ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL -10

Class: XII Sub: BIOLOGICAL SCIENCE Date: 20.07.2020

Topic - EVOLUTION (part 3)

EVIDENCES FROM PALAEONTOLOGY OR PALAEONTOBIOLOGY

Palaeontobiology is the study of fossils of animals and platns that lived in past. The fossils are actual remains, traces or impressions left by the organisms which have been preserved in rocks or otherwise. Fossils records have helped in building the broad historical sequence of biological evolution. Study of plant fossils is called **palaeobotany** and of animal fossils is **palaeozoology.** Leonardo da Vinci (1452-1519) of Italy is called the Father of Palaeontology and Cuvier (1800) is the founder of a Modern Palaeontology.

Formation of Fossils

Fossils are formed in different ways based on the environmental conditions. The fossils may include original remains of the hard parts (bones, teeth, shell, etc.) in the sedimentary rocks, petrifaction of hard and soft parts, carbonized film, molds (impressions of organisms in rocks), casts (molds filled with foreign material) and as actual remains in peat, amber, asphalt and ice.

The land animals may also get fossilized in amber (hardened resin), asphalt (hardened tar), volcanic ash, peat bogs and sand deposits or in ice.

Types of fossils

Fossils are of following types:

(i) Unaltered Remains of Entire Organisms : Under exceptionally favourable conditions, the entire animal body gets preserved in ice, petroleum springs, asphalts, resin, amber and oil soaked ground. Woolly mammoths from Siberia in Arctic Tundra remained preserved in ice for thousand of years. Actually, this area is described as 'nature's cold storage or warehouse'.

- **Amber** is hardened resin. A number of insects and arthropods are found preserved in the amber deposits of Oligocene epoch from middle Tertiary Period along Baltic coasts.
- **Asphalt** found in the tar pits of Rancho La Bera in Los Angeles (California) has preserved a number of birds and mammals.
- Oil soaked ground in Poland has complete remains of Woolly Rhinoceros.

(ii) **Petrified Fossils** (Altered Fossils) : Petrified fossils are formed by the replacement of organic material of dead and decaying organisms by minerals such as Calcium carbonate or silica. The process is called petrification. Petrified fossils are formed in the sedimentary rocks on the bottom of lakes, rivers or sea when animals or plants or their parts get buried in the sediment. The process of petrification successfully preserves the hard parts. Under very favourable conditions, even the finest details of soft tissues, like muscles or other organs are also preserved by the replacement of their organic material with minerals.

(iii) **Moulds** and **Casts** : Natural moulds are formed by the hardening of material that surrounds the buried organisms. Their bodies disintegrate leaving hollow cavities, called moulds. These moulds retain the exact body shape of the organisms preserved and get filled with natural deposits of minerals which harden to form exact casts of the original organism. Thus, both moulds and casts provide external details of the body's shape, size and form of the organisms. Fossils of men and their domestic animals of Pompeii city which got buried by volcanic eruption from Mount Vesuvius in AD 79 were preserved as moulds and casts.

(iv) **Prints** or **Impressions** : The foot prints of animals or impressions of leaves, stems, skin and wings, etc. Left in soft mud are preserved when it changes into a rock.

(v) **Tracks** and **Trails** : The foot prints or tracks and trails of moving animals left in the soft mud are preserved when the soft mud hardens into rocks, preserving the prints. The foot prints and trail fossils are called fossils.

(vi) **Coprolites**: These are fossils of faecal matter or droppings. These are found in association with the animal fossils. Their study may provide information pertaining to their food habits.

Microfossils as Fuel Indicators

Fossils of spores and pollens (palyno fossils) and of other vegetal remains of the past are used as indicators of environmental conditions whether these were favourable for the accumulation of organic matter and its conversion to fossil fuels by the transformation and subsequent thermal alternation. By quantitative analysis of microfossils, the approximate location and configuration of near shore marine deposits can be determined which present sites of formation and accumulation of hydrocarbons and coal.

Fossil fuels like coal, gas and petroleum are formed from remains of phytoplankton, marine and terrestrial algae and lipid-rich plants.

Determination of Age of Fossils or Dating of Fossils

Relative age fossils can be determined by stratigraphy which means that the lowest strata of rocks contain the oldest fossils and the uppermost strata contain the most recently formed fossils. However, radiometry or radioactive clock method helps in determining the age of rocks and the fossils contained therein. The method of radioactive dating was introduced by Boltwood in 1907. It is based on degradation of radioactive nuclei into stable nonradioactive element by loosing electrons. Each radioactive element has its half life which means one gram of a radioactive element changes into half a gram in a specific time. The half life of each radioactive element is fixed. For example, ^{238}uranium changed to ^{206}lead (^{206}Pb) in 4.5 billion years and radioactive carbon ^{14}C changes to radioisotope of carbon ^{12}C in 5,579 or $56X10^3$ years. It is done by two methods :-

(i) **Uranium-Lead Method** : In this method, the amount of 238uranium and 206lead in a given rock is estimated accurately and the age of the rock is calculated on the basis of half life.

(ii) **Radioactive Carbon Method** : Radioactive carbon (14C) method of determining age of fossils was suggested by W.F. Libby (1950). 14C is a radioisotope of carbon 12C. It half life is about 5,600 years. When bones are formed, small amount of 14C is incorporated and its amount remains constant throughout the life of an organism. Upon death the radioactivity is gradually lost. By determining the amount of

radioactivity in the bones, it is possible to approximate the time of death or fossilization. Since the half life of 14C is small, radioactive carbon dating method can give the age of fairly recent fossils (about 11,000 years to recent).

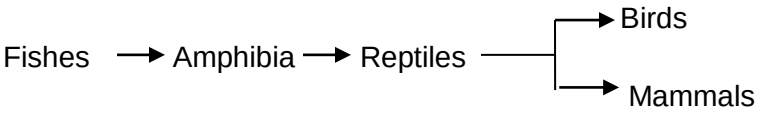
Geological Time Scale

By studying the types of fossils in different rocks strata and determining their age by radioactive dating method, geologists have constructed a geological time scale or stratographical scale. This scale is the calendar of the earth's past history indicating the evolution of life through time recorded in the sequence of rocks. The geological time was developed by **Glovanni Arduiana** (1760). It is estimated that the earth was formed about 4.6 or 5 billion years ago and life on the earth originated about 3.6 billion years ago. This period of history of life on the earth has been divided into **six major periods called eras which are divided into periods and periods into epochs.**

By determining the age of rocks and fossils contained therein, a geological time scale has been reconstructed. It depicts characteristic climatic conditions, occurrence of specific living plants and animals and adaptive modifications in them.

Missing Links (Transitional Forms)

The tranitional fossil organisms which possess characters of two different groups of present day living forms, are called missing links. These show evolutionary relationship between these group and are also called connecting links. With the help of missing links the evolutionary sequence of major vertebrate groups have been drawn.



Example of missing link :

Archaeopteryx lithographica is a connecting link between **reptiles and birds**. Its fossil was obtained by Andreas Wagner in 1861 from limestone rocks of Solenhofen in Bavaria, Germany. These rocks were from upper Jrassic period about 180 million years old. It was of the size of crow and had both reptilian and avian characters.

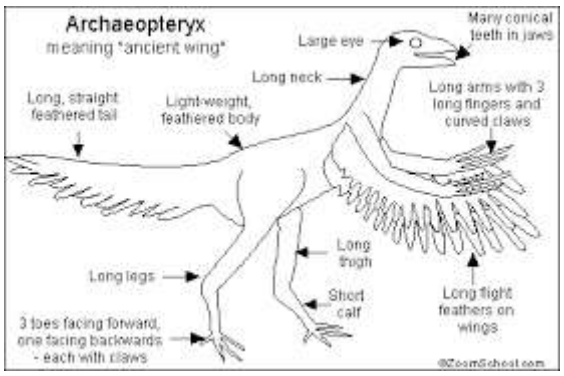
Reptilian Characters of *Archaeopteryx* :

(a) Present of teeth in jaws (b) Fingers having claws (c) Long tail with free caudal vertebrae (d) Presence of scales and (e) Sternum without a keel.

Avian characters of *Archaeopteryx* : (a) Presence of feathers on the body (b) forelimbs modified into wings (c) jaws drawn into a beak (d) presence of V-shaped furcula or wishbone and (e) limb bones and girdles bird-like.

TABLE 1.2 Geological Time Scale of Earth
(To be Read from Below Upward. Duration of each Epoch and Period is in Million Years)

Eras	Periods	Epoches	Dominant Animal and Plant Groups
5. COENOZOIC (Era of modern life) (Age of Mammals and Angiosperms) (65 million years)	1. Quaternary	Recent (1 million yrs)	Age of mammals: modern man, apes, monkeys and other mammals, birds and insects.
		Pleistocene (2–2.5 million yrs)	**Appearance of primitive man;** extinction of large mammals.
	2. Tertiary	Pliocene (6–7 million yrs)	**Emergence of man;** evolution of modern mammals (horse, camel, elephant).
		Miocene (25 million yrs)	Formation of first man-like ape; (mammals dominating and at the height of evolution).
		Oligocene (38 million yrs)	Extinction of archaic mammals; rise of first modern mammal.
		Eocene (54 million yrs)	**Diversification of placental mammals** (Eutherians), carnivores and hoofed forms appeared.
		Palaeocene (65 million yrs)	Rise of placental mammals and evolution of modern birds.
4. MESOZOIC (Era of intermediate or medieval life) (Age of Reptiles and Gymnosperms)	1. Cretaceous (135 million yrs)		**Appearance of archaic eutherian mammals;** rise of modern birds and teleost fishes; extinction of giant reptiles and toothed birds. Dwindling of gymnosperms and increase of angiosperms.
	2. Jurassic (180 million yrs)		**Age of gymnosperms and reptiles:** dominance of dinosaurs; rise of toothed birds; spread of reptiles. First angiosperm and first bird appeared.
	3. Triassic (225 million yrs)		Rise of first dinosaur and egg laying mammals; extinction of primitive amphibians. Abundance of cycadophytes, gymnosperms
3. PALAEOZOIC (Era of ancient life) (Age of Amphibians)	1. Permian (275 million yrs)		Abundance of primitive reptiles, decline of amphibians; extinction of many marine invertebrates; **rise of modern insects.**
	2. Carboniferous (345 million yrs) (Pensylvanian + Mississipian)		**Age of amphibians:** spread of ancient sharks; first reptile appeared; rise of insects.
(Age of Fishes)	3. Devonian (395 million yrs)		**Age of fishes:** Origin of amphibians; abundance and diversification of fishes.
(Age of Invertebrates)	4. Silurian (430 million yrs)		Origin of jawed fishes and wingless insects; wide expansion of invertebrate phyla.
	5. Ordovician (500 million yrs)		Origin of vertebrates and jawless fishes, corals and trilobites abundant; diversification of molluscs.
	6. Cambrian (600 million yrs)		All invertebrate phyla established; trilobites dominant.
2. PROTEROZOIC (Era of primitive life)	2000 million yrs		Sedimentary rocks; origin of first simple marine invertebrates; shelled protozoans, coelenterates (fossils scanty).
1. ARCHAEOZOIC (Era of dawn of life)	3800 million yrs	Precambrian period	Origin of life, fossils of primitive bacteria-like and algae-like forms found (fossils rare).



Evolution of Horse:

Fossil history of horse was described by Othniel C. Marsh in 1879. It started about 60 million years ago in the plains of North America. The ancestors of horse were small-sized, fox-like forms present in Eocene period of Coenozoic era. These had four toes in forefoot and three toes in the hindfoot. They increased in size and acquired modifications to suit grassland life for fast running.

Progressive and Retrogressive Trends in Evolution of Horse

Progressive Evolutionary Trends	Retrogressive Evolutionary Trends
1. General increase in size and weight. 2. Lengthening of limbs. 3. Lengthening of middle toe in both forelimbs and hind limbs. 4. Increase in height. 5. Increase in length of neck. 6. Enlargement and complexity of brain, specially cerebral hemispheres. 7. Lengthening of facial region of head. 8. Increase in the complexity of molar teeth.	1. Progressive loss of toes in both forelimbs and hindlimbs. 2. Progressive loss of canines in both upper and lower jaws. 3. Loss of hair from the body.

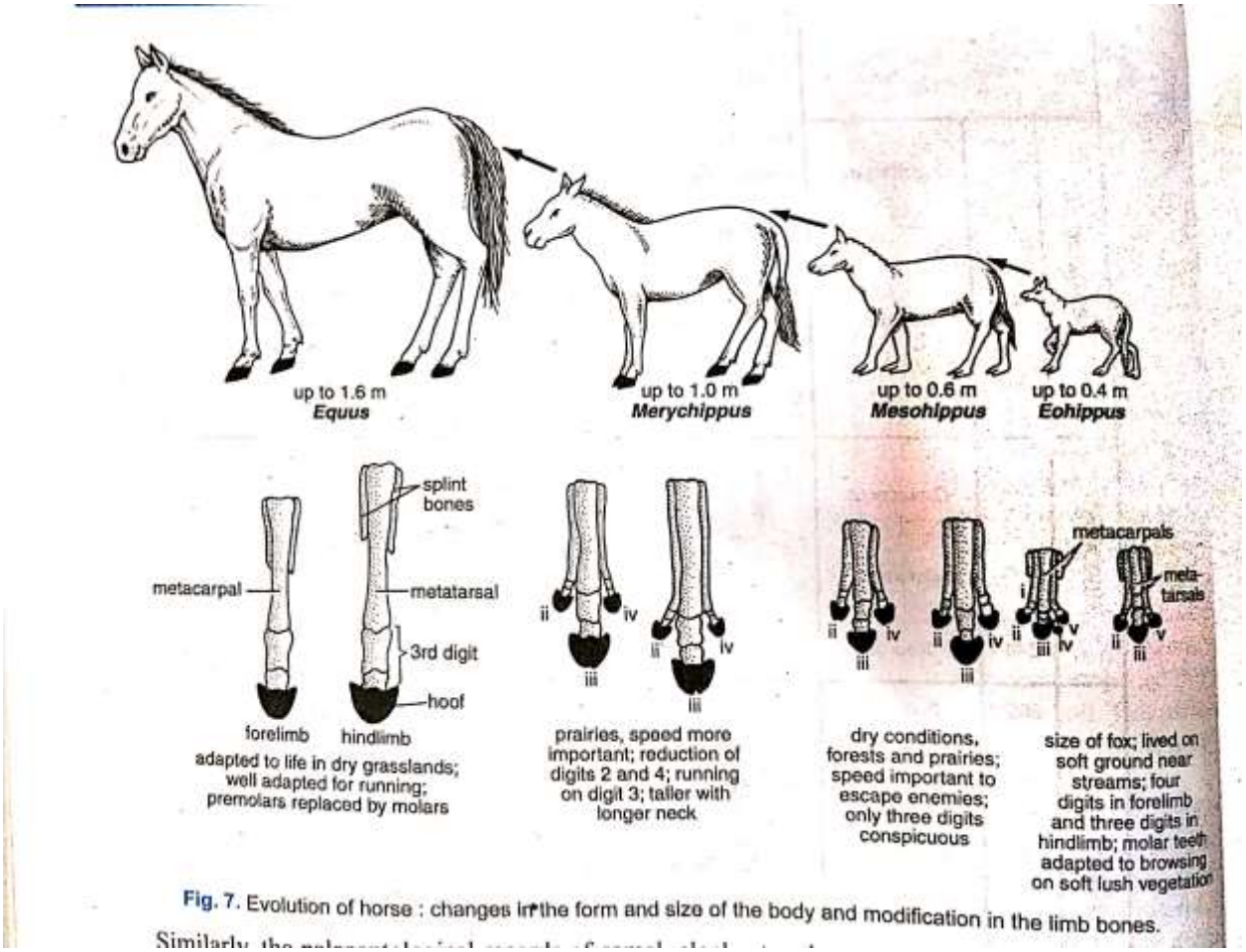


Fig. 7. Evolution of horse : changes in the form and size of the body and modification in the limb bones.

Similarly, the

Evidences from Darwin's Finches (Adaptive Radiation)

Darwin on his voyage on the ship H.M.S. Beagle to Galapagos islands observed about 13 species of Ground Finches. These species differ from one another in shape and size of their beaks and the type fo food they eat. The following types of beaks evolved from the stout, conical beaks of parental finches that lived on mainland of Africa and used to feed by crushing seeds.

- Insectivorous Warbler Finches developed slender warbler-like beak.
- Insectivorous Tree Finches developed short, thick and parrot-like beak to feed on beetles and other insects.
- Vegetarian tree Finches also developed parrot-like beak to feed upon leaves, buds and fruits.
- Woodpecker Finches have short and stout beak for searching insects under the bark and leaf clusters.
- Cactus Ground-Finches have long and decurved beak to probe flowers of Prickly pear cactus for nectar or to feed on soft pulp of cactus.

DARWINISM (Theory of Natural of Selection)

Darwinism is the term coined for the explanation presented by Charles Darwin (1809-1882). The origin of species by Natural Selection. It was explained by Darwin in his book 'The Origin species by Natural Selection'. An English biologist, Alfred Russel Wallace (1823-1913) also fed at the same consclusion independently. Theory of Natural Selection was announced on 30th, 1858 by Charles Darwin and Alfred Russel Wallace jointly.

Darwin's Observation

In 1831, Darwin travelled as a naturalist around the world on a survey ship, named H.M.S. Beagle. The voyage lasted for 5 years (1831-1836). During his voyage, Darwin visited South America, Australia, South-East Asia, Southern tip of Africa, and a number of islands including Galapagos islands. Darwin collected their flora and fauna and made careful observations about similarities and differences among them.They were:

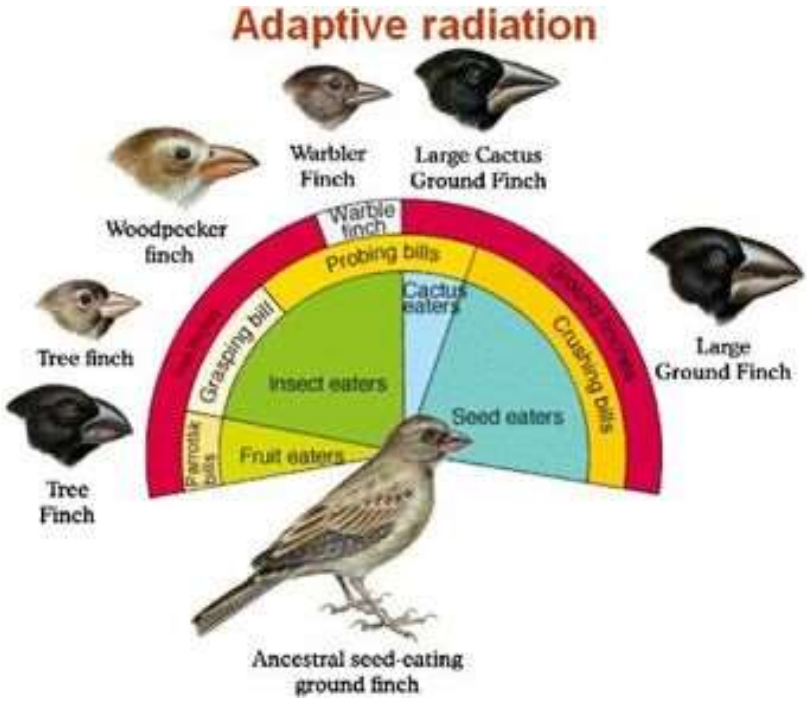
- Different islands, which are widely separated but have similar climate and topography, have different flora and fauna.
- The plants and animals living on nearby islands are related but differ amongst themselves and also from those found on mainland. Darwin described Galapagos Islands as Nature's living laboratory of evolution, and conceived the idea of selection.

Galapagos Islands are a chain of 14 Islands in the Pacific Ocean near Equator.

They are situated at the west coast of south America. Their fauna and flora resemble those of South Americaa mainland because these Islands were once connected with the mainland. After their separation, the fauna and flora on these Islands evolved Independently. The present flora and fauna on each Island are much different from those of mainland and also from other Islands.

- The flora and fauna of Galapagos Islands in the Pacific Ocean on west coast of South America, Darwin identified 13 species of finches, each species occupying a different island. They differed from each other as well as from the finches present on the

mainland of South America, from which they all are supposed to have evolved. These birds are popularly known as Darwin's finches. **This divergence in population due to adaptations is known as adaptive radiation.**



Basic Postulates of Darwinism

(i) Overproduction or Rapid Multiplication

- Elephant is the slowest breeder. It starts breeding at the age of 30 years and during its life time of 70 years, it produces only six offsprings. If all the young ones survive, a single pair of elephants would produce nineteen million elephants at the end of 750 years.

(ii) Limited Space and Food

Space in the universe is constant. The ultimate source of food for plants and animals also remains constant. Therefore, the carrying capacity of the environment does not allow the population to grow indefinitely. In spite of enormous reproductive potential of living beings, under natural conditions, the number of individuals of each species remains nearly constant over a long period of time.

(iii) Struggle for Existence

The struggle is intraspecific, interspecific and with the environment.

(iv) Variations

The offspring are similar to their parents and also exhibit some resemblance to each other. But they are not identical. They differ to some extent in shape, size, colour and behaviour, etc. It means variation is the law of nature. No two individuals are identical except the identical or monozygotic twins. Even they also exhibit some differences. Variations are nondirectional. They may prove to be beneficial, harmful or detrimental or even neutral. The useful variations have selective advantage while harmful variations have selective disadvantage for survival. The

everlasting competition among the organisms has compelled them to change in accordance with the conditions to utilize the natural resources and survive successfully.

(v) Natural Selection and Survival of the Fittest

Darwin believed that as man selects animals or platns with desired characters (artificial selection), in the same way nature selects or favours only those individuals which have more favourable variations and are the best adapted to the environment. The less fit and unfit organisms are left out by selection. For example,

- In a herd of herbivores, only weak or unable to flee fast or which are less alert are attacked by predators.

This sorting out of individuals with useful variations was called natural selection by Darwin and survival of the fittest by Wallace. Individuals with favourable variations survive, reach adulthood and reproduce offspring, others fail to do so. This is called differential reproduction.

Example : Evolution of long neck in Giraffe

Darwin explained evolution of long neck of modern giraffe by presuming existence of variability in the length of neck and legs in the ancestral population of giraffe. The longer-necked giraffe with longer forelegs were more successful in reaching the soft leaves of trees for feeding. Therefore, natural selection favoured longer-necked progeny generation after generation. Selection of longer neck for innumerable generations resulted in the evolution of present day longer-necked modern Giraffe.

(vi) Inheritance of Useful Variations

Individuals which survive the struggle for existence transmit their useful variations to the offspring, which will also prove to be fit. Thus, offsprings of selected indivual are born fit to the environment.

(vii) Formation of New Species

According to Darwin, new variations appear in every generation and supplement the favourable variations inherited from parents. Thus, variations keep on accumulating and after a number of generaions, the offspring become markedly different forming a new species. Origin of new species by gradual modification of older ones is called **speciation**

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MUTATION THEORY OF EVOLUTION:

Mutation theory for the origin of new species was proposed by Hugo DeVries (1901). According to mutation theory, new species arise from the pre-existing once in a single generation by the **sudden appearance of distinct heritable changes and discontinuous.** DeVries called such sudden distinct heritable changes as mutations (L mutare = to change). Darwin called them **sports** and Bateson named them **Saltations** or saltatory (discontinuous) variations.

Salient Features of Mutation Theory:

The main postulates of mutation theory are :

- Mutations are sudden, large and distinct discontinuous heritable changes.
- All organisms have an inherent tendency to change or mutate.
- Individuals showing mutations are called mutants.

Evidences to Support Mutation Theory

Several mutant forms were observed after DeVries, discovery of mutations. Some examples are:

- Birth of hairless cats, dogs and mice from normal parents.

Objections Against Mutation Theory (Criticism)

- Mutation theory cannot explain phenomenon of mimicry (the resemblance between mimic and model), protective colouration and the relationship between the position of nectarines in the flowers and thet length of proboscis of insects that pollinate these flowers. This is called coevolution.
- Most mutations are deleterious, harmful or lethal, whereas evolution is based on the usefulness of the mutant characters.

MECHANISM OF EVOLUTION:

According to Modern Synthetic Theory of Evolution of the unit of evolution is not individual but a part of population. It is the gene pool of population that changes, evolves and diversifies. Natural selection operates not on the genome of an individual of a species, but on the gene pool of a population. This is called **population genetics**. A population comprises of numerous organisms. It means evolution is the result of changes in the genes and gene cominations in the organisms of a **Mendelian population.**

Mendelian Population and Evolution

A group of all those organisms or individuals of a species that live in a geographical area at a particular time and interbreed freely is called a population or Mendelian population. The total number of genes of all the individuals of a population constitutes the gene pool of the population. All the members of a population share or contribute to the same gene pool by interbreeding freely (or **showing free gene flow**).

The term 'Mendelian population' was introduced by Dobzhansky, Sewall Wright called it panmictic population and Glimour and Gregor used the term deme for local population.

Characteristics of Mendelian Population

- Members of a Mendelian population have similar genetic constitution.
- All organisms of a Mendelian population share or contribute to the same gene pool.
- All members interbreed freely (there is free gene flow), and show random mating.
- There is no preferential interbreeding.

Gene Pool : The term 'gene pool' is used to represent the sum of total of genes present in the gametes of a Mendelian population. As a matter of fact, it should be described as gametic pool. An equilibrium is maintained in the gene and genotype frequencies in a population as long as there are no changes.

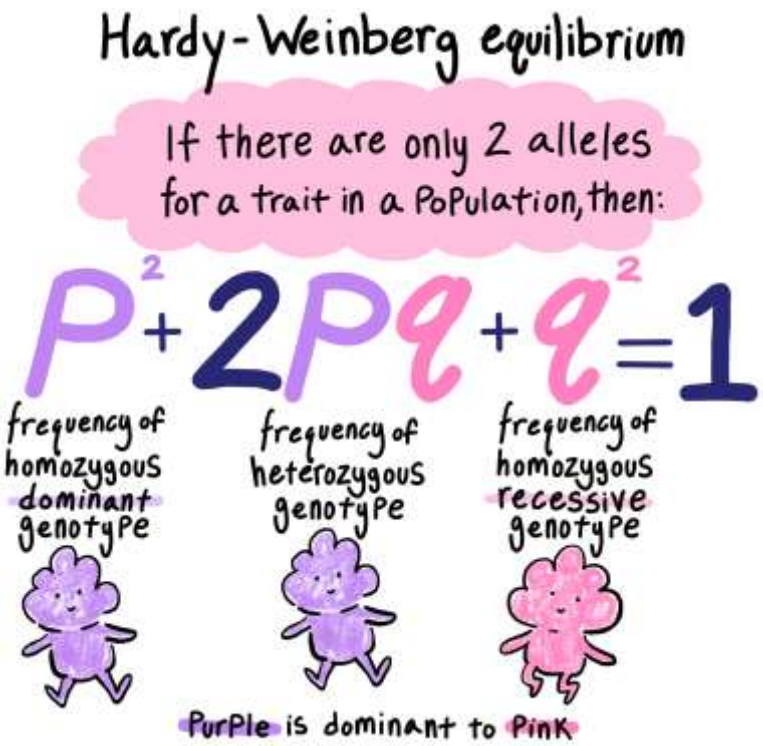
Hardy-Weinberg's Principle of Equilibrium

G.H. Hardy and W. Weinberg (1908) independently proposed Hardy-Weinberg's Principle of equilibrium, to describe the relationship of gene frequencies and genotype frequencies of alleles in the gene pool of a population.

- **Gene Frequency is the proportion of an allele in relation to the total alleles in relation to the toal alleles of a gene present in a randomly interbreeding population.**
- **Genotype Frequency is the proportion of one kind of phenotype from a population with respect to the locus under consideration. It is calculated by dividing the number of individuals with one genotype in a population by the total number of individuals in that population.**

According to Hardy-Weinberg's principle, **if the evolutionary forces (mutations, natural selection, etc) are not operating on a large and randomly mating panmictic population, the relative frequencies of various alleles in that population tend to remain at an equilibrium or constant generation after generation. This means, if gene frequency in a population remains constant, the population is static and is not evolving, or in other words, the gene frequency keeps changing in a population which is evolving. If we presume that in a Mendelian population :**

- Gene frequency of gene A = p
- Gene frequency of its allele a=q
- Sum of these alleles (A+a)= p+q=1
- Genotype frequency of AA, Aa and aa genotypes = $(p+q)^2$ = (1)2 or = $\mathbf{p^2+2pq+q^2=1}$
  i.e., genotype frequency of AA = p^2
  genotype frequency of aa = q^2
  and genotype frequency Aa= 2pq



According to this principle, if a population is large, its individuals have random mating. Each parent procures roughly equal number of gametes. These gametes combine at random and undergo no evolutionary changes, then the gene or allele frequency of different genes remains constant or uncharged and genetic equilibrium of genes is preserved through generations.

Evolutionary Forces or Factors affecting Gene Equilibrium in a Population

Following factors are known to disturb the gene equilibrium or Hardy Weinberg euqilibrium in a population:

- Genetic variability or variations in the gene pool of a population
- Reproductive isolation of a different populations of a species
- Natural selection.
- Genetic basis of adaptations.
- Speciation or Origin of speciation.

(i) Genetic Variations

The difference in the individuals of a population are called variations. These can be seen both in the genotype (genotypic variations or germinal variations) and in the phenotype (phenotypic variations or somatogenic variations

.

Causes of Genetic Variations

Variations that contribute to evolution are introduced in the gene pool of the population by gene mutations, recombination, chromosomal aberrations, change in the number of chromosomes, hybridization and immigration.

(i) Gene Mutations or Point Mutations : Gene mutations are changes in the structure and expression of genes caused by changes in the number or sequences or nucleotides or nitrogenous bases in DNA molecule. There are:

(a) Frame-shift Mutations : These are caused either by addition or deletion of one or more nucleotide pairs in a molecule of DNA segment at one or more places.

(b) Substitution Mutations: These are caused by the replacement of one or more nitrogenous bases by other ones. Substitution of purine by a purine A by G or pyrimidine by a pyrimidine C by T or T by C is called **transition** and the replacement of purine by a pyrimidine or a pyrimidine by purine (G and A by T or C or vice versa) is called **transversion**.

The factors responsible for introducing mutations are called mutagenic agents. These include radiations (X-rays, gamma rays, UV rays) and chemical mutagens like mustard gas formaldehyde, phenol, caffeine, organic peroxides and compounds of manganese and ferrous.

(ii) Chromosomal Mutations or Chromosomal Aberrations (Structural Changes) : These are :

(a) Change in Number of Genes :

(i) Deletion or Deficiency : Loss of one or more genes due to deletion of chromosome segment.

(ii) Duplication : Addition of one or more genes due to doubling of chromosome segment.

(b) Changes in the Arrangement of Genes :

(i) Inversion : Rotation of a block of genes in a chromosome at 180º, so that the sequence of genes in the inverted segment is reversed.

(ii) Translocation : Exchange of parts between nonhomologous chromosomes, so that new linkage groups are formed.

(iii) Change in the Number of Chromosomes (Heteroploidy) : These are :

(a) Changes Involving Entire Sets :

(i) Haploidy : Having only one set of chromosomes, i.e., n-chromosomes.

(ii) Polyploidy : Each set of chromosomes is represented more than twice.

Triploidy = 3n

Tetraploidy = 4n

Pentaploidy = 5n

(b) Changes Involving the number of Chromosomes in one Set of Chromosomes or Aneuploidy :

(i) Monosomic : Loss of one chromosome from one set, i.e., 2n-1.

(ii) Polysomic : Addition of one or more chromosomes to one set, i.e., 2n+1 or 2n+1+1.

(iii) Nullisomic : Loss of both the chromosomes of a pair, i.e., 2n-2.

The change in chromosome number occur by nondisjunction of chromosomes during meiosis.

(iv) Hybridisation : It is the intermingling of genes of two populations of a species by cross breeding.

(v) Migration : Individuals of closely placed sister populations keep on migrating and intermixing. The entry of new individuals in populations is called immigration and moving out of individuals from one population to other is emigration. As a result of immigration, new gene alleles are added to the gene pool of the population. If immigration occurs multiple times (more then once), it is called gene flow. Due to emigration, some alleles are lost or their frequency is changed.

Reproductive Isolation

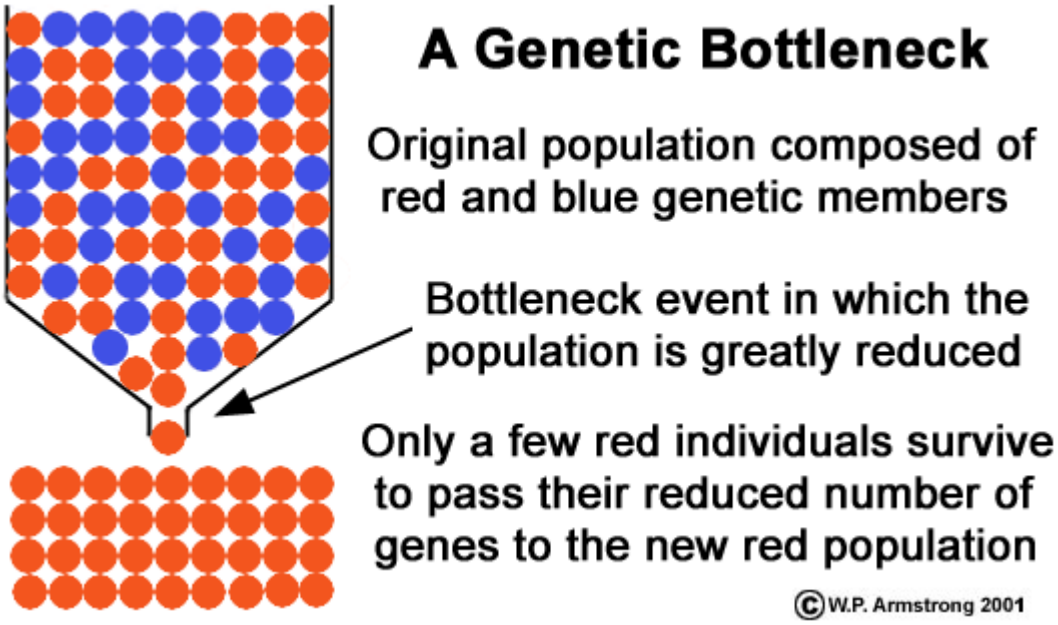
The mechanisms which reduce the chances of interbreeding in related groups of living organisms or among individuals of different populations of a species are called isolating mechanisms. Reproductive isolation is essential for the accumulation of genetic variations. Reproductive isolation helps in promoting genetic variability and evolutionary divergence. In the absence of reproductive isolation, the various mutant forms will interbreed freely with the normal forms and will lead to intermixing of their genotypes.

. Genetic Drifts of Sewall Wright Effect in Small Populations

In small populations, gene frequency or allele frequency exhibits great fluctuations generation after generation. Sewall Wright (1913) found that allele frequencies in small interbreeding populations are nondirectional and fluctuate purely by chance**. The sudden and random changes in the allele frequency occurring in small population by chance alone are called genetric drifts or Sewall Wright effect.**

According to this concept, mutations arising in a small population may be either fixed or lost just by chance irrespective of its being beneficial or harmful. For this reason, in small populations, sometimes unfavourable characters may also be fixed or beneficial characters may be lost. Sampling error, bottleneck phenomenon and founder's effect are responsible for genetic drifts.

(i) **Sampling Error or Bottleneck Effect** : These few surviving individuals become progenitors for the future generation. This is called population crash. The population in next generations may increase in size dramatically to undergo another population crash but may lack some of the alleles because their progenitors were without those alleles. A phenomenon causing reduction in the allele frequencies and loss of some alleles from the gene pool in a random fashion is called bottleneck phenomenon or genetic bottleneck. This causes loss of certain alleles by chance phenomenon. It retards the ability of the population to reestablish its genetic richness.



(ii) Founder's effect or Founder's Principle : Genetic drifts can produce dramatic changes in the frequencies of alleles in a population derived from a few founder individuals that enter a new or isolated geographical region.

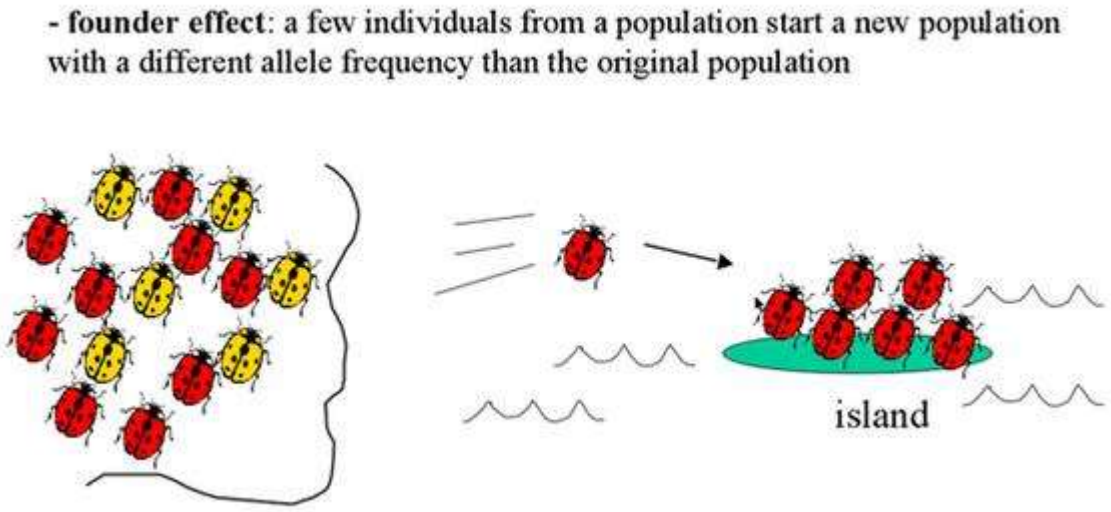
These founders carry only a limited portion of parental gene pool. Their gene pool may be homozygous for certain characters, thereby lacking the other alleles for those characters. It means different founder colonies will possess different gene pools and will soon become different from each other and from parental population. Such an effect is called founder's effect.

(iii) Effect of Genetic Drifts : Genetic drifts have three principle effects on populations of small size.

(a) Fixation of New Mutations : Genetic drifts fix the alleles of genes that arise by mutation from time to time

(b) Reduced Variability : Genetic drifts reduce genetic variability in small population by eliminating one of the two alleles either new or one old. Thus, eliminating effect of genetic variations is called decay of variability.

(c) Nonadaptive Changes : Genetic drifts can introduce nonadaptive changes in the gene pool of a population.



Forms of Natural Selection:

Nature selection operates in three different ways, producing the following three different types of results.

(i) **Directional Selection** : Directional selection produce a regular change in gene pool of a population in one direction with respect to one or some specific characteristics. It is progress selection that sets an evolutionary trend within the population is seed in response to direction changes in the environment for a long time as industrial melanism in the case of Biston betularia and evolution of Horse, Camel, Mice or Man.

Industrial Melanism : The industrial melanism in peppered moth, *Biston betularia*, provides the best example of directional selectiojn. In early nineteenth century, there was a dramatic rise of

industrilisation in Europe. The black sooly smoke covered the forests and fields. This changed the usual colour of tree trunks from mottled greenish-grey to black.

The wing colour of typical peppered moth was mottled grey that blended perfectly with lichen-covered tree trunks and protected it from the ememies. Until 1845, only light-coloured moths were known in England. In 1845, the first dark-coloured peppered moth was seen in the region east of Manchester. This variant was named *Biston betularia carbonaria*. During next 50 years, dark individuals gradually increased from less than 1 to about 99% in the vicinity was explained by E.B. Ford and H.B.D. Kettlewell. Ford found that the caterpillars of melanic variety (Carbonaria) were more vigorous and viable, capable to withstand the environmental hardships. Kettlewell showed that melanic variety could not survive in the nonsooty forests, because the birds could locate them on lichens. So, they were being devoured by birds irrespective of their number. With the elimination of lichens, the cabonarias were cryptically coloured and blended with the tree trunk. Therefore, the melanic variety became abundantly distributed in due course of time.

Natural selection has operated in the direction of eliminating gene for light-coloured and gradual increase of gene for dark pigment.

(ii) **Disruptive or Diversifying Selection** : This type of selection acts to break up a previously homogenous population into two or more populations due to different adaptive norms. It simultaneously favours individuals at both extremes of the distribution curve. As a result, two peaks in distribution of traits are produced.

(iii) **Stablising Selection :** This type of selection favours average or normal phenotypes and eliminates extreme variants. It occurs in a constant or unchanging environment and eliminates new mutations. It means stabilizing selection reduces variation and favours homozygosity without changing the mean value.

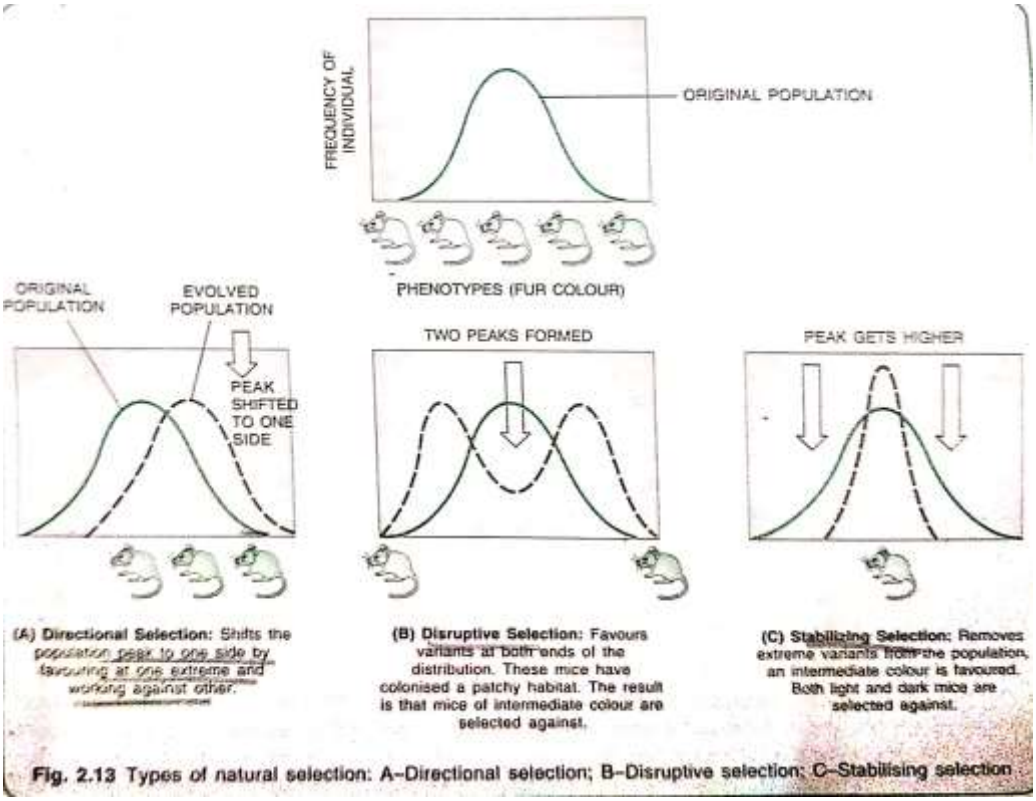


Fig. 2.13 Types of natural selection: A–Directional selection; B–Disruptive selection; C–Stabilising selection

Example of Natural Selection

(i) Resistence of Mosquitoes to Pesticides (DDT) : When DDT was introduced to control mosquitoes, it proved to be successful insecticide. But now, it has become ineffective again mosquitoes. It can be explained as below :

The original population of mosquitoes had some DDT-resistant individuals. In the absence of DDT, such DDT-resistent individuals had no additioanl adaptability or survival value over. DDT sensitive mosquitoes. National selection favoured them only when DDT was sprayed on large scale. Therefore, DDT-resistant genotype became more and more numerous over a period.

Difference between Natural and Artificial Selection

Natural Selection	Artificial Selection
1. Natural selection is exerted by nature. 2. This process operates in natural population. 3. It is a very slow process and takes thousands and millions of years. 4. Natural selection is responsible for the great biological diversity seen in the living world. 5. Natural selection or favours charters that are of the survival value to the organisms.	1. Artificial selection is exerted by man. 2. This process operates in domestic population. 3. It is a fast process and its results are immediate. 4. Artificial selection produces new varieties that are different from the starting generation. 5. In artificial selection, the breeder selection features are of interest or benefit in human.

SPECIFICATION OR ORIGIN OF NEW SPECIES

Speciation is the origin and evolution of new species. In nature, new species are continuously formed from the population of pre-existing population by gradual modifications in their morphology and genotype and the isolation of these populations to prevent free gene flow among their members.

Types of Speciation

Speciation is of following two types :

(i) Allopatric speciation

(ii) Sympatric speciation

(i) **Allopatric Speciation or Parapatric Speciation by Geographic Isolation**

Allopatric (GK. Allos = other + patria = Native land speciation is intraspecific speciation. Sometimes, a large population formerly enjoying continuous distribution and free gene flow gets geographically isolated into two or more populations, separated by some geographical barriers (mountain ranges, rivers, land patches, deserts, oceans, etc. The splitting of a species into two or more geographically separated species is called allopatric speciation or parapatric speciation and such speices are called allopatric or parapatric species. This means allopatric species occur in different geographical areas and allopatric speciation is caused by geographical isolation.

(ii) **Sympatric Speciation by Sudden Reproductive Isolation**

When a few individuals of a species within the same geographical area suddenly become reproductively isolated from the main population, they form a new species. This is called sympatric species and its origin as sympatric (Gk sym = together + patria = native land) speciation. The sympatric species arises in geographical area of its parents' species.

HUMAN EVOLUTION

Man's origin is considered to be about 15 million years ago from some common ancestral hominoid stock which included ancestor of both man and apes.Man is a member of order **Primates** sub order **Anthropoidea** and family **Hominidae.**Man's nearest relatives are monkeys and apes i.e. Gibbons ,chimpanzees ,gorilla and orangutan.

Factors responsible for Human evolution:

- Increased aridity
- Dwindling of forests and their replacement wide stretches of grasslands.
- Reduction of food from trees.
- Increased competition for arboreal habitat due to loss of trees- dwellers to get down to the ground and developed the adaptation for the survival on land.

Characters that developed during Human evolution:

Following morphological characters have evolved during human evolution:

- Bipedal locomotion.
- Straight posture.
- Development of distinct lumbar curve.
- Development of broad basin shape iliac bones in the pelvic girdles.
- Acetabular cavities shifted inward to give straight posture.
- Increased in the size of brain and cranial cavity.
- Flattening of face.(orthognathous)
- Loss of supra orbital ridges.
- Straightening of forehead.
- Formation of chin
- Opposable thumb in the hands for grasping.
- Sparse body hair.
- Narrowing of nose.
- Thinning of jaw bones.
- Reduction in the jaw musculature.
- Reduction in the size of canines.
- Increase in intelligence
- Social and cultural organization

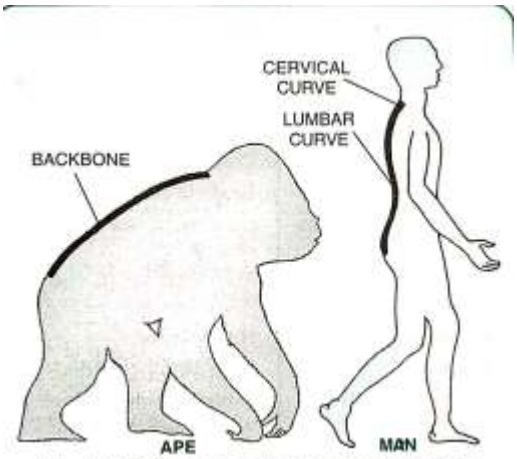


Fig. 3.2 Difference in the backbone of ape and man. Note the cervical and lumbar curves in human backbone for straight posture

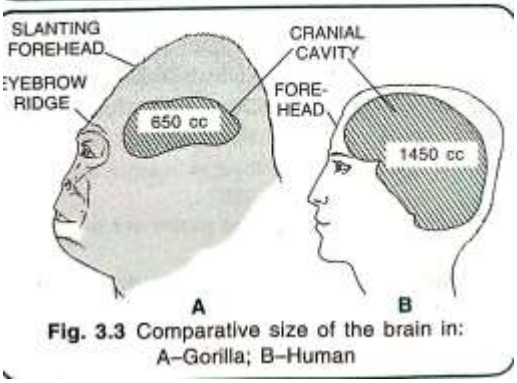


Fig. 3.3 Comparative size of the brain in: A–Gorilla; B–Human

Origin of Man

Early Human Ancestors :

About 25- 30 million years ,ape humans or hominoid stock started descending from the trees and gradually became ground dwellers.They evolved along along two lines : apes and men

1) Those that spent most of their time on trees and occasionally visited the ground : **evolved into apes .**
2) Those that were completely ground dwellers : **Evolved into man.**

Subsequent separation of ape and human ancestors is regarded to begin about 5 million years ago.After this, family **Pongidae (apes)** and **Hominidae (men)** evolved along different lines.

A) Prior to ape man:

1) *Dryopithecus:*

It is a group of apes whose fossils were obtained from rocks of Miocene (about 20-25 million years ago) from Africa and Asia. *Dryopithecus* resembled great apes

.Their arms and legs were of almost equal length.They had semi –erect posture and large canines like those of modern apes.They were supposed to be a **common ancestors of apes and men.**

Proconsul is the immediate ancestor of apes and it is from this apes evolved and therefore called **pre –ape.**

2) *Ramapithecus:*

Ramapithecus is the direct fore runner of of Hominids.It is the oldest man-like fossil obtained from Africa and Asia from Miocene and early Pliocene.

Following were the characteristics of *Ramapithecus:*

- Man like feeding habits
- Walking erect on the ground
- Canines small ,like that of man.
- Short face and small brain
- They could bend their knuckles.

By molecular clock method ,it was established that *Ramapithecus was the ancestor to Orangutan*

B) <u>The Ape man :</u>

1) *Austalopithecus:*

Austarlopithecus was the first African ape man whose fossil deposits were discovered by Raymond Dart in 1925 from South Africa from late Pliocene.It lived about 5 million years ago.

<u>Simian features (Similarities with Apes) :</u>

- Similar in size,average, about four feet.
- Face was prognathous (face protruding anteriorly)
- Chin is absent,forehead low.
- Bulge of occipital region was small.
- Eyebrows ridges projected over the eyes.
- Cranial capacity ranged from 450-600 cc, slightly larger than modern adult.Chimpanzee.

<u>Human features (Similarities with man) :</u>

- *Australopithecus* walked nearly straight.
- The vertebral column had a distinct lumbar curve.
- Pelvis broad and basin like.
- Teeth man – like with dental arch in the form of smooth rounded parabola.
- Canines man –like and did not project beyond the level of other teeth.
- Simian gap between incisors and canine absent.

Thus, *Australopithecus* is described as man with ape like brain and the immediate ancestor of man.

2) *Homo habilis:*

Fossils of *Homo habilis* were discovered by Leaky along the eastern shore along the eastern shore of Lake Turkana in Kenya.It was named handy because of the assosciated artefacts formed of bones .It survived 3-5 million years ago Pleistocene.

Following are the characteristics:

- It was about 4.5-5 feet in height.
- It showed a bipedal gait.
- Its cranial capacity were slightly more erect than *Australopithecus* about 735 cc.
- *H. habilis was with a human –like body and an ape –like head .*
- He lived in caves and used to collect berries,nuts,tubers and other plant material for food ,though raw meat was also eaten.
- They used tools of chipped stones to dig out tubers ,remove skin and meat and crush animal bones.

3) *Homo erectus:*

Homo erectus evolved from *H.habilis or Australopithecus about 1.7 million years ago.*It's first fossils were described under the name of *Pithacanthropus.* Following were the characteristics of *H. habilis* :

- *H. erectus* was around 5.5 feet tall.
- Its pelvis was more bowl shaped.
- The acetabulum was placed more inward than in *Australopithecus ,* so that *H.erectus* had a straight legged stance.
- Foot was arched to support body weight.
- Grasping ability of foot was completely lost.
- Hands had perfected the 'precision grip ' for holding twigs.
- It had a low sloping forehead ,thick eye brows and massive but less pronounced lower jaw than in *Australopithecus.*
- The size of cranial capacity ranged 750-1100 c.c

C) <u>The Early man</u>

1) *Homo sapiens neanderthalensis*

Fossils of Neanderthal man were discovered in 1856 by Fuhlrott from a cave Dusseldrof in Neander Valley ,Germany They arose 1,00,000 years ago and flourished in Europe in Europe,Asia and North America but became extinct about 25000 years ago It's main features are :

- The fore head was low and slanting
- The eyebrows ridges were heavy

- The lower jaw was strong with strong jaw muscles with no chin.
- The cranial capacity was 1450 cc
- They were about 1.5-1.66 m in height I,e, short statured .
- Semi erect stooping posture.
- Neanderthal were intelligent and good hunters.
- They made flint stone tools.
- They used clothes made up of animal skin and buried the ead .

2) *Homo sapiens fossilis:*

It's fossils were discovered by Mac Gregor in 1868 from the caves of north west Italy.Cro-Magnon man originated about 50,000 years ago, existed for about 30,000 years ago or more.The Cro Magnon had the following features:

- CroMagnon man was about 1.8 metres tall.
- It had a perfect erect posture.
- It had sparse hair on it's body.
- Prominent chin elevated and narrow nose.
- Face was prognathous
- Cranial capacity was 1650 cc
- They were cave dwellers and hunters
- They used animal hides as clothing.
- They had learnt drawing and painting pictures of contemporary animals around 18,000 years ago.
- they were nomadic but started settling down in permanent communities where food was abundant.

3) *Homo sapiens sapiens:*

It is the living modern man.It arose from Cro Magnon man about 25000 years ago and is associated with Neolithic culture.They had the following characteristics:

- They learnt to cultivate plants for crops.
- Domesticated animals.
- Started settling down near rivers and seas to catch fish
- Neolithic culture lead to the development of technology and use of metals for making tools,ornaments and utensils etc.
- Cranial capacity from 1300-1600 cc

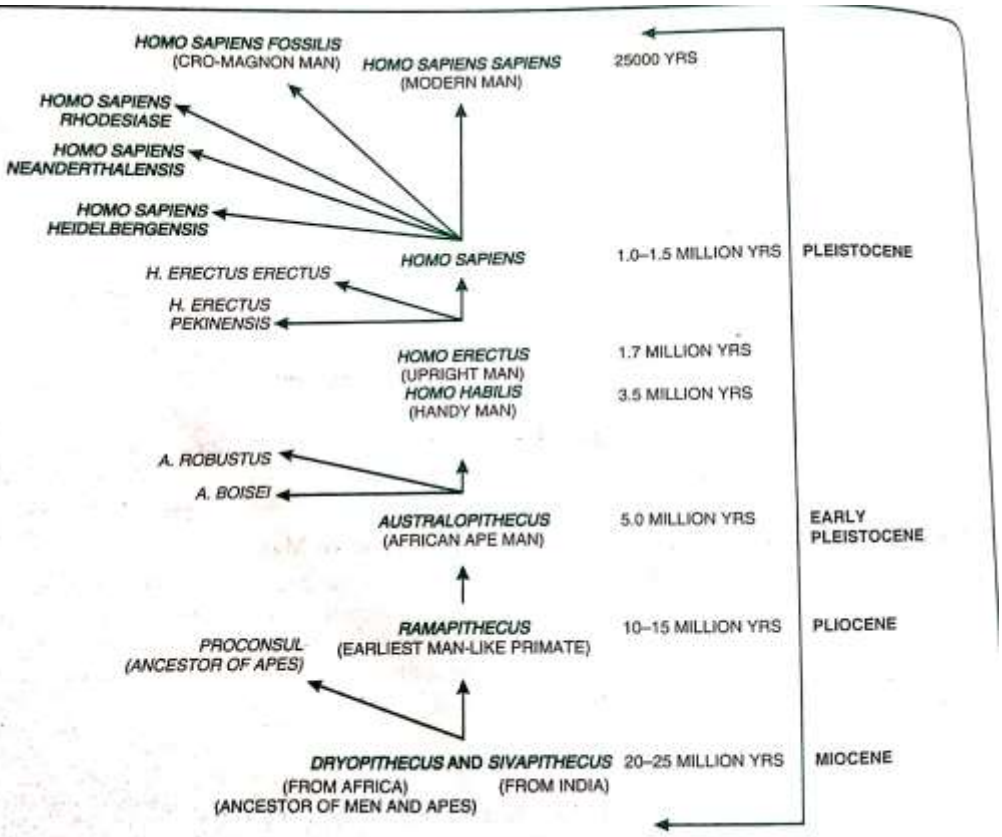


Fig. 3.9 Pedigree chart of human evolution

Shaista Ahmed