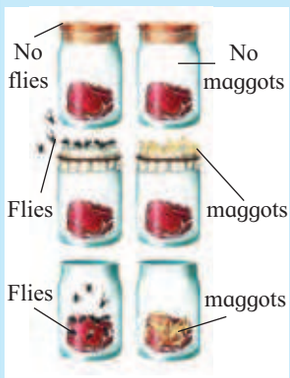
5 Origin and Evolution of life

Can you recall?

1. What is evolution?
2. Where was first life formed?
3. Why are many species of plants and animals getting (becoming) extinct?
4. The Lamarck's theory of inheritance of acquired characters.
5. What is Speciation?

Observe and Discuss

1. **Redi's Experiment**
2. **Louis Pasteur's Experiment**



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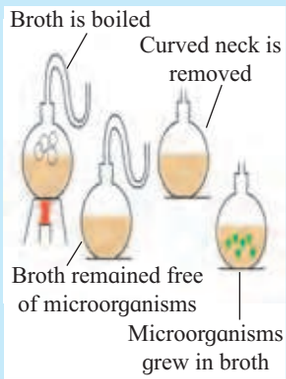


2.

5.1 Origin of life : (Protobiogenesis)

The living matter shows attributes or characters like responsiveness, growth, metabolism, energy transformations and reproduction.

As far as origin of life is considered, it has remained an enigma for intellectuals at all times. Despite of advancements in various fields like biochemistry, astrobioloy, geography, molecular biology, etc. scientists are unable to ascertain the truth. Various theories and hypotheses have been proposed to find the probable answer to this question.

a. Theory of special creation :

It is the oldest theory and is based on religious belief without any scientific proof. It states that all living organisms are created by a super-natural power.

b. Cosmozoic theory/Theory of Panspermia:

This theory advocates that life did not originate on the planet Earth. It may have descended to the earth from other planets in the form of spores or micro-organisms, called cosmozoa/panspermia. Recently, NASA has reported fossils of bacteria-like organisms on a piece of Martian rock recovered from Antarctica.This theory could not explain the origin of life on the other planets hence not accepted.

c. Theory of spontaneous generation (Abiogenesis) :

According to this theory, life originated from non-living (inanimate) material spontaneously. This theory was disproved by Louis Pasteur.

d. Theory of biogenesis :

According to this theory, living organisms are always produced from pre-existing living forms, by process called reproduction.

Theory of biogenesis however could not explain origin of first life on earth but could explain only the continuity of life.

5.2 Chemical Evolution of Life (Self assembly theory of origin of life) :

According to this theory, life originated on earth by combinations of several chemicals through constant chemical reactions over a long period of time. This theory is also called self assembly theory of origin of life or biochemical origin of life.

This theory was first formulated by Haeckel but later developed by the Russian scientist Alexander I. Oparin (1924) and British biologist J. B. S. Haldane (1929). The process of chemical evolution can be divided into following steps :

a. Origin of Earth and Primitive atmosphere:

The origin of universe was explained by the Big-Bang theory of Georges Lemaitre (1931). According to this theory the Universe originated about 20 billion years ago by a single huge titanic explosion. As the universe expanded, the temperature decreased and various galaxies of solid objects were formed. Milky Way is one such galaxy of which our solar system is one small part. Earth is one of the planets of solar system and originated about 4.6 billion year ago. When formed, it was a rotating cloud of hot gases and cosmic dust called Nebula. The condensation and cooling resulted in stratification with heavier elements like nickel and iron passing to the core and lighter ones like helium, hydrogen, nitrogen, oxygen, carbon, etc. remaining on the surface. They formed the atmosphere of the earth. The primitive atmosphere of the earth was quite different from the present one and it was of a reducing type, devoid of free oxygen.

b. Formation of ammonia, water and methane:

Primitive atmosphere was very hot. As it slowly cooled, the lighter elements started to react with each other. The early atmosphere was rich in hydrogen, carbon, nitrogen and sulphur of which hydrogen being more active, it reacted with other elements to form chemicals on earth like CH_4, NH_3, H_2O and H_2S.

c. Formation of simple organic molecules :

As temperature of the earth decreased, steam condensed into water that resulted in heavy rain fall and the earth gradually cooled. Rain water got accumulated on the land to form rivers, streams, lakes, seas and oceans. The atmosphere then did not contain ozone layer and thus ultra-violet radiations reached the surface of earth directly. Under the influence of available energy sources such as ultra-violet rays, radiations, lightening and volcanic activities, the early molecules of hydrocarbons, ammonia, methane and water underwent reactions like condensation, polymerisation, oxidation and reduction. These reactions resulted in formation of simple molecules like monosaccharides, amino acids, purines, pyrimidines, fatty acids, glycerol, etc. All these simple organic molecules accumulated at the bottom of water bodies. Haldane described it as the **"hot dilute soup"** or **"primitive broth"**. It did not show any degradation due to absence of free oxygen and enzymes (non-enzymatic reducing atmosphere).

d. Formation of complex organic molecules:

The primitive broth was neutral and free from oxygen. Polymerisation took place and simple organic molecules aggregated to form new complex organic molecules like polysaccharides, fats, proteins, nucleosides and nucleotides. Polymerisation of amino acids formed **protoproteins** which later formed proteins. Formation of protein molecules is considered as landmark in the origin of life. Proteins (enzymes) accelerated the rate of other chemical reactions.

e. Formation of Nucleic acids :

Nucleotides may have been formed by the reaction between phosphoric acid, sugar and nitrogenous bases (purines and pyrimidines). Number of nucleotides join together to form nucleic acids (RNA, DNA). Nucleic acids acquired self-replicating ability which is a fundamental property of living form.

f. Formation of Protobionts or Procells :

Nucleic acids along with inorganic and organic molecules formed the first form of life called **protobionts**. Protobionts are the prebiotic chemical aggregates having some properties of living system.

Protobionts are formed due to coacervation i.e. aggregation of organic molecules. Oparin (1924) called them **coacervates** and Sidney Fox called **protenoids** or **microspheres**.

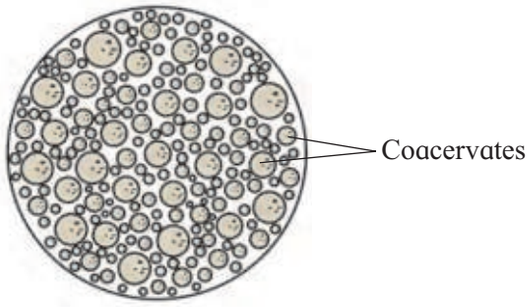


Fig. 5.1 : Coacervates

Coacervates are colloidal aggregations of hydrophobic proteins and lipids (lipoid bubbles). Coacervates grew in size by taking up material from surrounding aqueous medium. As they grew, they became thermodynamically unstable and split into smaller units, comparable to daughter cells of budding organisms. Microspheres are protenoids formed from colloidal hydrophilic complexes surrounded by water molecules. These bodies may have outer double-membrane, like primitive cell. Diffusion and osmosis may have occurred across the membrane. They were more stable than coacervates. Coacervates and microspheres were non-living colloidal aggregations of lipids and proteinoids respectively. They had some basic properties of living cells, such as growth and division. These colloidal aggregations turned into first primitive living system called **eobionts** or protocell.

g. Formation of first cell :

When RNA or DNA system developed within protocells, they look like bacteria or viruses. They regulated various metabolic activities. First cell was anaerobic, heterotrophic and obtained energy by chemoheterotrophic processes.

Urey and Miller's Experiment :

Stanley L.Miller and his teacher Harold C. Urey provided the first experimental evidence in support of chemical evolution theory of Oparin.

They designed a glass-apparatus called spark-discharge apparatus.

The apparatus (Fig. 5.2) was first sterilized and evacuated. Methane, ammonia and hydrogen gases were pumped in the proportion of 1:2:2 into the glass chamber. A tube carrying water vapour was also connected to the chamber. Lightning effect was mimicked by electric discharge carbon arc spark in the chamber. Process of evaporation and precipitation was also simulated by the use of heating mantle and condenser respectively.

The mixture of CH_4, NH_3, H_2 was exposed continuously to electric discharge for several days causing the gases to interact, after which these were condensed. The liquid collected in the U-tube turned brown. Chemical analysis of this liquid reported the presence of simple organic compounds. (urea, amino acids, lactic acid, etc). This experiment strongly supports that the simple molecules present in the earth's early atmosphere combined to form the organic building blocks of life.

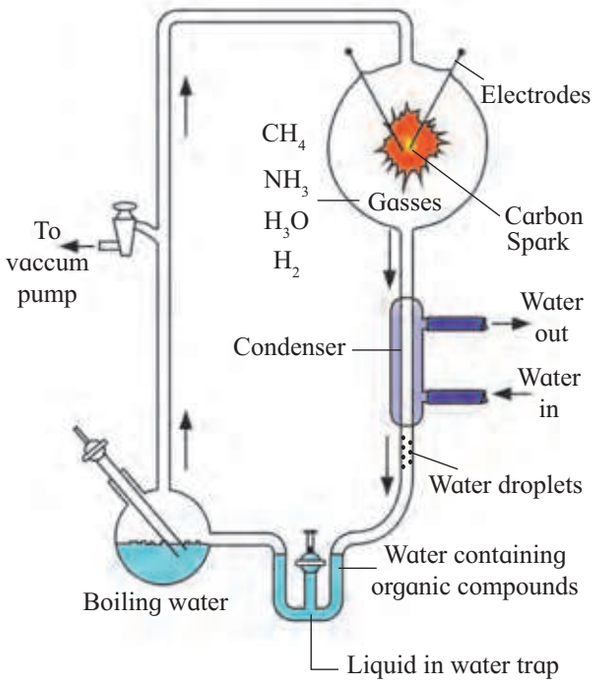


Fig. 5.2 : Urey and Miller's Experiment

RNA World Hypothesis :

Oparin-Haldane theory and Miller-Urey experiment gives us an understanding that pathway of origin of life on earth goes from non-living to living. 'Like begets like' necessitates presence of stable genetic material and cellular machinery to carry out routine activities essential for survival.

We are also aware that certain proteins which we call enzymes, catalyse the chemical reactions in the cell. It was in 1980 that Sidney Altman and Thomas Cech independently found out that RNAs can also act as biocatalysts. These catalytic RNAs are called as Ribozymes. For this discovery, Altman and Cech earned Nobel Prize in chemistry in 1989.

This discovery provided important support for RNA World hypothesis. The hypothesis suggests that early life (first) must have been based exclusively on nucleic acids, most probably RNA. It was first proposed by Carl Woese, Francis Crick and Leslie Orgel in 1960, long before discovery of ribozymes.

Fact is that RNA is found abundantly in all living cells, it is structurally related to DNA and chains of RNA can evolve or undergo mutations, replicate and catalyse reactions, all support this hypothesis.

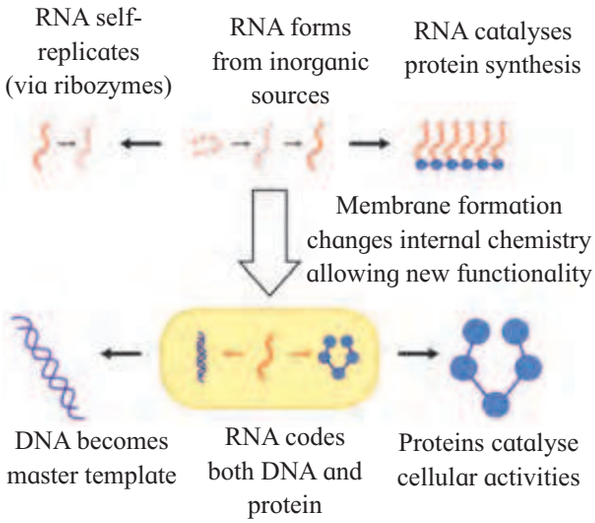


Fig. 5.3 : RNA World Hypothesis

Besides, biomolecules like Acetyl-Co-A have a nucleotide in their molecular structure. Major evidence is existence of ribosome (the protein assembly unit) in the cell. In ribosomes, translation process is catalysed by RNA. (Refer chapter- Molecular Basis of Inheritance).

These molecules might have undergone repeated replication and mutation forming varieties of RNA molecules with varying sizes and catalytic properties. Eventually they might have developed their own protein coats and machinery to survive the assembly of primitive cell. In due course, a double stranded stable structure, the DNA, might have been formed and thus continued the ongoing journey which resulted in rich biodiversity on earth.

5.3 Organic Evolution :

Evolution (Latin word, e = from; volvere = to roll) means the act of unrolling or unfolding of nature. It brings about orderly changes from one form to another. These changes result in descendants becoming different from the ancestors.

Organic evolution can be defined as slow, gradual, continuous and irreversible changes through which the present day complex forms of the life developed (or evolved) from their simple pre-existing forms.

According to **Charles Darwin**, evolution is 'descent with modification'. You have already studied Lamarck's **Theory of inheritance of acquired characters** in 10th std. According to this theory, the traits are acquired due to internal force, changes in environment, new needs and the use and disuse of organs. After several generations, it gives rise to new species.

This theory was disproved by a German biologist August Weismann, who cut the tails of many rats for several generations but could not find any change in size of tail even after

21 generations. He concluded that variations produced in somatic cells (somatoplasm) are not inherited while variations produced in germ cells (germplasm) are inherited to next generation and he proposed the **Theory of continuity of Germplasm.**

5.4 Darwinism :

Before Darwinism, several theories were proposed to explain the process of organic evolution.

Lamarck (1809) published 'Theory of origin of acquired characters' which then was ruled out.

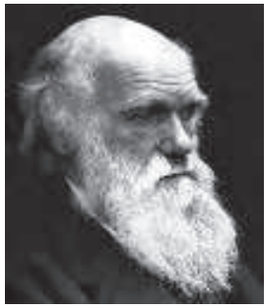


Fig. 5.4 : Charles Darwin (1809 - 1882)

Darwnism (Theory of origin of species by Natural Selection).

Charles Darwin as a naturalist travelled extensively the world over from 27th December 1831 to October 1836 and returned to England. Based on his collections of living and fossil material he published a book, ''on the origin of species by means of Natural Selection'', in 1859. Before publishing his book, he was very much influenced by C. Lyell (Geologist) who pointed out that natural forces which existed in the past are the same as those existing at present. Darwin also observed the changes in the earth's crust along the coast of South America, caused due to natural forces. He observed variety of strange plants and animals in the Galapagos islands and other nearby islands in the Archipelago in terms of variations between the tortoises and finches. Similar observations were also made by Wallace. He was also influenced by R. Malthus, an Economist, who worked on human population mentioning that the reproductive potential of humans is greater than others. This resulted in multiplication of human population without corresponding increase in the food supply. This increase lead to competition and struggle for existence of human species.

He was also influenced by plant/animal breeders who by using artificial selection, altered the characteristic of cultivated plant and domestic animals.

Darwinism is based on five main postulates:

1. **Overproduction (Prodigality of nature) -** It is the natural tendency to produce more number of progeny in geometric ratio, for perpetuation of the species. He observed prodigality potential of many species of plants and animals e.g. Salmon fish produces about 28 lakh eggs in a single season. In a span of 750 years, single pair of elephants would produce 19,000,000 elephants. However the size of given species in a given area remains relatively constant because of fluctuations that occur seasonally.
2. **Struggle for existence -** Tendency of over production leads to the struggle for existence between the members of population. The struggle is for limited supply of food or to overcome adverse environmental conditions, for a space and mate, and to escape from enemies etc.
3. **Organic variations -** The variations speak for all kinds of differences that occur in morphology, physiology, nutrition, habit, behavioural patterns etc. Darwin recognized these variations as raw material for evolution. Variations were observed among members of the same species and even in different species.
4. **Natural selection -** Organic variations can serve as evidence for some organisms that are better adapted to survive under existing environmental conditions than the others. In the struggle for existence, organisms with favourable variations are

selected by the nature while those with unfavourable variations perish. According to Darwin, the principle by which useful variations are preserved by nature, is called **'Natural Selection'**. H. Spencer named this process as **'survival of fittest'**.

5. **Origin of new species (speciation) -** As favourable variations are transmitted from generation to generation, the successive generations become better adapted to environment. Gradually these adaptations with few new modifications become fixed in the life cycle and finally give rise to a new species.

Evidences for Darwinism - (i) Evolution of long-necked Giraffe to pluck and eat more leaves from tall trees and woody climbers. This adaptation became fixed in the life for survival. The Giraffe borne tall could survive in famine heat areas. This adaptation was transmitted to their offspring. This is how, present long-necked Giraffe came to existence. (ii) Black colour peppered moths evolved gradually as new species. (iii) DDT resistance in mosquitoes : intensive DDT spraying destroyed all types of mosquitoes. However some mosquitoes developed resistance to DDT and survived the onslaught of DDT spray. Such resistant mosquitoes survived and reproduce giving rise to more resistant offspring.

Drawbacks and Objections to Darwnism -

a. He considered minute fluctuating variation as principal factors which are not heritable and not part of evolution. i.e. he was unable to distinguish between the envirnomental and hereditary variations.
b. He also did not distinguish somatic and germinal variation and considered all variations are heritable.
c. He did not explain the 'arrival of the fittest'.
d. He also did not explain the cause, origin and inheritance of variations and of vestigial organs, nor he could explain the extinction of species.
e. According to natural selection new species are formed by gradual accumulation of useful variations. If it is so, then there should be intermediate forms. But in most cases intermediate form were not recognised. Moreover, Darwinism also could not explain existence or occurrence of neutral flowers and the sterility of hybrids.

5.5 Mutation Theory :

This theory was proposed by Hugo de Vries (1901), after the rediscovery of Mendel's work (1900). He proposed this theory based on his observations on seven generations of the plant-evening primrose (*Oenothera Lamarckiana*). He found that though most of the offsprings resembled their parents in many characters, some of the offsprings show the appearance of sudden or spontaneous variation clearly different from the phenotypic expression of the parent. These sudden variations were called mutations or discontinuous variations. The variant offsprings produced variants and not normal plants i.e. these changes were inheritable. He also observed that some variants also produced more variations. He noted that these sudden changes are heritable, and proposed the **Mutation theory**.

The main features of mutation theory are :

- Mutations are large, sudden, random and discontinuous variations in a population.
- These changes are inheritable and may not be directional.
- Mutations provide the raw material for organic evolution. '
- Mutation may be useful or harmful. Useful mutations are selected by nature.
- Accumulation of these mutations over a period of time leads to the origin and establishment of new species.
- Harmful mutation may persist or get eliminated by nature.

Objections to Mutation Theory :

i. The large and discontinuous variations observed by Hugo de Vries were actually due to chromosomal aberrations whereas gene mutations usually bring about minor changes.

ii. Rate of mutation is very low as compared to the requirement of evolution.

iii. Chromosomal aberrations have little significance in evolution as they are quite unstable.

Always Remember

1. According to Darwin variations are small and directional where as mutations are large, sudden, random and directionless.
2. Darwin believed that the gradual inheritable variations over a long period of time, lead to speciation (formation of new species) while de Vries believed that mutations are the cause of speciation.
3. A single step large mutation is called saltation.

5.6 Modern Synthetic Theory of Evolution :

- It is the result of true synthesis of all biological disciplines. Studies pertaining to genetical, ecological, anatomical, geographical, palaeontological etc. were persued to explain mechanism of evolution. Also due importance was given to both mutations and natural selection.
- R. Fischer, J. B. S. Haldane, T. Dobzhansky J. Huxley, E. Mayr, Simpson, Stebbins, Fisher, Sewall Wright, Mendel, T. H. Morgan etc. are the main contributors of modern theory of evolution.
- Stebbins in his book discussed five key factors viz. gene mutations, mutations in the chromosome structure and number, genetic recombinations, natural selection and reproductive isolation. These contributed in the evolution of new species.
- All individuals of the same species constitute a population. The populations occur in small groups of 'interbreeding populations'. Such small interbreeding group of a population is referred as '**Mendelian population**'.
- The total genetic information encoded in sum total of genes in a Mendelian population is called **gene pool**. Simply, gene pool means the total number of genes of all individuals in a population. The gametes produced by individual furnish a pool of genes of next generation from which the genes will be selected.
- The migration of population effectively alter the gene pool. The gene pool also changes due to replacement of one generation by another in the Mendelian population. Thus any change in the gene pool affects population.
- Genes are arranged linearly on the chromosome and occupy a definite position (locus). According to Mendel, every gene that influences a trait has two alleles. The proportion of an allele in the gene pool, to the total number of alleles at a given locus, is called **gene frequency**.
- Modern synthetic theory comprises five main factors that are broadly divided into three main concepts - a. **genetic variations** caused due to various aspects of mutation, recombination and migration. b. **natural selection** and c. **isolation**. These help in explaining the evolution of species.

a. Genetic variations : The change in gene and gene frequencies, is known as genetic variation. Genetic variations are caused by following factors :

i. Gene Mutation : A sudden permanent heritable change is called mutation. Mutation can occur in the gene, in the chromosome morphology and in chromosome number. Mutation that occurs

within the single gene, is called **point mutation** or **gene mutation**. This leads to the change in the phenotype of the organism, causing variations.

ii. **Genetic recombination :** In sexually reproducing organisms, during gamete formation, exchange of genetic material occurs between non-sister chromatids of homologous chromosomes. This is called **crossing over**. It produces new genetic combinations which result in variation. Fertilization between opposite mating gametes leads to various recombinations resulting into the phenotypic variations causing change in the frequencies of alleles.

iii. **Gene flow :** Gene flow is movement of genes into or out of a population. Gene movement may be in the form of migration of organism, or gametes (dispersal of pollens) or segments of DNA (transformation). Gene flow also alters gene frequency causing evolutionary changes.

iv. **Genetic drift :** Any random fluctuation (alteration) in allele frequency, occurring in the natural population by pure chance, is called genetic drift. For example, when the size of a population is severely reduced due to natural disasters like earthquakes, floods, fires, etc. thus cause elimination of particular alleles from a population. Smaller populations have greater chances for genetic drift. It will result in the change in the gene frequency. Genetic drift is also an important factor for evolutionary change.

v. **Chromosomal aberrations :** The changes in chromosome number (gains and losses) and the changes in the morphological structure of chromosome/s (deletion, inversion, etc.) constitute the chromosomal aberrations. The changes in the genes arrangement (order or sequence) results in the variations. Chromosomal aberrations occur due to -

a. **Deletion :** Loss of genes from chromosome.

b. **Duplication :** Genes are repeated or doubled in number on chromosome.

c. **Inversion :** A particular segment of chromosome is broken and gets reattached to the same chromosome in an inverted position due to 180^0 twist. There is no loss or gain of gene complement of the chromosome.

d. **Translocation :** Transfer (transposition) of a part of chromosome or a set of genes to a non-homologous chromosome is called translocation. It is effected naturally by the transposons present in the cell.

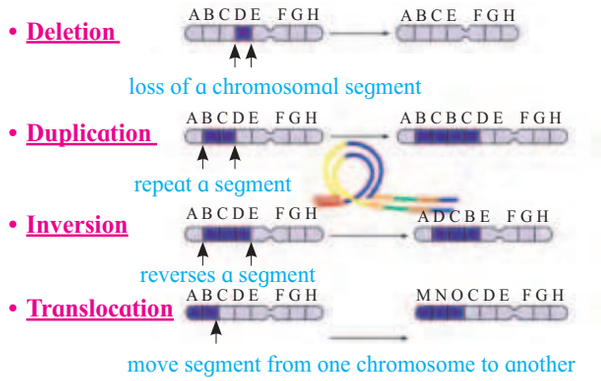


Fig. 5.5 : Chromosomal aberrations

b. Natural selection :

According to Darwin, natural selection is the main driving force behind the evolution. This holds that genetic variations rise within the population. The 'fittest' will be at the selective advantage and will be more likely to produce more offsprings than the rest, The 'fit' continues to enjoy greater survival and reproductivity. New species will eventually evolve.

Alternatively, natural selection is the process by which better adapted organisms grow and produce more number of offsprings in the population.

It brings about evolutionary changes by favouring differential reproduction of genes that bring about changes in gene frequency from one generation to next generation.

Selection against harmful mutations leads to a mutation balance, in which allele frequency of harmful recessives remain constant generation after generation.

Fig. 5.6 : Natural selection (*Biston betularia and Biston carbonaria*)

Natural selection encourages those genes or traits that assure highest degree of adaptive efficiency between population and its environment. **Industrial melanism** is one of the best example for natural selection. In Great Britain, before industrialization (1845) grey white winged moths (*Biston betularia*) were more in number than black-winged moth (*Biston carbonaria*).

These moths are nocturnal and during day time they rest on tree trunk. White-winged moth can camouflaged (hide in the background) well with the lichen-covered trees that helped them to escape from the predatory birds. on other hand, the black-winged moth resting on lichen covered tree trunks were easy victims for the predatory birds and their number was reduced. During industrial revolution, large number of industries came up in Great Britain. The industries released black sooty smoke that covered and killed the lichens growing on tree and turn the tree black due to pollution.

This change become an advantage to the black-winged moth that camoflaged well with the black tree trunks and their number increased while the white-winged moth become victims to predatory birds due to which their number reduced. Thus natural selection has resulted in the establishment of a phenotypic traits in changing the environmental conditions.

c. Isolation :

Isolation is the separation of the population of a particular species into smaller units which prevents interbreeding between them. Some barrier which prevents gene flow or exchange of genes between isolated populations, is called isolating mechanism.

Number of isolating mechanisms operate in nature and may promote divergence and speciation may occur. The isolating mechanisms are of two types namely, geographical isolation and reproductive isolation.

I. Geographical Isolation :

It is also called as physical isolation. It occurs when an original population is divided into two or more groups by geographical barriers such as river, ocean, mountain, glacier etc. These barriers prevent interbreeding between isolated groups.

The separated groups are exposed to different kinds of environmental factors and they acquire new traits by mutations. The separated populations develop distinct gene pool and they do not interbreed. Thus, new species have been formed by geographical isolation. E.g. Darwin's Finches.

II. Reproductive Isolation :

Reproductive isolations occurs due to change in genetic material, gene pool and structure of genital organs. It prevents interbreeding between population.

Types of Isolating Mechanisms :

A. Pre-mating or **pre-zygotic isolating mechanism :** This mechanism prevent fertilization and zygote formation.

i. Habitat isolation or (**Ecological isolation**) : Members of a population living in the same geographic region but occupy separate habitats so that potential mates do not meet.

ii. **Seasonal** or **temporal isolation :** Members of a population living in the same geographic region but are sexually mature at different years or different times of the year.

iii. **Ethological isolation :** Due to specific mating behaviour the members of population do not mate.

iv. **Mechanical Isolation :** Members of two population have difference in the structure of reproductive organs.

B. Post-mating or **Post-zygotic barriers :**

i. **Gamete mortality -** Gametes have a limited life span. Due to one or the other reasons, if union of the two gametes does not occur in the given time, it results in the gamete mortality.

ii. **Zygote mortality -** Here, egg is fertilized but zygote dies due to one or the other reasons.

iii. **Hybrid sterility -** Hybrids develop to maturity but become sterile due to failure of proper gametogenesis (meiosis). e.g. Mule is an intergeneric hybrid which is sterile.

Can you tell?

1. What is variation?
2. What is mutation?
3. What is gene frequency?
4. Why variations occur in population?

5.7 Mechanism of organic evolution :

One has to give the importance to the population while considering the mechanism of evolution. It is the population that evolves and not its individual members. Individual's role is to pass its genetic variation to its offspring.

The following are the basic processes which bring about evolution viz. Mutations, gene recombination, gene flow (migration), genetic drift, natural selection, isolation and speciation.

Mutations - These are permanent heritable changes in the genetic material of an organism. Mutations are already described earlier in this chapter. Gene mutations will alter the genetic make up and the gene pool.

Gene recombination - These are variation produce due to coming together of alleles during sexual reproduction. Gene recombinations occur due to random union of gametes, anaphasic separation of chromosomes and crossing over.

Gene flow - It is the transfer of gene during interbreeding of populations that are genetically different. As explained earlier in this chapter gene flow is due to emigration and immigration. Its brings about changes in the allele frequency.

Genetic drift - Any alteration in allele frequency of a natural population by chance, is called **genetic drift.** Concept of genetic drift was first given by Sewall Wright, hence, called **Sewall Wright effect**. For example, elimination of a particular allele from a population due to events like accidental death prior to mating of the organism. Genetic drifts are random or directionless. The effect of genetic drift is more significant in small population than in large population. Due to genetic drift, some alleles of a population are lost or reduced by chance and some others may be increased. Sometimes, a few individuals become isolated from the large population and they produce a small new population in new geographical area. The allele frequency of the new population become suddenly different. The original members that drifted and established the new population become 'founders' and the effect is called **founder effect**.

The bottle neck effect is a type of genetic drift is seen when much of a population is killed due to a natural disaster (sunami, floods, tornedo, disease epidemic, etc.) and only a few individuals are left to begin a new population.

Natural selection - It is a process by which better adapted individuals with useful variations are selected by nature and leave greater or more number of progenies (Differential reproduction).

Type of Natural selection :

a. Stabilizing selection : (Balancing selection)

1. Here more individuals of a population acquire a mean character value.
2. It tends to favour the intermediate forms and eliminate both the phenotypic extreme. For e.g. More number of infants with intermediate weight survive better as compared to those who are over-weight or under-weight.
3. It reduces variations.
4. It does not lead to evolutionary change but tends to maintain phenotypic stability within the population, therefore, it is described as stabilizing selection.
5. Genetically stabilizing selection represents a situation where a population is adapted to its environment.

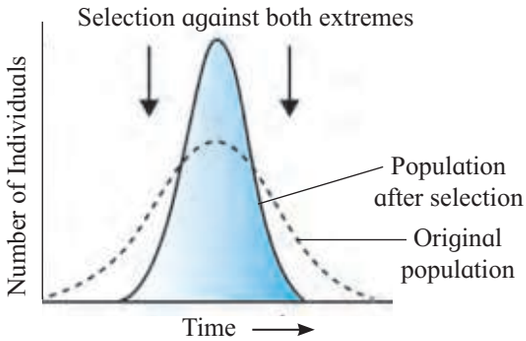


Fig. 5.7 : Stabilising selection

b. Directional selection :

1. In this type, more individuals acquire a value other than the mean character value.
2. Naural selection acts to eliminate one of the extremes of the phenotypic range and favour the other. e.g. systematic elimination of homozygous recessives.
3. Directional selection operates for many generations, it results in an evolutionary trend within a population and shifting of the peak in one direction.
4. Example - Industrial melanism, DDT resistant mosquito etc.

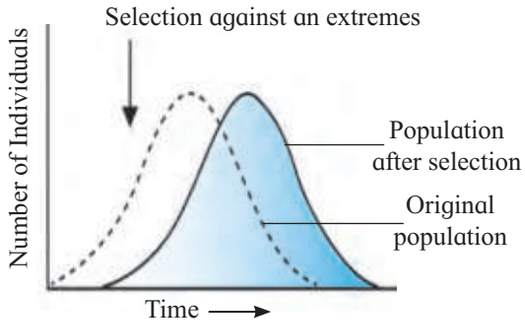


Fig. 5.8 : Directional selection

c. Disruptive Natural selection :

1. Here more number of individuals acquire peripheral character value at both ends of the distribution curve.
2. Nature selects extreme phenotypes and eliminates intermediate. Hence two peaks are formed in distribution of traits.
3. This kind of selection is rare.
4. It ensures the effect on the entire genepool of a population, considering all mating types or systems.
5. Example - It was observed in the different beak size of African seed cracker finches. The birds have different size of beak and they feed on seeds. The avilable seeds were of two kinds small and large sized seeds. Large beak sized birds feed on large seeds while small beak sized birds feed on small seeds and their number was increased. Intermediate beak sized birds are unable to feed on either type of seeds so their population was decreased gradually and then eliminated by natural selection.

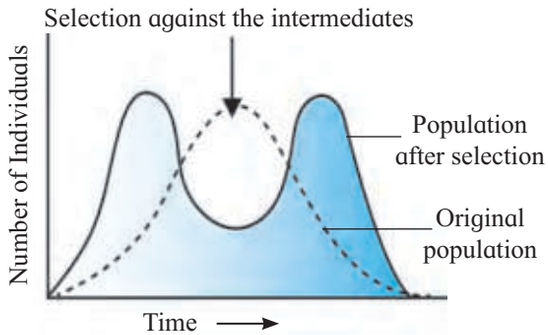


Fig. 5.9 : Disruptive selection

Isolation - It is separation of a single interbreeding population into subunits. Isolation restricts gene flow between discrete (non-continuous) population due to different barriers like geographical barriers. (This part is already explained in detail earlier in this chapter)

Speciation - The sub units of single interbreeding population due to the geographical barriers like river, mountains, desert, sea etc. become isolated in such a way that their interbreeding is prevented. This will finally lead to origin of new species (i.e. speciation). (Discussed in detail ahead in this chapter).

5.8 Hardy-Weinberg's principle :

It is also known as Hardy-Weinberg's equilibrium law. The law states that 'at equilibrium point both the gene (allele) frequency and geneotypic frequency remain constant from generation to generation'. It occurs only in the diploid, sexually reproducing, large, free interbreeding population in which mating is random and no selection or other factors are present for changing the allele frequency. e.g. A single locus has two alleles (A and a). The frequencies of these allele are p and q respectively. The allele frequency for any locus is always one. i.e. p + q = 1. The genotypic frequencies of both the alleles are represented by $(p + q)^2 = 1$. The binomial expansion of this is $P^2 + 2pq + q^2 = 1$ i.e. AA=p^2, aa=q^2 and for 2Aa= 2pq.

Hence $p^2 + 2pq + q^2 = 1$. This is a binomial. expansion of $(p + q)^2$.

This can be explained by punnett square as follows :

		Hybrid A a	
		A (p)	a (q)
Hybrid Aa	A (p)	AA (p^2)	Aa (pq)
	a (q)	Aa (pq)	aa (q^2)

Like allele frequency, the genotypic frequencies together are also equal to 1.

i.e. AA + 2Aa + aa = 1

There are few factors such as gene migration (gene flow), genetic drift, mutation, genetic recombinations, natural selection, non-random mating, etc. which affect or change the Hardy-Weinberg equilibrilium,

If these factors do not occur in the population, then population is genetically stable or non evolving population.

Can you tell?

In which conditions the gene frequency of a population will remain constant?

5.9 Adaptive Radiation :

The process of evolution which results in transformation of original species to many different varieties, is called, adaptive radiation.

Darwin's Finches is one of the best example of adaptive radiation. During his visit to Galapagos Islands, Charles Darwin also noticed a variety of small birds. These birds are called Darwin's finches.

Fig. 5.10 : Darwin's finches

Darwin concluded that the American main land species of bird was the original one from which they migrated to the different islands of Galpagos. They adapted to the different environmental conditions of these islands. From original seed eating features many other forms with altered beaks evolved into insectivorous features.

Another example of adaptive radiation is Australian Marsupials. In Australia, there are many marsupial mammals who evolved from common ancestor.

Can you tell?

1. What is carbon dating and how does it work ?
2. What is fossil ?
3. What are Homologous organs ?
4. What is Embryology ?

5.10 Evidences of organic evolution :

The theory of organic evolution states that the present day complex organisms have originated from earlier simpler forms of life.

The process of evolution is supported by evidences provided by various branches of biology such as : Palaeontology, comparative anatomy, embryology and molecular biology.

A. Palaeontology : The study of ancient life with help of fossils is called palaeontology. Fossils are the dead remains of plants and animals that lived in past in various geological layers.

- The study of fossils provides the most convincing and direct evidence of evolution.
- Fossils are formed in sedimentary rocks, amber (yellowish fossils resin), ice, peat bogs etc.
- During fossilization, the primitive forms of organisms occupy the older, lower layers and the advanced forms occupy the upper, more recent layers of the earth.

Types of fossils :

1. **Actual remains :** These are most common type of fossils. The plants, animals and human bodies got embedded in permafrost of arctic or alpine snow remain preserved in the actual state, e.g. Wooly Mammoth in Siberia. Amber or hardened resin contains preserved bodies of many insects and arthropods.
2. **Moulds :** These are the hardened encasements formed in the outer parts of organic remains which later decayed leaving cavities. Body parts of plants or animals later decays but the impression still remains and becomes permanent. For example Foot – prints are formed in this manner.
3. **Cast :** They are hardened pieces of mineral matter deposited in the cavities of moulds.
4. **Compressions :** Internal structure is absent but a thin carbon film indicates the outline of external features.

Significance of Palaeontology :

1. It is useful in reconstruction of phylogeny.
2. It helps in studying various forms and structures of extinct animals.
3. It provides record of missing link between two groups of organsims.
4. It helps in the study of habits of extinct organisms.
5. Palaeontology provides the following types of evidences.

Connecting link (missing link) :

These are fossil forms transitional or intermediate between two groups of organisms. They show shows some characters akin to both the groups. Thus it indicate the evolutionary line *Seymouria* (between amphibians and reptiles) and *Archaeopteryx* (between reptiles and birds).

***Archaeopteryx lithographica* :**

It is fossilized crow size toothed bird found from jurassic rocks in Germany. It is known as missing link between reptiles and birds because it shows characters of both.

Reptilian characters :

1. Presence of long tail, claws and scales on the body.
2. Single headed ribs.
3. Abdominal ribs are present which look like ribs of crocodile.
4. Jaws with homodont teeth.

5. Sternum without keel.
6. Bones are solid (nonpneumatic).
7. Hind limbs had four clawed digits.

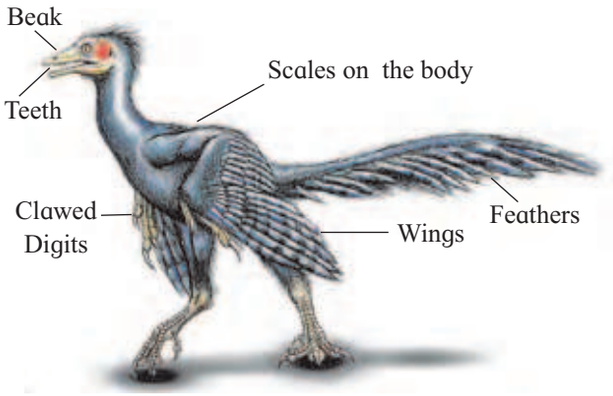


Fig. 5.11 : *Archaeopteryx*

Avian characters :

1. Feathery exoskeleton.
2. Forelimbs are modified into wings.
3. Jaws are modified into beak.
4. Skull bone is completely fused.
5. Large rounded cranium.
6. Cranium with large orbits and a single condyle.
7. Limb bones are bird like.
8. Hind limbs with four toes first toe is opposible.

Thus from the above study it is very clear that birds evolved from reptiles. Huxley justified this by calling **birds** as **glorified reptiles**.

Activity :

Complete the following chart.

Animals	Connecting link between
1. Balanoglossus	.....
2.	annelida and arthropoda
3. Lung fishes	.....
4.	reptiles and mammals
5. Seymouria	.....
6. Ichthyostega	fishes and amphibia

Do you know ?

First fossil of *Archaeopteryx* was found in Jurassic rocks of Bavaria. It was discovered in 1861 and preserved in British museum by Andreas Wanger.

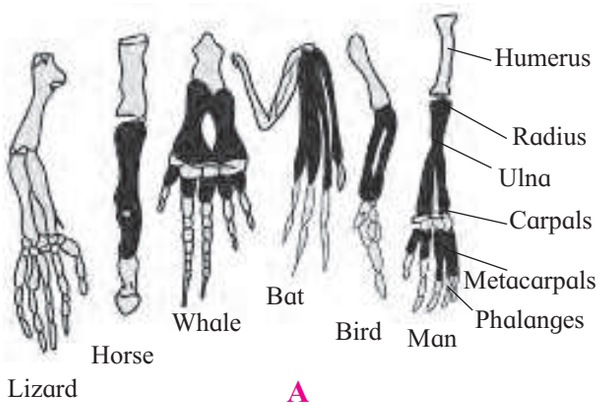
The second specimen found in 1877, known as *Archaeornis*, is kept in the Berlin museum.

B. Morphology : Morphology deals with study of external structures while, anatomy deals with study of internal structures. From comparative study of morphology and anatomy we can understand the evolutionary aspects in the form of homologous, analogous and vestigeal organs.

a. Homologous organs : Homologous organs are those organs, which are structurally similar but perform different functions.

For example :

1. Forelimbs of vertebrates such as lizzard, bird, bat, horse, whale and man,



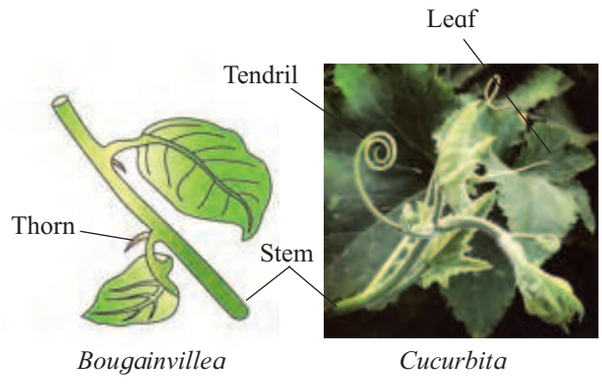


Fig. 5.12 : Homologous organs

all of them have humerus, radius-ulna, carpals, metacarpals and phalanges in their forelimbs. Forelimbs of these vertebrates are structurally similar but perform different functions.

2. Vertebrate heart and brain.
3. In plants, thorns of *Bougainvillea* and tendrils of *Cucurbita* represent homology. Thorns of Bael and tendrils of passion flower are homologous.

The structural similarities between the homologous organs indicates that they have a common ancestry.

Differences in homologous organs are examples of divergent evolution or adaptive radiation.

b. Analogous organs : Analogous organs are those which are structurally dissimilar but functionally similar. These organs have external superficial similarity due to similar functions but they are different anatomically.

For e.g. wings of butterfly (insects) and of birds look superficially alike but they are no anatomically similar structures though they perform similar functions.

Other examples of analogous organs.

1. Eye of the octopus (mollusca) and of mammals. They differ in their retinal position, structure of lens and origin of different eye parts.
2. The flippers of penguins (birds) and dolphins (mammals).
3. Sweet potato (root modification) and potato (stem modification) store food in form of starch.
4. Terminal leaflets of pea and apical bud in *vitis* are modified into tendrils.

Analogous organs leads to convergent evolution i.e. different organisms shows same superficial structural similarities due to similar functions or habitat. These organs do not help to trace the common ancestry. Thus analogous

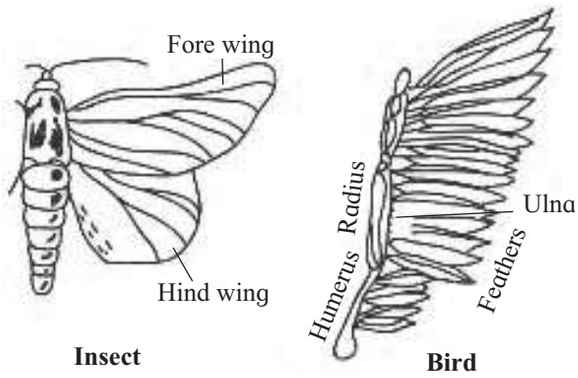


Fig. 5.13 : Analogous organs

organs do not have significant role in evolution.

c. Vestigeal organs : (Rudimentary organs)

Vestigeal organs are imperfectly developed and non-functional, degenerate structures which were functional in some related and other animals or in ancestors. The vestigeal organs are no longer required by the organism but indicate the relationship with those organisms where these organs are fully developed.

Examples : Human beings show some vestigeal organs like -

1. Presence of vestigeal nictitating membranes.
2. Presence of wisdom teeth (third molars).
3. Coccyx (tail bone) : It is greatly reduced in man since the tail is of no use due to erect posture.

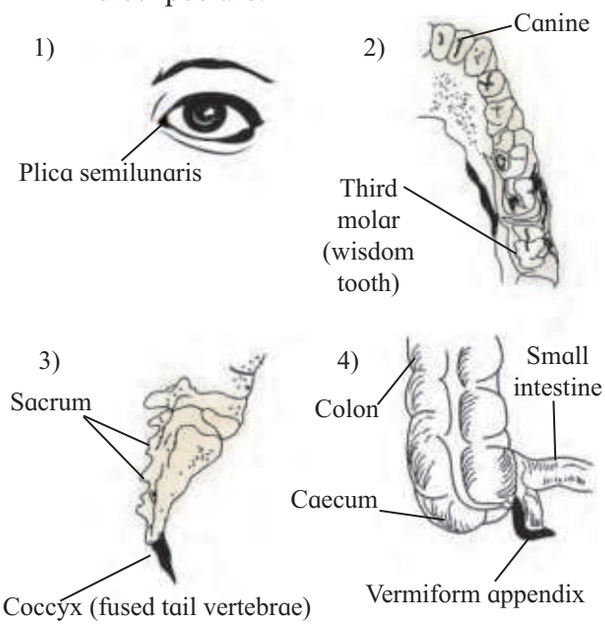


Fig. 5.14 : Vestigeal organs

4. Vermiform appendix and the caecum. It is functional in herbivorous mammals for digestion of cellulose. In man due to eating of cooked food it has lost its function.

Presence of these vestigeal organs provide evidence that man has (evolved) descended from simple primates.

Can you recall?

Give examples of embryological evidences studied in lower classes.

d. Molecular Evidences :

1. Cell is the basic structural and functional unit of life in all organisms.
2. Similarities in proteins and genetic material performing a similar function among diverse organisms gives evidence of a common ancestry.
3. Basic metabolic activities also occur in a similar manner in all organisms.
4. ATP is the energy source in all living organisms.

5.11 Speciation :

The process of formation of a new species from the pre-existing species is called speciation.

Species is a group of similar organisms that can interbreed and produce a fertile offspring in nature. New species are formed by the following modes.

a. Intraspecific Speciation :

i. **Allopatric speciation :** It is the formation of a new species due to separation of a segment of population from its original population by distance or by a geographical barrier cutting across the species range. e.g. creeping glaciers, development of mountains. Migration of individuals also causes allopatric speciation. The mode of evolution here is called **adaptive radiation** e.g. 14 different species of finches in Galapagos islands and several marsupial species in the Australian continent.

ii. **Sympatric speciation:** It is the formation of species within single population without geographical isolation. These are formed due to reproductive isolation. e.g. *Cichlid* fishes in Lake Victoria. Mutations are helpful in sympatric speciation.

b. Interspecific Speciation :

Hybridisation :

Two different species on crossing may give rise to hybrid that on doubling of chromosomes form a new species. e.g. . *Triticum aestivum (hexaploid) and Gossypium herbaceum (tetraploid).*

Can you recall?

1. What are fossils? why should we study fossils?
2. How do we find age of fossils ?
3. Where do we find fossils ?

5.12 Geological time scale :

The planet earth with its present biodiversity was not so when it was born. Study of fossils tells us that life forms were not the same like todays, millions of years ago (MYA). Geological time scale is used to understand the sequence of events that took place on the earth in different ages over a period of time. It is divided into six major 'Eras'. Eras ended with major environmental changes on earth resulting into extinction of some species and emergence of new species. The eras are further divided into periods and epochs based on minor but landmark events in each era. Table 5.15 shows the geological time scale at a glance.

The first life appeared on the earth some 2000 million years ago. It took billions of years for this process to take place, from protenoids to first cells the transition is still a mystery. Once formed, the living forms diversified into various groups. Life began in the sea water and

plants were the first living beings to adapt to terrestrial life. Fishes evolved and diversified. The lobefin group of fishes too got diversified. Some developed stout and strong fins and could go to land and come back to water.

The coelecanth was considered a **living fossils**. It was thought that lobefins are extinct, but the variety of the lobefin fish, called coelacanth was caught in 1938 in South Africa.

Reptiles evolved from amphibians. They are the first true land vertebrates. They do not have to go to water for reproduction. (Hint : think of amphibian and reptilian eggs). But about 200 million years ago (mya) some reptiles

Table 5.15 : Geological time scale

Era	Period	Time MYA	Epoch	Plant life	Animal life
Cenozoic	Quarternary 0.01-2.0	0.1-0.6	Recent (Holocene)	Angiosperms, Dicots, Monocots. spread of agriculture.	Age of mammals : Development of modern man, birds, fishes and insects. Development of human culture.
		0.6 - 2.0	Pleistocene	Increase in herbs	Extinction of great mammals. Appearance of primitive man.
	Tertiary 2-6.5	2-13	Pliocene	Hard woody plants conifers, bryophytes, monocots, grasslands dominated	Emergence or origin of man. Evolution of ruminants - horse, camel, elephant.
		13-26	Miocene	Abundance of deciduous trees, origin of grasses	Formation of first man like apes. Adaptive radiation or spread of mammals.
		26-38	Oligocene	Rise of monocots and flowering plants	Extinction of Archiac mammals, Appearance of apes and monkeys. Turtles and crocodiles attained development.
		38-54	Eocene	Development of angiosperms	Diversification of placental mammals and modern birds.
		54-65	Palaeocene	advancement of flowering plants	Arrival of early or first primates, rise of placental mammals.
Mesozoic	Cretaceous	65-135		Decline of ferns - sphenopsids (horsetails) and Bennetitales. Ginkos, Gnetales. 1st appearance of flowering plants.	Extinction of Dinasours and toothed birds. Appearance of placental mammals and first modern birds
	Jurassic	135-165		Origin of angiospersms Dominance of herbaceous lycopods, ferns, conifers, cycads.	Age of reptiles. Dinasaurs dominant, Appearance of toothed birds (Archaeopteryx) Rise of marsupials.
	Triassic	165-225		Dominance of Bennetitales gymnosperms,extinction, of seed ferns	Appearance and rise of dinosours. Extinction of primitive amphibians. Diversification of reptiles. Rise of oviparous mammals. Therapsids, diversification of flies.

Palaeozoic	permian	225-280		Origin of conifers Decline of arborescent lycopods Abundance of ferns, cycads and Advanced conifers	Rise of modern insects, Disappearance of trilobites, appearance of mammal like reptiles (Pelycosaurs). Decline of amphibians.
	Carboniferous	280-345		Development of diverse, arborescent lycopods mosses, seed ferns and primitive conifers. age of ferns and coal forests, different fungal groups	Abundance of amphibians (age of amphibian).Appearance of reptiles and winged insects.
	Devoniam	345-400		Appearance of first pro - gymnosperms. Formation of forests, wood decaying fungi, chytrids and origin of bryophytes.	Diversification of fishes. Evolution of amphibians. Appearance of ammonites
	Silurian	400-440		Appearance of lycopods and ferns. Domiance of algae, ascomycetean fungi	Appearance of first terrestrial animals, wingless insects and jawed fish
	Ordovician	440-500		Appearance of first seedless vascular land plants, abundant algae	Abundance of diversed invertebrates. Appearance of first vertebrates jawless fishes, Appearance of corals, giant cephalopods like *Nautilus*.
	Cambrian	500-590		Rhynia like plants. All types of marine algae	Abundance or age of trilobites, Diversification of invertebrate phyla.
Proterozoic		600-1600		Tracheophyte ancestors, chlorophyte ancestors bacterial single-cellled protista, blue green algae	Primitive flat worms, annelids, sponges, coelenterates, primitive metazoans, scanty fossils of prokaryotes
Archaeozoic		1600-3800		No fossil records	Origin of life Simple unicellular forms like viruses, bacteria and algae
Azoic		3800-4600		No life	Absence of living being chemical evolution Formation of earth,

* (MYA = Million Years Ago)

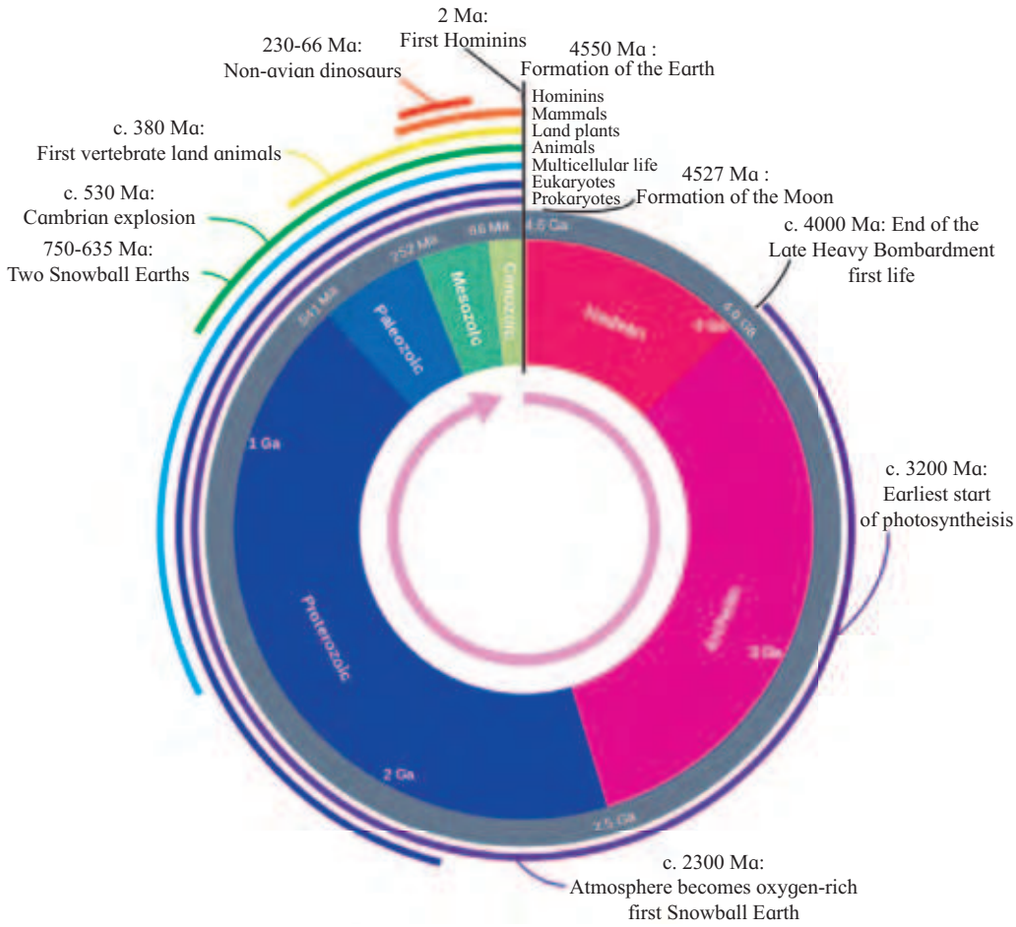


Fig. 5.16 : Geological time scale pie diagram

moved back to aquatic mode of life and gained fish like form as seen in *Ichthyosaurs*. The giant reptiles like Dinosaurs once dominated the earth but are now **extinct**. When was this? Around 65 million years ago! why it must have happened? Can we give affirmative reason for this extinction? At around the same time giant ferns were present on earth. However, they also became extinct and got converted to fossil fuels. How this must have happened?

Decline of giant reptiles marked the begining of dominance of mammals. These viviparous organisms were more intelligent. They could avoid danger. Early mammals were small shrew like organisms, but this group **diversified**. Whales, dolphins, seals and sea cows live in water, bats are the flying mammals, kangaroo rats are fossorial, lemurs are arboreal. Major physical disturbances led to phenomenon like the **continental drift** i.e. continents moved from their original place. As a consequence when south America joined north America, ancestral forms of horse, hippos, rabbits, etc. native to south america were dominated by north American animals. At the same time, marsupials diversified into different habitats in Australia. These survived due to lack of competition.

From the fossil records we can trace complete evolutionary history of horse, elephant, dog, etc. Human beings are the most evolved animals on the earth.

Internet my friend

You may gather information out of curiosity about geological events occurred in the past.

5.13 Human Evolution :

Use your brain power

Since your earlier school days you have been solving mysteries/puzzles labelled as **use your brain power**. Did you ever wonder why human brain has such a capacity? Why and how we evolved along these lines? What is the extent of similarity between humans, chimpanzees and monkeys ?

It has been traced that the human evolution appeared to have evolved from a tree dwelling shrew like animal. This process began in Palaeocene epoch. During this period, dwindling forests forced arboreal mammals to adapt to life on land. This descent must have been the driving force. In the following chart, it can be seen that we are most closely related to gibbons, chimpanzees and gorillas.

Do you know ?

There is a difference of only 2.5 % between DNA of chimpanzee and man while between monkey and man it is 10 %.

The major evolutionary trends in transition from ape to man are considered further. Special characteristics have been acquired by man in the course of evolution. Major changes that took place in evolution of man include increase in size and complexity of brain and enhanced intelligence, increase in cranial capacity, bipedal locomotion, opposable thumb, erect posture, shortening of forelimbs and lengthening of hind limbs, development of chin, broadening of pelvic girdle, development of lumbar curvature, social and cultural development (articulated speech, art, development of tools, etc).

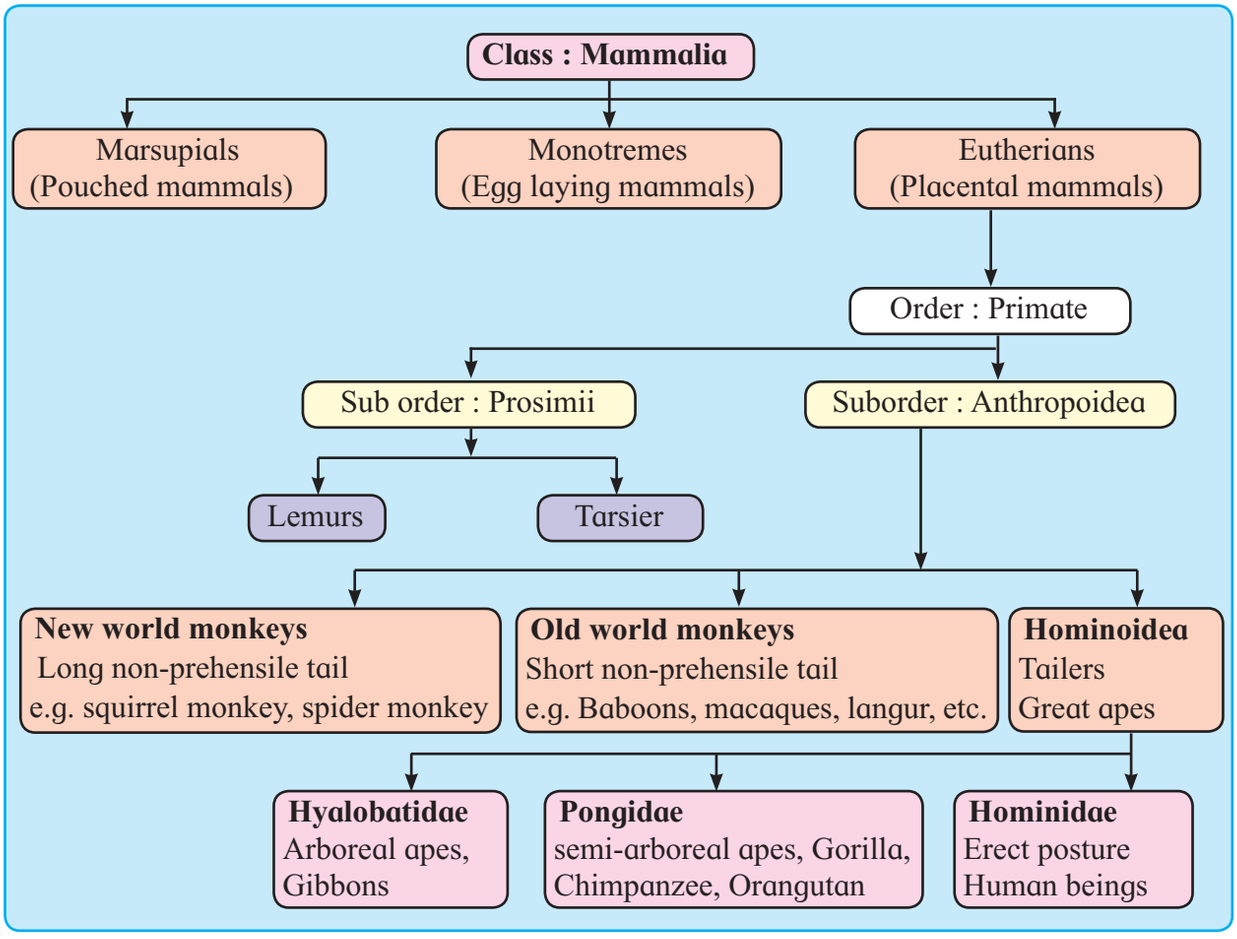


Chart 5.17 : Classification of mammals

Table 5.18 : Human evolution

Heads	Dryopi-thecus	Ramapi-thecus	Australopi-thecus	Homo habilis	Homo erectus	Neanderthal man	Homo-sapiens
Appearance	Ape like	Man like	Connecting link between Ape and man	Handy man like	Ape man	Advanced prehistoric man	Modern man
Site of fossil record	Lake victoria of Africa, Haritalyngar of Himachal Pradesh	Shivalik Hills in India and even in Kenya	Toung in South Africa, Ethiopia, Tanzania	Olduvai Gorge Tanzania in Africa	Java and peking	Neanderthal valley, Germany	Africa
Period	Miocene epoch 20 – 25 mya	Miocene and early pliocene epoch 14 -12 mya	late pliocene or early pleistocene epoch about 4 – 1.8 mya	Late pliocene or early pleistocene 2.5 to 1.4 mya	middle of pleistocene epoch 1.5 mya ago	Late pleistocene epoch 100000 to 40000 yrs ago	
Skeltal features			Not taller than 4 feet, jaws larger, prognathus face, chin absent, lumbar curvature present.	Lower jaw, lighty built, dentition more like modern man, smaller molars	5 feet in height prognathus face, massive jaws, Huge teath, chin absent, Bony eye brow ridges present	Heavy built short prominant brow ridges low forehead, deep jaws, chin absent, outwardly curved thigh bones	
Posture	semi erect	erect	upright	erect	erect	erect	erect
Cranial capacity			450 to 600 cc	650 to 800 cc	900 cc	1400 cc	1450 cc
Special features if any	close similarity to chimpanzee		man with ape brain	probably did not eat meat, made tools from stones, nicknamed handy man	probably ate meat, omnivorous might have used fire	used hide, burried their dead, constructed flint tools	developed distinct races. Developed cave art about 18000 yrs ago

Cranial capacity of human begins increased over a period of time and large size of frontal lobe helped in development of high forehead.

Increase in intelligence necessitated physical development so that body and brain could be used effectively and productively. Freedom of forelimbs from locomotory function and opposable thumb led to better utilization of hands for holding objects effectively and development of motor skills etc.

Bipedal locomotion, upright posture coupled with stereoscopic vision helped man to move around safely on land.

Evolutionary history of man was traced with the help of fossil remains found over a period of time.

Use your brain power

Even though the cranium of elephant is larger than that of humans, why humans are considered more intelligent than elephants ?

Some of our ancestors and their evolutionary history is shown in the table.

The above table clearly shows the gradual increase in cranial capacity, shape of skull and dentition of the ancestral humans till date.

Our journey of evolution still continues.....

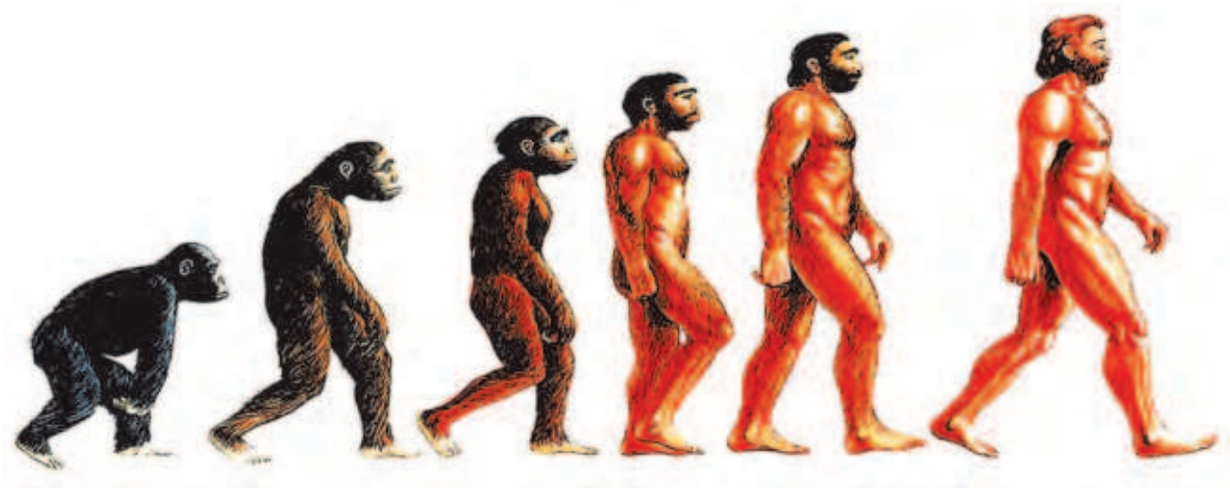


Fig. 5.19 : Human Evolution

Internet my friend

1. Recently a fossil park has been established in Gadchiroli district of Maharashtra state. Find more information about Wadadham fossil park.
2. Find out information about caves in India. One such place is in Madhya Pradesh. It is at Bhimbetka rock shelter in Raisen district. Here we can see cave paintings by prehistoric humans.

Think about it

Human being is said to be most evolved, intelligent living being. Yet we are not self sufficient. Think of various aspects for which we depend on other living beings for our survival.

Activity :

Collect the information about the organisms depicted in the following diagrams and write on the same.

A.  B.  C.  D.  E. 	
	
	

Exercise

Q. 1 Multiple choice questions.

1. Who proposed that the first form of life could have come from pre- existing non-living organic molecules?
   a. Alfred Wallace
   b. Oparin and Haldane
   c. Charles Darwin
   d. Louis Pasteur

2. The sequence of origin of life may be-
   a. Organic materials- inorganic materials – Eobiont- colloidal aggregates- cell.
   b. Inorganic materials – organic materials – colloidal aggregates – Eobiont- cell.
   c. Organic materials- inorganic materials – colloidal aggregates - cell
   d. Inorganic materials- organic materials – Eobiont- colloidal aggregates - cell

3. In Hardy - Weinberg equation , the frequency of homozygous recessive individual is represented by :-
   a. P^2 b. pq c. q^2 d. 2pq

4. Select the analogous organs-
   a. Forelimbs of whale and bat
   b. Flippers of dolphins and penguin
   c. Thorn and tendrils of bougainvillea and cucurbita.
   d. Vertebrates hearts or brains.

5. *Archaeopteryx* is known as missing link because it is a fossil and share characters of both-
   a. Fishes and amphibians
   b. Annelida and arthropoda.
   c. Birds and reptiles
   d. Chordates and nonchordates.

6. Identify the wrong statement regarding evolution.
   a. Darwin's variations are small and directional.
   b. Mutations are random and non-directional.
   c. Adaptive radiations leads to divergent evolution.
   d. Mutations are non- radamon and directional.

7. Gene frequency in a population remain constant due to –
   a. Mutation
   b. Migration
   c. Random mating
   d. Non- random mating

8. Which of the following characteristic is not shown by the ape?
   a. Prognathous face
   b. tail is present
   c. Chin is absent
   d. forelimbs are longer than hind limbs

9. ..... can be considered as conncting link between between ape and man.
   a. Austalopithecus
   b. Homo hablis
   c. Homo erectus
   d. Neanderthal man.

10. The cranial capacity of Neanderthal man was
    a. 600 cc b. 940 cc
    b. 1400 cc d. 1600 cc

Q. 2 Very short answer question.

1. Define the following terms-
   a. Gene pool b. gene frequency
   c. Organic evolution d. Population
   e. Speciation

2. What is adaptive radiation?
3. If the variation occur in population by chance alone and not through natural selection and it brings change in frequencies of an allele. What is it called?
4. State the Hardy – Weinberg eqnilibrium.
5. What are homologous organs?
6. What is vestigeal organ?
7. What is the scientific name of modern man?
8. What is coacervate?
9. Which period is known as "age of Reptilia"?
10. Name the ancestor of human which is described as man with ape brain.

Q. 3 Short answer question.

1. Write a note on Genetic drift.
2. Enlist the different factors that are responsible for changing gene frequency.
3. Draw a graph to show that natural selection leads to disruptive change.
4. Give the significance of fossils.
5. Write the objections to Mutation theory of Hugo de vries.
6. What is disrruptive selection? Give example.

Q. 4 Match the following.

Columu- I	Column – II
1. August Weismann	a. Mutation theory
2. Hugo de Vries	b. Germplasm theory
3. Charles Darwin	c. Theory of inheritance of acquired characters
4. Lamarck	d. Theory of natural selection

Q. 5 Long answer questions.

1. Would you consider wings of butterfly and bat as homologous or analogous and why?
2. What is adaptive radiation? Explain with suitable example.
3. By taking industrial melanism as one example, explain the concept of natural selection.
4. Describe the Urey and Miller's experiment.
5. What is Isolation? Describe the different types of reproductive Isolatons.
6. What are Genetic variations? Explain the different factors responsible for genetic variations.

Q. 6 Complete the chart.

Era	Dominating group of animal
1. Cenozoic	.....
2.	Reptiles
3. Palaeozoic	.....
4.	Invertebrates

Project :

Prepare a diagrammatic chart of the chemical evolution of life.