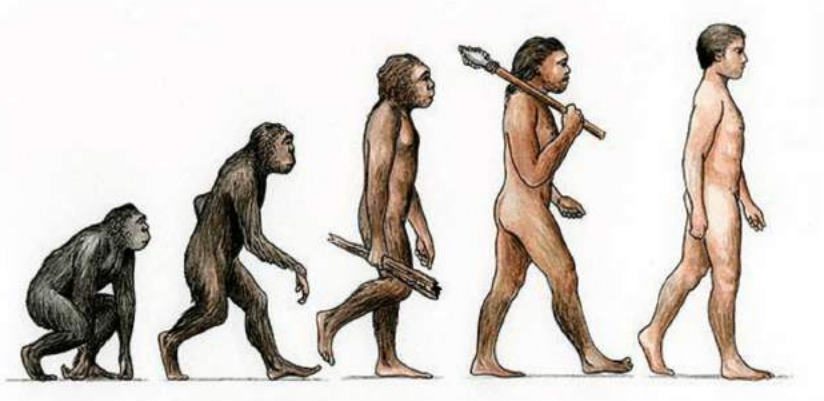
Chapter 7

Evolution

Evolution of Life: Mechanism & The Big Bang Theory

What is Evolution?

The evolution of life on earth has not been a simple process. Some explain it as a process while some interpret it as a result of various natural occurrences. The evolutionary theory tries to convey the message of the origin of the earth and how lives on earth evolved. Evolution as a process, explains how the world came into existence. It has resulted in biodiversity.
The process by which modern organisms have descended from their ancestors, with changes in their allele frequencies, is called evolution.



Mechanism of Evolution

The mechanism of evolution occurs due to the changes in the gene pool- the collection of genes. There are four key mechanisms that cause a population. These include:

- Mutation.
- Gene Flow.
- Genetic Drift.
- Natural Selection.

1. Mutations

Mutations are defined as the changes in the DNA sequence of a living organism. The mutations occurring in the germ cells, i.e., the egg or sperm cells only are passed on to future generations. These mutations are inherited from the parents and are present in every cell throughout a person's life. These are the mutations that lead to evolution. The acquired mutations occur during a person's life and are present only in some cells. These are caused due to environmental factors such as ultraviolet radiations and do not pass on to future generations. They are not a part of evolution.

2. Gene Flow

The transfer of genes from one population to another is called gene flow. For eg., pollen moving from one place to another by the action of wind or people moving to different cities or countries. When a person from one country moves to the other and mates with a person there, a transfer of genes occurs between the individuals. This is how the gene flows between different populations. Gene transfer can be horizontal, i.e., transfer of genetic material from one population to another by asexual means. This phenomenon is prevalent in prokaryotes.

3. Genetic Drift

It refers to the change in the allele frequency of a population as a matter of chance. It is a random event whose effect is larger in smaller populations and smaller in larger populations. The two examples of genetic drift are the bottleneck effect and founder effect.

- **Bottleneck Effect:** It occurs when there is a sudden decrease in the population due to some environmental factors, such as an earthquake, tsunami, epidemics, etc. In this event, some genes are depleted from the population. This causes a drastic reduction in the genetic diversity of the original gene pool. That means that the genetic makeup of the surviving population becomes different from that of the original one.
- **Founder Effect:** When a small number of individuals separated from a larger population make up a new population, there is a loss of genetic diversity. They do not carry the genetic diversity of the previous population. Due to this, some genetic traits become more prevalent than the others, which results in genetic diseases in future generations.

4. Natural Selection

Some individuals with certain traits have higher survival and reproductive rate than others. They pass on these genetic features to their offspring which brings an evolutionary change in the future generations. This selection of the genetic qualities that prove beneficial for survival in future generations is known as natural selection. Darwin's Finches is one classic example of natural selection. Darwin's finches have

evolved into 15 different species depending upon their adaptation and feeding habits.

What is the Big Bang Theory?

- The Big Bang Theory is an astrophysical model of the universe that can be observed by human senses. The theory gives details about the origins of the universe from its early formations to its modern-day evolutions.
- The Big Bang Theory explains how the universe expanded from an initial state of extremely high density and high temperature by offering a detailed explanation of observed phenomena, radiation, an abundance of light elements, and large-scale structures.

What does the Big Bang Theory state?

- The Big Bang Theory states that the universe began to cool down sufficiently in order to allow the formation of particles that would later become atoms after its initial phase of expansion.
- Primordial elements – Hydrogen, Helium, and Lithium – condensed through gravity that formed early stars and galaxies. In simpler terms, it can be stated that the universe inflated into the cosmic system 13.8 billion years ago to form the galaxy and the solar system as we know it.

Misconception about the Big Bang Theory

- The most frequent misunderstanding regarding the Big Bang Theory is that it gives the complete origin of the universe but ith does not describe the energy, time, and space involved in the creation of the universe. It only explains how the universe emerged from its initial high-temperature state. It would be false to draw parallels to everyday objects when trying the explain the Big Bang Theory, especially where size is concerned. The theory only describes the size of the observable universe and not the universe as a whole
- Accurate derivation requires the use of general relativity, and while treatment using simpler Doppler effect arguments gives nearly identical results for nearby galaxies, interpreting the redshift of more distant galaxies as due to the simplest Doppler redshift treatments can cause confusion.

Modern Synthetic Theory of Organic Evolution

Modern Synthetic Theory Of Organic Evolution :-

This theory is the result of the work of a number of scientist namely **Dobzhansky, Fisher, Haldane, Swall wright, Mayr, Stebbins.**
Stebbins discussed this theory in his book **"Process of Organic Evolution"** and Dobzhansky explained it is his book **"Genetics and the origin of species"**.
According to this theory new species can not evolved by the presence of variable genotype in a population. Two factors are also required-natural selection and reproductive isolation.
Natural selection guides different population in to different adaption direction and reproductive isolation between them due to geographical barriers leads these direction to the evolution of new species.
In this theory following factors are included –
(i) Gene mutation
(ii) change in chromosome number and structure
(iii) Genetic recombination
(iv) Natural selection
(v) Reproductive isolation.
Besides these factors there are two more processes which cause evolutionary changes. These are –
(i) Migration of individuals from one population to another.
(ii) Hybridization among species and also related genera which causes genetic variation in the population undergoing process of evolution.

Mutation Theory

Proposed by Hugo-de-vries on the basis of his experiments on a plant Oenothera lamarckiana.

Main Point of mutation theory :

1. Mutation or discontinuous variation are the raw material of evolution.
2. Mutation appears suddenly and produced their effect immediately.
3. Mutants are different from the parents and there are no intermediate stages between the two.
4. The same type of mutation can appear in several individuals of a species.
5. Mutation can appear in all direction and all mutations are inheritable.
6. useful mutations are selected by nature and lethal mutations are eliminated.
7. Mutation are recurring so that the same mutant can appear again & again so change of selection by nature are increased and new species is formed.
8. De-vries termed single step large mutation as **saltation.**
9. Mutations are large, random and directionless while Darwinism variations are small and directional.

Points in favour of mutation theory :

1. Mutations are actually the source of all variations and fountainhead of evolution.
2. Mutation theory can explain both progressive & retrogressive evolution.

Significance :

De-vries mutation theory generally accepted because the mutation were found to be inheritable. It was later through that evolution cannot occur by mutation alone, natural selection and isolation of mutants are also necessary for evolution.

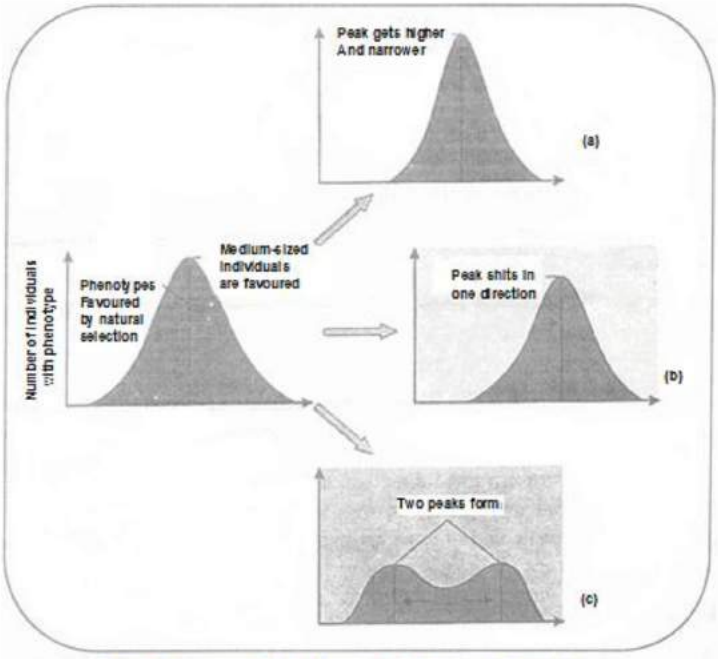
Natural Selection & Polymorphism :

A population is called polymorphic for a character if two or more distinct form are present in this population.

Ex.: ABO Blood Group :

There are 4 types of blood group are present in human being A, B, AB. and O. They are due to the presence of different genotype.
Sickle cell anemia is also an example of polymorphism. In this disease on amino acid is changed in polypeptide chain due to change in one N_2 base. That's why the normal shape of RBC is changed into sickle shape.
The organism in which heterozygous condition is present for this characters, the RBC become sickle shaped.
In this type of RBC malarial parasite can't have a normal growth that's why these individuals are resistant towards malaria.
The HbS, HbS, condition leads to the death of organism.
The organism with HbS, HbA condition are selected by nature because these are the fittest of all. The lose of HbS gene due to the death of organism having HbS, HbS is recovered & balanced by the reproduction of heterozygous condition (HbS, HbA).
This type of selection is called **balancing selection.** It means the preservation of genetic variability is maintained by the selection of hertozygotes which is called **'Balanced polymorphism'.**
But this kind of balancing selection is found very rarely in nature.

Types of Natural Selection :



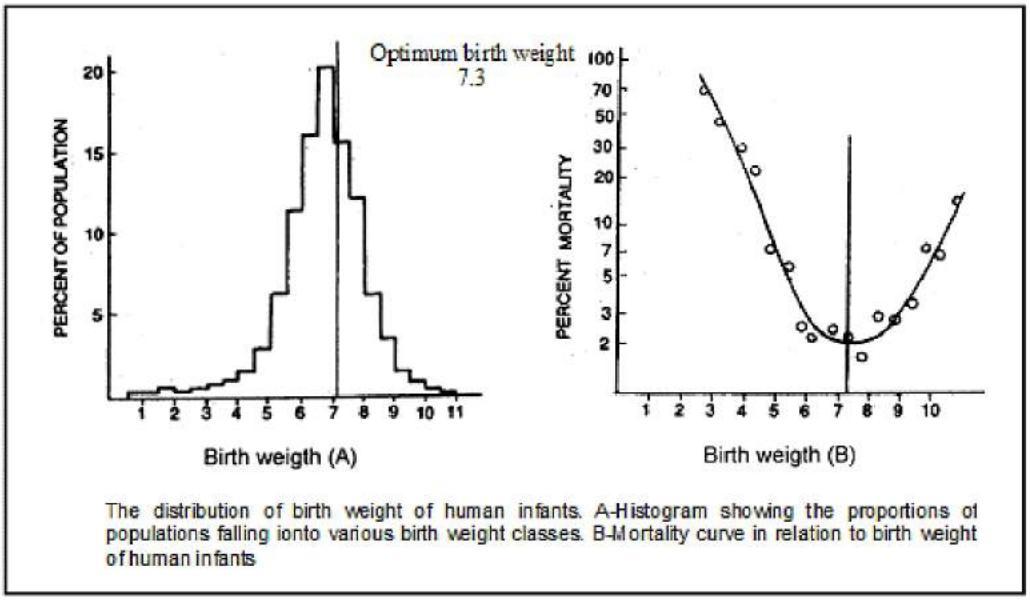
Diagrammatic representation of the operation of natural selection on different on different traits : (a) Stabilising (b) Directional and (c) Disruptive

Based upon different organism – environment relationship. Following different kinds of natural selection have been recognised.

- Stabilizing selection.
- Directional selection.
- Disruptive selection.

(1) Stabilising selection :

Stabilizing selection operates when phenotypic feature coincide with optimum environmental conditions and competition is not present.
It keeps a population genetically constant.
It favours the average or normal phenotypes and eliminate the extreme variants, that fall towards both ends of the bell-shaped curve of variability for the distribution of measurements of phenotypic traits.
Due to continuous elimination of both extremes, the bell shaped curve tends to narrow.
Stabilising selection always operates in constant or unchanging environment.
Ex. **Mortality in babies** : The birth weight of human babies provides another example influenced by stabilizing selection.
The optimum birth weight favoured by stabilizing selection is 7.3 pounds.
New born infants less than 5.5 pounds and more than 10 pounds have the highest mortality rate. The curve for mortality is virtually the complement of the curve of survival.



The distribution of birth weight of human infants. A-Histogram showing the proportions of populations falling ionto various birth weight classes. B-Mortality curve in relation to birth weight of human infants

(2) Directional selection or Progressive selection :

Directional selection produce a regular change in a population in respect to certain traits.

This form of selection operates in response to gradual changes in environmental condition.

It favour the phenotype which is non average or extreme and then pushes the phenotype of the population in that direction.

Directional selection removes more individuals from one end of the normal curve of variability distribution and adds towards the other end and alters the mean value of the trait in the population in a particular direction.

So the mean moves in one direction.

Directional selection operates when environment is changing in one direction.

Ex. (1) Biston betularia

(2) Resistance of insects to DDT.

(3) Disruptive selection :

This is probably the rarest form of selection but can be very important in bringing about evolutionary change.

Presence of more than one phenotype in a population.

Selection pressure acting from within the population as a result increased competition may push the phenotype away from the population mean towards the extremes of the population.

This can split a population into two sub-population.

If the gene flow between the sub-population is prevented, each population may give rise to a new species. In some cases this form of selection can give rise to the appearance of different phenotype within a population, known as polymorphism.

Eg. Shell pattern in limpets : Shell patterns of limpets (marine mollusca) present a continuous, ranging from pure white to dark tan. These are either attached to white goose neck barnacles or to tan-coloured rocks. The white or light-coloured limpets camouflaged with white barnacles and tanned ones were protected on the tan-coloured rocks. Limpets of intermediate shell patterns, being conspicuous are preyed by predatory shore birds, resulting in disruptive selection.

Evidence of Evolution & Adaptive Radiation

EVIDENCES OF ORGANIC EVOLUTION

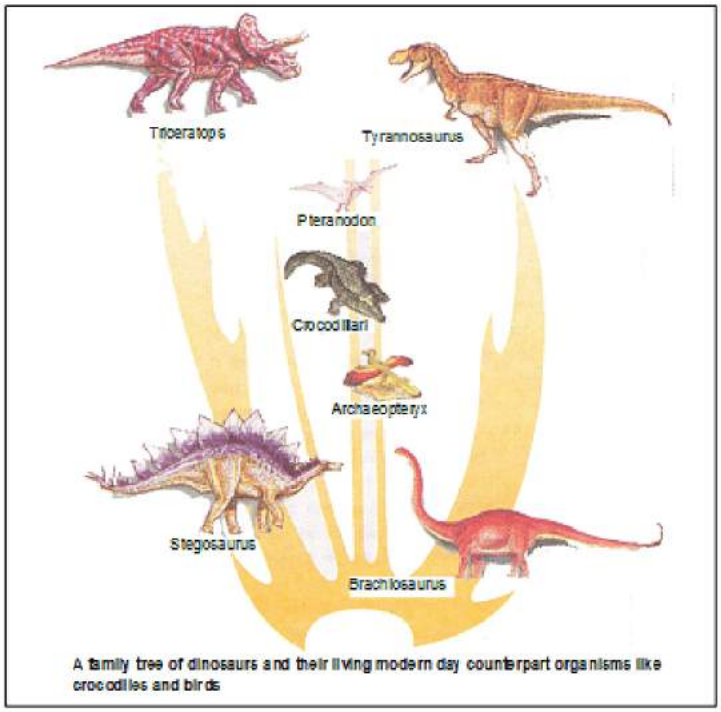
Some important evidences are –

1. Palaeontological Evidences –
The study of fossils is known as : **Palaeontology.**
Fossils : **Taken from Fossilis/Fossolium**
Father of palaeontology : **Leonard da vinci**
Founder of modern palaeontology : **George cuvier**
Birbal Sahni is famous for Indian palaeonotology
Two branches of palaentology –
1. **Palaeobotany :** Study of plant fossils
2. **Palaeozoology :** Study of Animals fossils

Definition of Fossils was given by Charls Lyell "Impression of past found in Rocks called fossils" **fossils provide one of the most acceptable evidence in support of organic evolution.**
Type of Fossils :

1. Unaltered Fossils :
In this type whole bodies of extinct organisms are found frozen in ice at the polar regions eg. Wooly mammoths (25000 yrs before extinct fossils were found from Siberian region)

2. Petrified fossils – Most common type of fossil.
Replacement of organic part by mineral deposits is called **petrification.**
These fossils consists of only the hard parts e.g. bones, teeth, shells, wood etc. of extinct organisms.
In human body first fossilization occurs of teeth.



A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

3. Mould fossils –
Here no part of the original organism is present, only an impression of the external structure of body is preserved in wet soil.

4. Cast fossils –
Sometimes minerals fills in the mould, resulting in cast fossils

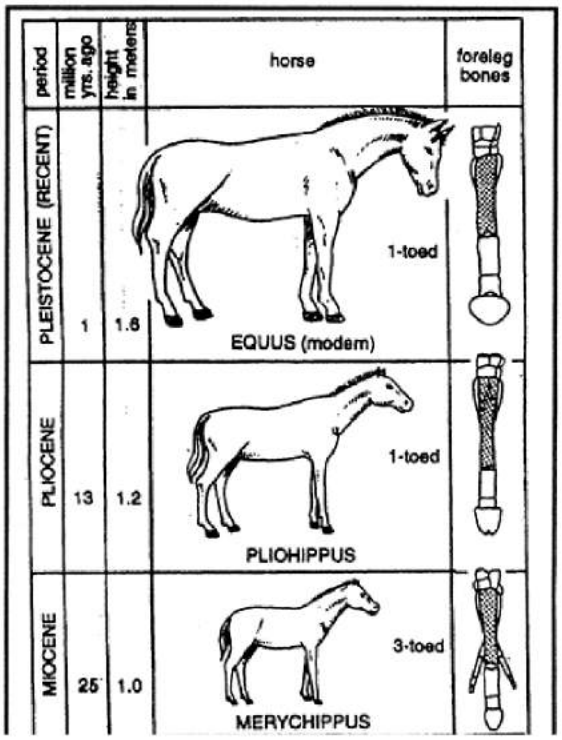
5. Print Fossils –
Foot print or prints of wings, skin,leaves, stems etc made in soft mud which subsequently become fossilized are a common type of fossils.

6. Coprolites –
These fossils include the fossil preservation of contents of the intestine or excreta of many ancient animals including particularly the reptiles or fishes.

By studying fossils following facts about organic evolution are evident –
1. Fossils found in older rocks are of simple type and those found in newer rocks are of complex types.
2. In the beginning unicellular protozoans were formed from which multi-cellular animals evolved.
3. Some fossils represents connecting links between two groups

Evolution of Horse –

Evolution of horse was described by **C.marsh.**



The primitive fossil of the horse was found in North America named **Eohippus.**
Changes during evolution of horse are as follows –

1. Increase in body height
2. Increase in the length of neck
3. Development of high crown on the surface of teeth and formation of cement.
4. There is gradual increase in the length of legs.
5. Number of toes or fingers in legs have reduced in modern horse. Only middle toe touches the ground, other toes reduced gradually.
6. Legs become more powerful for fast running.
7. As new species were formed, previous ones becomes extinct.
8. Enlargement of brain size.

Fossils of important Ancestors of horse

1. Eohippus or Hyracotherium –
It evolved in **Eocene** Epoch.
It's size was like a **fox.**
(**Orohippus :** It evolved in middle Eocene epoch.)
2. Mesohippus –

It evolved from eohippus during **Oligocene** epoch.
It's size was like a **sheep.**

(**Miohippus :** In the late oigocene Mesohippus was replaced by another slightly advanced horse like form named miohippus. It was much like mesohippus in a appearance but some what large in size)

(**Parachippus :** It evolved in early miocene).

3. **Merychippus –**
It evolved in middle and upper miocene epoch. It's size was like a **donkey.**

4. **Pliohippus –**
This horse evolved during **pliocene** epoch. It was of the size of modern pony.

5. **Equus –**
This is modern horse which evolved from pliohippus during **pleistocene** epoch (height 60-64 inches).

"Dating of fossils" or "The clock of the Rock"

The fossils give valuable information about the history of organic evolution by giving information about the organisms which existed in the past.
This is possible only if the correct age of the fossils can be determined. Methods have been developed to find out the correct age of the fossils by determining the age of the rocks where the fossils are found.
Rocks have been found to contain certain radioactive elements which lose their radioactivity and change into other nonradioactive isotopes at a fixed rate irrespective of the environmental conditions prevailing at different times.
If the rate of this loss of radioactivity of an element is known, the relative proportions of the Quantities of radioactive and nonradioactive element in a given rock will enable us to find out the age of the rock.
This method is called **absolute dating.**
This will be illustrated with the help of four different methods.
(1) Lead method
(2) Radio-carbon method
(3) Potassium – Argon method
(4) Electron spin resonance method (ESR method)

Geological Time Scale – Firstly given by Giovanni Avduina.
Chronological order of the history of organic evolution, which is presented in the form of geological time scale.

This time scale includes the history of earth itself ever since it was formed to formation of its crust from lava of ancient volcanic eruptions.
The period between the origin of gaseous cloud (4.6 billion years ago) from which the earth was formed and the formation of earth's crust is called **Azoic Era** (era of no life).
The remaining period (about 4.0 billion years) is divided in to five Eras namely –

1. Archaeozoic
2. Proterozoic
3. Palaeozoic
4. Mesozoic
5. Coenozoic

The Archaeozoic Era had "**invisible life**" and the remaining four era had "**visible life**" **(Phanerozoic).** Archaeozoic and proterozoic eras are also grouped together as Precambrian because the first part of palaeozoic is Cambrian.
The three eras namely palaeozoic, mesozoic and coenozoic, each is further divided into smaller time spans called **Period** and the periods of coenzoic era are each further subdivided into **Epochs.**
It is also believed that each era of earth's history started with a **revolution or cataclysm** and ended with yet another revolution.
These revolutions meant intense geological disturbances that occurred on earth, so that most of the pre-existing organisms perished in each revolution and the few remaining ones evolved into new and varied organisms.

The first great revolution is believed to have occurred between archaeozoic and proterozoic eras.
The second great revolution between proterozoic and palaeozoic eras.
Applachian revolution between palaeozoic and Mesozoic eras.

Finally the rocky mountain revolution between Mesozoic and coenozoic eras.
Fossils park of India –

1. Birbal sahni institute of palaeobotany, Lucknow.
2. 50 million year old fossil forests preserved in mandla district Madhya Pradesh.
3. 100 million year old fossil forest in rajmahal hills Bihar.
4. 260 million year old Coal forming forest in Orissa.

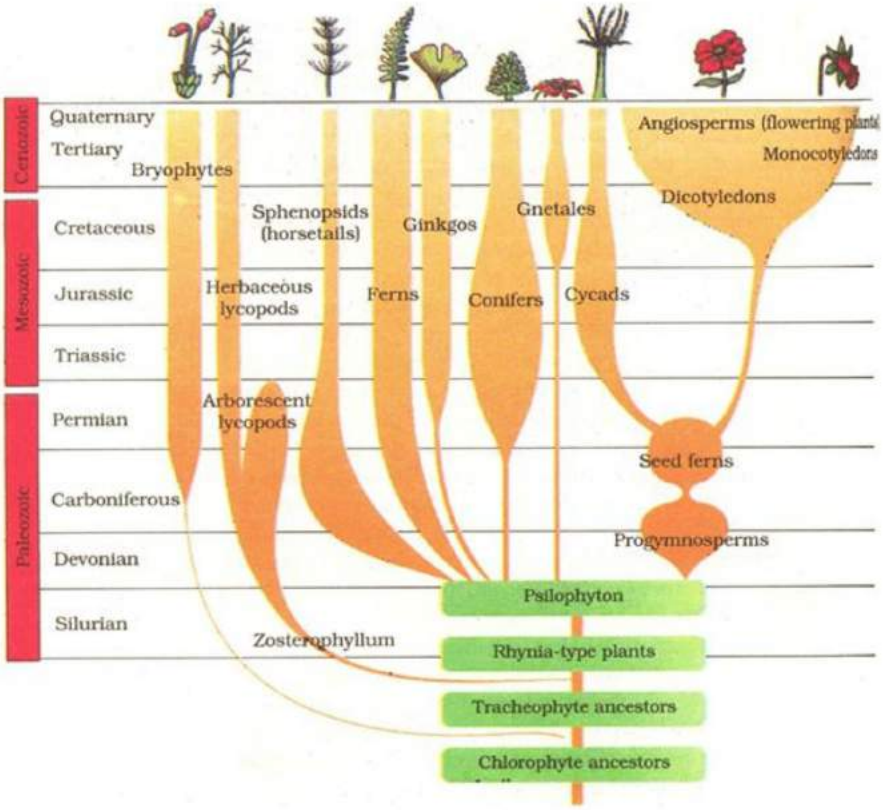
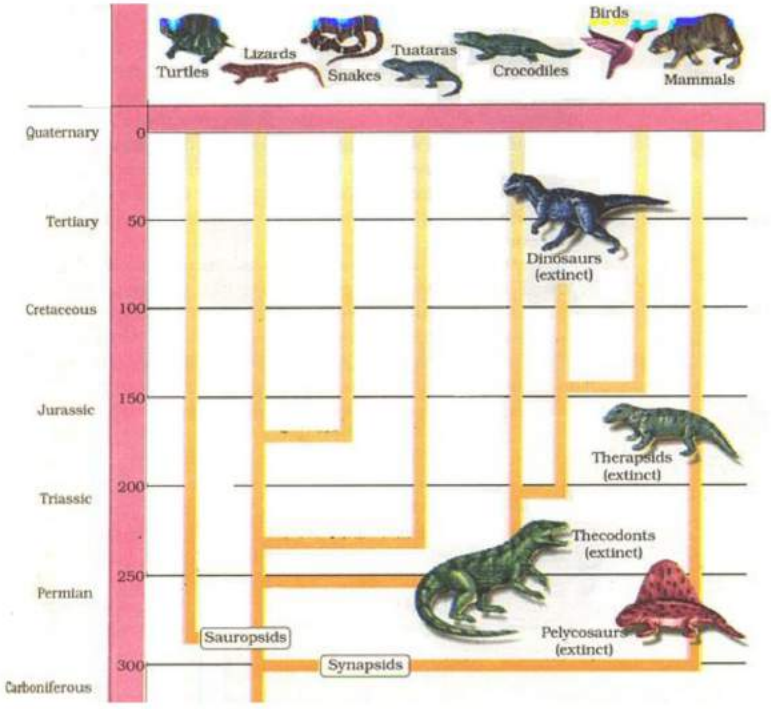


Figure : A sketch of the evolution of plant forms through geological periods



2. Morphological and Anatomical Evidences –

Different animals and plants show dissimilarities in their structure but in some characters they show similarities. These similarities are of two types.

1. Homology
2. Analogy

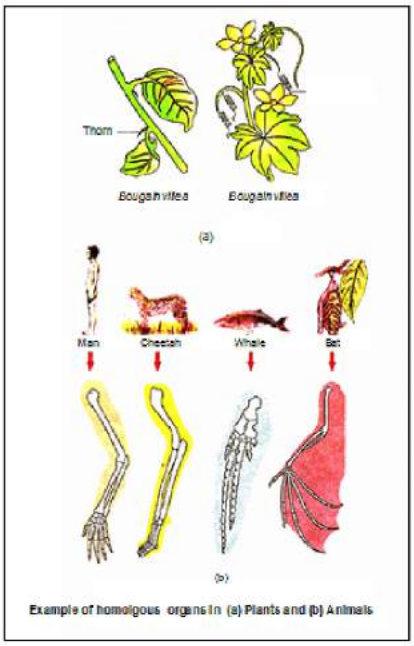
1. Homology –

The similarity based on common origin, similar basic plan of organization and embryonic development is called **homology.**

Similarity in appearance and function is not necessary.

The organs which have common origin, embryonic development and same basic structure but perform different functions are called **Homolgous organ. Homologous term given by Richard Owen.**

Examples of Homologous organs –



Example of homolgous organs in (a) Plants and (b) Animals

(i) Forelimbs of mammals –

	Horse	Bat	Whale	Seal	Man
Appearence	Foot	wings	Paddle	Flipper	Hard
Function	Running	Flying	Swimming	Swimming	Holding

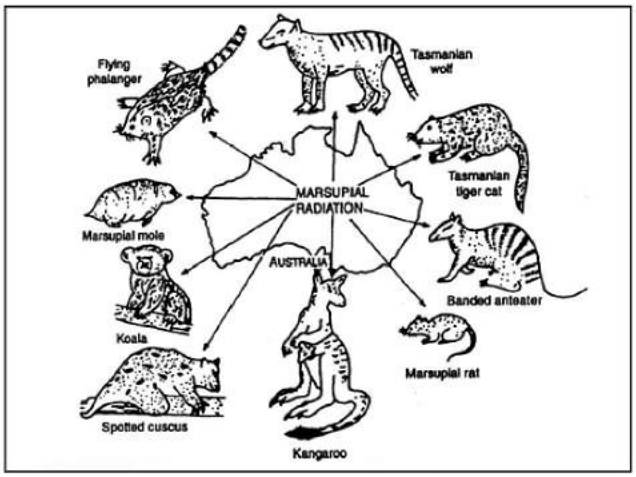
In their fore limbs similar bones are present like – **humerus, radius, ulna, carplas, metacarpals and phalanges.**

(ii) Legs of invertebrates –
Cockroach - Honey bee
Walking - Collecting of pollens
But in both segmented legs are present are segments are same
like **coxa, Trochanter, Femur, tibia, 1-5 jointed tarsus.**

(iii) Mouth parts of insects
Cockroach - Honey Bee - Mosquito
Biting and chewing - Chewing and lapping - Piercing and sucking
In each of these insects the mouth parts comprise **labrum, mandibles and maxillae.**
(iv) Homology is also seen in the skeleton, heart, blood vessels and excretory system of different vertebrates.

(v) Thorn of Bougainvillea and tendril of cucurbita (Modification of axillary bud).
(vi) Wings of sparrow and pectoral fins of fish.
(vii) Hind limb of mammals.
(viii) Potato & ginger.
(ix) Radish & Carrot
(x) Homology is also seen among the molecule. This is called **molecular homology.** For example the proteins found in the blood of man and apes are similar.
(xi) Testes in male and Ovaries in female develop from same embryonic tissue.
(xii) Pectoral fin of fish and flipper of seal.
(xiii) Flipper of penguin (bird) and dolphin (mammal)

Divergent evolution (adaptive divergence/adaption radiation)



Homology found in different animals indicate their evolution from common ancestors.
Species which have diverged after origin from common ancestor giving rise to new species adapted to new habitats and ways of life is called **adaptive radiation,** exhibit large number of homologous organs.
Homology shows **Divergent evolution.**
For Example Adaptive radiation gave rise to a variety of marsupials in Australia.

2. Analogy –
It is similarity in organs based on similar function.
Organs which have different origin and dissimilar fundamental structure but have similar function are called **Analogous organs.**

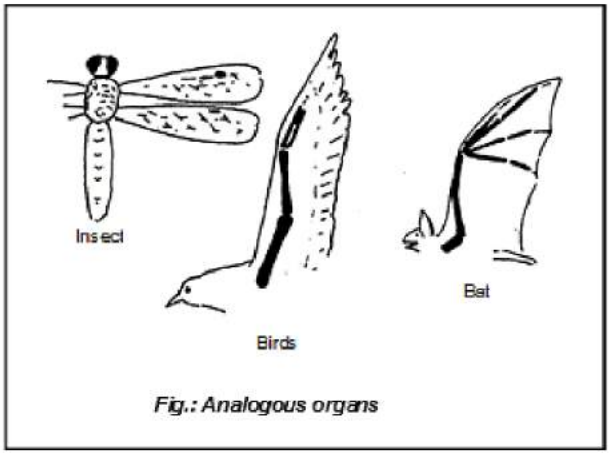


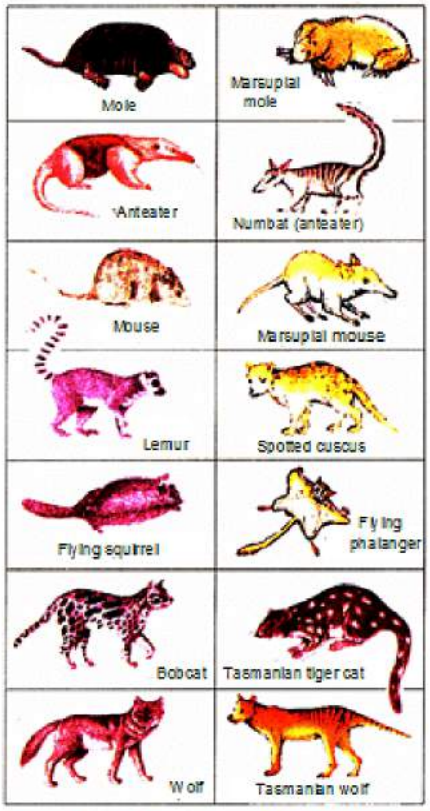
Fig.: Analogous organs

Examples of Analogous organs –

(i) Wings of bat & birds are analogous to wings of insects.
(ii) Pelvic fins of fish, flipper of seal
(iii) Sting of bee and scorpion.
(iv) Phylloclade of Ruscus and leaf
(v) Chloragogen cell of pheretima and liver of vertebrate
(vi) Hands of man and trunk of elephant
(vii) Potato and sweet potato.
(viii) Eyes of Octopus and eyes of mammals (different in their retinal position).
(ix) Dog fish and whale.

Convergent evolution (adaptive convergence/parallel evolution)

Development of similar adaptive functional structures in unrelated groups of organisms is called **convergent evolution.**
For Example : Some of the marsupials of Australia resemble equivalent placental mammals that live in similar habitats of other continents.
When adaptive convergence is found in closely related species, it is called **parallel evolution.**
Analogous organs do not show common ancestory but they show evolution.



Picture showing convergent evolution of Australian Marsupials and placental mammals

3. Evidences from vestigial organs –

The organs which are present in reduced form and do not perform any function in the body but correspond to the fully develop functional organs of related animals are called vestigial organs.
They are remnants of organs which were complete and functional in their ancestors.

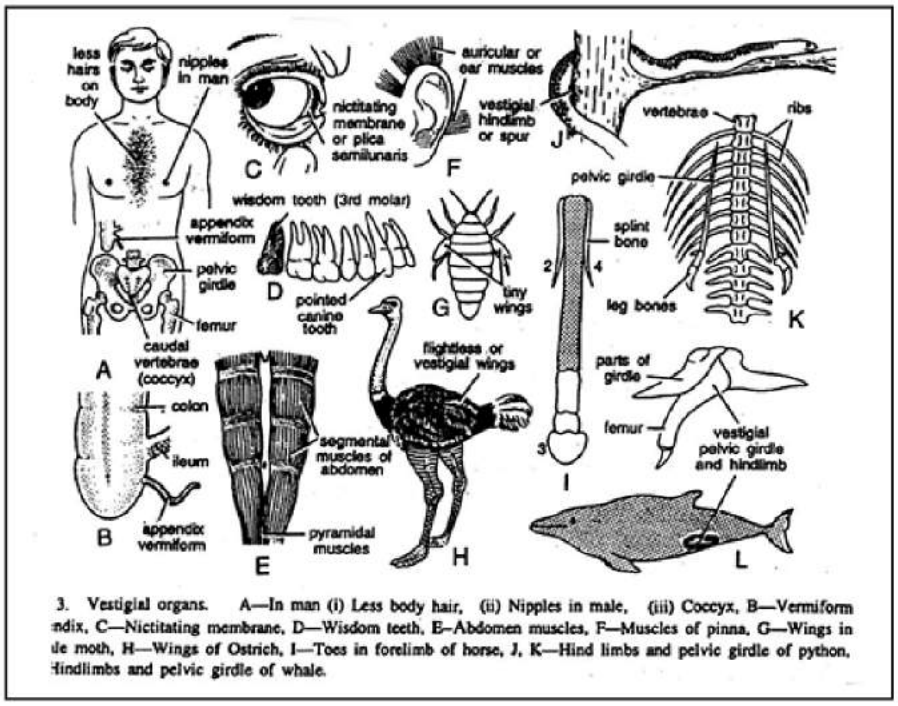
Vestigial organs in Human body –

Human body possess about 180 vestigial organs eg:-

a. nictitating membrane
b. muscles of pinna (auricular muscles)
c. vermiform appendix
d. coccyx
e. canine teeth
f. third molars (wisdom teeth)
g. segmental muscles of abdomen
h. caecum
i. body hairs
j. nipples in male
k. ear pinna

Vestigial organs in other animals –

– Hind limb and pelvic girdle of python



3. Vestigial organs. A—In man (i) Less body hair, (ii) Nipples in male, (iii) Coccyx, B—Vermiform ndix, C—Nictitating membrane, D—Wisdom teeth, E–Abdomen muscles, F—Muscles of pinna, G—Wings in de moth, H—Wings of Ostrich, I—Toes in forelimb of horse, J, K—Hind limbs and pelvic girdle of python, Hindlimbs and pelvic girdle of whale.

– wings of flightless birds such as ostrich, Emu, Kiwi, Dodo, Reha etc. (Dodo recently extinct)
– Eyes of deep sea fishes
– splint bones in feet of horse [2nd and 4th finger]
– external ear in whale
– rudiment of reptilian jaw apparatus.
– Hind limb and pelvic girdle of whale.

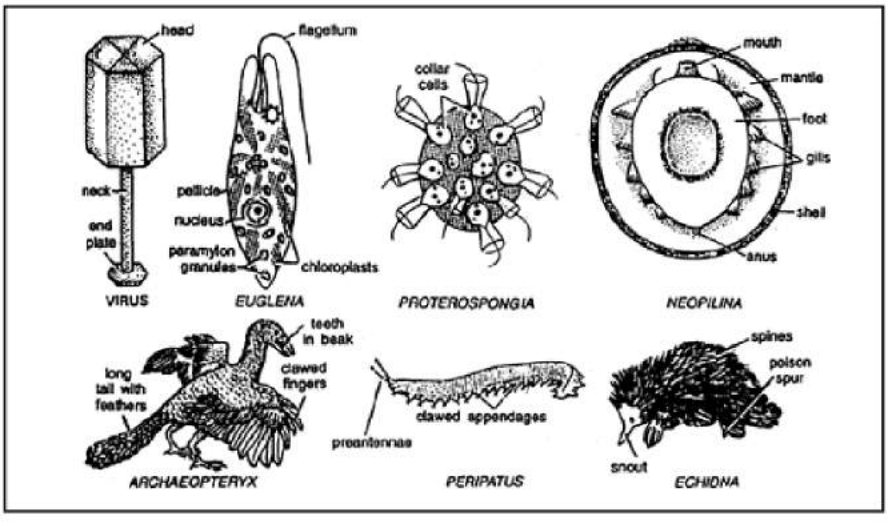
Vestigial organs in plants –
Scale leaves of Ruscus and various underground steams.

Vestigial organs are example of lamarckism (Theory of inheritance of acquired character)

4. Evidences from connecting links –

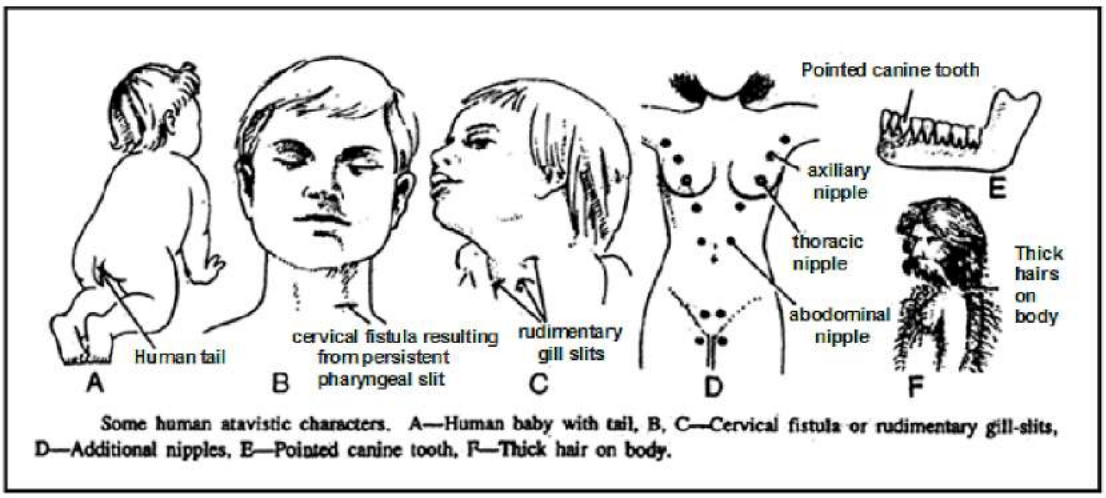
Some animals and plants possess characters of two separate groups. One being primitive and the other is advanced group.
These species as bridge between two taxonomic groups such organism are called **connecting** link. They provide good example of organic evolution of common ancestory.

(i) **Virus :** between living and non living
(ii) **Euglena :** Between plants and animals
(iii) **Proterospongia :** Between protozoa and porifera
(iv) **Neopilina :** Between mollusca and annelida
(v) **Peripatus :** Between Annelida and arthropoda
(vi) **Archaeopteryx :** Between reptiles and birds
(vii) **Balanoglossus :** Between non-chordates and chordates
(viii) **Chimera :** Between cartilaginous fish and Boney fish
(ix) **Lung fish (Protopterus) :** Between fishes and amphibia
(x) **Platypus :** Between reptiles and mammals
(xi) **Echidina :** Between reptiles and mammals.



5. Evidences from Atavism (Reversion) –

Sometimes in some individuals such characters suddenly appears which were supposed to be present in their ancestors but were lost during the course of development.
This phenomenon is known as **atavism or reversion.** Atavism proves that animals developing atavistic structure have evolved from such ancestors in which these structures were fully developed.



Some human atavistic characters. A—Human baby with tail, B, C—Cervical fistula or rudimentary gill-slits, D—Additional nipples, E—Pointed canine tooth, F—Thick hair on body.

Examples :

1. ***Human baby with tail***
2. ***Cervical fistula*** *– in some human babies an aperture is present on neck behind the ear called as cervical fistula. It represents pharyngeal gill slits which were present in aquatic vertebrate ancestors.*
3. ***Long and pointed canine teeth represented carnivorous ancestors.***
4. ***Large and thick body hair reflect our relationship with apes.***
5. ***Extra nipples (more than two)***

6. **Evidence from physiology and biochemistry –**

Different organism show similarities in physiology and biochemistry. Some clear examples are :–

1. **Protoplasm :** Structure and chemical composition of protoplasm is same from protozoa to mammalia.

2. **Enzymes :** Enzymes perform same function in all animals like **Trypsin** digest protein from amoeba to man. **Amylase** digest starch from porifera to mammalia.

3. **Blood :** Chordates show almost same composition of blood.

4. **ATP :** This energy rich molecule is formed for biological oxidation in all animals.
5. **Hormones :** Secreted in different vertebrates performs same function.
6. **Hereditary material :** Hereditary material is DNA is all organism and its basic structure is same in all animals.
7. **Cytochrome C** is a respiration protein situated in the mitochondria of all organism. In this protein from 78-88 A.A. are identical in all organism, which show common ancestory.

Physiology and biochemistry thus prove that all animals have evolved from some common ancestor.

7. Evidences from bio geographical distribution –

The study of geographical distribution of animal and plant species in different parts of earth is called **Biogeography.**

Different animal species occurring in an area are called **Fauna** and those of plants are called **Flora.**

On the basis of fauna and flora **Alfred Russel Wallace** divided the whole world into six major biogeographical regions called **realms.**

Nearctic : North America fro Mexixan highlands to Arctic islands and Greenland.

Palaearctic : Europe, North Asia up to Himalayas and North Africa up to Sahara desert.

Neotropical : Central and South America, Mexican lowlands and West Indies.

Oriental : Asia, South of Himalayas; India, Ceylon, Malay, Peninsula, Sumatra, Bornea, Java Celebes and Philippines.

Ethiopian : South Africa from Sahara Desert, Madagascar and Adjacent islands.

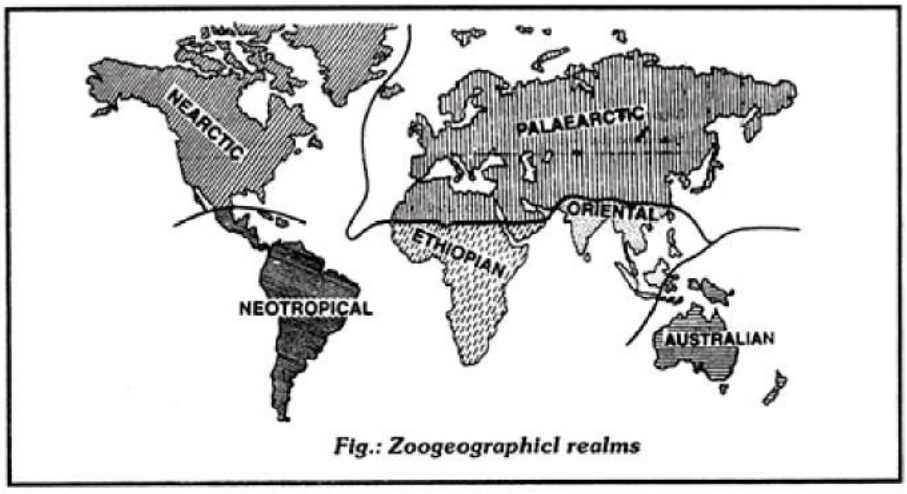


Fig.: Zoogeographicl realms

Australian : Australia, Tasmania, New Guinea, New Zealand and Oceanic islands of the pacific. It is believed that millions of years ago all the continents were present in the form of a single land mass called **Pangaea.**

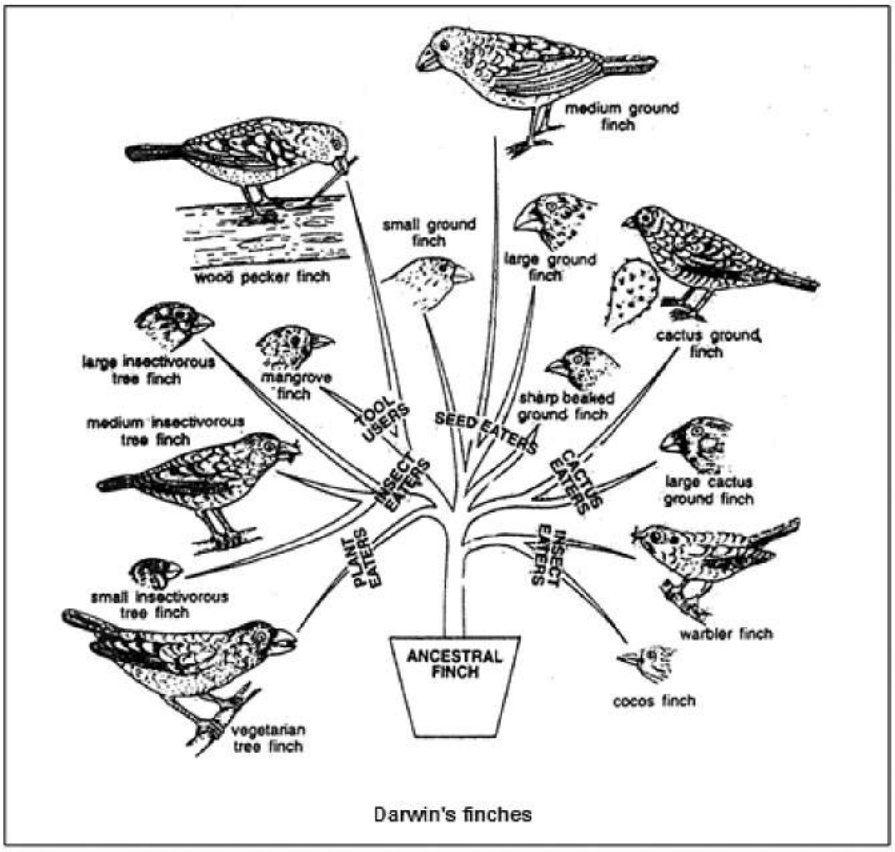
Later on due to varies geological changes, these continents drifted fro one another. As these continents moved away, they got separated from each other by the seas. As these continents had different environmental conditions so plants and animals evolved there were of different varieties. **(New species).**

Palaearctic and oriental realms are separated by high Himalayan Mountains.

1. **Prototheria –**

This is sub class of mammalian, which includes egg laying mammals like **Platypus** and **Echidna** found in Australia.
After the evolution of prototherians from reptiles Australia got separated from mainland of Asia.
Later on Eutherian mammals evolved in Asia, Due to their carnivorous nature they destroyed prototherians and metatherians from Asia.
So these groups became extinct on the mainland but they survived in Australia due to absence of Eutherians.
Today eutherians are also found in Australia **(they were later transported by man).**

2. **Marsupialia –** The subclass of class mammalian includes kangaroos and Opossum which are found only in Australia.
3. **Darwin's finches –** Darwin studied Fauna and Flora of Galapagos island situated near south America (consisted 22 islands). Here he saw 22 types of finches (birds) .



Darwin's finches

A related species of these birds were also present in South American continent. Probably some member of this species migrated to Galapagos island where these birds evolved into different species as a result of adaptation to environment. These birds are now known as **Darwin's Finches.**

Darwin described that a particular species is evolved in a particular area, progenies of this species migrate to different geographical areas and are gradually adapted to changing environmental conditions.

These adaptations gradually give rise to new species as a result of isolation.

Special Point :

a. Darwin's finches are also an example of adaptive radiation (different shape of beak and claws due to their habitat)

b. Darwin's finches are example of allopatric speciation.

4. Elephants and lions are mainly found in Africa and India.
5. Giraffe, Zebra and hippopotamus are found only in Africa.
6. Main land of human evolution in Africa.

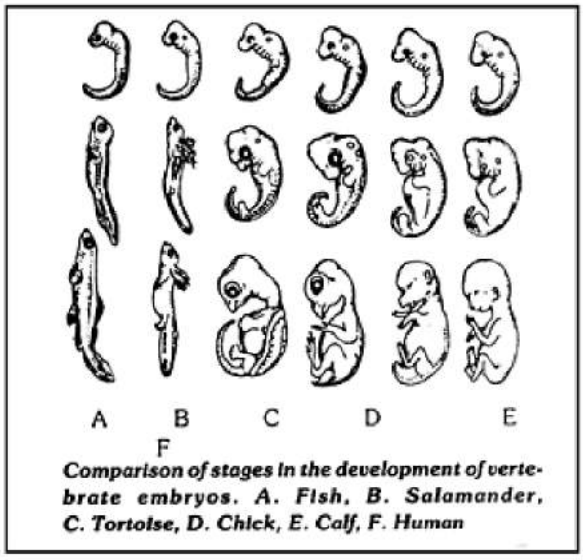
Important Point :

Palaeontological and Biogeographical evidences are considered as best evidences in support of organic evolution.

8. Evidences from Embryology –

Baer's Law : An organism show its ancestor stages in embryonic development. In embryonic stage general characters appear first then specialized characters appear.
Muller : First to propose '**Recapitulation theory**'.
– According to it '**ontogeny recapitulate phylogeny**' it means any organism show its ancestral adult stages during its embryonic development.
It shows that all organism evolved from a common ancestor.
– Ernest Haeckel explained it in detail and gave the name '**Biogenetic law**'

Examples : -
(i) The Zygotes from which the development of all metazoan bodies starts, are single-celled and quite comparable with the Bodies of simple protozoans.
This indicates the origin of **Metazoans from Protozoan Ancestors.**



Comparison of stages in the development of vertebrate embryos. A. Fish, B. Salamander, C. Tortoise, D. Chick, E. Calf, F. Human

(ii) The early stages of Embryonic development, Viz. Morula, Blastula and gastrula are Basically similar in all metazoans, indicating a **Monophyletic Origin** of the latter.

(iii) The Phylogenetically earliest metazoans i.e., the sponges and cnidarians, have retained early gastrula like double – layered (Diploblastic) structure of Body of Metazoans.
(iv) In fishes, the young individual, developing from gastrula, is almost-like the adult, but the tadpole larvae of Amphibians bear more resemblance to the young once of fishes than to their own Adults. This indicates **Origin** of **Amphibians from fishes.**

(v) Even after gastrulation in the vertebrates, the early postgastrula stages are quite similar in members of all the different classes, Viz, fishes, amphibians, reptiles, birds and mammals.
The differentiation of class characters appear in later stages, moreover, the embryo of phylogenetically higher vertebrates pass through the adult stages of lower vertebrates before finally attaining the characters of their respective classes.
This proves that **All Vertebrates** have evolved from common fish like Ancestors and also that both Birds and mammals have evolved from reptiles.
(vi) When the heart develops in the embryos of Amphibians, reptiles, Birds and Mammals, it is 2-chambered same as in the embryos and Adults of fishes. In later stages of Embryonic development in Amphibians, reptiles, the heart become, 3-chambered. In Birds and Mammals the heart is 4-chambered in the last embryonic stages to continue as such in the Adults.
(vii) Modern Scientists have discovered "**Biochemical recapitulation**" also.
For example, fishes mainly excrete Ammonia. Adult Amphibians Excrete urea, but their tadpoles excrete Ammonia like the fishes.
Birds excrete uric acid, but their embryos excrete first Ammonia and then urea during earlier stages.
(viii) In embryonic stage birds showed tooth buds for some time, which became extinct later. It show that birds evolved from toothed reptile like ancestors.

9. Evidences from Taxonomy –
Plants and Animals show a great diversity of form. They also show some similarities among themselves.
It is on account of these differences and resemblances that the taxonomists have to arrange them in to smaller and larger groups.
Among species also there are differences and resemblance of varying degree. Some species resemble one another more closely than they resemble others and form a closely related group.
Similarly, there are other groups of closely resembling species.
The members of each group resemble each other more closely than they resemble the members of other groups.
Each such group of species is called a genus. Genera also show different degrees of resemblances among themselves.
Those that resembles one another more closely than others are placed in a large group called a family.
Families are grouped in to larger units called orders, orders into classes and classes in to Phyla.
Evolution has a ready explanation for this system of grouping or classifying plants and animals in groups indicates relationship.
Special points : -

1. The aquatic mammals [eg - **Dolphins, Whales, Seals, Porpoises** etc.] don't have gill slits **because their adaptation to aquatic life is secondary.**
2. In Acacia tree well developed compound leaves are found. But seedling has simple leaves like those found in all stages of development of its ancesters. This provide a good example of **Recapitulation**
3. Modern day Oaks of southern United State of America retain their foliage throughout the year where as the oaks of northern United States are **deciduous** and shed their leaves during water. The southern species, on the basis of this character of leaves are considered to be more primitive than the northern oaks. However, the seedling of northern species are generally seen to retain their leaves during winter. This provide a good example of - **Recapitulation**

4. EVOLUTIONARY TREND :

The continuous change of a character within an evolving lineage is termed as **evolutionary trend.**

THEORIES OF ORGANIC EVOLUTION

lamarckism :

First theory of evolution was proposed by
Jean Bapttiste de Lamarck (17-44 - 1829)
Book : **Philosophie Zoologique (1809)**
Lamarck coined the terms – **Invertebrates, Annelida.**
The term **Biology** was given by **Lamarck & Treviranus.**

Theory of Inheritance of Acquired Character–
Basic Concept of Lamarckism–

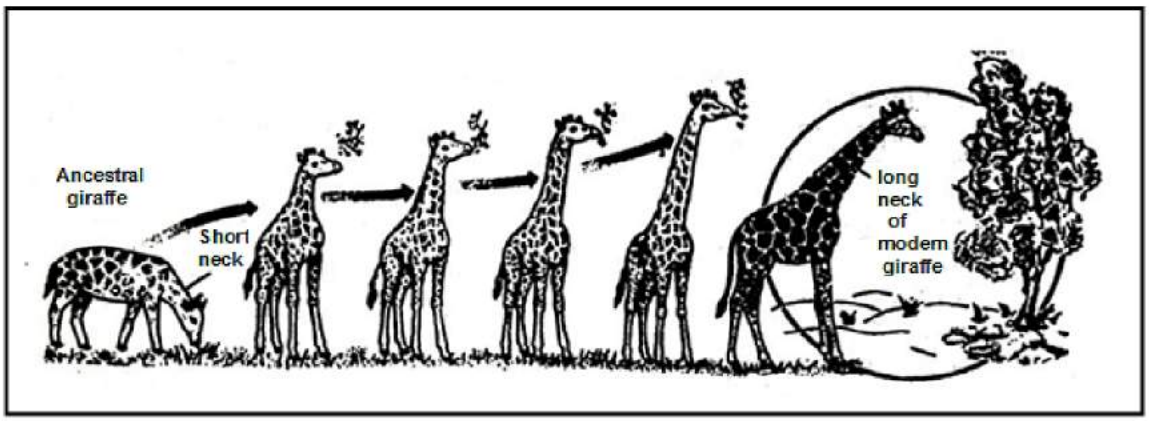
(i) Internal Vital Forces :

Some internal forces are present in all organisms. By the presence of these forces organism have the tendency to increase the size of their organs or entire body.

(ii) Effect of environment and new needs:

Environment influences all type of organisms. Changing environment gives rise to new needs. New needs or desires produce new structures and change habit of the organism.

(iii) Use and disuse of organs:
If an organ is constantly used, it would be better developed whereas disuse of organ result in its degeneration.
(iv) Inheritance of acquired character:
During the life of an organism new character develop due to internal vital forces, effect of environment, new needs and use and disuse of organs.
These acquired character are inherited from one generation to another. By continuous inheritance through many generation these acquired characters tend to make new generation quite different from its Ancestors resulting in the formation of new species.



Example in support of Lamarckism :

1. Long neck and high fore limb of Giraffe.
2. Aquatic birds stretched their toes and developed web.
3. Snakes lost their legs.
4. Deers became good runners by the development of strong limbs and streamlined body.
5. Retractile claws of carnivorous animals

Criticism of Lamarckism –

1. According to first concept organism tends to increase their size but it is not universally true.
For Example among angiosperm the trees seem to be primitive and the shrubs, herbs and grasses have evolved from trees but the size was reduced during evolution.
2. Second concept is false. Can we sprout wings wishing to fly like birds.
3. The third concept is some what true like the well developed biceps muscles of blacksmith and less developed wings in flight less birds.

But this concept also have many objections like the eyes of a student/reader do not increase in size and power with increasing age, the constantly beating heart maintains a constant size through generation.

4. Fourth concept is completely false because acquired characters are not inherited.

- **Weismann**

Weismann cut off the tails of rats for about 22 generations but there was no reduction in the size of tail on the basis of this experiment Weismann proposed **the theory of continuity of germplasm.**

According to Weismann.

(i) Two types of matters are present in organism, **somatoplasm and germplasm.**
(ii) Sometoplasm in somatic cells and germplasm in **Germinal cell.**
(iii) Somatoplasm dies with the death of organism while germaplasm transfers into the next generation.
(iv) If any **variation** develops in germplasm, it is inherited , while if variation develop in somatoplasm it is not transmitted.

- **Pyane :** Pyane kept drosophila in dark up to **69 generation,** but there was no reduction in the size or sight of eyes
- Boring of ear and nose in Indians.
- Iron shoes of Chinese.

Neolamarckism-Term by Packard

Although Lamarckism remained controversial but some scientists gave the following evidences in favour of Lamarckism. The are known as **neo-lamarckians.** According to neo lamarckism environment effected the inheritance of acquired character. According to it changing environment give rise some physical and chemical changes in organism, which effect their germplasm, and these acquired characters are definitely inherited.

1. Sumner's Experiment–
Sumner kept white rat in warn temperature resulting in elongation of body, large pinna and long tail. These features were inherited by the offspring.

2. Kammerer's Experiment–
Kammerer kept salamander in dark background. The black spots found on skin were widely spread. In lighter, background the skin became yellow with limited black spots. These character were inherited by the offspring.

3. Mc Dugal's Experiment-

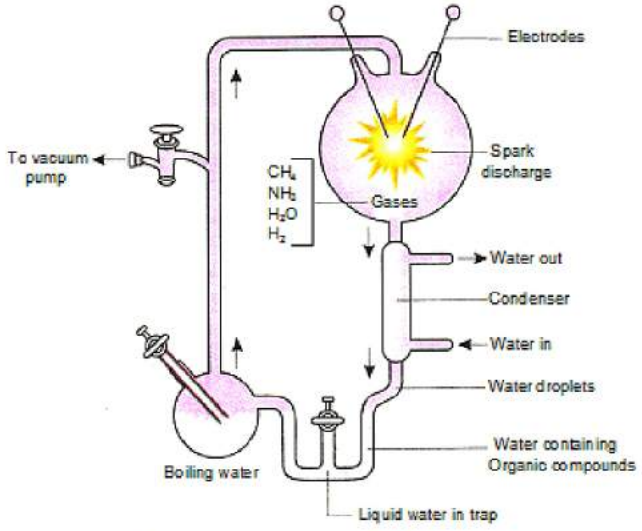
Mc Dugal trained white rats to cross a tank of water following a definite route. These trained rats were mated and their offspring were again trained. It was observed that there was decrease in the number of errors by offsprings of white rats.

Biological Evolution: Miller Urey & Louis Pasteur Experiment

Experimental evidence for formation of simple organic compounds –

By Stanley Miller who was a student of **Harold Urey.**
In this experiment Miller took the mixture of **methane, ammonia and hydrogen (ratio 2 : 1 : 2)** in a large flask and passed steam over it by boiling water and connecting it with a glass tube.
Electric spark discharged in the mixture by using two tungsten electrodes as **source of energy.**
After **18 days** this fluid was collected and analysed. This dark red fluid was found to contain.

- Simple amino acids – **glycine**, **alanine**, **aspartic** acid.
- Simple organic acids – formic, acetic, oxalic, lactic, succinic acids.
- Pentose, hexose, aldehyde, ketone etc.

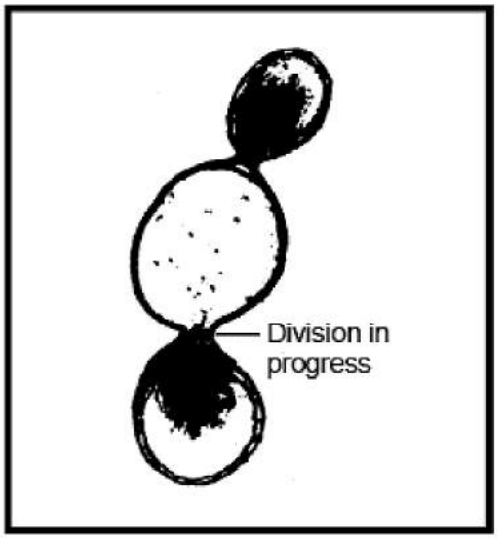


Diagrammatic representation of Miller's experiment

BIOLOGICAL EVOLUTION :

(i) Origin of Protobionts and Nucleoprotein (Coacervates)

Macro molecules which were synthesized abiotically in primitive ocean later came together and formed large colloidal drop like structures named as Protobionts **(Later called coacervates by oparin, Fox and called them Microsphere and Deamer called them vesicles).**



- Each protobiont was **cluster** of macro molecule.
- They contain proteins, nucleic acids, lipids, polysaccharides etc.
- They grew by absorbing molecules from their environment.

- They could divide by budding like bacteria, many chemical reactions including the decomposition of glucose took place inside the protobionts.
- The sun provide energy for chemical reaction.
- According to oparin **coacervates were the first sole living molecules** which gave rise to cell.

Different type of Protobionts obtained by scientists
Oparin (1924) took a solution of carbohydrate and large protein. The solution was shaken. It caused separation of coacervates.
In coacervates higher concentration of protein, carbohydrate were present with small amount of water.
Oparin's coacervates could grow and exhibit simple form of metabolism. However a lipid membrane and reproduction was absent.
Fox (1957) obtain **microspheres** with a primitive membrane. He heated **a** dry mixture of Amino acids at 130° -180° C. It formed **PROTEIDS** **PROTEXOIDS** (Polymer of ammo acid).
When these proteids poured in Cool water along with lipids, microsphere get separated, (size 1-2 p m) **Dearner** (1993) Microsphere and coacervates could fused to form protobionts having various type of chemicals like proteins, Nucleic acids, Carbohydrates etc. enclosed inside a lipid membrane. Dearner called them **vesicles.**

(ii) Origin of protocells [Eobiont] :

The first living form named **protocell** originated in the primitive oceans.
The protocell were clusters of nucleo-proteins which formed by composition of nucleic acids and enzymetic proteins.
Nucleo proteins had the property of self duplication.
Nucleo proteins were first sign of life.

The protocell represented the beginning of life.

From protocells or eobionts few core of nucleoproteins gets separated free in oceans and became inactive but when they enter in another bionts they became active so virus like structures were formed.
Origin of virus like structure is an example **retrogressive evolution** (complex to simple).
Important
1. Khorana (1970)artificially synthesized 77 nucleotide RNA molecule out side a living cell which suggests that probably RNA was the primordial genetic material rather than DNA.

Zaug, Thomas cech and Altman described that some RNA molecules have enzymatic activity hence probably the RNA enzymes called ribozymes were able to replicate the primordial RNA.
The discovery of RNA molecule working as enzyme has also changed our thinking about origin of life.
It is now believed that about 4 billion years ago earth was an 'RNA world' in which RNA molecule carried out all the process of life without the help of either protein or DNA,
By this discovery evolution is named as RNA world.

2. It is estimated that life originated about 3.0 billion years ago as protocell (eobionts) in precrambian era which was anaerobic heterotrophic.

(iii) Origin of Prokaryotes –
As a result of mutation the protocells became more complex and efficient and used the materials available in the surrounding medium and condensed themselves into prokaryotic cells.
Thus the first living being were prokaryotic, like bacteria they were single celled and consisted of naked DNA. Nutritionally they were **chemo heterotrophs** (saprotrophs), respiration was **anaerobic.**
(iv) Origin of Autotrophism –
It includes the origin of **chemosynthesis** and **photosynthesis.**
(a) Origin of chemosynthesis :
Due to continue withdrawal of organic molecules by chemo heterotrophs organic material decreased in oceans.
Before the organic material disappeared in sea, new modes of Nutrition developed, one of them was **chemosynthesis**.
The organism which perform chemosynthesis are called as **chemoautotrophs.** They were anaerobic and synthesise organic molecules from inorganic material. The energy was obtained by oxidizing inorganic materials present in the sea.
Such mode of nutrition is found in Bacteria e.g. sulphur bacteria, nitrifying bacteria.
(b) Origin of Photosynthesis :
After some time bacterio-chlrophyll developed in some autotrophic bacteria like organism.
They could absorb solar energy and convert it into chemical form these organism called **photoautotrophs.**
They utilize solar energy in synthesizing organic compounds. The process is called **photosynthesis.**
They were anaerobic and utilized hydrogen from sources other than water like H_2S. Therefore, no oxygen was evolved and atmosphere remained reducing .

This stage of photosynthetic autotrophism is represented by planktonic sulphur bacteria of today.

$$6CO_2 + 12H_2S \xrightarrow{\text{Solarenery}} C_6H_{12}O_6 + 6H_2O + 12S$$

The Bacterio chlorophyll by molecular changes formed true chlorophyll.

Such organism which were bearing true chlorophyll are similar to today's **Cyanobacteria (B.G. Algae).**

They utilized water as hydrogen donor and evolved oxygen.

$$6CO_2 + 12H_2O \xrightarrow{\text{Solarenery}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Oxygen revolution –

Liberation of free O_2 by blue green algae like prokaryotes due to photosynthesis was a revolutionary change in the history of earth. It is called **oxygen revolution.**
It includes important changes like –
(1) Atmosphere of earth changed from **reducing to oxidising**, hence possibilities of further chemical evolution and a biogenesis got over, because chemical evolution always take place in reducing environment.
(2) Free O_2 oxidized CH_4 and NH_3 to form gases like CO_2 , N_2 and H_2O.
(3) Accumulation of free O_2 formed a layer of **O_3 (ozone)** above the atmosphere of earth, which started absorbing most of the U.V. rays of sunlight.

Origin of Eukaryotic cell –

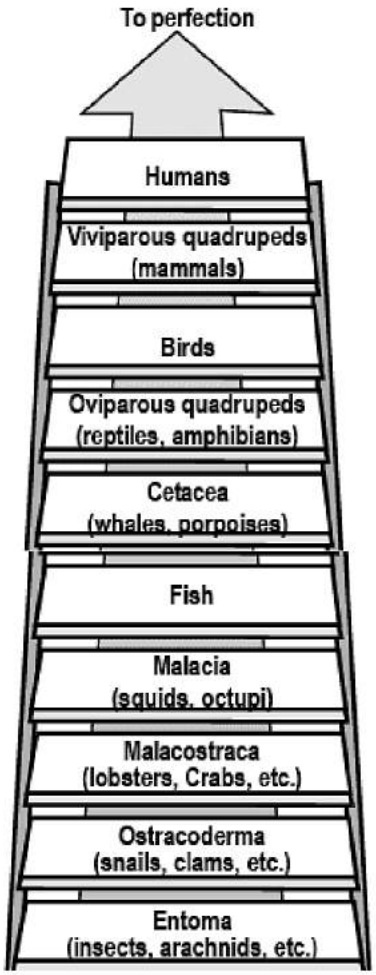
About 2.7 billion years ago conditions become suitable for aerobic respiration with the release of free O_2 . Aerobic respiration yields about **20 times more energy** then anaerobic respiration hence the prokaryotes adapted themselves for aerobic mode of respiration.
Nucleus, mitochondria and other cell organelles developed in the cell and free living eukaryotic cell like organism originated about 2.0 billion years ago in the primitive ocean.

Organic Evolution –

1. Though life originated by chemical evolution on primitive earth, was later replaced by organic evolution.
2. Organic evolution states "Descent with modification". i.e. the present day complex organism have evolved from earlier simpler organism by small but gradual changes which have occurred over millions of years.
3. Though living organisms show diversity in size, structure, function, behaviour etc. they also show basically similar metabolic processes indicating **common ancestory.**

Points to remember :

1. Evolution up to formation of coacervates termed as **chemical evolution,** in which complex organic compound were formed which were essential for formation of cellular structure.
2. Evolution from coacervates to simple cell structure known as **biological evolution.**
3. From simple cell to recent.....evolution is called **organic evolution,** in which organism developed structures and modified them by which they became more adaptive in their changing environment.
4. First protein which is formed during evolution in primitive oceans were not structural.
5. First nucleic acid which was formed in primitive oceans from combination of nucleotides, did not have power of replication. They obtained power of replication later by mutation.
6. Evolution term introduced by - **Herbert Spencer.**



7. **What is evolution ?**

The word evolution means to unfold or unroll or to reveal hidden potentialities.
Evolution simple means an orderly change from one condition to another.

8. Evolution is a slow but continuous process which never stop-**Buffon.**

9. Dollo's low – it states that evolution is irreversible.

10. According to **Theodosius Dobzhansky** (1973), nothing in biology makes sense except in the light of evolution.

11. Scala nature or ladder of nature : –

Aristotle represented the evolution of complex organism from simple organism in the form of a ladder which is called **Scala Nature or Ladder of nature.**

He kept simple organism at the bottom of ladder and complex organism at the top of this ladder.

George cuvier studied the evolutionary history of organism by studying fossils and rejected Scala nature.

12. The history of life actually comprises two events :

(i) The origin of life

(ii) Evolution of life [the mechanism involved in the changes of living organisms through time]

13. Two great themes of evolutionary biology :

(i) The diversity of life, including both the differences and similarities.

(ii) The characteristics of organism, both adaptive and non-adaptive.

14. For origin of life, at least **three conditions** needed to have been fulfilled.

(i) There must have been a supply of replicators i.e. self producing molecules.

(ii) Copying of these replicators must have been subject to error via mutation.

(iii) The system of replicators must have required a perpetual supply of free energy and partial isolation from
the general environment.

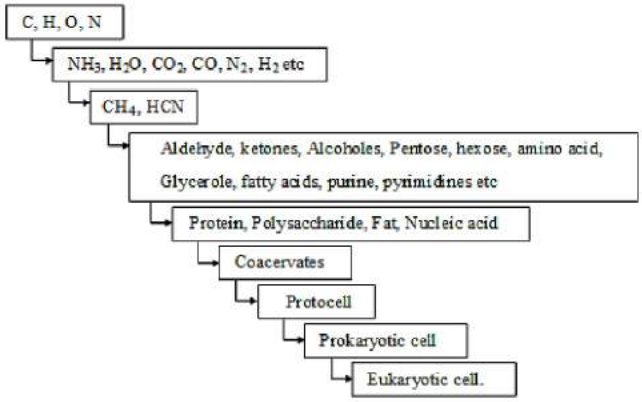
15. Cosmology–Study of universe.

16. Biological evolution is also known as biogeny.

17. Unit of evolution is population.

18. Oparin's theory also known as primary abiogenesis.

19. Evolutionary biology-Study of history of life forms on earth.



Speciation & Its Types

Speciation

Formation of one or more new species from an existing species is called **speciation.** Speciation are of 2 types.

A. DIVERGENT SPECIATION : Origin of one or more new species from an ancestor species is called divergent speciation.
In this type of speciation ancestor speciation also continuous to exist with new species.
In this type of speciation no. of species are increased.
Divergent speciation are of two types –

(1) Allopatric Speciation : When a species split into two or more geographically isolated population and these population finally form a new species.
This mode of speciation is called allopatric speciation and these speciation are known as allopartic species.
Ex. : Finches of Darwin are example of **Allopatric speciation.**

(2) Sympatric species : In this type of speciation a sub population becomes reproductively isolated from its parental population.
Sympatric speciation is the formation of species without geographical isolation and these speciation are known as sympatric species.

B. Transformation speciation : In this type of speciation an ancestor species change into a new speciation with time. In this process no. of species is not increased.
Transformation speciation are of two types –

(1) Phyletic Evolution : When an ancestor speciation changed in to a new species by gradual change in thousand of years.

e.g. Eohippus → Mesohippus → Merychippus → Pliohippus → equus

(2) Quantum Species : In this process suddenly major changes appears in ancestor species and ancestor species immediately changed into new speciation. No. connective links are present in this type of speciation. It is caused by major mutation.

Special point

Micro evolution : - Micro evolution is the occurrence of small-scale changes in gene frequencies in a population, over a few generations.

It occurs at or below the species level. It often cause the formation of new subspecies.
These changes may be due to several process-Natural selection, gene flow. mutation, recombination, genetic drift etc.
eg. Formation of clines.

Macro evolution : - Macro evolution is the evolution, which results in the production of new adaptive types through a process of population fragmentation and genetic divergence.
It is the occurrence of large-scale changes in gene frequencies in a population, over a geological time period (consisting of lots of micro evolution).
Macro evolution operates above the species level and results in the establishment of new genera, families and order.
The changes in the organization occurs due to accumulation of large mutation (macro mutation).
The divergent evolution of different reptilian group from initial reptile ancestor is example of macro evolution
.

Mega evolution : - The origin and evolution of new types of biological organization as a result of general adaptation from its predecessor resulting in the formation of new classes, phylum.
Mega evolutionary changes are rare and have occurred only a few times in the evolutionary history of living beings.
Ex. Origin of Amphibia from fishes, origin of reptiles from amphibian, origin of bird and mammal from reptile.

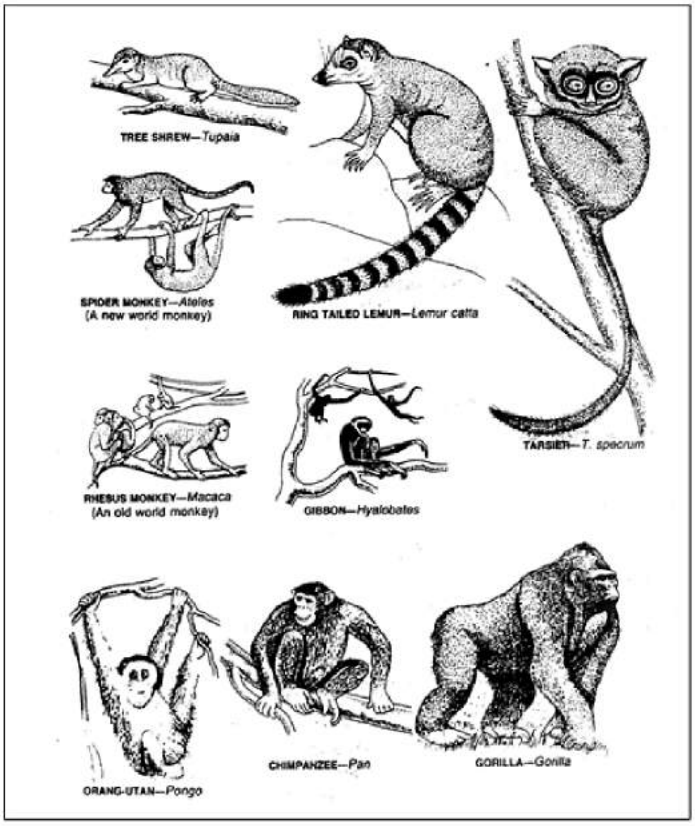
Anagenesis : - It is the evolution of species involving a change in gene frequency in an entire population. It is also known as phyletic change. Anagenesis may also be referred to as phyletic species or gradual species.

Cladogenesis : - It is an evolutionary splitting event in which each branch and it's smaller branches form a ' clade' an evolutionary mechanism and a process of adaptive evolution that leads to the development of a greater variety of sister organism.

Origin & Evolution of Man

HUMAN EVOLUTION

The primates include **Prosimians** (Lemurs, tarsiers and related forms) and **Anthropoids** (Monkeys, apes and Human). They are descended from small rodent like or insectivorous mammals that evolved about 80 million years ago.



Elephant Shrews : -	Tree shrews : -
- Originated in late Mesozoic era in Cretaceous Period.	They were first real primates originated in Palaeocene epoch.
- They were not real primates because	
1. In their retina, only rods were present (cones absent).	1. Both rods and cones are present in their retina
2. Nails absent and claws present	2. Claws absent and nails presents on digits.
3. Long snout	3. Shorter snout.
4. V-shaped Jaw.	4. V-shaped jaw.
5. By nature insectivorous.	5. By nature insectivorous
6. Two pairs mammary glands are present.	6. Two pairs mammary- glands are present.

Order primate is divided into 2 sub orders.

(A) Prosimians : -

Lemur - Evolved in Medagaskar	↑	3	
Loris - Evolved in China		2	**Closest relation to human**
Tarsiers - Evolved in Indonesia		1	

They are prosimian ancestors of human,

(B) Anthropoids : - Monkeys
Apes
Human

Monkeys : - 2 types

(1) Old world monkeys : - Rhesus (Macaca), Baboon (Old world = **Africa. Asia**)

(1) Tail, non prehensile tail.
(2) Narrow flat nose with downward direction of nostril.
(3) U-shaped Jaw.
(4) Dental formula same as human
(5) Menstruation cycle is present in female.

(2) New world monkeys : - spider monkey, marmosets (New world = **South & Middle America**)

(1) Long, prehensile tail
(2) Protruding nose with upward direction of nostril
(3) U-shaped jaw
(4) Dental formula
(5) Menstruation cycle absent but estrous cycle is present.

So, Old world monkeys are more closer to human.

Apes : - 4 types

1.	Chimpanzee	→	400 c.c.	Family - **Pongideae**
2.	Gorilla	→	500 c.c.	
3.	Oranguttan	→	400 c.c.	
4.	Gibbon	→	100 c.c.	Family - **Hyalobatideae**

Human - Hominidae Family

Similarities between man and apes : -
(1) Tail absent
(2) Erect posture
(3) Grasping hands
(4) Hairs are present on body
(5) Larger head, more cranial capacity

(6) More intelligent than other animals
(7) Facial muscles are present for expression of surprise, pleasure.
(8) Menstruation cycle is present in female of both
(9) Blood group of AB series are present in both.
(10) Composition of Hb is same in both. **Only one amino acid is different in human and Gorilla.**

(11) **Chromosomal similarities : -**
(i) No. of chromosomes are approximately same in man and apes.
Apes = 48
Man = 46
(ii) DNA contents and DNA matching is same in both. This similarity is
100% with Chimpanzee
94% with Gibbon
88% with Rhesus monkey
(iii) Banding pattern of chromosome is same in both.
Comparisons have been made between banding pattern of chromosomes of man and those of the great apes.

Banding pattern of ch. no. 3, 6 of human and chimpanzee is 100% similar.

Banding techniques enable the identification of individual chromosomes and their parts.
Somatic cells of human contain 46 chromosomes (44 Autosomes and 2-sex chromosomes).
The diploid number of chromosomes in Gorilla, chimpanzee and Oranguttan is 48.
⇒ The total amount of DNA in human diploid cells and that of the great apes are dissimilar.
⇒ Similarity in the fine structural organization of the chromosomes is understood only in terms of a
common origin for man and chimpanzee.

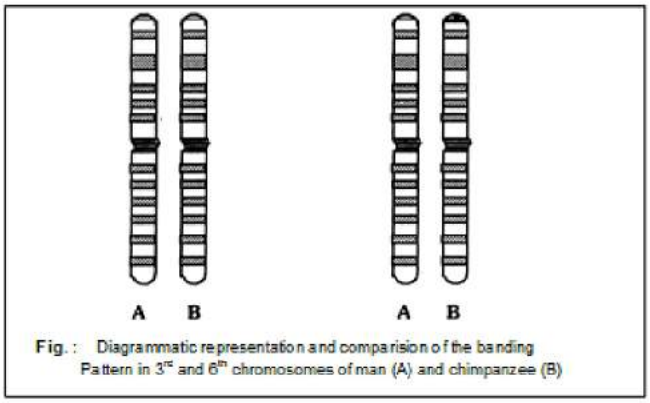


Fig. : Diagrammatic representation and comparision of the banding Pattern in 3rd and 6th chromosomes of man (A) and chimpanzee (B)

Differences : -

Apes	Human
1. Serai erect posture	1. Complete erect posture
2. Shorter neck and embedded.	2. Long and erect neck
3. Thick growth of hairs on complete body	3. Only on certain body part
4. Less cranial capacity (650 c.c.)	4. More cranial capacity' (1300-1600 c.c.)
5. Less intelligent	5. More intelligent
6. Forelimbs longer than hind limbs	6. Forelimbs are shorter than hindlimb
7. 'U'shaped jaw	7. Semi circular jaw
8. Chin absent	8. Chin present
9. Thumb is parallel to palm	9. Thumb is opposable
10. Elongated pelvic girdle	10. Broad pelvic girdle
11. Less hair on body	11 More hairs on body

Human evolution :

(1) Propliopithecus : - Origin & evolution in Oligocene epoch so called as Oligocene apes. Evolution about 30-35 million years ago.

(2) Aegyptopithecus : - Origin and evolution in late Oligocene and Miocene epoch so called as Miocene apes.

(3) Proconsul : - Its fossils were discovered by Leakey from East Africa near Victoria lake in Kenya from Miocene rocks. It walked on its four legs (considered as common ancestor of man and apes).

(4) Dryopithecus : - Evolution » 15-20 million years ago.

- Direct ancestor of modern day apes.
- They were forest dwellers spending most of the time one the trees.
- Origin & evolution in **Miocene epoch.**
- Semi erect posture
- Quadra pedal locomotion, forelimbs longer than hind limbs.
- Thick growth of hair
- U shaped jaws
- Teeth larger and sharper
- By nature vegetarian, fruit eater

(5) **Ramapithecus**
(6) **Shivapithecus**] Fossils discovered by **Lewis** from **Shivalik** hills in India
(7) **Kenyapithecus**] Fossils discovered from **Kenya** by **Leakey**.

- Origin and evolution in **Pliocene epoch.**
- They are considered as ancestors of human but in characteristics same as Dryopithecus, but spending most of the time on the land.

(8) Australopithecus :- Prof. Raymond dart discovered a fossil of skull of 5-6 year old baby from the old Pliocene rocks of **Tuang region** (S. Africa). He named it **Tuang baby**, later on he renamed it **A. africanus.**

- About 3-2 million years ago it lived in East African grasslands.
- Evidences shows they hunted with stone. Probably ate fruits.
- It was an apeman because it have many characters of man and apes so it is also considered as **connecting link between apes and man.**

Apes like characters :

- Less cranial capacity – 400 – 500 c.c.
- Thick growth of hair on body
- Prognathous.

Man like characters :

- Complete erect posture **(first man who stood erect)**
- Forelimb shorter than hindlimbs.

- **Bipedal locomotion (first man)**

- Some other varieties of Australopithecus were also discovered by some other scientist.
- A. boisei [zinjanthropus] by Leakey from East Africa [Tanzania]
- A. afaransis [Lucy] by Donald Johanson from Ethiopea.

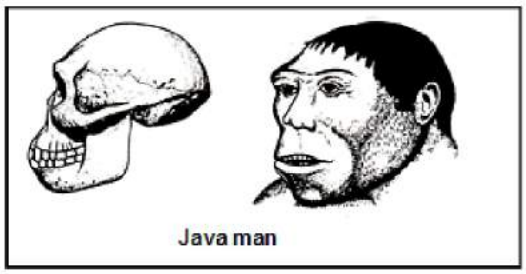
Prehistoric man : -

A number of other species of Homo appeared and became extinct from time on the evolutionary sense before the origin of homo-sapiens. These extinct species are called **prehistoric species of man.**

(1) Homo habilis : - The Tool maker or Handy man.

- First human being like
- By nature omnivorous, also show cannibalism

(2) Homo erectus : - direct ancestor of homo sapiens



Java man

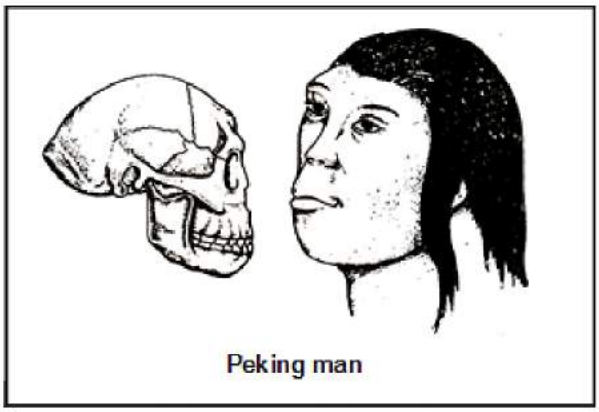
- Origin and evolution, 1.5 million years ago.
- Java man
- Peking man
- Heidelberg man (Branch from main line of Human evolution)

Java man :

Homo erectus erectus name given by **Mayer.** or **Pithecanthropus erectus** given by **Dubois.**

- Fossil obtain from central java by **Eugene Dubois.**
- Lived in caves
- They used Tools of bones and stones
- Cranial capacity – 900 c.c.
- **First man who used fire for hunting, protection and cooking**
- Chin absent, Jaw Prognathous
- Complete erect posture
- Omnivorous, cannibalism have also found.
- **It is also known as erect ape man**

Peking man : - Homo erectus pekinensis name given by **Mayer**
Sinanthropus erectus name was given by **Davidson Black**



Peking man

- **W.C. Pai** discovered the fossil of peking man from China.

- Lived in caves
- Cranial capacity – 1100 c.c.
- Chin absent, Jaw Prognathous
- Used sharp **chisel shaped tools** of stones, bones for cutting and killing animals.
- Omnivorous, cannibalism has been also found
- Used fire for cooking meat and for protection.

Heidelberg man : -

A fossil of lower jaw obtain from **Heidelberg in germany** it was discovered by **Ottoschotensack.**

- Cranial capacity – 1300 c.c.
- Origin & evolution – in Pleistocene epoch. It is believed that this species was evolved as a branch from main line of evolution and got extinct after some time

(3) Homo sapiens : -

- Neanderthal man
- Cromagnon man - Direct ancestor of modern man
- Homo sapiens sapiens - **Modern man (Man of today)**

(i) Neanderthal man : - Homo sapiens neanderthalensis

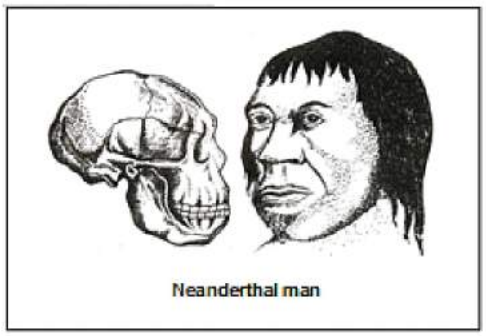
- Origin & evolution before a 30,000 – 1 lakh years

-- Fossils were discovered by **C. fulhrott from Neanderthal valley of Germany.**

- They live in huts.
- Cranial capacity 1400 c.c

Complete erect posture
Ceremonial burial of dead body
Used animals skin as cloths
Beginning of development of speech center.
By nature – omnivorous.

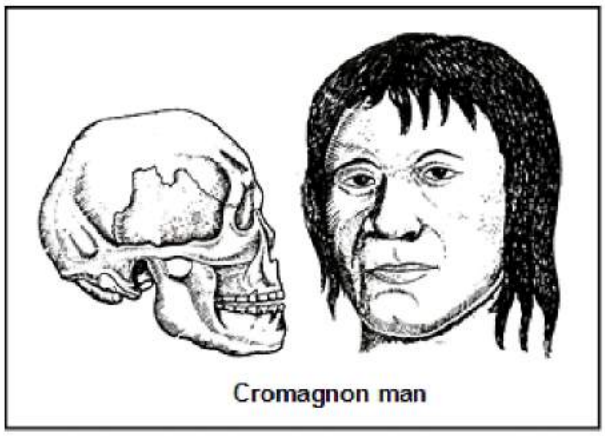
- **First man believed in "immortality of soul"**


Neanderthal man

(ii) Cromagnon man : - Homo sapiens fossils

- Origin and evolution **34000 years ago.**
- Fossils discovered **from Cromagnon rocks of France**
- Lived in caves
- Cranial capacity - 1650 c.c. **(maximum)**
- Complete erect posture
- Well developed speech centre
- Orthognathous jaw.
- Used animal skin as cloth.

- **This man was hunter and used domesticated dogs in hunting, so domestication of animals started by cromagnon man.**
- **Known for cave paintings.**
- **Regarded as the direct ancestor of modern man.**
- By nature **carnivorous.**



Cromagnon man

(iii) Homo sapiens sapiens (Modern man) : - Man of today

- 10,000 years ago.
- Cranial capacity 1450 cc
- Complete erect body posture
- Orthognathous
- Well developed speech centre, developed languages.
- Less hairs on body as compared to fossil man
- Omnivorous.
- It is believed that modern man evolved in Africa.
- **Agriculture was also started by them.**

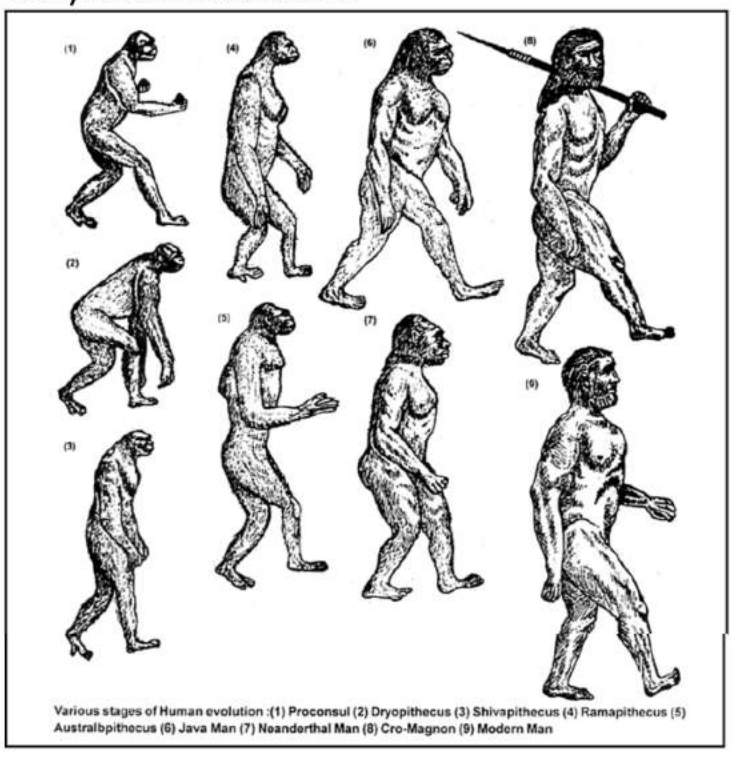
Special Point :

The course of cultural evolution is divided in to three age.

Palaeolithic – Age of tools of stones and bones.
Mesolithic – Age of animals husbandry, language, reading, writing.
Neolithic
(i) Bronze age – Age of agriculture, knowledge and use of clothes.
(ii) Iron age – Present age is also known as Iron age.
Man of future : - homo sapiens futuralis
- **Dr. Shapiro** named man of future as Homo futuralis
- Taller and hairless body
- Tomb like head and larger brain.
- With no fifth finger

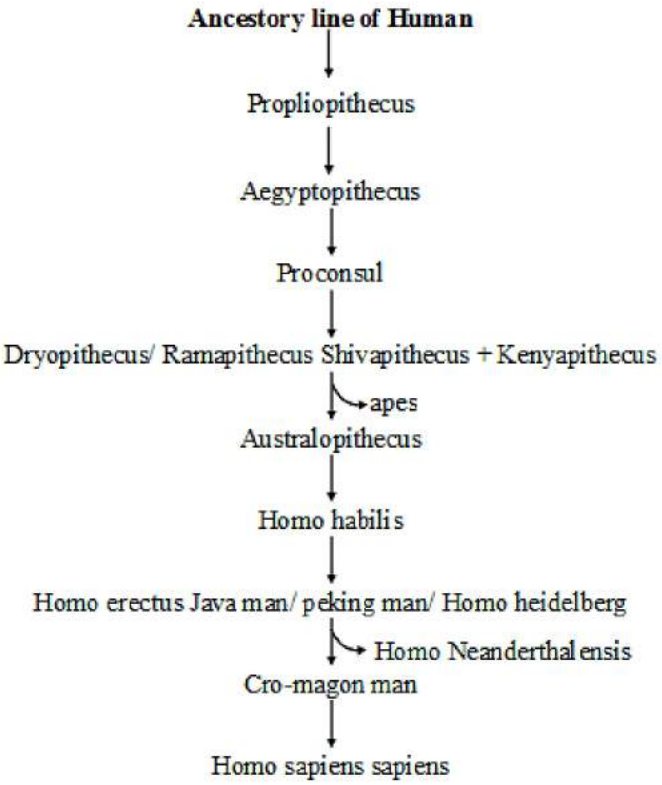
Special Point : -

(1) **Anthropology :-** Study of evolutionary history of man.
(2) **Ethology : -** Study of animal habbits and behaviour.
(3) **Hylobates hoolock :-** (The Gibbon) is the only ape found in India (forests of Assam)
(4) **Races of human - 4 types - Caucasoid, Negroid, Mongoloid, Australoid.**
(5) **Hobit : -** Recently **Richard Roberts** scientist discovered a **18,000 years** old fossil of a lady form **flores island situated near Australia.** He gave name it to **Hobit/Dwarf man/Homo florasiansis.**



Various stages of Human evolution :(1) Proconsul (2) Dryopithecus (3) Shivapithecus (4) Ramapithecus (5) Australbpithecus (6) Java Man (7) Neanderthal Man (8) Cro-Magnon (9) Modern Man

BRIEF REVIEW



- Tree shrews were first real primates.
- Old world monkeys are more closer to human as compared to new world monkeys.
- Chimpanzee is closest ape to human.
- Australopithecus firstly show bipedal locomotion.
- Homohabilis is also known as handy man or the tool maker man.
- Java man firstly used fire.
- W.C. Pai discovered the fossils of Peking man from China.
- Neanderthal man was first man who believed in 'immortality of soul.'
- Cromagnon man was a painter and regarded s the direct ancestor of modern man.
- Homosapiens sapiens is the man of today.
- Carolus Linnaeus called human as **Homo sapiens wiseman.**
- Huxley explained origin of man in his book **The man's place in nature'.**
- Darwin explained ancestory of man in his book **'The descent of man'.**
- Human is a member of order primates of class mammalia.
- Primates originated 80-100 million years ago in palaeocene epoch of coenozoic era.
- Primates originated from elephant shrews but they were not **real primates.**

Hardy Weinberg Principle

What Is Hardy Weinberg Law?

Statement of Hardy Weinberg Law
"In a large, random-mating population, the genotype and allele frequencies remain constant in the absence of any evolutionary influences from one to another generation. Influences are inclusive of a choice of mate, natural selection, genetic drift, mutation, sexual selection, gene flow, genetic hitchhiking, founder effect, meiotic drive, population bottleneck, inbreeding and assortative mating."

Genotype frequencies and allele frequencies are related to each other in a way that it is the square expansion of such allele frequencies. In other words, the law conveys that in a population, it is possible to estimate the expected frequencies of genotypes under a certain limited set of assumptions, provided the frequency of different alleles in a population is already known.
Take a case of a single locus with only two alleles indicated by A and a with corresponding frequencies $f(A) = p$ and $f(a) = q$ respectively, then the genotype frequencies that can be expected under limited condition being random mating is
$f(AA) = p^2$ for AA homozygotes
$f(aa) = q^2$ for aa homozygotes
$f(Aa) = 2pq$ for heterozygotes
The Hardy Weinberg Equation can be represented by
$\mathbf{p^2 + q^2 + 2pq = 1}$
The allele frequencies p and q remain constant in the absence of any kind of influences such as mutation, natural selection, genetic drift, etc from one to another generation. This is how the equilibrium can be reached.

Who Proposed The Law?

The law is named after G.H. Hardy and Wilhelm Weinberg. They were pioneers in mathematically illustrating this principle also referred to as Hardy–Weinberg equilibrium, theorem, law or model.
Hardy's thesis centrally paid attention to debunk the view that prevailed in those times that a dominant allele has the tendency to increase in frequency automatically. In today's times, the uncertainty on selection and dominance is not very remarkable. In the current times, the Hardy-Weinberg genotype frequencies tests are applied to evaluate population stratification and other sorts of non-random mating.

Inferences From Hardy–Weinberg Law

Listed below are a few deductions from the law:

- Only sexual reproduction can take place
- Process of mating is random
- The size of the population is indefinitely large
- Entities are diploid
- Generations do not overlap
- Equality of allele frequencies in terms of sexes
- No traces of gene flow, selection, mutation, migration or admixture

In case there is any breach with regard to the above-mentioned assumptions, it can lead to discrepancies from the expected outcome. The consequences are completely dependent on the deduction that has been digressed.
The law mentions that the population shall have the Hardy Weinberg proportions (given genotypic frequencies) once a single generation of random mating is carried out in a population. In case the assumption of random mating is breached, this population will not possess the Hardy Weinberg proportions. The most common source of a non-random mating is inbreeding. It leads to the rise in the homozygosity of all genes.
Breaching any one of these 4 assumptions can cause the population at each generation to still possess the Hardy–Weinberg proportions, however, with time, there will be a change in the allele frequencies.

Mutation – it has a mild impact on the allele frequencies. The rate of mutation is in this o order 10^{-4} to 10^{-8}. Mostly, modifications to the allele frequencies are of this order. Even if there persists a sturdy selection against the alleles in the population, recurrent mutations will conserve it.

Selection – typically this leads to a change in the allele frequencies and is a rapid one. Few types of selections, the selected ones can result in equilibrium with no loss of alleles, namely balancing selection, while some other selections such as directional selection can gradually result in the loss of alleles.

Size of the population being small can lead to a random alteration in the allele frequencies which can be attributed to the sampling effect known as genetic drift. When alleles are found in a fewer copy, sampling effects are significant.

Migration – two or more than two populations can be associated together, genetically with migration. Here, amongst the populations, the allele frequencies have the tendency to become more homozygous. Essentially, a few migration models are the Wahlund effect (non-random mating). Hardy–Weinberg proportions typically are invalid for such models.

Applications of the Hardy-Weinberg Principle

Natural populations persistently depict genetic variation altering from mutation, genetic drift, migration, sexual selection and natural selection. The Hardy-Weinberg law provides a mathematical criterion of that of a population that is non-evolving which can be compared to evolving populations. Over time, if the allele frequencies are noted and estimated for the expected frequencies basis the values of Hardy-Weinberg law, then workings that drive the evolution of the population can be hypothesized.

The law offers a prototype which is typically used as a point of origination to study the population genetics of diploid entities, which fulfil the fundamental assumption of random mating, large population, no mutation, migration or selection.

However, the Hardy-Weinberg model is not applicable to haploid pathogens. In the event of a population not being found in Hardy-Weinberg equilibrium, one of the assumptions in this law then gets violated. This conveys that selection, non-random mating or migration has influenced the population, in which case experiments are carried out and hypotheses are advanced in order to understand the reasons behind the non-equilibrium of the population.

I. Complete Dominance

Allele frequencies can be detected in the presence of complete dominance when Hardy-Weinberg equilibrium prevails wherein it is not possible to differentiate between two genotypes. Two genotypes AA and Aa having the same phenotype as a result of complete dominance of A over a, can help determine the allele frequencies from frequencies of the individuals indicating recessive phenotype aa. Here, the frequency of aa individual should be equivalent to the square of the frequency of the recessive allele.

II. Multiple Alleles

Calculation of genotypic frequencies at a locus with more than two alleles is allowed in the Hardy-Weinberg principle, for instance in the ABO blood groups. Three alleles are present in I^A, I^B, I^C with p,q and r frequencies respectively where $p + q + r = 1$. With random mating, the genotype of a population will be given by $(p + q + r)^2$

III. Linkage Disequilibrium

Take, for instance, two or more alleles on the same chromosome, at two different loci with 2 or more alleles. As a result of genetic exchange by recombination taking place at regular time intervals, at two syntenic loci, the frequency of allelic combinations attains equilibrium.

In the event of not being able to attain an equilibrium, alleles are known to be in a linkage disequilibrium, which is as a result of two or more linked alleles to be inherited jointly, more frequently than expected. Such gene groups are also known as supergenes.

IV. Frequencies If Harmful Recessive Alleles

The law can also be applied to estimate the frequency of heterozygous carriers of

recessive genes that are harmful. In a population, two alleles, A and a are at an autosomal locus with p and q frequencies respectively, and $p + q = 1$, then AA, Aa and aa genotypes will have the following frequency, $p^2 + q^2 + 2pq$. In case, the aa genotype tends to express a phenotype that is harmful, such as cystic fibrosis, then in the population, the proportion of the affected individuals shall be q^2, the recessive allele frequency of the heterozygous carrier shall be 2pq.

Summary

- In a given population, the Hardy-Weinberg principle assumes that the population is indefinite and not influenced by sexual, natural selection, mutation and migration.
- Frequency of alleles can be calculated by the frequency of recessive genotypes. Then estimate the square root of this frequency to find the frequency of the recessive allele
- In a population, the frequency of alleles can be indicated by $p + q = 1$, with p = frequency of the dominant allele and q = frequency of the recessive allele.
- In a population, the frequency of alleles can be indicated by $p^2 + q^2 + 2pq = 1$, where p^2 is the frequency of homozygous dominant genotype, q^2 is the frequency of recessive genotype and 2pq is the frequency of heterozygous genotype.

Genetic Drift

What is Genetic Drift?

Genetic drift is an evolutionary change in allelic frequencies of a population as a matter of chance. It occurs in very small populations but its effects are strong. It occurs due to an error in selecting the alleles for the next generation from the gene pool of the current generation. It does not occur due to any environmental influences. In large populations allele frequency of the genes remain relatively stable because the genes are not affecting the fitness and do not have a natural selection pressure against the alleles.

Types of Genetic Drift

Bottleneck Effect

In the bottleneck effect, the population size severely decreases due to competition, predators, or diseases. The frequency of certain alleles in a population change because the organisms that carry them are eliminated. The others increase in number because they are the only alleles left. This is observed

during natural disasters like volcanic eruptions, earthquake, etc. leading to the death of most of the population.

Founder Effect

In the founder effect, a new population is founded in a new location due to physical or geographical barriers. The new population formed does not interact and mate with the original population. As a result, the allelic frequencies of the new population will be different from the original population. There are many species that are found only on a particular island. This is due to the founder effec.t. Eg., two birds of the same species reach an island. Their alleles will be responsible for the diversity on that island. These alleles will dominate and mutations in the population will lead to the formation of new species. The new population will diverge to such an extent that they will no longer interbreed.

What Causes Genetic Drift?

Genetic drift usually occurs in smaller populations. In a small population with many alleles, any of the alleles can become extinct. In a population with many organisms, there is less chance of losing an entire allele. This is because many organisms contain the alleles and all the alleles cannot be wiped away. If the allele affects the organism such that it causes more reproduction of DNA, the allele frequency increases. If the allele harms the organism, the allele frequency decreases. When the allele frequency increases or decreases because of its presence in some random organism that survived, it is known as genetic drift.

Genetic Drift Example

Genetic drift can be observed in the following examples:

- The American Bison was once hunted to such an extent that it became endangered. The population which have recovered today show very little genetic variations.
- Consider a population of rabbits with brown fur and white fur, white fur being the dominant allele. Due to genetic drift, only the brown population might remain, with all the white ones eliminated.
- A couple with brown and blue eyes have children with brown or blue eyes. Even if there is a 50% chance of having blue eyes, brown eyes being the dominant allele, all the children might have brown eyes in the future generations as a matter of chance.

- A bird has an allele for two different sizes of beaks. Genetic drift might eliminate one of the beak sizes from the population, thus reducing the genetic variations of the gene pool of birds.
- Hypothesize a plant that produces blue or yellow flowers. If the yellow flowers are destroyed in a fire and the blue allele is the dominant one, the plant will produce only blue flowers.

Genetic Drift vs Gene Flow

Gene flow is the movement of genes between the populations, species, or organisms. E.g., bacteria can transfer genes between different cells. On the contrary, genetic drift refers to the random selection of genes in a population. When individuals from one population migrate to some other population and breed there, gene flow occurs. Unlike genetic drift, gene flow does not evaluate the allele frequencies.