Organic Evolution

- The word organic evolution, coined by **Herbert Spencer,** is the branch of biology that deals with the origin of life and diversity among living organisms through ages.
- The word evolution means *"change"* or *"roll out"* over a period of time. To Darwin, evolution means descent with modification.
- In simple words evolution means *unfolding.* It is one of the most powerful ideas in biology that" living things may have evolved from relatively simple chemicals".
- The study of evolution provides the knowledge of the origin of life and the great diversity of living things.
- Life had a beginning. When did life begin on the earth? What is the mechanism involved in the origin of the life? Since the origin of living organisms, did they change through time?- are the fascinating questions that confuse our minds.
- We find the scientific explanations for these questions in this chapter. According to **Theodosius Dhobzhansky** nothing in biology makes sense except in the light of evolution.

EVOLUTIONARY CONCEPTS AND ORIGIN OF LIFE

EVOLUTIONARY CONCEPTS

1. Theory of Special Creation :

- This theory states that living organisms on the earth were created by **Divine Power. Father Suarez** (1548-1671) believed that universe was created in 6 days.
- This concept of special creation was followed until middle of 19^{th} century. It is purely a mythological belief.

2. Cosmozoic theory or Panspermia :

- Life is distributed all over cosmos in the form of resistant spores as per this concept.
- Resistant spores of living organisms, called **cosmozoa,** together with cosmic dust might have reached the earth accidentally from other planets of the universe

3. Theory of spontaneous generation or Abiogenesis :

- It explained that life originated from nonliving substances. Worms generated from manure; insects from dew, rotten slime, dry wool, sweat and meat; frogs and salamanders from coagulated slime; eels from sea mud; butterflies from cheese; toads, snakes and mice from the mud of the Nile.
- **Aristotle, Thales, Plato** and **Von Helmont** believed this idea of abiogenesis until 17^{th} century.
- Francesco **Redi**, **Spallanzani** and **Louis Pasteur** experimentally disproved abiogenesis theory.

4. Biogenesis theory :

- The theory of biogenesis states that ***living organisms originated from the preexisting living organisms*.**
- **Louis Pasteur** conformed a death blow to the theory of abiogenesis by his swan-neck flask experiment. He created a swan-neck flask and had taken the boiled meat broth in it.
- Flask was left unsealed. The broth remained free of microbial contamination for several months. The microbes present in the air were trapped in the neck and they did not reach the solution.
- When the neck of the flask was broken, the solution of flask had shown the thick growth of microbes. In this case microbes directly reached the solution.

5. Theory of Catastrophism :

- **Cuvier** advocated that the earth was subjected to periodic catastrophes.
- These catastrophes destroyed the life from time to time and created new and special form of life after each destruction.

6. Theory of organic evolution :

- The origin of primordial life on the earth was associated with the origin of universe.
- Primitive organisms evolved spontaneously from the inorganic matter as a result of formative action of physical forces like electric charges, U.V. radiations and radiations of radioactive elements.
- This hypothesis was strongly supported by **Haldane**, **A.L Oparin**, **H. Urey** and **Stanley** Miller. **A.I. Oparin** described the origin of life in his book *"The Origin of Life on the Earth".*
- According to Haldane and Oparin the first phase of the origin of life was the spontaneous generation of early molecules. These molecules later transformed into protobionts (molecules with limited metabolic activity).
- Finally the protobionts evolved into early living organisms. Thus *origin of life is a phenomenon of chemical evolution that led to biological evolution.*

ORIGIN OF THE EARTH AND THE LIVING ORGANISMS

- Origin of life is explained in different phases, the **origin of the earth** and its **primitive atmosphere, the origin of molecules** and the origin and **evolution of living organism**.

i. Origin of the earth and its primitive atmosphere

- The earth originated 4.5 to 5 billion years ago along with other planets in the following phases :
  Fragmentation of an interstellar cloud.
  b) Contraction and flattening of the solar nebula.
  c) Condensation of nebular material in to meteorites and protoplanetary bodies.
  d) Solidification of planets.
- The temperature of the early earth was estimated to be about 5000° to 6000°C In millions of years it was cooled down to a **core** surrounded by mantle and crust.
- The elements like helium, hydrogen, nitrogen and carbon etc. flowed to the surface and formed the earth's atmosphere.
- This primitive atmosphere was a hot, rapidly rotating ball of gases.
- Hydrogen was abundant of all. Hence it was **reducing atmosphere.**
- Oxygen in free gaseous state was absent. Ozone layer was absent.

ii. Origin of molecules :

- The elements in the atmosphere combined due to cooling of atmosphere and formed steam, ammonia, cyanamide, methane etc.
- Temperature was further reduced.
- Steam condensed into water resulting in rain.
- Rivers, streams and oceans were formed. Ammonia and methane were washed down to the oceans from the atmosphere along with the rain droplets.
- Mineral-rocks were also dissolved leading to their accumulation in the sea water.
- Highly reactive radicals $CH^{\bullet}$ and $CH_2^{\bullet}$ are condensed to form variety of hydrocarbons like acetylene, ethylene etc., with the cooling of atmosphere and water.
- The molecules of ammonia, hydrocarbons and water underwent condensation, oxidation, reduction and polymerisation to produce complex molecules like sugars, amino acids, fatty acids, purines and pyrimidines.
- All these reactions occurred in the ocean, which was described as the **hot dilute soup** or **prebiotic soup** by **Haldane**.
- The sources of energy for these reactions were UV-rays, other radiations, lightening and volcanic activities.
- In the prebiotic soup, simple organic molecules later produced the complex polymer molecules like **polysaccharides, proteins, fats, nucleosides** and **nucleotides**.
- Nucleotides later formed the complex molecules of nucleic acids.
- Nucleic acids and proteins combined together to form macromolecules like **nucleoproteins.**

Biological Evolution :

1. Formation of prebiotic structures or protobionts "

- Thus polymers that formed faster might have predominated as they are more stable. Stable polymers shifted the chemical equilibrium from unstable monomers to stable polymers.
- For the origin of life, three conditions were needed.
  1. Self-reproducing molecules called free **genes** or **replicators.**
  2. Errors during the copying of replicators i.e. **mutations.**
  3. A continuous supply **of free energy and partial isolation** of the molecules from the environment.
- High temperature was responsible for mutations resulting in the formation of different molecules. Partial isolation had been attained within aggregates of artificially produced prebiotic **protobionts** like **coacervates** and **microspheres.**
- Oparin observed the formation of coacervates while shaking the mixture of proteins and polysaccharides in water. These coacervates formed the colloidal system in the hot dilute soup.
- Suspended coacervates also later acquired the lipids to form the membranes.
- Some of the proteins inside the protobionts acquired the property of enzymes resulting in the fast multiplication of molecules.

2. Formation of living organisms :

- The free genes started absorbing the organic compounds from the prebiotic soup and evolved into anaerobic heterotrophs, **three billion years ago.**
- They obtained their energy by the fermentation of some of the organic molecules. The earliest living organisms had clumps of nucleoproteins containing one or two DNA molecules, which are similar to organisms of Monera.
- During the course of evolution early prokaryotes acquired the "carbohydrate-synthesis" catalysing enzymes. Thus early **chemoautotrophs** were evolved.

- They used organic molecules for their energy and CO_2 as the source of carbon. Meanwhile **bacterial chlorophyll** was synthesized in some bacteria from the metalloporphyrin (magnesium porphyrin) of ocean waters.
- This pigment trapped the solar energy and fixed the CO_2. Thus **photoautotrophs** like blue green algae were evolved.
- O, released in the atmosphere, by the blue-green algae, brought about radical changes in the primitive atmosphere. The bacterial chlorophyll evolved into **true chlorophyll** which can release O_2 in the synthesis of carbohydrates.
- Eukaryotes are evolved by two processes. Endomembrane system of eukaryotes including nuclear membrane might have evolved by infolding of the plasmamembrane of ancestral prokaryotes.
- Symbiotically prokaryotes lived in the ancestral eukaryotes and evolved into organelles like mitochondria and plastids.

EXPERIMENTAL VERIFICATION OF CHEMICAL ORIGIN OF LIFE :

- Stanley **Miller** and **Harold Urey** experimentally supported the chemical origin of life, which was explained by Haldane and Oparin.
- They tried to replicate the primordial atmosphere and successfully proved the chemical origin of life with their simulation experiment.
- Miller sealed a mixture of **water vapour, methane, ammonia and hydrogen** (simulation of primeval atmosphere) in the spark chamber which was provided with electrodes for electric charge (simulation of lightning).
- The spark chamber was connected to another flask with the provision for boiling (simulation of evaporation). The spark chamber was connected on the other end to a trap by a tube that passed through condenser (simulation of rain and condensation of Haldane's soup).
- The trap was also connected to the boiling flask for circulation. They noticed simple organic molecules like ammo acids and peptide chains in the aqueous solution after a few days.
- **Glycine, alanine, aspartic acid** were produced. Later all amino acids were produced. **Using hydrogen cyanide even adenine and other nitrogen bases were produced.**