

Origin of Life

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- **Origin of life** is the process by which living organisms developed from inanimate matter, which is generally thought to have occurred on Earth between 3500 and 4000 millions years ago.
 - **Methane** which has **helped develop life on Earth** occurs on Jupiter, Saturn and interstellar space.
 - Origin of life is known as **biopoiesis** means biopoiesis is the development of living matter from complex organic molecules that are themselves nonliving but self replicating.
 - **First life evolved 3800-4200 million years back.**
 - There are **several theories about the origin of life.** These are – theory of special creations, theory of eternity, theory of catastrophism, cosmozoic theory or theory of panspermia, theory of spontaneous generation and Oparin Haldane theory.
 - **Theory of special creation was proposed by Hebrew *et.al.* and supported by Father suarez** (Spanish Priest).
 - According to this theory life was created by supernatural power either once or at successive intervals.
 - The **theory of eternity of life**, also called the **steady state theory**, states that the life has ever been in existence as at present and will continue to be so for ever, changing only in form. It neither had a beginning nor will have an end.
 - Steady state theory **does not accept the palaeontological evidence** that, presence or absence of a fossil indicates the origin or extinction of the species represented and quotes, as an example the case of coelocanth, *Latimeria*.
 - According to this theory, scientist like **Richter, Preyer, Helmholtz, Arrhenius, Hoyle, Bondi**, believed that life is immortal.
 - Sudden creation of life from inorganic material was supported by **George Cuvier**. This theory is called **theory of catastrophism** or **Cataclysm**.
 - **According to this theory**, the abrupt faunal changes geologists saw in rock strata were the result of periodic devastations that wiped out all or most extant species, each successive period being repopulated with new kinds of animals and plants.
 - **Cosmozoic theory was proposed by Richter** (1865) and **supported by Arrhenius** (1908).
 - Cosmozoic theory is also called **theory of panspermia** and **spore theory**.
 - This theory states that life had reached the Earth from some other heavenly body in the form of resistant spores of simple organisms (called cosmozoa) in meteorites or in spaceships.
 - **Theory of spontaneous generation or abiogenesis or autogenesis** states that life originated from non living things in a spontaneous manner. For eg., insects were believed to originate from dew, frog and toads from moist soil under the influence of Sun, butterflies from cheese and fly and maggots from flesh.
 - The theory of abiogenesis was believed and supported by **Thales, Anaximander, Newton, Descrates & Van Helmont**.
 - Theory of spontaneous generation was **disproved by Francesco Redi** (1668), **Abbe Lazzaro Spallanzani** (1767) and **Louis Pasteur** (1867).
 - **Francesco Redi** (1626-1698) performed a series of experiments to disprove the theory. He placed meat or fish (eel) under clean muslin coverings and demonstrated that while flies laid eggs on muslin, maggots or larvae appeared only when those eggs were transferred to the meat and allowed to hatch. He **concluded that maggots develops only from pre-existing flies and were not spontaneously generated by any other form of material.**

- In 1765, **Abbe Spallanzani**, an Italian scholar prepared flasks of meat broth which were boiled for several hours and then sealed. The broth remained clear for months, and when the seals were broken and the broth tested, it was shown to be free of microbes.
- Louis Pasteur (in 1864) used a swan-neck flask and prepared a meat broth in this flask, and boiled it for several hours. He then left the flask unsealed on a laboratory bench. The flask was not sealed, and there was a free exchange of air with the environment, so the system did not lack oxygen. Still, the swan-neck remained free of microbial contamination for months, because, their swan-necks were shaped so to trap viable microbial particles and to allow only air to enter the flask. After several months when he broke the neck of one of these flasks, contamination by air and proliferation of micro-organisms in the fluid ensued. **This experiment thus disproved the concept of spontaneous generation completely.**
- Pasteur is **famous for germ theory of disease.**
- The process of destroying all living organisms is called **sterilization.**
- Sterilization is done to surgical instruments to kill all the pathogens present on the instrument.
- All three scientists (Redi, Spallanzani and Pasteur) **developed theory of biogenesis.**
- According to theory of biogenesis **life originated from pre-existing life.**
- **The modern hypothesis of origin of life was formulated by Haeckel.** This idea was elaborated in the chemical theory by two workers independently : a Russian biochemist **A. I. Oparin** (in 1923) and an English biologist **J.B.S. Haldane** (in 1928). It was summarized by Oparin in his book : The '*Origin of Life*', published as an English edition (in 1938).
- Oparin and Haldane state that –
 - Spontaneous generation of life under the present environmental conditions is not possible.
 - Earth's surface and atmosphere during the first billion years of its existence were radically different from today's conditions.
 - Initial atmosphere of Earth was reduced
 - First life arose from a collection of chemicals through a progressive series of chemical reactions.
 - Solar radiation, heat radiated by earth & lightning provided energy for evolution of molecules.
- **Modern theory of origin of life was propounded by Oparin** which is based upon **chemical evolution.**
- The Oparin Haldane theory (also called **protobiogenesis**) was **experimentally supported by Stanley Miller in 1953.**
- Modern views regarding the origin of life include **origin of Earth & its primitive atmosphere; chemical evolution (chemogeny) and biological evolution.**
- It is considered that the Earth was formed about 4600 million years ago.
- **Four basic requirements for the life to arise are -primitive atmosphere [with little or no oxygen, (O₂)],**

Table : Some notable milestones in origin of life showing approximate origins in million years.

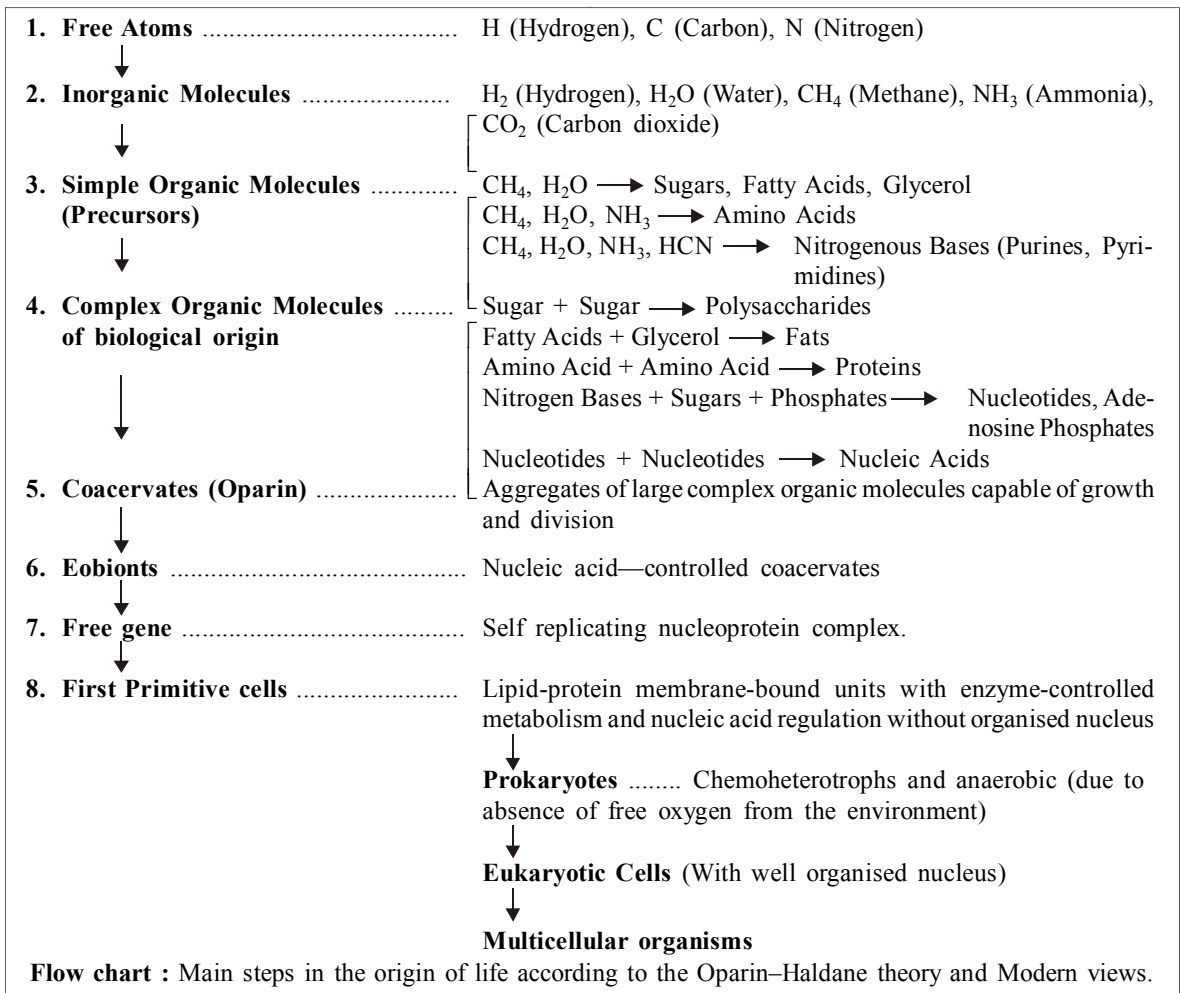
S. No.	Origin of	Time in million years
1.	Universe	10,000-20,000 [through big bang hemaitre (1931) of cosmic material]
2.	Solar system	4,600
3.	Earth	4,600
4.	A biotic origin of anaerobic life	4,200
5.	Anaerobic photosynthetic bacteria	3,500-3,800
6.	Beginning of traces of oxygen	3,800
7.	Oxygen producing photosynthetic cyanobacteria	3,300-3,500
8.	Eukaryotes with a nucleus	1,600-1,200
9.	First land plants	459
10.	First mammals	220
11.	Man (<i>Homo sapiens</i>)	3.5
12.	Traces of O ₂	3.8

right chemicals (including water, various inorganic ions & organic molecules); an **energy source**, and **infinite time**.

- The **energy** needed for the chemical evolution on the primitive Earth mainly **came from solar radiation & cosmic rays; electric discharges; volcanic eruptions, heat etc.**
- Early earth had innumerable free atoms of all those elements which are essential for formation of protoplasm.
- The lightest atoms of nitrogen, hydrogen, oxygen etc. **formed the primitive atmosphere.**
- Free atoms combined to form molecules and simple inorganic compounds.
- **Primitive atmosphere was reducing atmosphere** because hydrogen atoms (most numerous and most reactive) combined with all available oxygen atoms to form water and leaving no free oxygen.
- **Water and ammonia were probably the first compound molecules of primitive earth.**
- **Chemical evolution** (also called **chemogeny**) involves the **synthesis of simple organic molecules.**
- With slight lowering of the surface temperature of the earth, the lighter elements interacted to form water, methane (**first organic compound**), ammonia, CO₂, HCN etc.
- The **early compounds interacted and produced simple organic compounds** such as simple sugars, nitrogenous bases, amino acids, glycerol etc.
- Simple organic compounds were formed with the help of **external sources** (UV rays, cosmic rays, lightning etc) acting on the mixtures.
- **Experimental evidence for formation of simple organic compounds** was given by **Stanley Miller.**
- The **Oparin-Haldane theory** suggests that complex organic molecules would have been formed through a series of chemical reactions in the earth's '**primordial soup**'.
- Synthesis of complex organic compounds from their simple constituent molecules were experimentally proved by Stanley Miller with the help of '**simulation experiments**'.
- The apparatus used by Miller is called '**Spark discharge apparatus**'.
- Miller passed an electric discharge in a mixture of **methane, ammonia, hydrogen** (ratio 2 : 1 : 2) and **water** (steam).
- By simulation experiments, **Miller synthesized**

about 15 amino acids and identified as glycine, alanine, glutamic acid and aspartic acid.

- The energy used in the Miller Urey experiment was **electric spark.**
- The first simplest organic compounds to arise were **methane, ethylene, acetylene**, etc. (hydrocarbons).
- Carried to the earth's surface by rainwater, the simple organic compounds then would have accumulated in the ocean as a warm, **dilute "soup"**.
- The oceanic water rich in mixture of organic compounds was termed by **J.B.S. Haldane** (1920) as '**hot dilute soup** of organic substances, or '**Prebiotic soup**'.
- The large organic molecules which were synthesized abiotically on primitive earth later came together and formed large colloidal aggregates.
- **Protenoids** are protein like substance formed by polymerization of aminoacids under inorganic conditions such as heating to over 140°C.
- **The formation of protein molecules** can be **considered a land mark in the origin of life.**
- Colloidal aggregates were named **microspheres** by **Sydney Fox** and **coacervates** by **Oparin.**
- The model proposed by **S.Fox** of protenoid microsphere for protocells is widely accepted because of its following significances : (1) Such protenoid microspheres arise from monomers, rather than from polymers obtained from organisms already in the biota, as is true for the usual experiments with coacervate droplets. (2) This model suggests that protenoids are informational and it shows the origin of communication which may be intercellular or intergenerational communication.
- **Nucleic acid**, formed by the polymerization of nucleotides, are the basis of life as these represents the genetic material of an organism and is the molecular basis of heredity.
- **Nucleoproteins** gave most probably the **first sign of life.**
- **Biological evolution** (or **biogeny**) involves formation of prokaryotes to eukaryotes.
- More complex coacervates and microspheres **function as precells or prebionts.**
- The **first living form** named **protocell or eobiont or protobiont**, originated in the primitive ocean.
- Amino acids, sugars, glycerol and fatty acids gave rise to polymers, which may have assembled into spherical structures called **protobionts.**



- **Protocells** were prokaryotic unicells which had naked DNA, protein manufacturing machinery, mode of energy liberation and its utilization.
- Protobionts made of polypeptides are called **microspheres**, those of lipids are called **liposomes** and those of combinations of polypeptides, nucleic acids and polysaccharides are called **coacervates**.
- The **origin of prokaryotes were probably from protocell**.
- The **first prokaryotes** were **anaerobes and chemoheterotrophs**.
- Chemoautotrophs were formed when environment over the earth became cooler.
- The organisms performing chemosynthesis are called **chemoautotrophs**.
- Simple one celled organisms somewhat similar to today's cyanobacteria were present on earth about 3600 million years ago.
- **Atmosphere become richer in oxygen due to photoautotrophs**.
- Free living eukaryotic cell like organisms originated in the ancient ocean presumably about 1.5 billion years ago.
- Primitive eukaryotes **led to the evolution of protists, plants and animals**.
- The oxygen present in the modern atmosphere must have been liberated as a result of photosynthesis of green plants.
- The **most important condition for the origin of life** is the **presence of water** because life can originate from abiogenetic materials in water.

- There is **no life on the moon** because there is no water.
 - **Life originated in the ocean (water)** presumably about 3.7 billion years ago in **precambrian era**.
 - The prokaryotes evolved before the eukaryotes. The oldest known fossil cells are about the same size as modern prokaryotes.
 - Some of the oldest known fossil cells appear as parts of **stromatolites**, which are formed today from sediments and photosynthetic prokaryotes.
 - The **earliest autotrophs** must have been **anaerobic chemoautotrophs**.
 - The first organisms to give off oxygen were probably **cyanobacteria**.
 - When a primitive bacterium is exposed to oxygen gas, it dies.
- Organisms that can grow with or without oxygen gas are called **facultative anaerobes**.
 - Organisms that are poisoned by oxygen gas are **obligate anaerobes**.
 - Organisms that cannot grow without oxygen gas are **obligate aerobes**.
 - Prokaryotes were limited in genetic variability because they reproduced by binary fission.
 - Haeckel (1894) proposed to create a separate subkingdom **protista** to include all unicellular eukaryotic plants and animals.
 - Prokaryotes are more diverse than eukaryotes in terms of metabolism.
 - Of the planets of our solar system, only **Mars** is supposed to have life, but no evidence of life has yet been found by the scientists.

End of the Chapter
