way from becoming a fully functional self-replicating life-form. Moreover, spontaneous formation of complex polymers from abiotically-generated monomers under the conditions presumed in Miller's experiments is not at all a straight forward process.

Scientists now think that the atmosphere of early Earth was different than in Miller and Urey's setup (that is, not reducing, and not rich in ammonia and methane). So, it's doubtful that Miller and Urey did an accurate simulation of conditions on early Earth. However, a variety of experiments done in the years since have shown that organic building blocks (especially amino acids) can form from inorganic precursors under a fairly wide range of conditions

From these experiments, it seems reasonable to imagine that at least some of life's building blocks could have formed abiotically on early Earth. However, exactly how (and under what conditions) remains an open question.

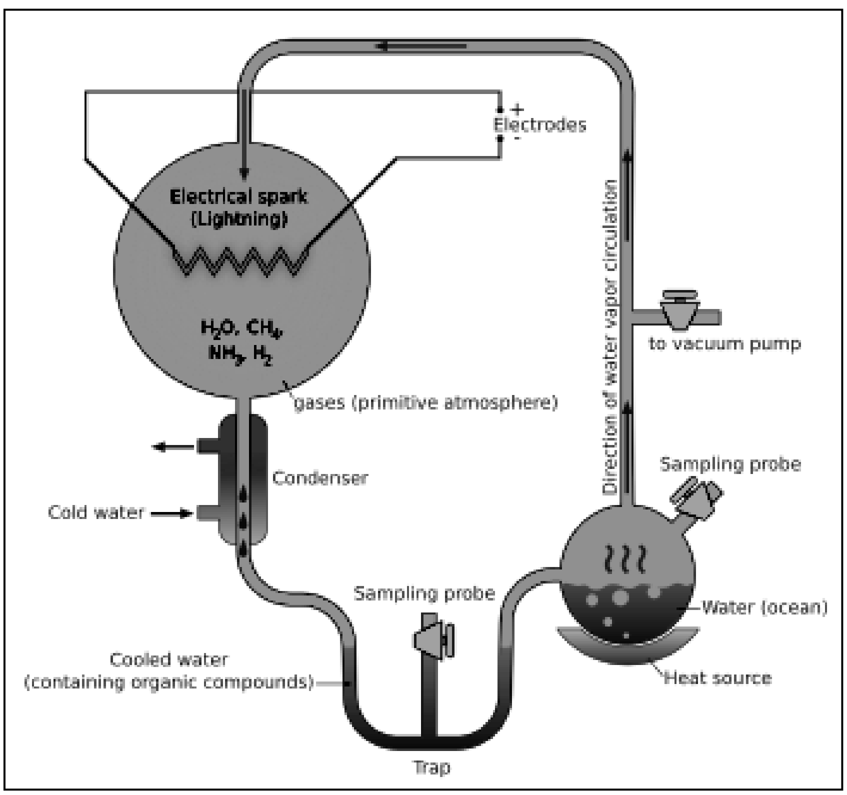



Fig- : Miller-Urey experiment,

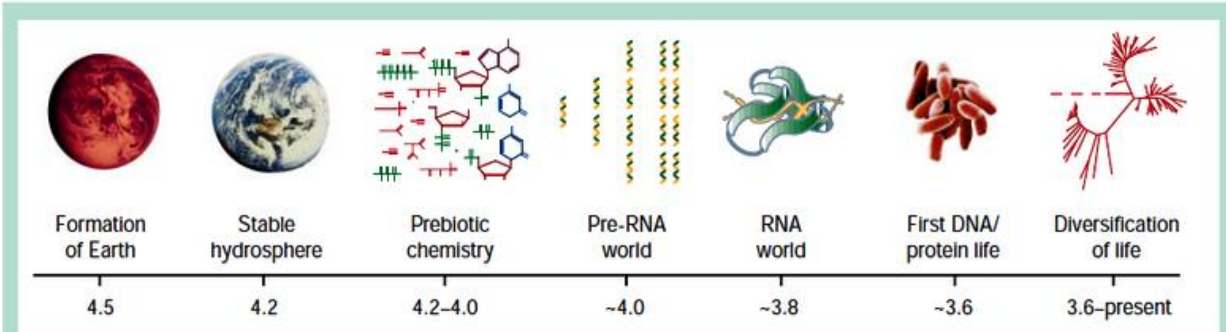


**Figure 1** Timeline of events pertaining to the early history of life on Earth, with approximate dates in billions of years before the present.

## Chemogeny, Biogeny and RNA world Hypothesis

**A. Chemogeny** can also called chemical evolution. In this type of evolution the complex organic compounds are synthesized. There are various steps involved in the formation of these complex compounds. The steps are as follows: The synthesis of a simple organic molecule (which is the origin of the organic compounds); this step is followed by the formation of complex organic molecule and the formation of nucleoprotein. These organic compounds are necessary for the structure and the functioning in the living organism.

Actually it was synthesis of simple organic molecules from C, H, N, and O. As the earth surface gradually cooled these element combined each other to form $H_2O$, $NH_3$, $CH_4$, CN etc. As the temperature of earth cooled up to $100^0$c the highly reactive free radicals –CH and –$CH_2$ condensed to form different hydrocarbon.

$CH+CH$à$C_2H_2$ ( acetylene)

$CH_2+CH_2$à$C_2H_4$ (ethylene)

$CH_2+CH_2$à$CH_4+C$ (methane)

When hydrocarbon reacted with steam aldehydes and ketones were formed.

$CH_2+ H_2O$à$CH_3CHO$ (acetaldehyde)

Similarly sugar amino acids and fatty acids formed.

$CH_4+ H_2O$à$C_6H_{12}O_6$ sugar

$CH_4+H_2O+NH_3$àAmino acids

These molecules were formed due to condensation, polymerization, oxidation and reduction.

These molecules reacted each other again in hot water and form new molecules purines pyrimidines and nucleotides. Energy for such reaction was available form UV-radiation, electric energy form lightning heat energy form volcanoes and temperature of each itself. The hot sea water with primary organic compounds (Purines, Pyrimidines, and nucleotide) was known as "**hot dilute soup**" or *pre-biotic soup* by **Haldane**. There was no free $O_2$ on the primitive earth.

**B. Biogeny** is also called biological evolution. Biological evolution is defined as any genetic change in a population that is inherited over several generations. These changes may be small or.

For an event to be considered an instance of evolution, changes have to occur on the genetic level of a population and be passed on from one generation to the next. This means that the genes, or more specifically, the alleles in the population change and are passed on. These changes are noticed in the phenotypes (expressed physical traits that can be seen) of the population.

Actually it was synthesis of complex and self reproducing biological molecules. This can be described under the following steps.

1. Formation of nucleic acid- Sugar, phosphate purines and pyrimidine combined to form basic unit of DNA and RNA. Then the nucleic were formed.
2. Formation of co-acervates- The nucleic acids, other macromolecules and primordial soup combine to form an intermediate form of life called **co-acervates**. Oparin said **co-acervates** gave rise to life.
3. Formation of primary organism- These coacervates absorbed organic soup and multiplied. These grew in size and formed first cells. Oparin called them **protobionts**. These formed monera and later protista.

A change on the genetic level of a population is defined as a small-scale change and is called microevolution. Biological evolution also includes the idea that all of life is connected and can be traced back to one common ancestor. This is called macroevolution.

**<u>The RNA World Hypothesis</u>**

The RNA World Hypothesis is a concept put forth in the 1960s by Carl Woese, Francis Crick and Leslie Orgel. It proposes that earlier life forms may have used RNA alone for the storage of genetic material.

Walter Gilbert, a Harvard molecular biologist, was the first to use the term "RNA World" in an article published in 1986. The hypothesis posits that DNA later became the genetic material as a result of evolution because RNA was a relatively unstable molecule. According to the RNA World Hypothesis, around 4 billion years ago, RNA was the primary living substance, largely due to RNA's ability to function as both genes and enzymes.

The main reasoning behind the hypothesis is that RNA is capable of self-replication and could therefore have carried genetic information across generations independently. This concept has been highly debated in the scientific world over the last 50 years.

Experts now generally agree that non-living chemicals could not have given rise to bacterial cells in a single step and that intermediate, pre-cellular life forms must therefore have existed. Of the possible pre-cellular life models considered, the most popular is the RNA World.

### Ribozymes and the RNA world

It was previously thought that the only bio-molecules that could catalyze essential chemical reactions in cells were proteins. However, Sidney Altman, Thomas Cech and colleagues discovered a class of RNAs that is capable of catalyzing chemical reactions – ribozymes. Altman and Cech were awarded the Nobel Prize in Chemistry in 1989 for this discovery.

The discovery of ribozymes supported the RNA World Hypothesis. The strongest argument for proving the hypothesis is perhaps that the ribosome, which assembles proteins, is itself a ribozyme. Despite the fact that the ribosome is composed of both RNA and protein, the processes involved in translation are not catalyzed by protein, but by RNA, indicating that early life forms may have used RNA to catalyze chemical reactions before they used proteins.

By: Dr. Bibha Kumari, Department of Zoology, Magadh Mahila College, Patna University Patna. Email: bibhak136@gmail.com