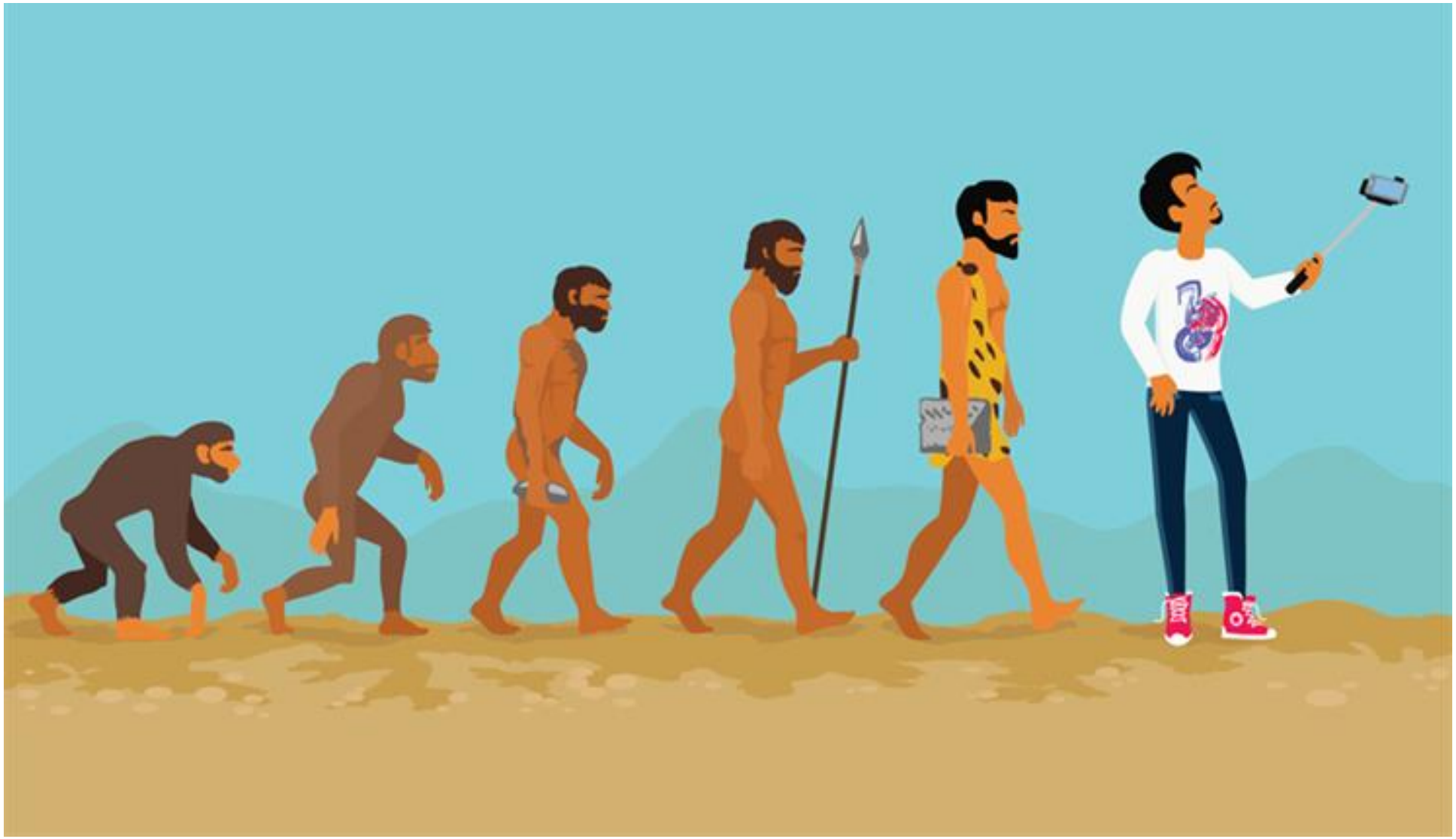
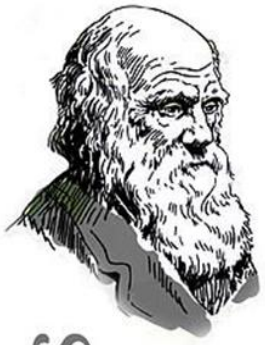
Evolution



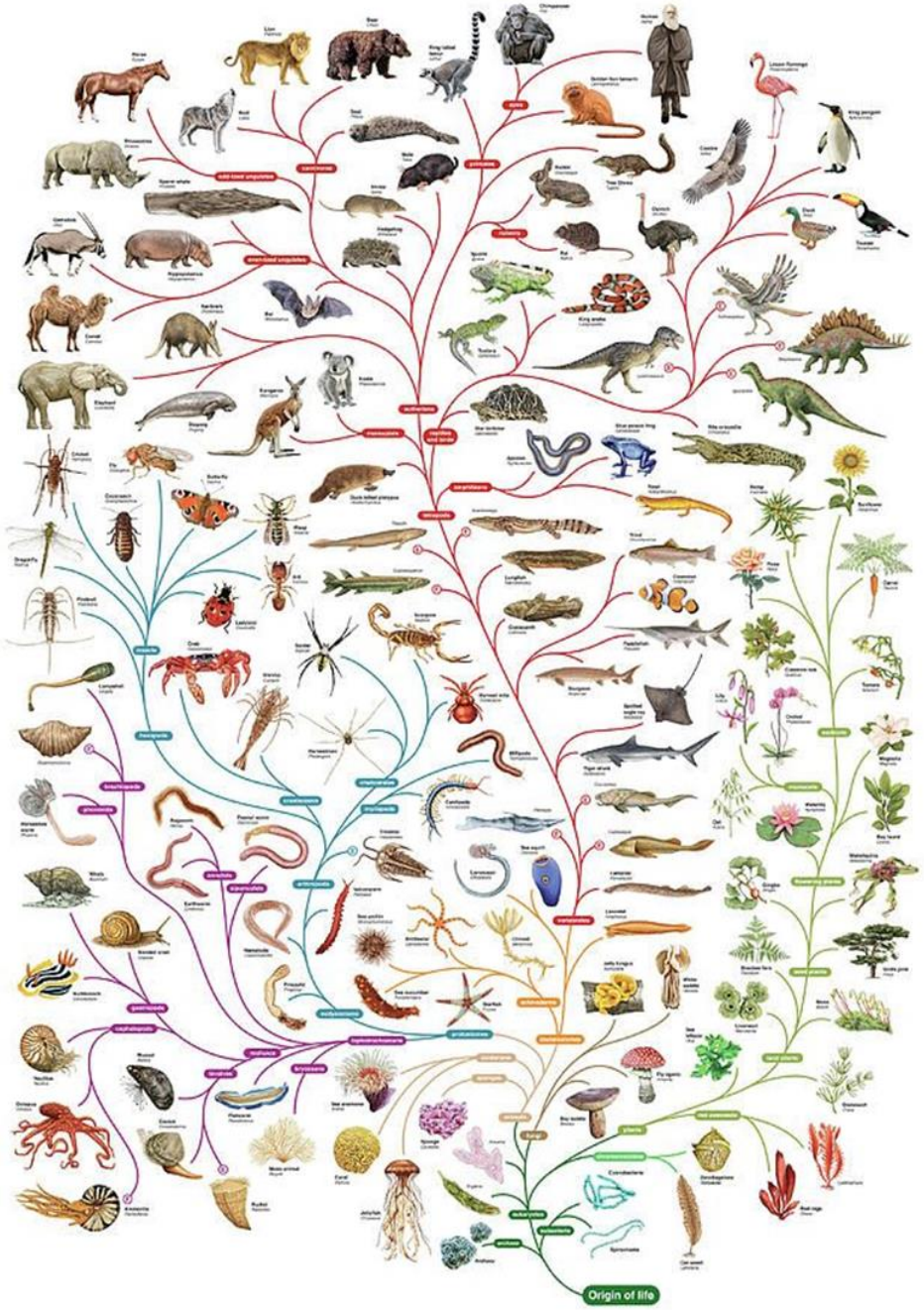


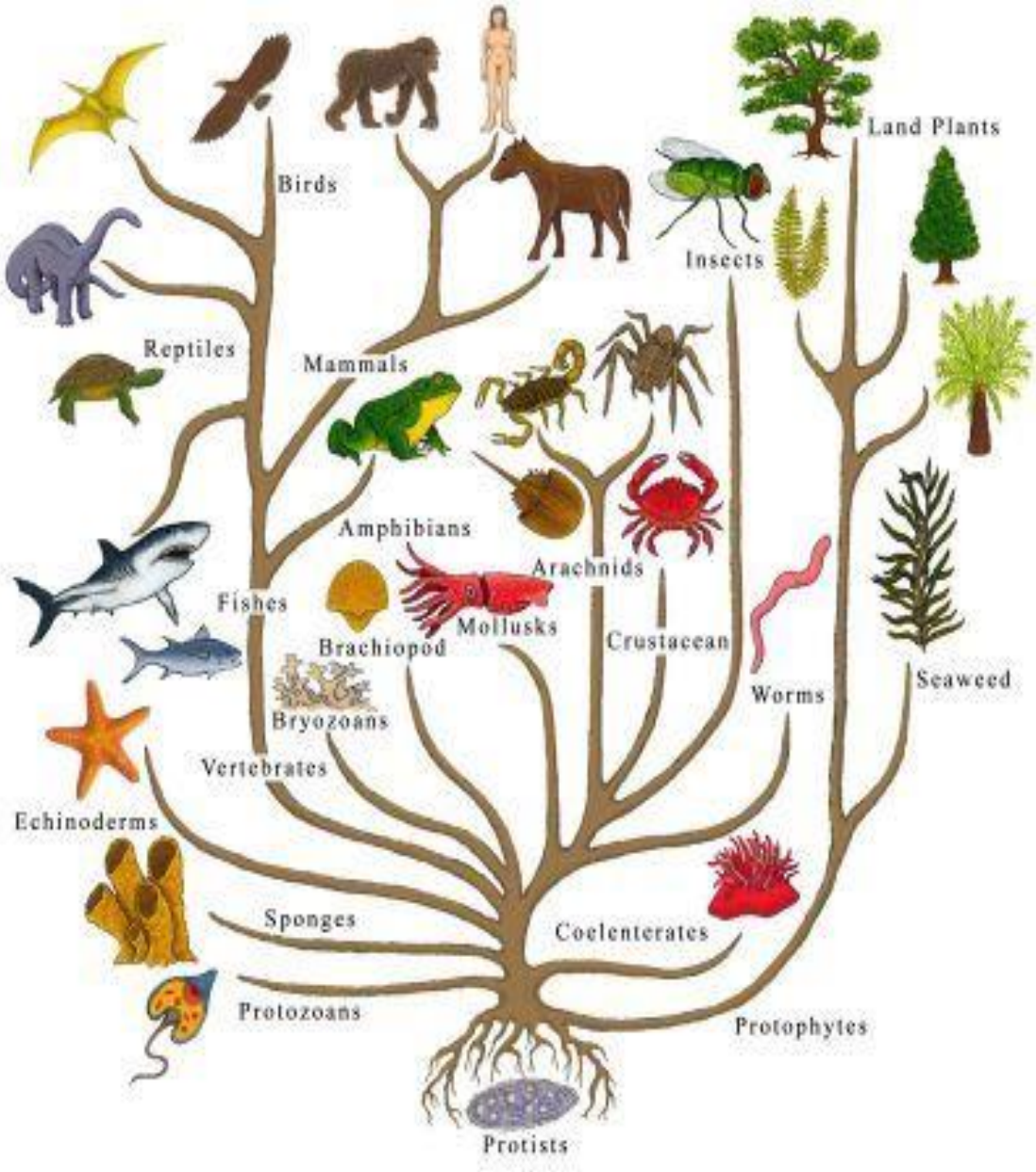
The Origin of Species

by Charles Darwin

1809 - 1882

Darwin published his theory of evolution with compelling evidence in his 1859 book On the Origin of Species. By the 1870s, the scientific community and a majority of the educated public had accepted evolution as a fact. However, many favoured competing explanations which gave only a minor role to natural selection, and it was not until the emergence of the modern evolutionary synthesis from the 1930s to the 1950s that a broad consensus developed in which natural selection was the basic mechanism of evolution. Darwin's scientific discovery is the unifying theory of the life sciences, explaining the diversity of life.





Evolution

Note: In this world, there are so many types of plants and animals and they are different from each other according to their habitat and ecosystem. **How it came or originated** ???

Therefore from ancient period of time peoples (**Scientists**) are trying to identify and solve these question in order to understand the life, from where it came and how its came.

Many scientists gave their view or opinion and theories on how life started and originated. First simple life came which then later changed into various types according to their surroundings or habitats.

These major group or species of organism, that has been evolved gradually from simpler life (unicellular) to complex (multicellular) life during the period of million years through evolution (**the process of continuous change**).

Evolution is a slow but continuous gradual change, which is progressive and heritable from one generation to another over a long period of time.

Theory on origin of life on Earth

The origin and evolutionary history of life is one of the complex and most speculative interpretation of all time. Various theories were put forwarded by many peoples (scientists) from time to time to explain the origin of life. Some of the important theories are as follow.

1. Theory of Special creation

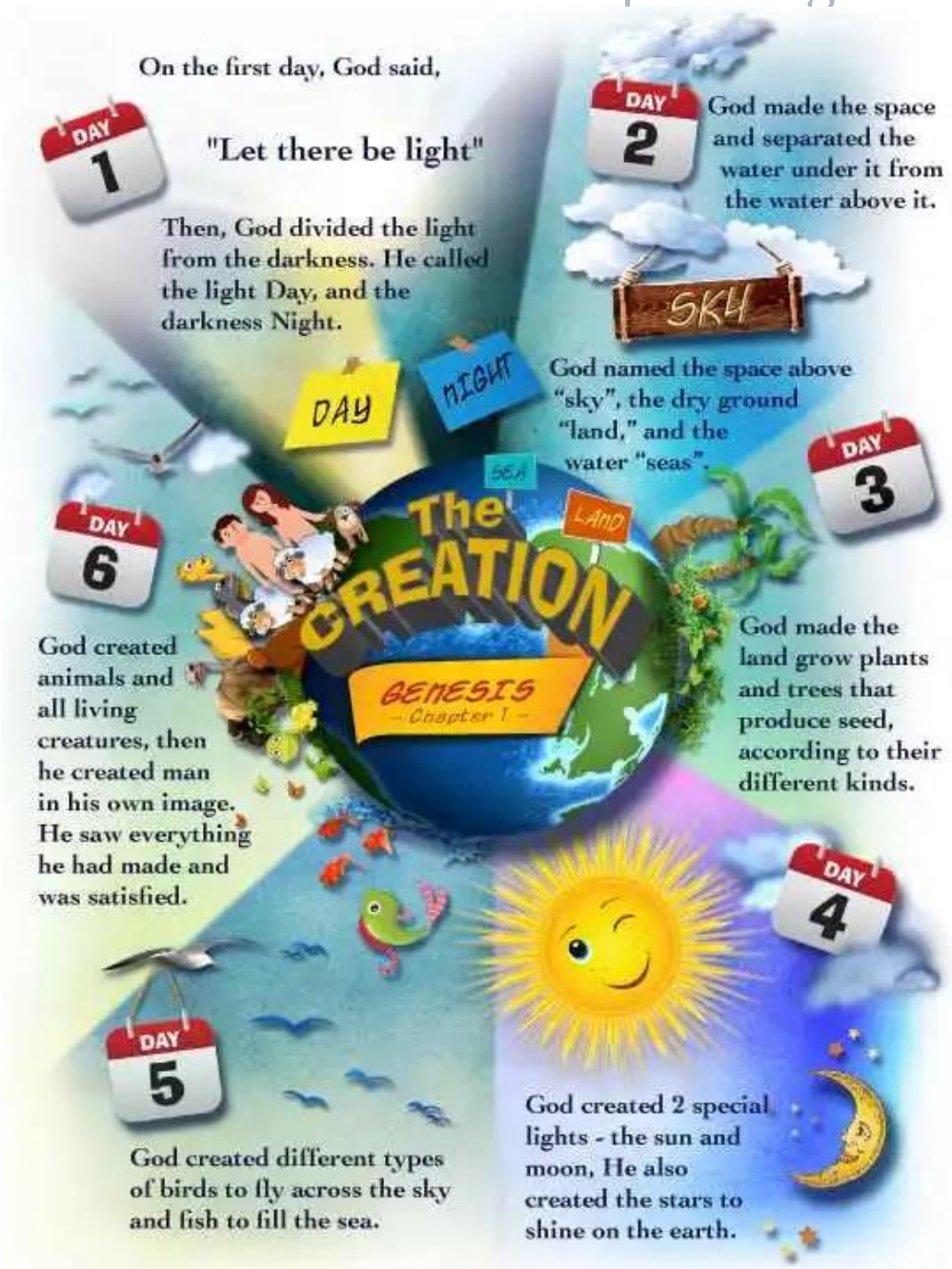
Proposed by Spanish Priest Father **Saurez** (1548-1671 AD)

This theory was proposed by some spiritual peoples. According to them, all the existing plants, animals were created by some supernatural power or **God**.

Accordingly to **Hindu**, God Brahma (the god of creation) created the universe and life in one stroke. The first man is **Manu** and women is **Shradha**.

Similarly, according to **Christian** (Bible), God created the universe, plants and animals in seven days. The first man is **Adam** and women is **Eve**.

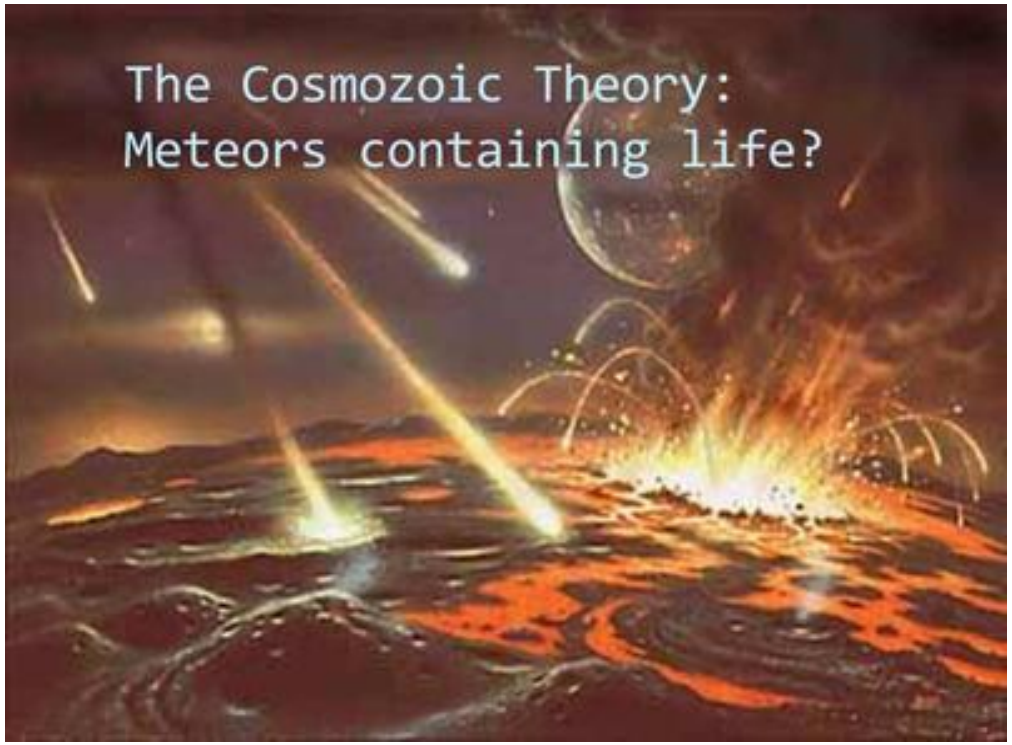
Conclusion: However, as this theories has no scientific evidence, it is not accepted.



2. Theory of Cosmogeny

This theory was proposed by philosopher **Ritcher** (1865) and supported by **Arrhenius** (1908). According to this theory, life came on the earth from another planet in the form of small spores called Panspermia or Cosmozoa during the collision of planets or asteroids.

Conclusion: However, as this theories has no scientific proof, it is not accepted.



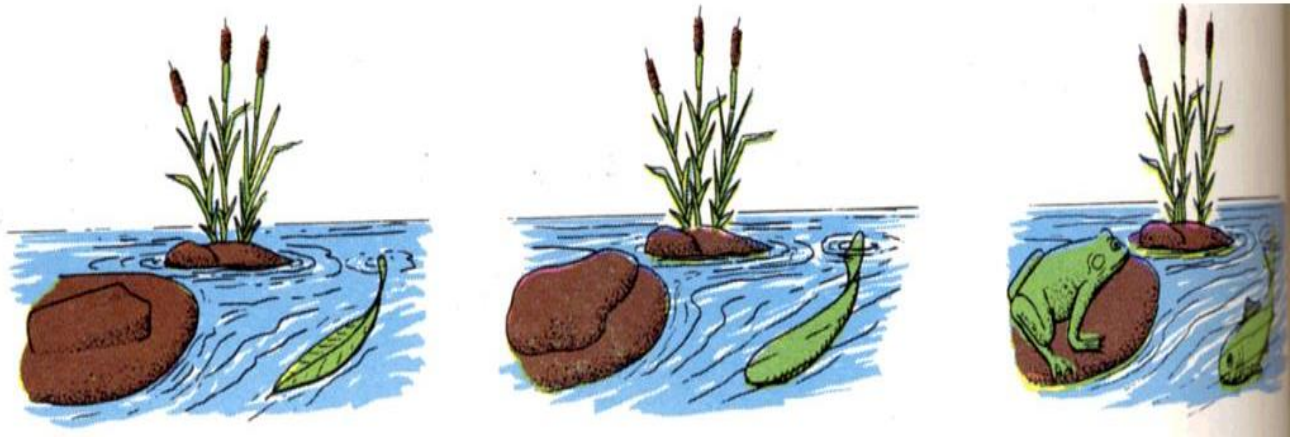
3. Theory of Abiogenesis (Spontaneous generation)

This theory was proposed by **Aristotle** (384–322 BC). According to this theory, Living things (life) arise spontaneously from the non-living (inanimate) substances. For e.g., young nice could arise from wheat grain in dark store room along with moist dirty cloths. Frogs, toads, snakes etc., were believed to be created from mud. Fly maggots and insect are originated from meat, micro-organism from air and water etc.

Conclusion: However, as this theories has no scientific proof, it is not accepted.

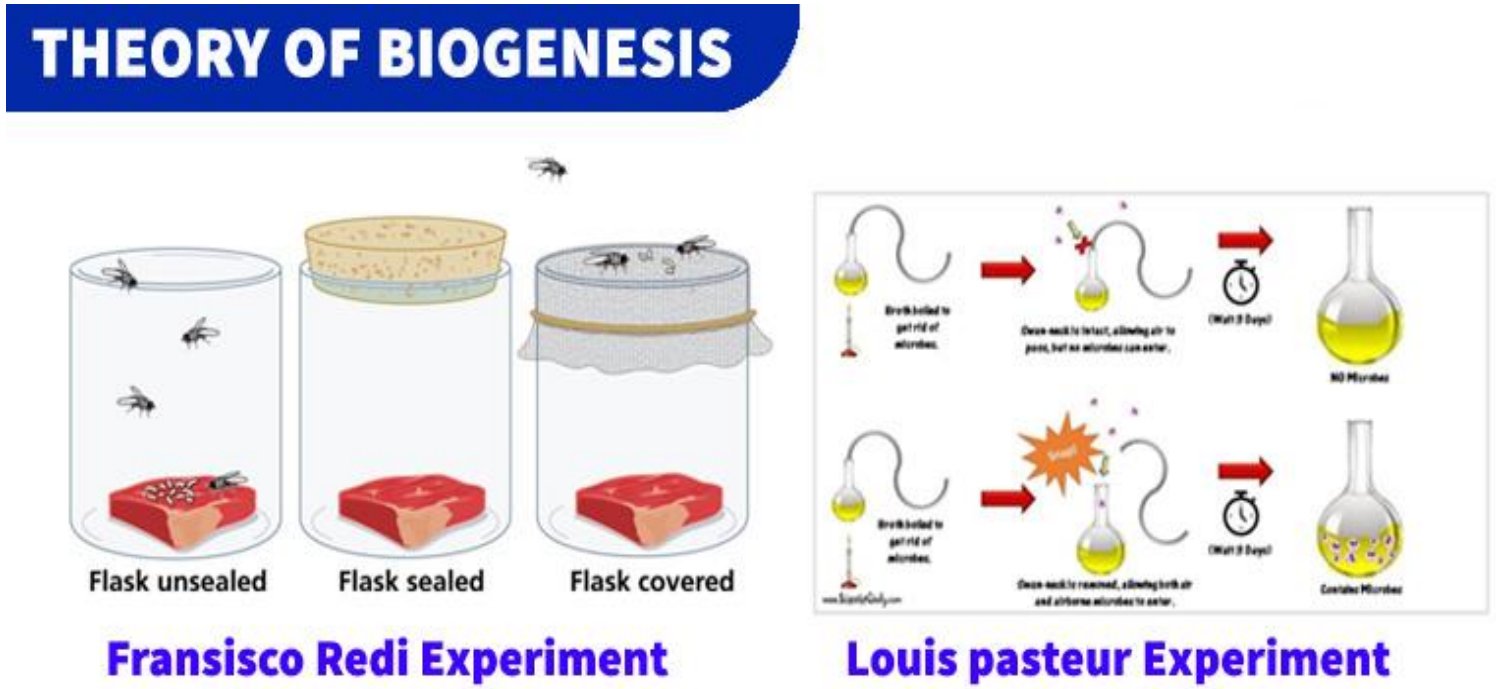
Stated by **Van Helmont** (1577-1657 AD)

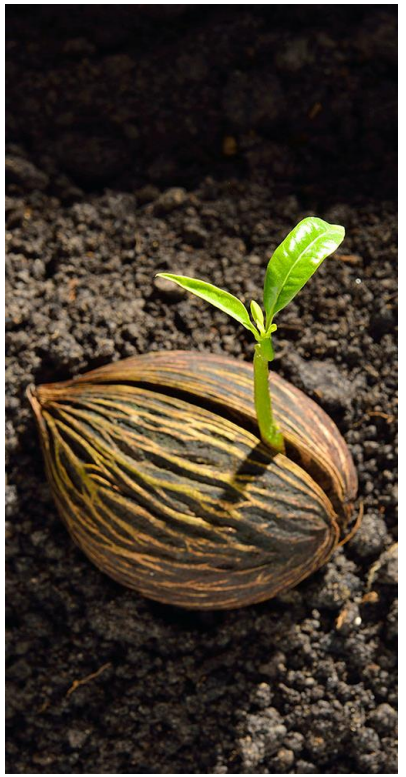
- This is called **abiogenesis**
- Also known as **spontaneous generation**

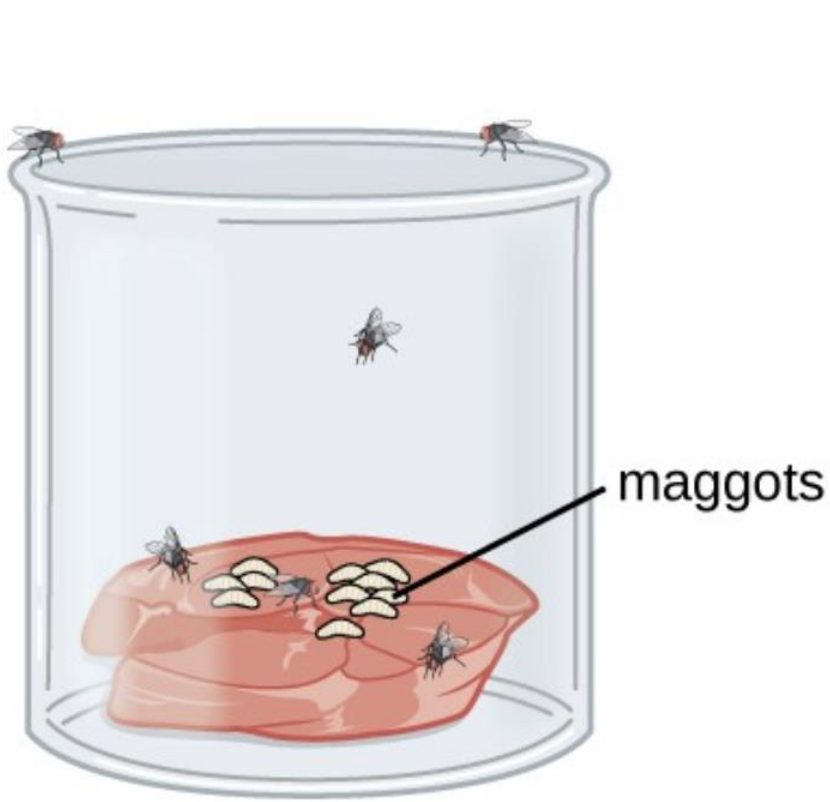


4. Theory of Biogenesis (Life from life)

This theory was proposed by French biologist **Louis Pasteur** (1822-1895 AD). According to this theory, Living things (life) was originated from the living organisms already present in the atmosphere in the pre-existing forms. This theory is applicable to explain the origin of recent life from pre-existing life but is not applicable to explain the origin of the earlier life (pioneer), hence not accepted later.







open container

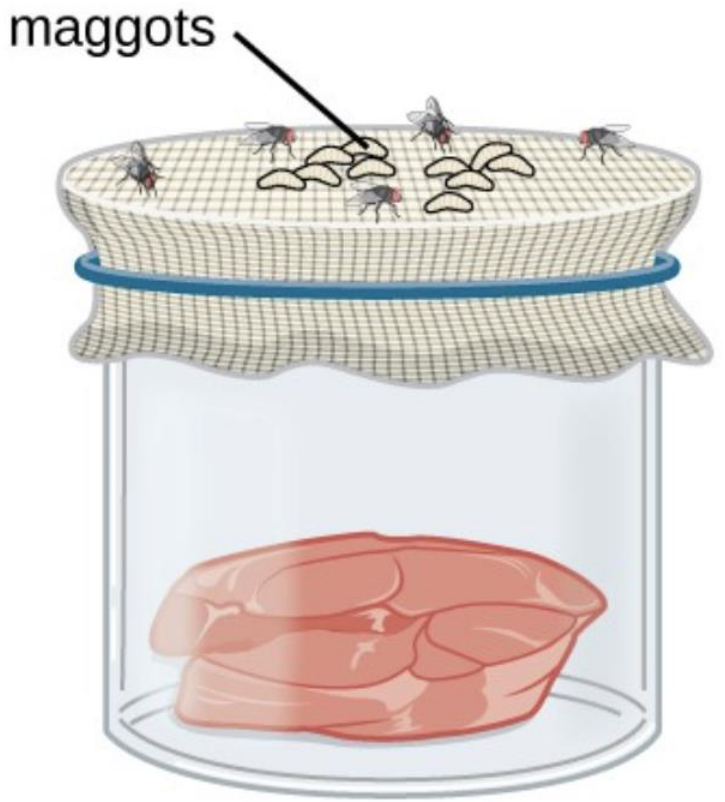
↓

formation of maggots
in meat

cork-sealed container

↓

no formation of maggots
in meat



gauze-covered container

↓

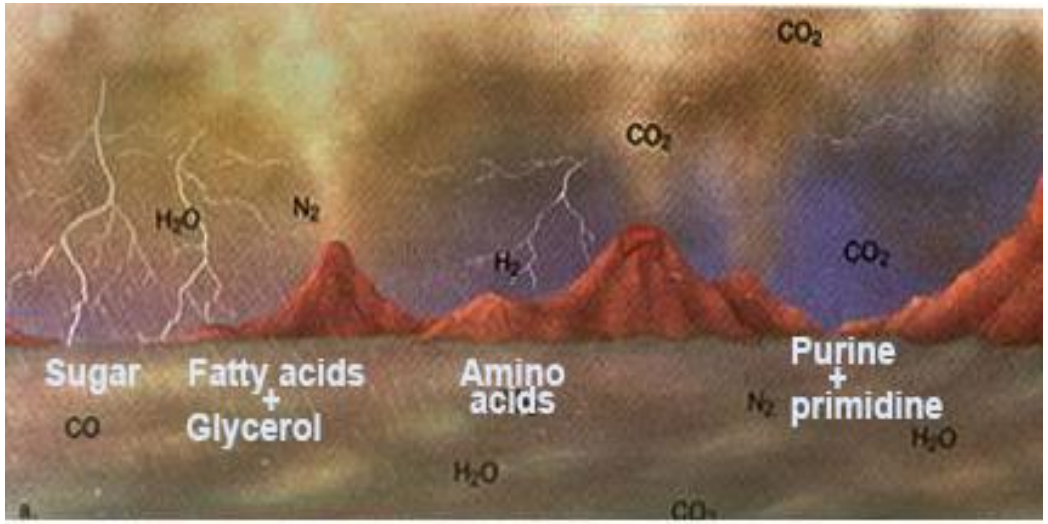
no formation of maggots
in meat

K. Deepak Singh

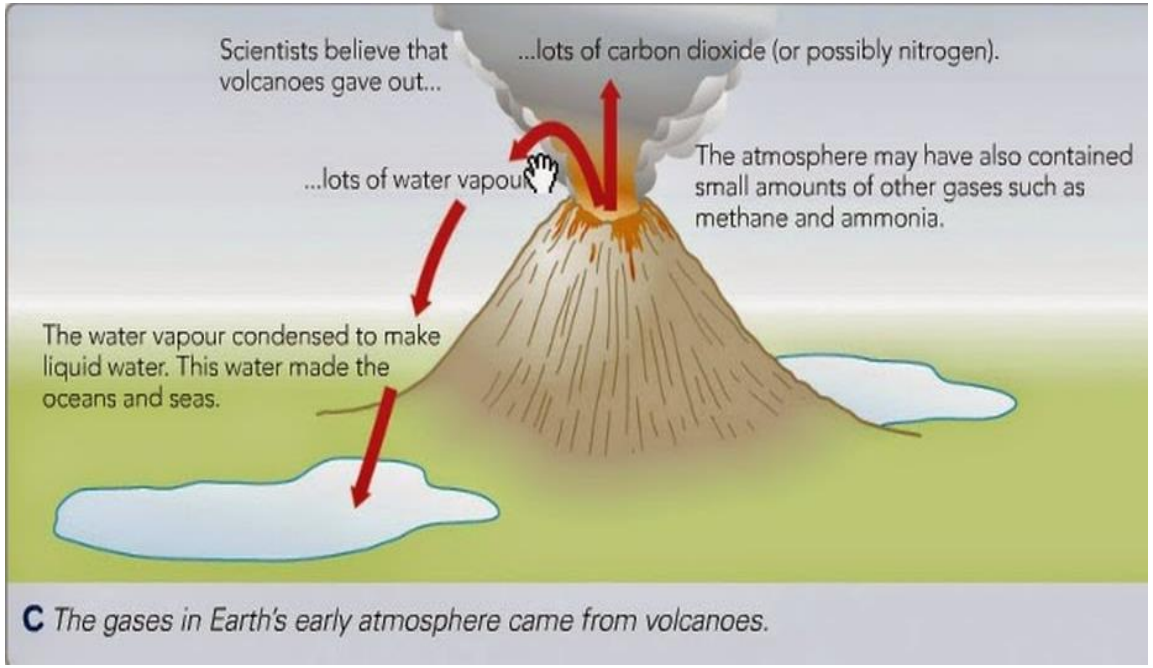
K. Deepak Singh

5. Theory of Biochemical origin of life

It is the modern and widely accepted concept of origin of life. This theory was proposed by Russian scientist **Alexander Ivanovich Oparin** in **1923** and British scientist **John Burdon Sanderson Haldane** in **1928**. Therefore this theory is known as **Oparin-Haldane** theory or famously known as **Oparin theory**. According to this theory, Living things (life) was originated from the some non-living inorganic substances in the ocean of primitive earth about 3.3 billion year ago.



The primitive atmosphere contained gases, including water vapour, that escaped from volcanoes; as the water vapor cooled, some gases were washed into the ocean by rain.



C *The gases in Earth's early atmosphere came from volcanoes.*

This theory was published by the **Oparin** in his book "**The origin of life on the earth**" in **1938**.

According to this theory, primitive atmosphere of the earth had inorganic chemical compounds such as water, methane, ammonia, cyanide etc., which had gone through series of chemical reaction in the land (atmosphere) and ocean. As a result, various organic compound (biologically important macromolecules) like proteins, sugars, nucleic acid etc., were formed which later developed life on earth.

Oparin grouped this theory in there step…

1. **Chemogeny** (Chemical evolution)
2. **Biogeny** (Biological evolution)
3. **Cognogeny** (Diversification of life)

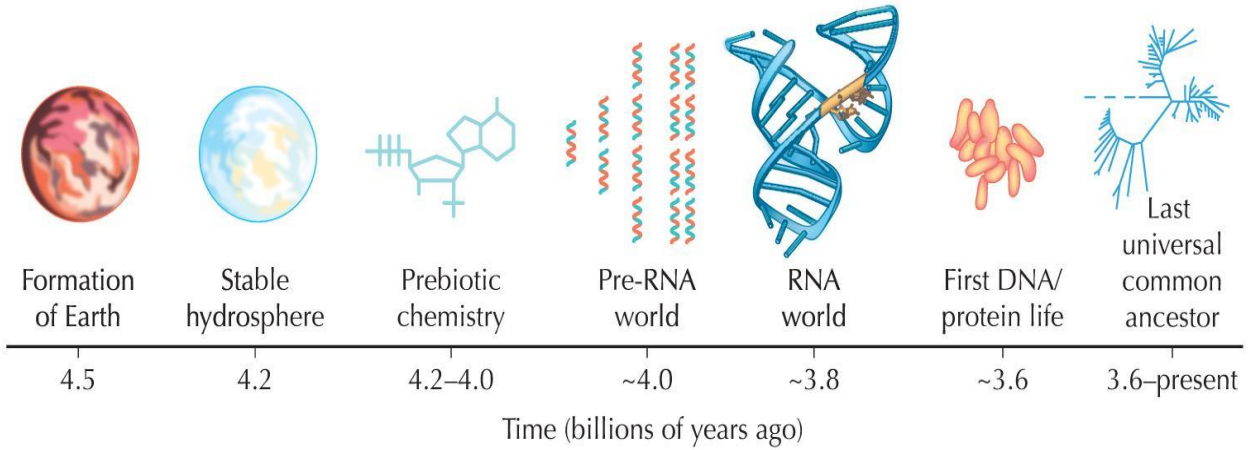


FIGURE 4.4. Steps in the origin of life.

1. Chemogeny: (Synthesis of simple organic molecules)

This step involves in the synthesis of simple to complex organic molecules such as carbohydrates, protein, amino acids, Fatty acids, purines, pyrimidine etc. from the inorganic molecules found in the water of primitive earth (sea) by various chemical reactions such as **condensation** and **polymerization**.

This process involves following sub-steps…

i) Formation of water, ammonia, methane and cyanamide:

Elements like carbon, hydrogen, nitrogen and oxygen were most abundant on the primitive earth in the beginning. These element existed in the gaseous state due to its high temperature. As the Earth surface gradually cooled, these elements are reacted with each other to form water, ammonia and methane etc. These molecules are considered as the key molecules in the process of origin of life on earth.

- $H_2 + O_2 \longrightarrow H_2O$ (Water)
- $2H_2 + C \longrightarrow CH_4$ (methane)
- $N_2 + 3H_2 \longrightarrow 2NH_3$ (Ammonia)

K. Deepak Singh

ii) Formation of Hydrocarbons

As the time passes, the temperature of the earth surface is cooled down to 100°C or even low. Due to this highly reactive agents like ammonia, water, methane etc. (-CH and -CH_2), they form various saturated and unsaturated hydrocarbons

- $CH + CH \longrightarrow C_2H_2$ (acetylene)
- $CH_2 + CH_2 \longrightarrow C_2H_4$ (ethylene)
- $CH_2 + CH_2 \longrightarrow CH_4$ (methane) + C

iii) Formation of oxy and hydroxy- Hydrocarbons

These above hydrocarbons reacted with superheated steam to form oxy and deoxy-derivatives of hydrocarbons such as aldehydes (-CHO) and ketone (Cn H_2n O).

$C_2H2 + H_2O \longrightarrow CH_3CHO$ (acetaldehyde)

K. Deepak Singh

iv) Formation of carbohydrates, amino-acid and fatty acid.

Due to condensation, polymerization, oxidation and reduction reactions of above molecules, complex macro-molecules such as simple sugar, fatty-acid and amino-acid were formed

- $6CH_4+6H_2O = C_6H_{12}O_6$ (Simple sugar) + $12H_2$
- $CH_4 + H_2O + NH_3 = NH_2\text{-}CH_2\text{-}COOH$ (amino acid)

v) Formation of purines, pyrimidines and nucleotides

The above molecules again reacted and aggregated together in hot diluted soup or primordial soup (ocean) and formed new molecules like purines, pyrimidines and nucleotides under the influence of available energy source like UV-rays, radiations, lightening and volcanic activities.

(i) Chemical Evolution (Chemogeny)

ATOMIC STAGE (4.5 bya)
C, H, O, N, Cl, F, He, Ar etc.

↓

MOLECULAR STAGE
H_2O (vapour), N_3H, CO_2, CO, N_2, H_2, CH_4, HCN, Cyanides, Carbides, Nitrides

↓

SIMPLE ORGANIC COMPOUNDS
Aldehydes, ketones, alcohols, pentose, hexose, amino acids, glycerol, fatty acids, purines and pyrimidines

↓

COMPLEX ORGANIC COMPOUNDS
Protein (non structural & non enzymatic), polysaccharides, fats/lipids, nucleotides → Nucleic acids (non replicable)

↓

CLOUD — RAIN — EARLY GASES — LIGHTNING — SUN — RADIATIONS

HIGH TEMPERATURE

H_2, NH_3, HCN, H_2O, CH_4

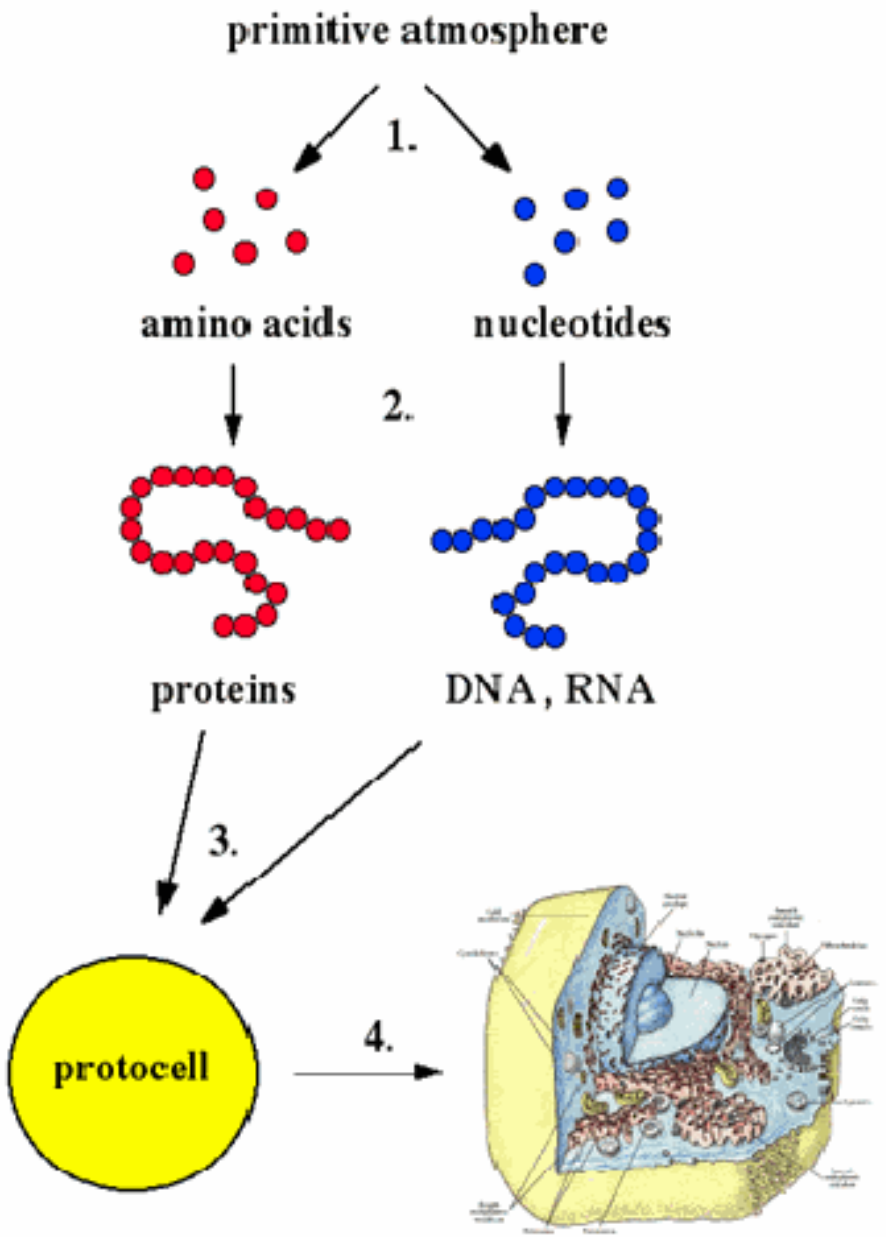
N-BASES (PURINES PYRIMIDINES) → NUCLEOTIDES

SUGARS → POLY SACCHARIDES

AMINO ACIDS → PROTEINS

GLYCEROL, FATTY ACIDS → FATS/LIPIDS

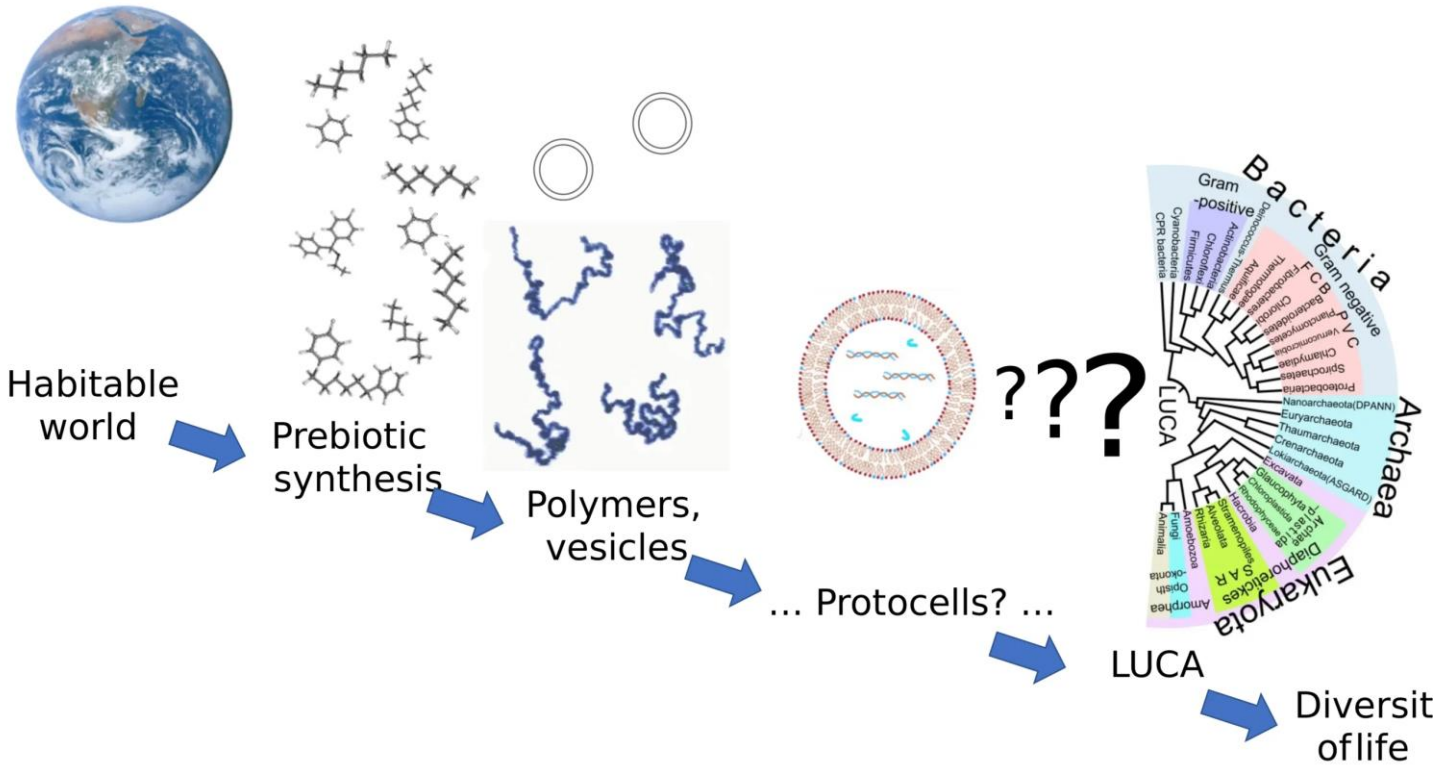
Primitive oceans
Hot dilute soup/
pre biotic soup



2. **Biogeny:** (Formation of complex biological molecules)

This step involves in the formation of complex and self-reproducing biological life. This stage is further sub-divided into 3 steps

i. **Formation of Nucleic acid**
ii. **Formation of Coacervates**
iii. **Formation of Primary organism**



I. Formation of Nucleic acid:

In this step, sugar, phosphate, purines and pyrimidines are combine together to form nucleotides or nucleoproteins. A large number of Nucleotides were combined to form nucleic acid such as DNA and RNA.

II. Formation of Coacervates:

In this step, the nucleic acid along with other macromolecules of the ocean aggregated together to form a colloidal system which were called Coacervates. These where the intermediate between the non-living molecules and the life (organisms)

III. Formation of Primary organisms:

In this step, Coacervates absorb organic substances from the oceanic soup and start multiplying. These grow in size, reproduced and multiplied, resulting to the formation of anaerobic heterotrophs or proto-cells or first cells. Oparin called them **protobionts** or **eobionts**. These were similar to Virus.

These first cells later gradually gave rise to two types of cells…

- **Prokaryotes Cells**: Cells without definite nucleus like Monera (Bacteria & blue green algae)
- **Eukaryotes Cells:** Cells with definite nucleus like Protista (Protozoa, metazoan, Metaphyta)

K. Deepak Singh

3. Cognogeny:

This step involves in the diversification of protozoa, metazoan and Metaphyta. As the food materials in the ocean got depleted, the organism started to change their feedings habits. Some prefer parasitic, some saprophytic, some photosynthetic and so on.

Those organism which depends on others for food or nutrition led to the heterotrophic mode of nutrition called **heterotrophs**, which later become **animals**. And some organism developed green pigments like chloroplast that began to synthesize the food themselves called **autotrophs** and become **plants**.

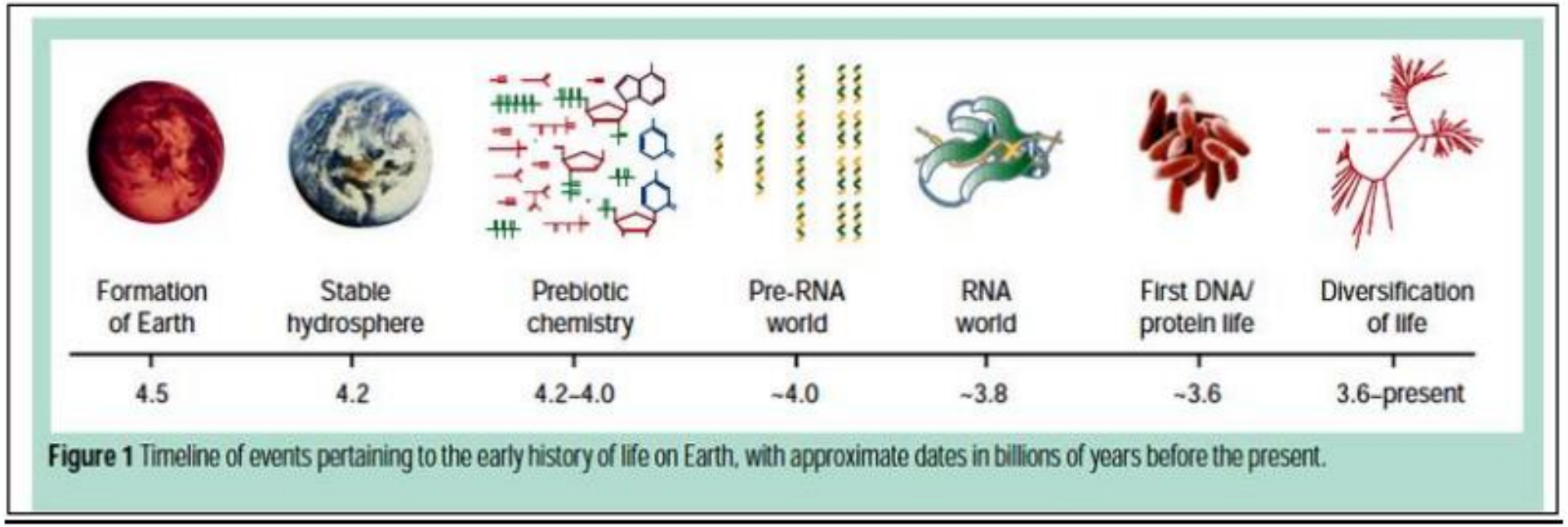
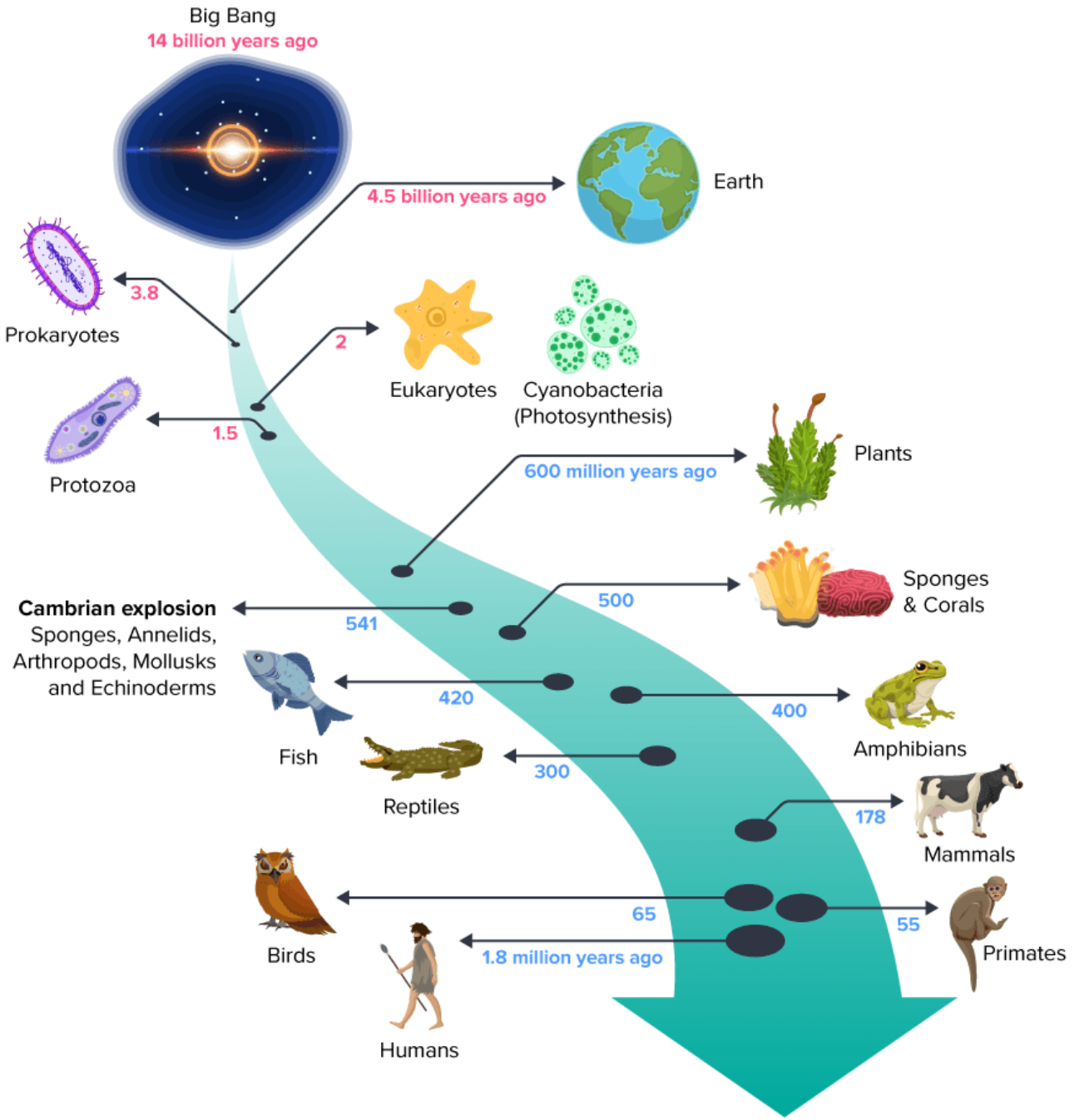


Figure 1 Timeline of events pertaining to the early history of life on Earth, with approximate dates in billions of years before the present.



K. Deepak Singh

Note:

Reducing atmosphere: It was the primitive atmosphere where there is no free oxygen present in the atmosphere.

Oxidizing atmosphere: It the modern or present atmosphere where there is a lot of free oxygen in the atmosphere.

Oxygen evolution:

- As the simple life evolved in the primitive earth, various microorganism such as blue green algae developed the autotrophic mode of nutrition's by the process of photosynthesis and released large amount of free oxygen in the atmosphere.
- As the large amount of free oxygen was accumulated in the atmosphere, the reducing atmosphere was changed into oxidizing atmosphere which forced the anaerobic respirator to changed into aerobic respirator.
- These free oxygen released in to the atmosphere form the layer of ozone in the stratosphere which blocked the UV lights from sun to come on earth directly.
- These conditions helps the organism to develop more further and possibly to migrate on to the land from sea water.

Miller and Urey Experiment

In 1953, **Stanley L. Miller** and his professor **Harold C. Urey** designed an instrument and conducted an experiment to verify the "Oparin's biochemical theory"

Experiment: Miller and Urey designed an apparatus of glass flasks as shown in the figure. The apparatus contain two glass chamber (water chamber and gas chamber).

- First the water is boiled in the flask to promote steam circulation of water vapor in the gas chamber. The gas chamber contain gases like methane, ammonia and hydrogen in the ratio of 2:1:2.
- Then the energy is supplied in a closed chambers by electric discharge from UV-electrodes and heating of water.
- The condenser is also used to cool down the mixture formed by the passing steam over the gases by maintain the same conditions as that of primitive earth.
- The whole set-up or experiment was run for a week…

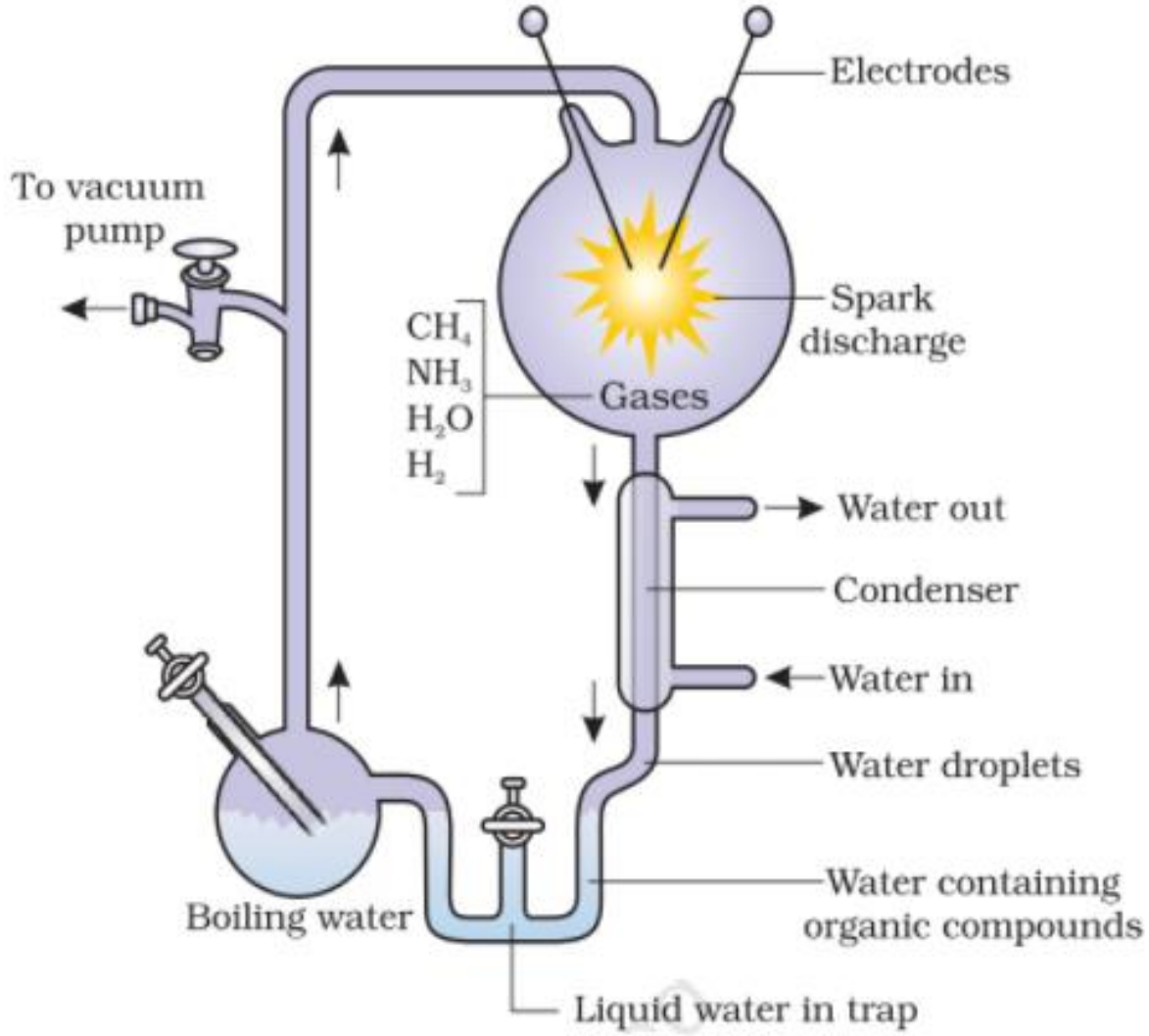
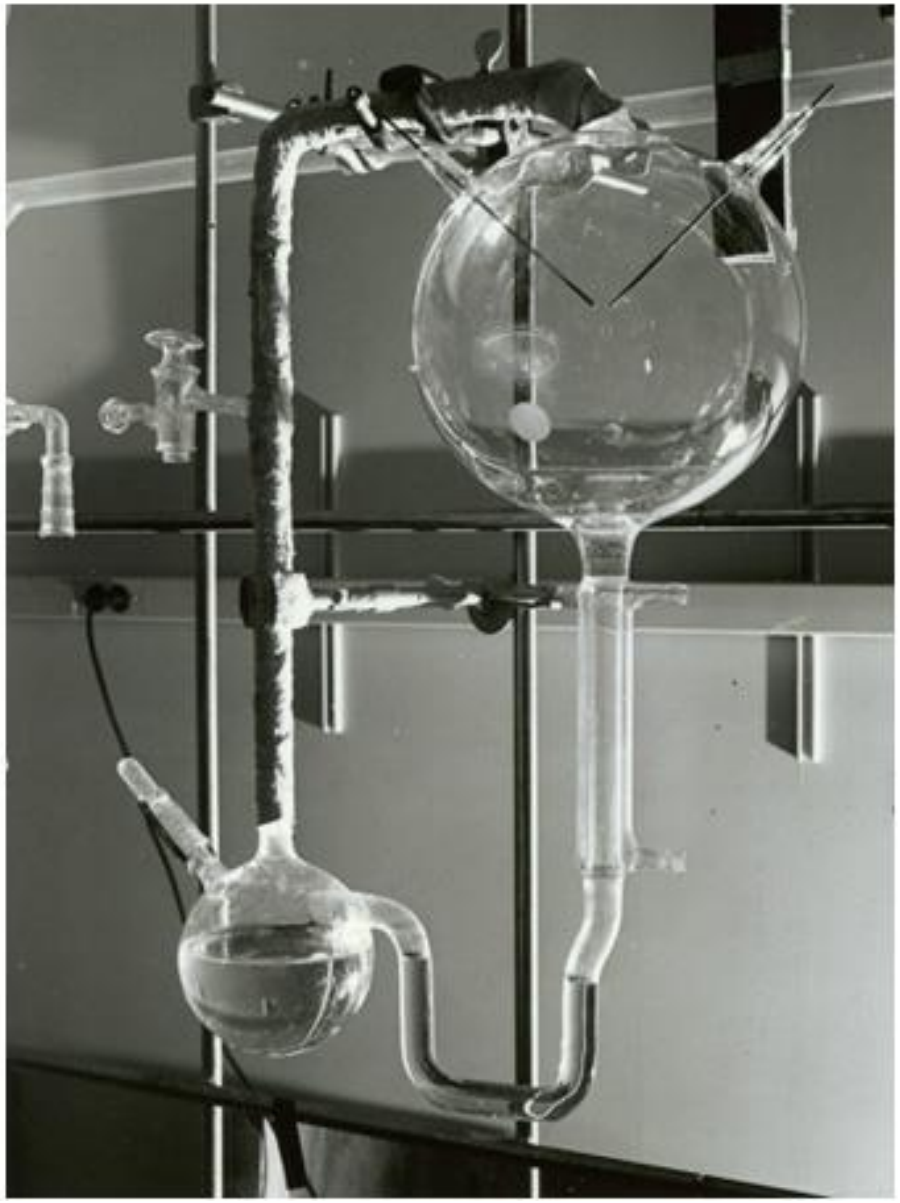


Fig: The apparatus set up by Miller and Urey to simulate conditions in the atmosphere of the primitive earth



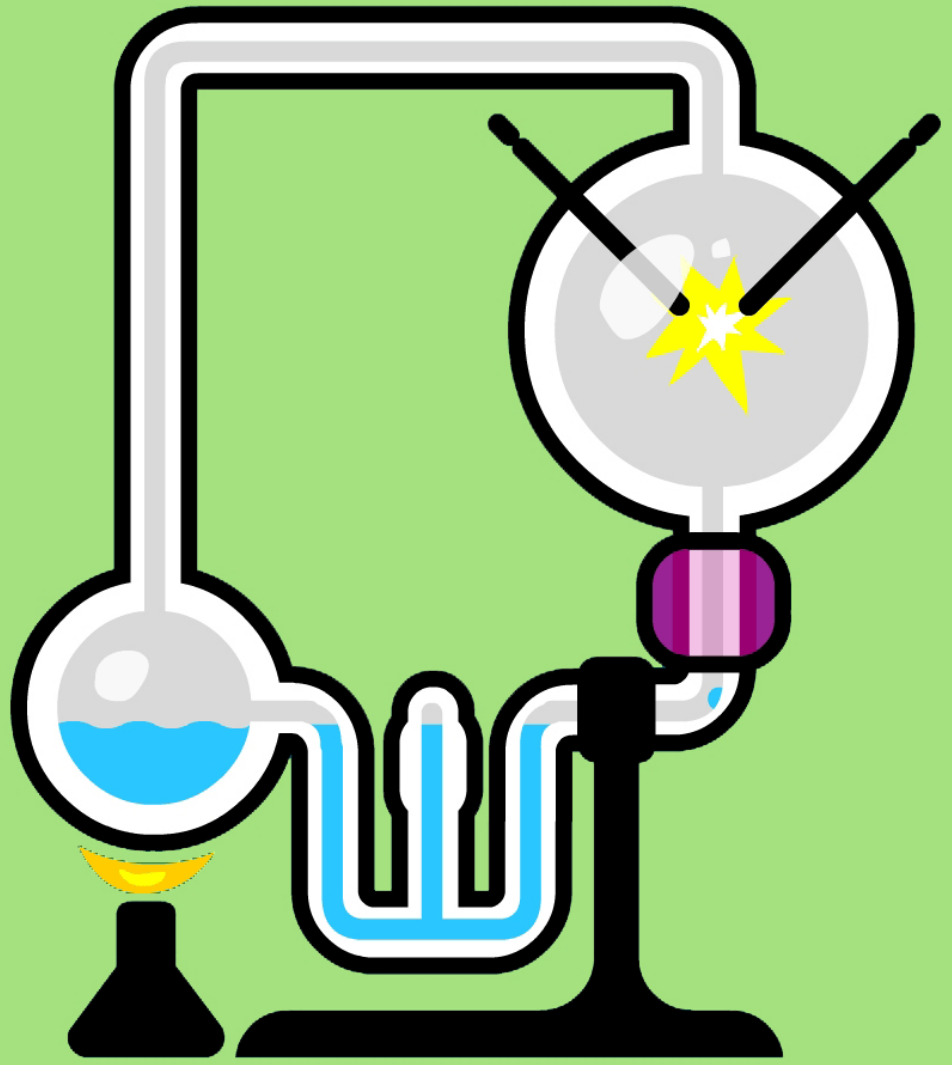
K. Deepak Singh

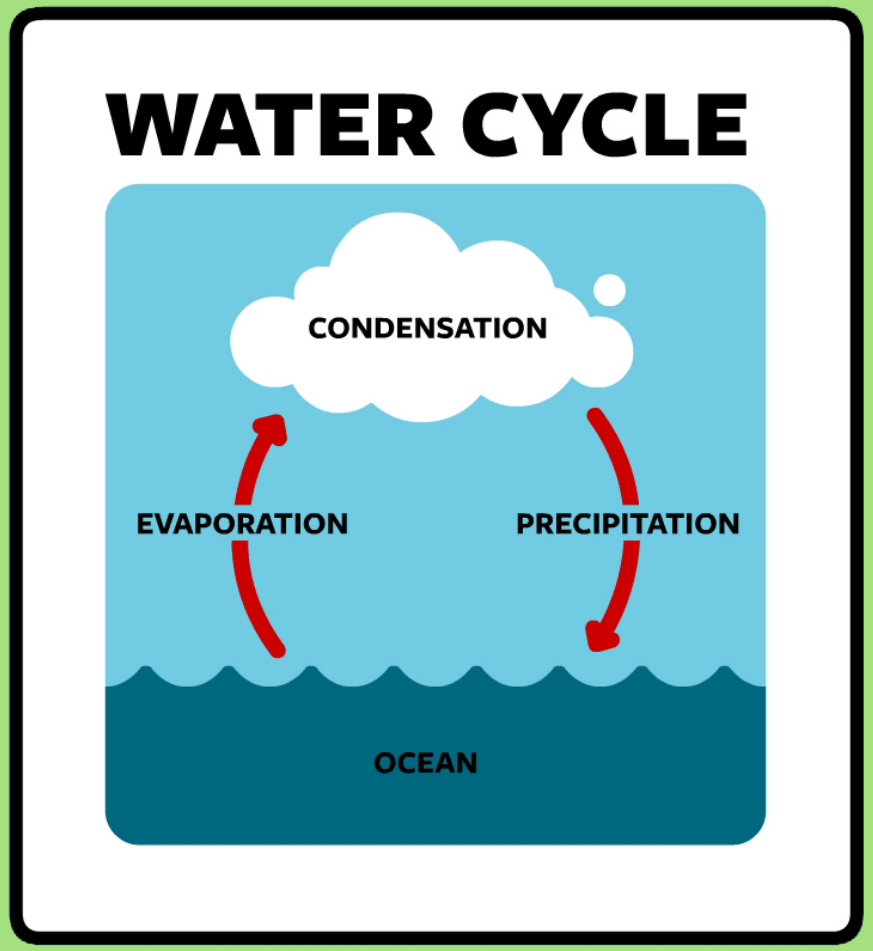
K. Deepak Singh

Observation: With the experiment, a series of chemical reaction took place in the gas chamber. As a result, various products were formed, condensed and collected in a collecting tube.

Result: Chemical analysis of products indicated the presence of a number of amino acid like glycine, alanine etc. and certain other organic compound like simple sugar, aldehydes, ribose etc. as same as explained by Oparin biochemical theory.

Conclusion: The result of the above experiment suggested that, the electric discharges produced during lightning in the primitive atmosphere of the earth contained NH3, CH4, H2 and water vapor might have resulted in the formation of amino acids and other organic compounds naturally on the primitive earth. This provide evidence in favour of Oparin's biochemical origin of life.





K. Deepak Singh

K. Deepak Singh