Chapter-5

EVOLUTION

Universe

- The universe is very old **– almost 20 billion years old**.
- Huge clusters of galaxies comprise the universe.
- Galaxies contain stars and clouds of gas and dust. Considering the size of universe, earth is indeed a speck.
- The **Big Bang** theory attempts to explain to us the origin of universe. It talks of a **singular huge explosion** unimaginable in physical terms.
- The **universe expanded** and hence, the temperature came down. **Hydrogen and Helium formed sometime later**. The gases condensed **under gravitation** and formed the galaxies of the present day universe.

Earth

- In the **solar system** of the **milky way galaxy**, earth was supposed to have been formed about **4.5 billion years back**.
- There was no atmosphere on early earth.
- **Water vapour, methane, carbondioxide and ammonia** released from molten mass covered the surface.
- The UV rays from the sun brokeup water into Hydrogen and Oxygen and the lighter H_2 escaped.
- **Oxygen combined with ammonia and methane to form water, CO2 and others**.
- The ozone layer was formed. As it cooled, the water vapor fell as rain, to fill all the depressions and **form oceans**.

Origin of life

- The origin of life is considered a unique event in the history of universe Life appeared **500 million years** after the formation of earth,
  i.e., almost **four billion years back**.
  There are several theories to explain the origin of life. Some of the theory are given below

1.Theory of panspermia/ cosmozoic theory

Early Greek thinkers thought units of life called **spores (Cosmozoa)** were transferred to different planets including earth.

2. Spontaneous generation of life/ /theory of abiogenesis

For a long time it was also believed that life **came out of decaying and rotting matter like straw, mud, etc**. This was the theory of spontaneous generation.

Louis Pasteur by careful experimentation demonstrated that life comes only from pre-existing life. He showed that in pre-sterilised flasks (Swann necked flask), life did not come from killed yeast while in another flask open to air, new living organisms arose from 'killed yeast'. Spontaneous generation theory was dismissed once and for all. However, this did not answer how the first life form came on earth.

3. Theory of biogenesis

According to theory living organisms are formed from pre existing life.

4. Theroy of special creation

Religious literature tells us about the theory of special creation. This theory has three connotations.

i) All living organisms(species or types) that we see today were created as such.
ii) The diversity was always the same since creation and will be the same in future
iii) The earth is about **4000 years old**

5. Chemical evolution/Organic evolution

- **Oparin of Russia and Haldane of England** proposed Chemical evolution.
- According to this theory the first form of life could have come from **pre-existing non-living organic molecules (e.g. RNA, protein, etc.)** and that formation of life was **preceded by chemical evolution**,
  i.e., formation of **diverse organic molecules from inorganic constituents**.
- **The conditions on primitive earth were – high temperature, volcanic storms, reducing atmosphere containing CH_4, NH_3, etc.**

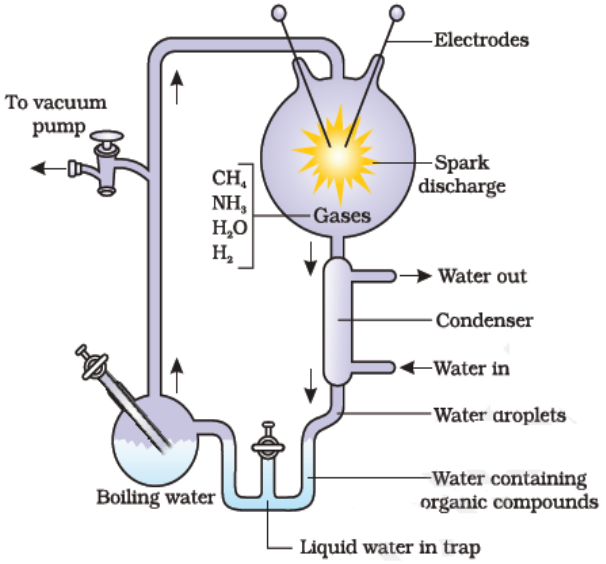
Experimental proof of chemical evolution

- ✓ **In 1953, S.L. Miller, an American scientist** created similar conditions in a laboratory scale similar to that of primitive earth.

- ✓ **He created electric discharge in a closed flask (Sparkle discharge apparatus) containing CH_4, H_2, NH_3 (2:2:1) and water vapour at 800^{0}C.**
- ✓ He observed formation of **amino acids**. In similar experiments others observed, formation of **sugars, nitrogen bases, pigment and fats**.
- **Analysis of meteorite content also revealed similar compounds indicating that similar processes are occurring elsewhere in space.** With this limited evidence, chemical evolution was more or less accepted.

- The **first non-cellular forms** of life could have originated **3 billion years** back. It would have been giant molecules (RNA, Protein, Polysaccharides, etc.).

- The first cellular form of life did not possibly originate till about **2000 million years ago**. These were probably single-cells. All life forms were in water environment only. This version of a biogenesis, i.e., the first form of life arose slowly through evolutionary forces from non-living molecules is accepted by majority.



Diagrammatic representation of Miller's experiment

Evidences of evolution.

1. Comparative anatomy and morphology

Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago. Such similarities can be interpreted to understand **whether common ancestors were shared or not.**

a)Homologous organs

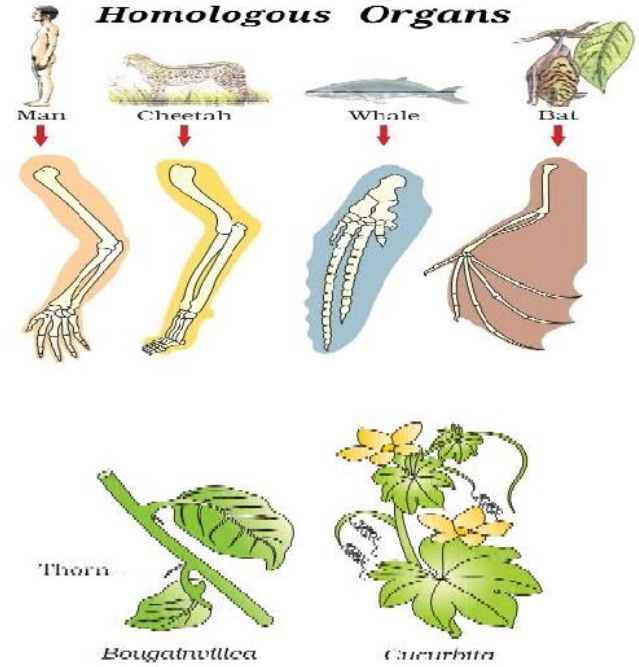
Homologus organs are organs having **same structure** and origin **but different functions**. This phenomenon is called **homology**. such organs are developed due to **divergent evolution**.

Eg:1) whales, bats, Cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs

Though these forelimbs perform different functions in these animals, they have similar anatomical structure – all of them have humerus, radius, ulna, carpals, metacarpals and phalanges in their forelimbs. Hence, in these animals, the same structure developed along different directions **due to adaptations** to **different needs**. This is **divergent evolution** and these structures are **homologous**

Eg;2) the thorn and tendrils of *Bougainvillea* and *Cucurbita* represent homology

Eg;3) vertebrate hearts or brains



b) Analogous organ

Organs having **same function** but different structure and origin. This phenomenon is called Analogy. Such organs are developed due to **Convergent evolution**.

Eg;1) Wings of butterfly and of birds look alike. They are not anatomically similar structures though they perform similar functions. – here different structures evolving for the same function and hence having similarity

Eg;2) the eye of the octopus and of mammals

Eg;3) the flippers of Penguins and Dolphins.

Eg;4) Sweet potato (root modification) and potato (stem modification)

- So one can say that it is **the similar habitat** that has resulted in selection of similar adaptive features in **different groups** of organisms but toward the same function. It results in the formation of Convergent evolution

3. Biochemical evidence

Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry.

4. Molecular evidence

Similarity of organism at the molecular level indicate phylogenetic (Evolutionary history) relationship. Human DNA differs in only 1.8% of its bp from chimpanzee DNA and there is no difference between two in the amino acid sequence for protein cytochrome C. Similarly molecular structure of **actin and tubulin** protein in all animal point their common ancestory.

A common **genetic code** is overhelming evidence that all organisms are related

5.Embryological evidence

It is proposed by **Earnst Heckel**. According to his observation certain features are common to all vertebrates during their embryological stage. It is absent in their adult (Ontogeny repeats phylogeny/ re capitulation theory)

Eg: appearance of **vestigial gill slit** behind the head during embryological development in all vertebrates. But it is functional only in fishes

This observation was disproved by Von Baer. He noted that embryos never pass through the adult stage of other animal.

Horticulutre :The art or practice of garden cultivation and management

Industrial Melanism

- Interesting observation supporting evolution by natural selection comes from **England**.
- In a collection of **moths** made in **1850**s, i.e., before industrialisation set in, it was observed that there were **more white-winged moths on trees than dark-winged** or melanised moths.
- However, in the collection carried out from the same area, but after industrialisation, i.e., in **1920**, there were more dark-winged moths in the same area, i.e., the proportion was reversed.
- The explanation put forth for this observation was that 'predators will spot a moth against a contrasting background'. During post industrialization period, the **tree trunks became dark due to industrial smoke and soots.** Under this condition the white-winged moth did not survive due to predators, dark-winged or melanised moth survived**.**
- **Before industrialisation set in, thick growth of almost white-coloured lichen covered the trees** - in that background the white winged moth survived but the dark-coloured moth were picked out by predators. **the lichens can be used as industrial pollution indicators** They will not grow in areas that are polluted. Hence, moths that were able to camouflage themselves, i.e., hide in the background, survived. This understanding is supported by the fact that in areas where industrialisation did not occur e.g., in rural areas, the count of melanic moths was low.
- **This showed that in a mixed population, those that can better-adapt, survive and increase in population size**
- **Branching descent and natural selection are the two key concepts of Darwinian Theory of Evolution**

Types of Natural selection

a)Stabilsing selection/Normalizing selection

Here more individuals acquire mean character value. This occurs when the environment doesnot change. Fossil evidence shows that , many species remain unchanged

for long period of geological time. One of the most stable environment on earth is the deep sea.

Eg: Birth weight of human. The heaviest and lightest babies have the highest mortality

b)Directional selection

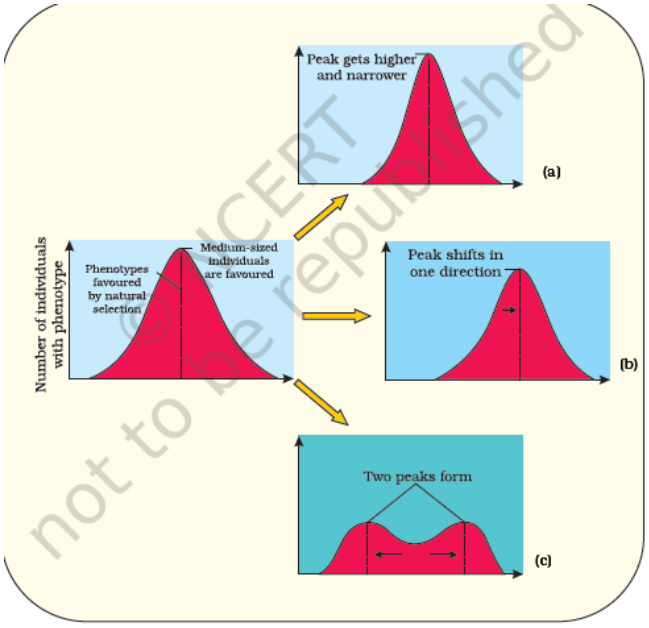
Here more individuals acquire value other than the mean character are favoured

Eg:Industrial melansim

c)Disruptive selection

Here more individuals acquire peripheral character value at both ends of the distribution curve

Eg: adaptive radiation



Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive

HARDY-WEINBERG PRINCIPLE

- Proposed by G.H Hardy and Wilhelm Weinerg.
- This principle says that allele frequencies in a population are stable and is constant from generation to generation.
- **The gene pool (total genes and their alleles in a population) remains a constant**. This is called genetic equilibrium.

Sum total of all the allelic frequencies is 1.

Disturbance in genetic equilibrium, or Hardy-Weinberg equilibrium, i.e., change of frequency of alleles in a population would then be interpreted as **resulting in evolution**

$$(p + q)^2 = p^2 + 2pq + q^2 = 1$$

Where:

p = the frequency of allele A
q = the frequency of allele a
p^2 = the frequency of individual AA
q^2 = the frequency of individual aa
2pq = the frequency of individual Aa

Five factors are known to affect Hardy Weinberg equilibrium. These are

i) Gene migration or gene flow,
ii) Genetic drift,
iii) Mutation,
iv) Genetic recombination and
v) Natural selection.

✓ When migration of a section of population to another place and population occurs, gene frequencies change in the original as well as in the new population. New genes/alleles are added to the new population and these are lost from the old population. There would be a gene flow if this gene migration, happens multiple times.

✓ Change in gene frequency occurs by **chance**, it is called **genetic drift.**

(c) Sixteen percent of the population of Europe is Rhesus negative. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be heterozygous for the Rhesus gene. Show your working. (2)

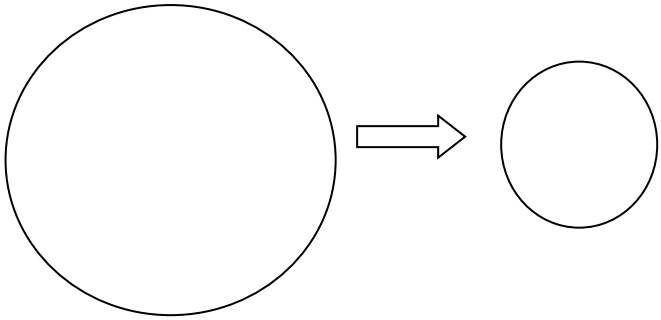
$$q^2 = \frac{16}{100}$$

$$q = \sqrt{0.16} = 0.4$$

$$p = 1 - 0.4 = 0.6$$

$$2pq = \text{heterozygotes} = 2 \times 0.6 \times 0.4 = 48\ \%$$

✓ The **founder effect** is change in allele frequency that occurs when a new population is established by a very small number of individuals from a larger population. Here the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and the effect is called **founder effect**.



ORIGIN AND EVOLUTION OF MAN

Ape→ Drypithecus → Ramapithecus → Australopithecus→ *Homo habilis* → *Homo erectus* → Neanderthal man→*Homo sapiens*