Evolution

Evolution: The process of gradual modification of simpler forms into the present complex forms over millions of years is called evolution.

Origin of life: A scientific theory called the big bang theory explains that an unimaginable large explosion created the universe.

- As the universe expanded and cooled, the temperature came down and materials condensed under the influence of gravitation to form the present day galaxy.
- Our galaxy is called the Milky Way, formed 4.5 billion years back.
- Water vapour, methane, carbon dioxide and ammonia released from molten mass covered the surface.
- The UV rays from the sun broke up water into Hydrogen and Oxygen and the lighter H_2
- Oxygen combined with ammonia and methane to form water, CO_2 and others.
- The ozone layer was formed, as it cooled, the water vapor fell as rain, to fill all the depressions and form oceans.
- Life appeared 500 million years after the formation of earth, i.e., almost four billion years back.

Evolution of life forms– a theory: Conventional religious literature reveals about the theory of special creation based on three connotations–

1) All living organisms were created as such.

2) The diversity in all organisms has always the same since creation and will be the same in future.
3) Earth is about 4000 years old.

All the ideas were challenged during the 19th century.

- Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also life forms that existed millions of years ago.
- Darwin' s theory of natural selection is based on the fact that those who are better fit in an environment, leaves more progeny than others and the progeny will survive more hence are selected by nature which he implied as a mechanism of evolution.

- Alfred Wallace stated that all the existing life forms share similarities and share some common ancestors which are present at different periods in the history of earth.
- The geological history of earth closely correlates with the biological history of earth and a final conclusion is that earth is not thousand years old as was thought, but millions of years old.

Evidences for evolution:-

➢ Paleontological evidence: Paleontology is the study of fossils.

- Fossils are remains of hard parts of life forms lived in the past but found in rocks or sediments.
- Different aged rock sediments contain fossils of different life forms that probably died during the formation of the particular sediment which represent extinct organisms.

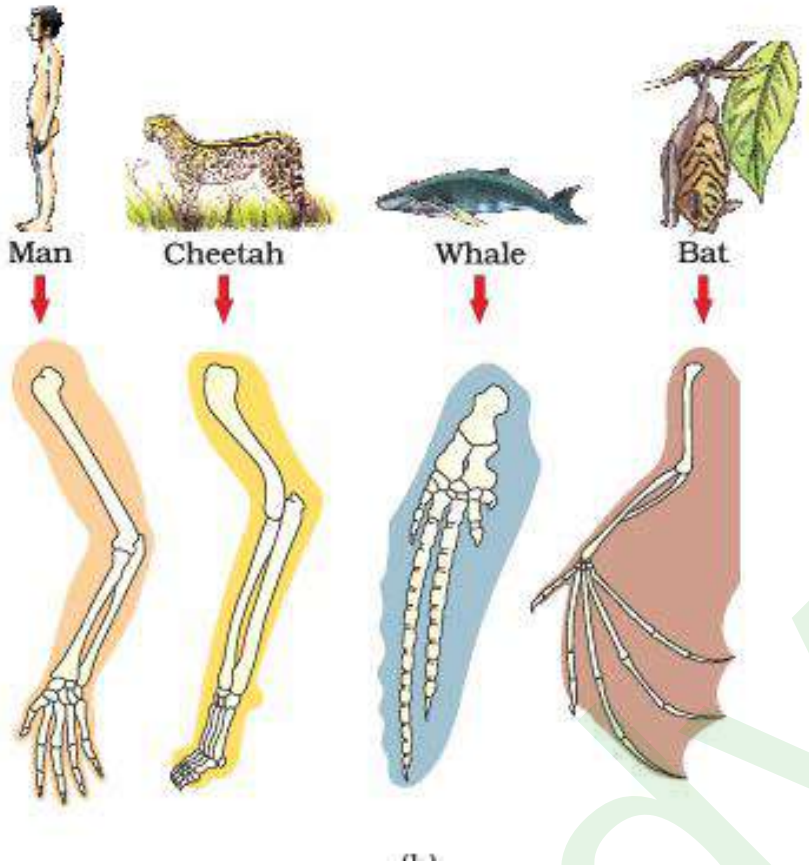
- A study of fossils in different sedimentary layers indicates the geological period in which the organisms existed. The study showed that life forms varied over time and certain life forms are restricted to certain geological time spans.
- New forms of life have arisen at different times in the history of earth.

➢ **Comparative anatomy and morphology:** This shows similarities and differences among organisms of today and those that existed years ago.

❖ **Homologous organs:** The organs whose structure or origin is same but functionally different.

Example– i) Vertebrate hearts or brains.

- ii) In plants, the thorns and tendrils of Bougainvillea and Cucurbita.
- iii) The forelimbs of whale, bats, cat and human share similarities in the pattern of forelimb bones.



- All the animals have similar anatomical structure in their fore limb bones such as humerus, radius, ulna, carpals, metacarpals and phalanges but they perform different functions.
- The same structure developed along different directions due to adaptations to different needs.
- Homology is based on divergent evolution.
- Homology indicates common ancestry.

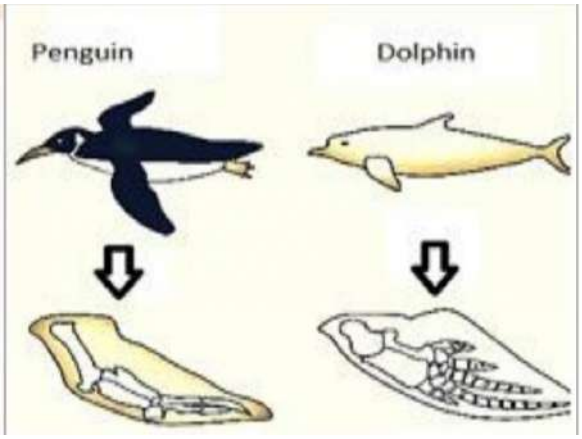
❖ **Analogous organs:** The organs whose structure or origin is not similar but functionally active are called analogous organs.

Example– i) The wings of birds and butterflies perform similar functions.

ii) Eye of octopus and mammals.

iii) The flippers of penguins and dolphins.

iv) In plants, sweet potato and potato.



- Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry.
- It is the similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but towards the same function.

➢ **Natural selection–**

❖ **Industrial melanism:** Before industrialization, in Great Britain it was observed that there were more white winged moths on trees than dark or melanized moth.

- After industrialization, there were more dark– winged moths.
- Before industrialization, almost white– coloured lichen covered the tree trunks and in that background the white– winged moths survived but the dark coloured moths were eaten by predators.
- During the post industrialization period, the tree trunks became dark due to industrial smoke and under such conditions the white– winged moths did not survive due to predators and the dark– winged moths' survived hence industrial melanism supports evolution by natural selection. Fig. flippers of whale and bat

❖ **Antibiotic resistant bacteria:** By employing antibiotics to bacterial colonies, the colonies sensitive to penicillin died, whereas the others that were resistant to penicillin survived.

- Probably the bacteria that survived underwent a chance mutation there by possessing a gene that contributed to their resistance to the penicillin drug and hence selected by nature, in course of time was considered as fittest and established as a new species.

Adaptive radiation: The evolution of different species in a given geographical area starting from its original character and radiating to other geographical area is called adaptive radiation.

- During Darwin' s journey to Galapagos Island he observed small black birds called Darwin' s Finches.
- The finches were diverse in their food habitats , from seed eating features to many other forms with altered beaks that arose enabling them to become insectivorous and vegetarian finches.

➢ **Australian marsupials:** A number of marsupials, each different from the other evolved from an ancestral stock but all within the Australian continent.

Examples– Tasmanian wolf, tiger cat, marsupial rat, kangaroo, wombat, sugar glider etc.

➢ **Placental mammals:** In Australia adaptive radiation is exhibited where placental mammals are evolved into varieties each of which appears to be similar to a corresponding marsupials.
Example– placental wolf and Tasmanian wolf marsupial.

Biological evolution:–

➢ **Darwin' s theory of evolution:** The essence of Darwinian Theory about evolution is natural selection.

- Theory of natural selection states that individuals that are less adapted to the environment are eliminated and selecting those better adapted by nature.
- The rate of appearance of new forms is linked to the life cycle or the life span.
- There must be a genetic basis for getting selected and to evolve.
- Some organisms are better adapted to survive in an otherwise hostile environment.
- Adaptive ability is inherited and it has a genetic basis.
- Nature selects for fitness.
- Fitness is the end result of the ability to adapt and get selected by nature. Fitness is based on characteristics which are inherited.
- Branching descent and natural selection are the two key concept of Darwinian Theory of evolution.

➢ **Lamarck' s theory of evolution:** Lamarck had said that evolution of life forms had occurred but driven by use and disuse of organs.

- Lamarck gave the example of Giraffes who in an attempt to forage leaves on tall trees had to adapt by elongation of their necks and they passed on this acquired character of elongated neck to succeeding generations.
- Giraffe, slowly over the years, came to acquire long necks.

Mechanism of evolution: Evolution needs variations. Origin of variation and reason for speciation is inheritable factors influencing phenotype.

- Mendel explained the influence of inheritable actors on phenotype.
- Darwin mentioned that natural selection is the reason for evolution.
- Hugo de Vries based on his work on evening primrose believe that mutation causes evolution.
- Evolution for Darwin was gradual while de Vries believed that mutation caused speciation and hence called it as Saltation.

Hardy– Weinberg principle: It is also called genetic equilibrium.

- Gene frequency remains constant from generation to generation and is stable, this is called genetic equilibrium.
- Sum total of allelic frequencies is 1 and individual frequencies can be named as p,q etc. hence, $p+q=1$, where P and q represent the frequency of allele A and allele a.

- In diploids, the frequency of AA is P^2, aa is q^2 and of Aa is 2pq. Hence, the formula is $P^2 + 2pq + q^2$ which is a binomial expansion of $(p+q)^2$ which can be applied to any population to find out the gene frequency.
- When frequency measured differs from expected value, the difference indicates the extent of evolutionary change.

Factors affecting Hardy– Weinberg principle are:–

➢ **Gene flow:** The transfer of section of population to another place resulting in a change in gene frequencies in both old and new population is called gene flow.

• New genes and alleles are added to new population which are genetically different but can interbreed.

➢ **Genetic drift:** The random change in gene frequency occurs by chance is called genetic drift.

• Sometimes, the change in allelic frequency is so different in the new population, that they become a different species and the original drifted population becomes founders hence the effect is called founder effect.

➢ **Mutation:** The spontaneous change in the genetic makeup of an individual is called mutation.

• Pre– existing advantageous mutations when selected will result in observation of new phenotypes and over few generations this would result in Speciation.

➢ **Genetic recombination:** Exchange of genes between non sister chromatids of homologous chromosomes during gametogenesis is called genetic recombination.

• Variation due to recombination during gametogenesis, or due to gene flow or genetic drift results in changed frequency of genes and alleles in future generation.

➢ **Natural selection:** The process by which better adapted individuals with useful variations are selected by nature and leave greater number of progenies is called natural selection.

Natural selection can lead to–

- Stabilizing selection– here, more individuals acquire mean character value.
- Directional change – here, more individuals acquire value other than the mean character value.
- Disruptive selection– here, more individuals acquire peripheral character value at both ends of the distribution curve.

A brief account of evolution: About 2000 million years ago (mya) the first cellular forms of life appeared on earth.

- Some cellular forms had the ability to release O2 and slowly single cell organisms became multicellular organisms.
- By the time of 500 mya, invertebrates were formed and active. Jawless fish probably evolved around 350 mya. Sea weeds and few plants existed probably around 320 mya.
- First organisms that invaded land were plants.
- Fish with stout and strong fins could move on land and go back to water was about 350 mya.
- In 1938, a lobe finned fish caught in South Africa happened to be a Coelacanth which evolved into first amphibians that lived on both land and water and these

were the ancestors of modern day frogs and salamanders.

- The amphibians evolved into reptiles which lay thick shelled eggs which do not dry up in sun.
- The modern day descendants of reptiles are the turtles, tortoises and crocodiles.
- In the next 200 million years or so, reptiles of different shapes and sizes dominated on earth.
- Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly.
- Some of the reptiles went back into water to evolve into fish like reptiles around 200 mya.
- The land reptiles were the dinosaurs and the biggest of them is Tyrannosaurus rex was about 20 feet in height and had huge fearsome dagger like teeth.
- About 65 mya, the dinosaurs suddenly disappeared from the earth, some of them evolved into birds or might be killed by the climatic changes.
- The first mammals were like shrews and their fossils were small sized.
- Mammals were viviparous and protected their unborn young inside the mother' s body.
- Mammals dominated the earth when the population of reptiles came down.

- In South America there were mammals resembling horse, hippopotamus, bear, rabbit, etc.

- Due to continental drift, when South America joined North America, these animals were overridden by North America.
- Due to the same continental drift pouched mammals of Australia survived because of lack of competition from any other mammal.
- Some mammals live wholly in water.
- Examples– Whales, dolphins, seals and sea cows.

Origin and evolution of man: The stages of evolution of man are–

1) Dryopithecus and Ramapithecus: About 15 mya, primates called Dryopithecus and Ramapithecus were existing.

- They were hairy and walked like gorillas and chimpanzees.
- Ramapithecus was more man–like while Dryopithecus was more ape–like.
- Few fossils of man–like bones have been discovered in Ethiopia and Tanzania.
- These revealed hominid features leading to the belief that about 3–4 mya, man–like primates walked in eastern Africa.

2) Australopithecus: About two mya, Australopithecines probably lived in East African grasslands.

- They hunted with stone weapons but essentially ate fruit.
- Some of the bones among the bones discovered were different.

- They were intermediate between apes and man.

3) Homo habilis: The brain capacities were between 650-800cc.

- They probably did not eat meat.
- They were the makers of stone tools.

4) Homo erectus: About 1.5 mya, Homo erectus arose.

- Homo erectus had a large brain around 900cc.
- Homo erectus probably ate meat.

5) Neanderthal man: The Neanderthal man with a brain size of 1400cc lived in near east and central Asia between 1,00,000- 40,000 years back.

- They used hides to protect their body and buried their dead.

6) Homo sapiens or modern man: Arose in Africa and moved across continents.

- During ice age between 75,000-10,000 years ago modern Homo sapiens arose.
- Pre-historic cave art developed about 18,000 years ago.
- Agriculture came around 10,000 years back and human settlements started.