Evolution

Evolution is a process that results in heritable changes in population spread over many generation leading to diversity on earth.

The study of history of life forms is called Evolutionary biology.

Origin of universe -

1. Universe - It's the collection of clusters of galaxies. Galaxies contain stars and clouds of gas and dust.

→ Universe is very vast, earth is only speck of it.
→ It is almost 20 Billion year old.

Origin - Big Bang Theory :-

- Early in universe everything was condensed in an single small point of infinite denseness and heat.
- A huge explosion inimaginable in physical terms occur.
- The universe expanded and temperature came down. Hydrogen and Helium formed sometime later.
- The gases condensed under gravitation and form the galaxies of the present time.

Origin of Earth :-

Like all other galaxies our galaxy Milkyway also formed. This galaxy contain our solar system, in which earth was formed about 4.5 Billion year ago.

Origin of Earth's atmosphere :-

Milky way
↓
Solar system
↓
Earth

- There was not atmosphere on early Earth.
- NH_3, CH_4, CO_2, H_2O (g) released from molten mass covered the surface.
- water $\xrightarrow{\text{UV rays.}}$ $H_2 + O_2$
- Hydrogen gas is lighter so escaped.
- O_2 combined with NH_3 and CH_4.

Ammonia + O_2 $\longrightarrow$ Nitrogen + water

Methane + O_2 $\longrightarrow$ CO_2 + water

$O_2 \xrightarrow{\text{UV rays}} O + O$

$O_2 + O \longrightarrow O_3$ (ozone)

- Ozone layer formed. As it cooled, the water vapour condensed and fell as rain.
- water of rain fell all depression and form ocean.
- Early atmosphere was reducing as there is no oxygen left which is suitable for origin of life. Life form 4 B.Y.A.

Origin of Life :-

① Theory of special creation -

↳ Religious theory.

- All living organism were created as such.
- The diversity was always the same since creation and will be same in future.
- Earth is about 4000 years old according to this theory.

② Cosmic - Panspermia Theory :-

Some scientists believe that life came from outside. It states that the seed of life exist all over the universe and can be propagated through space from one location to another.

③ Theory of spontaneous Generations :-

Life came out of decaying and rotting matter like straw, mud etc.

Non living things $\xrightarrow{\text{spontaneously}}$ living thing.

It is also known as Abiogenesis.

- F. Redi, Spallazani & Louis Pasteur disapproved this theory.

④ Theory of Biogenesis :-

Louis Pasteur demonstrate that life comes only from pre existing life.

- He showed that in Pre sterilised flasks, life did not come from killed yeast and sugar syrup.
- while in another flask open to air, new living organism arose from killed yeast and sugar syrup.

Limitation of biogenesis :-

This did not answer how the first life form came on earth.

⑤ Theory of Chemical Evolution :-

Oparin of Russia and Haldane of England proposed that the first form of life came from pre-existing non-living organic molecule and these molecules also evolved from inorganic molecules. The formation of life was preceeded by chemical evolution.

Simple inorganic atom —chemical evolution→ complex organic compound.

Complex organic compounds —biological evolution→ First life (in water).

→ Initial condition on earth were high temperature, volcanic storms, reducing atmosphere containing CH_4, NH_3 etc.

- **Chemical Evolution –**

Atomic state - C, H, O, N etc.
H most abundant, very reactive at high temperature

Molecular state - H_2O (g), NH_3, CO_2 etc.

Simple organic compound - CH_4 (first)

HCN, alcohol, aldehyde, organic acids, amino acids, monosaccharides, fatty acids, glycerols, Nitrogen bases etc.

→ energy for these compound formation obtain by volcanic eruption, Lightening, U.V.

Complex organic compounds-

Monosaccharide ⟶ Polysaccharide

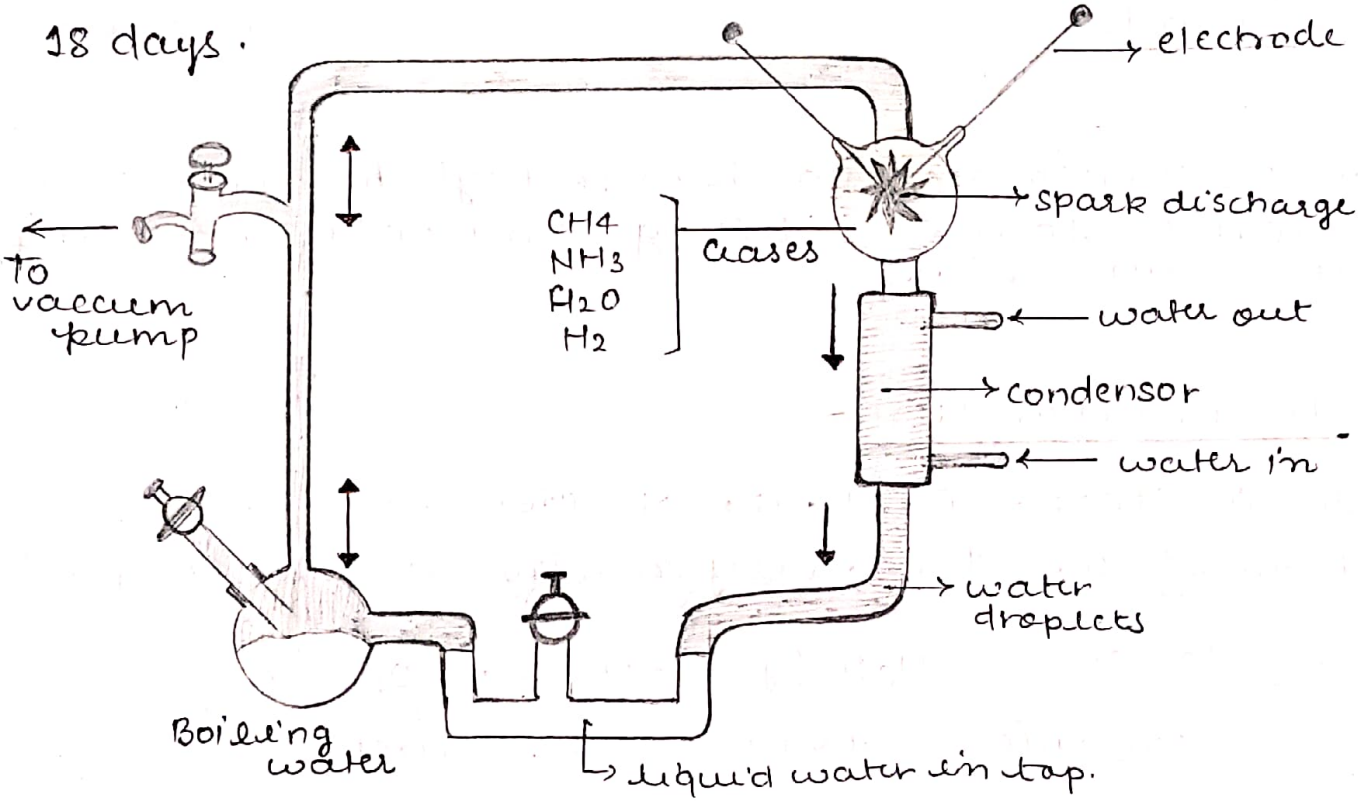
Amino acid ⟶ Proteins

Fatty acid + Glycerol ⟶ Fat / Lipid

N-base + 5C sugar + Phosphate ⟶ Nucleic acid

They all present in hot water as hot dilute soup- Prebiotic soup [Haldane]

Experimental verification was given by American scientist S.L. Miller in 1953. He created similar condition in lab.



He took CH_3, NH_3, H_2 and water vapour at 800°C in large flasks.

He observed formation of amino acids.

In similar experiments other observed formation of sugar, Nitrogenbases, pigments and fats.

↝ Analysis of meteorite contents also result similar compounds indicating that similar process× compounds which indicate that similar processes are occuring elsewhere in space.

- Biological evolution -

First form of life from non-living organic molecule.

Ⓐ Formation of protobiont -

Nucleic acid + Protein → colloidal drop [Protobiont]

- Protobiont is first sign of life.
- Oparin formed coacervates in lab.
  Protein + Carbohydrate → coacervates.
- Sydeney fox form microsphere in lab.
  Mixture of Amino acid —Heat then cold→ Proteniod body
  Proteniod body —lipid coat→ Microsphere

Ⓑ Formation of Eobiont / Protocell -

Protobiont (gain replication property) + lipid membrane → Eobiont or protocell or First cell.

→ First cellular form of life - 2 B.Y.A
→ First non-cellular form of life - 3 B.Y.A.
→ First life - 4 B.Y.A
→ water and reducing environment is essential for origin of life.

First cell / Prokaryotes - Anaerobic chemoheterotroph

↓

Anaerobic - chemoautotroph

↓

Anaerobic - non oxygenic photosynthetic autotroph

↓

Aerobic - oxygenic photosynthetic autotroph

↓

Eukaryote.

→ symbiotic way

→ membrane invagination.

Evolution of life-forms - A Theory

Theory of evolution - Charles Darwin

i) According to Darwin, existing life form share similarities not only among themselves but also with life form that existed million year ago.

ii) There is gradual evolution of life forms, some life form exinct and some arose at different time.

iii). Any population has built in variation which enable some to survive better than natural condition. Due to this these outbreed others. So, they leave more progeny than others.

iv). These will survive more and hence selected by nature. It is called Natural Selection.

v). Geological history of earth closely related with earth. Hence earth is very old.

Evidences of Evolution :-

i) Palentological evidences [fossils]
ii) Embryological evidences
iii) Comparitive anatomy and morphology
iv) Brochemical evidences.
v) Evidences of natural selection
   - Artificial selection
   - Industrial melanism
   - Evolution by anthropogenic action.

vi) Other evidences -
   - Connecting link
   - Atovism
   - Vestegial organs.

→ study of fossils

1. Palentological Evidence [Fossils] :-

Fossils are remains or impressions of hard part of life forms found on rocks.

Importance -

- Represent exinct life such as Dinosours.
- It also indicate the geological period in which they existed.
- It shows that lifeform varied over time.
- Certain life form are restricted to certain geological time spans.
- New life forms arisen in different times of history.

Methods of finding ages of fossils :-

i). Radiocarbon dating method
ii). K-Ar method.
iii). Uranium - lead dating method
iv). Electron spin resonance.

2. Embryological Evidence :-

This was proposed by Ernest Heckel.
His theory is based on observation of certain feature during embryonic development in all vertebrates which are absent in adult stage.

Example: The embryo of all vertebrates including human develop a row of vestigial gills slit just behind the head but functional only in fishes but also not found in adult other vertebrate.

Note: Von Baer rejected this theory.

3. Comparitive Anatomy and Morphology :-

It shows similarity and differences among organism of today and which existed years ago.

(i) Homology / Homologous organ:

Homology means same origin or embryonic develop or fundamental structure.

The organs in a different group of organism that have same basic structure and origin but differece in basic function they carry out is called Homologous organ.

→ Homology indicates common ancestry.
→ Homologous organ is result of divergent evolution.

Divergent evolution is evolutionary pattern in which species sharing common ancentor become different due to adaptation to different need.

Example :

1). Forelimbs of mammals.

Forelimbs of mammals like Man, cheetah, whale bat etc. have same anatomical structure as all of them have humerus, radius, ulna, carpalas, metacarpalas and phalanges hence they are homologous.

2) vertebrates heart and brain :

All vertebrates have heart and brain which are similar in orgin.

3). Thorn and tendrils :

Thorn in Bougainvillea and tendrils of cucurbits bothe are modified axillary buds.

ii) Analogy / Analogous organs :

Analogy means different structure evolving for same function due to similar adaptation of habitat.

The organs in different group of organism which have similar function but are diffent in anatomical structu

→ Analogy indicates uncommon ancestoy.

→ Analogous organ is result of Convergent evolution.

convergant evolution is a evolutionary pattern in which species not having common ancestor having different structure become similar in function due to adaptation to same need.

Example -

1). wings of butterfly and birds.

wings of birds are forelimbs while butterfly wing's are fold of membrane associated with few muscles. Both have different origin / structure but similar function

2) Sweet Potato (↳ modified root) and Potato (↳ modified stem)

Both have different origin but similar function (food storage).

3). Eyes of Octopus and eyes of mammals.
4) Flippers of Penguine and Dolphine.

4). Biochemical Evidence - Similarities in proteins & genes performing a given function among diverse organism gives clues of common ancestry.

Example: ATP - Energy currency
Trypsin - Protein digesting enzyme
Genetic codon
Insulin hormone

5) Others -

i) Vestegial organ

These organs not useful in current organism but functional and more developed in ancestor.

examples -

- Nictitating membrane (Plica semilunaris) → third eyelid
- Auricular muscles / muscles of ear pinna
- Wisdom teeth / 3rd molar
- Body hair.
- Vermiform appendix
- Coccyx (tail bone).

ii) connecting links

Those organism show character of two different group.
Virus - between living and non-living
Euglena - B/w plant and animals
Neopilina - b/w annelida and mollusca
Peripatus - b/w annelida and arthopoda.
Archeopteryx - b/w reptiles and birds.

iii) Atavism is reappearance of ancestoral character.
eg. long and pointed canines.
Thick body hair
Tail in new born.

ADAPTIVE RADIATION

Process of evolution of different species in a given geographical area starting from a point and radiating to other areas of geography / habitat.

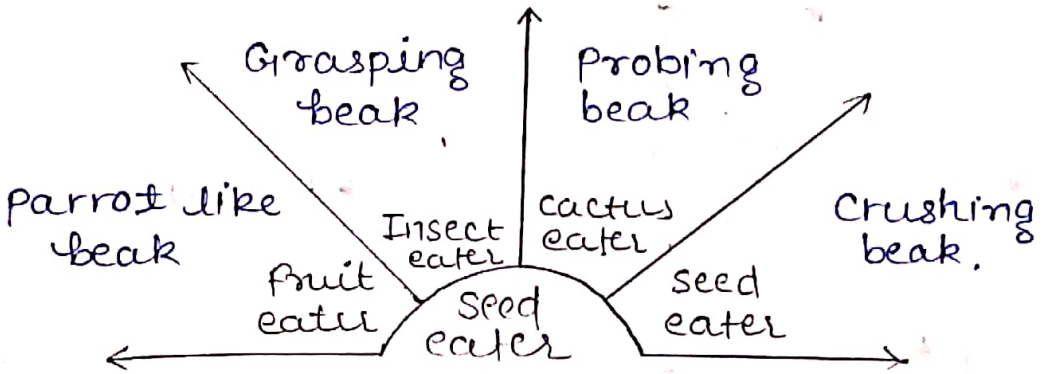
Eg. 1. Darwin Finches
2. Australian Marsupials
3. Australian Placental Mammals.

① Darwin Finches –

During his journey Darwin went to Galapagos Island. He observed an amazing diversity in a small black bird (Darwin Finches).

→ There were many varieties of finches in same island. All these varieties evolved on the island from original seed-eating bird.

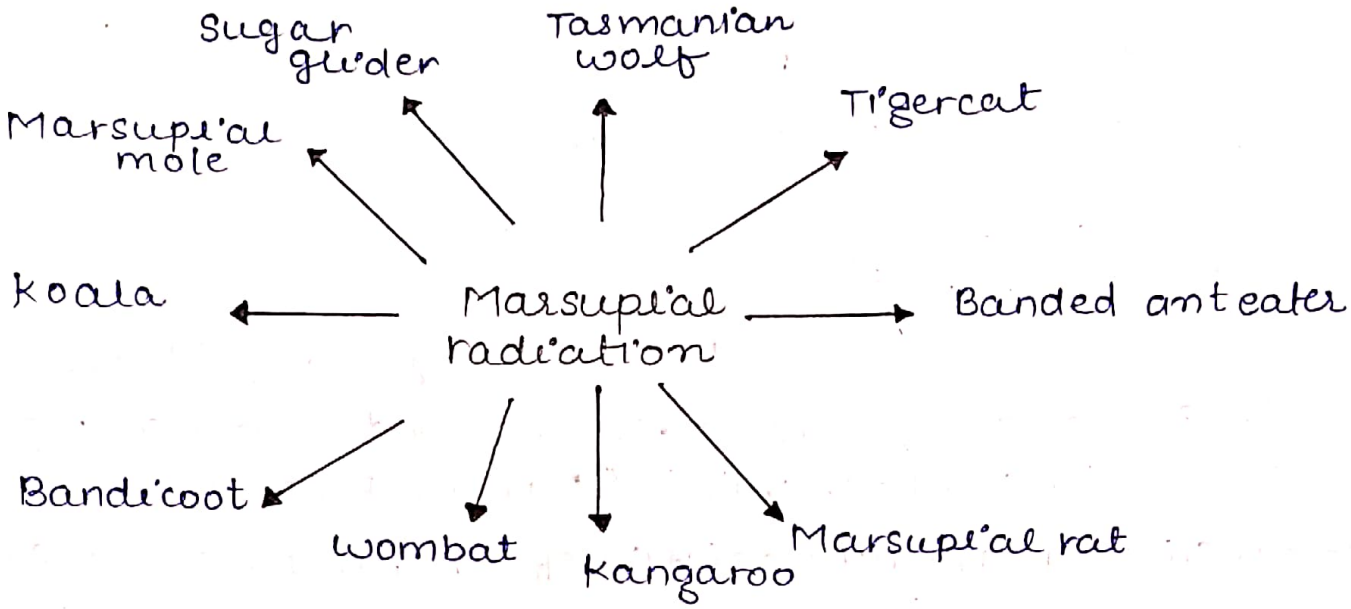
→ All finches have different beak enabling them to become insectivorous and vegetarian finches.



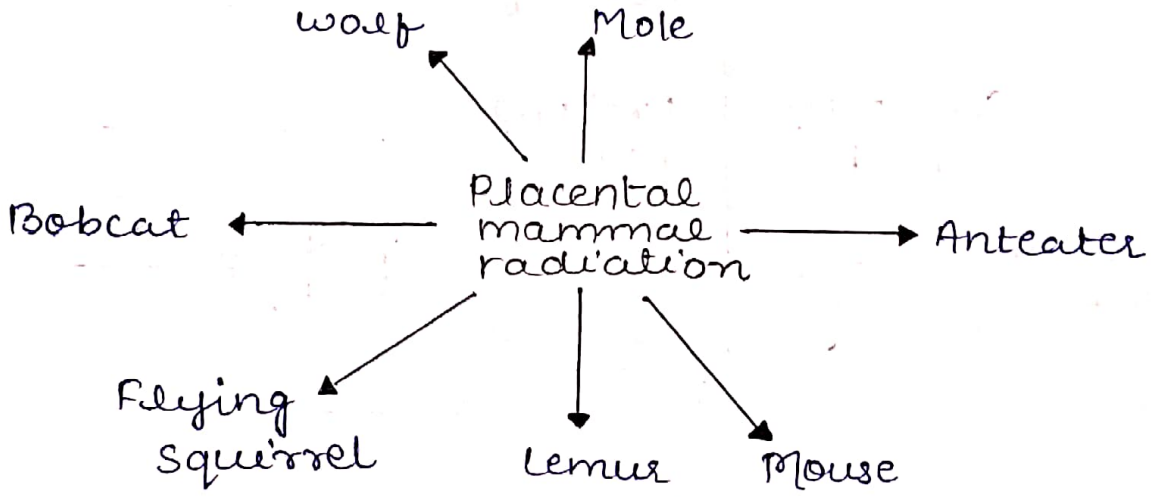
(i) A common ancestor.
(ii) Move to different habitat and developed certain variation to adapt in that habitat like beak shape size.
(iii) After sometime adaptation is so permanent. Prominant that they can't interbreed.
[new species]

(2) Marsupial Mammals :

A number of marsupials, each different from the other, evolved from an ancestral stock, but all within the Australian geographical area



3. Australian Placental mammals:



Convergent Evolution in Adaptive Radiation :

When more than one adaptive radiation appeared in an isolated geographical area with different habitat then convergent evolution occur.

→ It is due to similar adaptation in same habitat

Example: Adaptive radiation of placental mammals and adaptive radiation of a Australian marsupials show convergent evolution. In similar habitat show similar adaptation. So, there is correspond member of both type in same habitat.

Biological Evolution :-
[Theory of organic evolution]

1. Theory of Inheritance of acquired character -

→ Given by French naturalist Lemarch.
→ His theory also known as 'Theory of use and disuse of organ'.
→ According to it, "Evolution of life forms driven by use and disuse of organs".

(i) Influence of environment : Environment is not constant. change in environment develops new need.
(ii) Acquired character : To fulfill need organism acquire new character by more or less use of a organ
- more use - more developed organ.
- less use - less developed organ
(iii) Inheritance of acquired character :
These acquired characters pass to next generation. Slowly accumulate the passed character and these produce new species.

Support - Long Neck of Giraffe.

② Theory of Natural Selection -

Darwin's theory based on -

(i) His observation during voyage by H.M.S Beagle in Galapagous Island (living laboratory).

(ii) Thomas Malthus essay on population.

→ He gave theory of Natural selection and wrote a book 'Origin of species'.

→ Two key point of theory -

- Natural selection
- Branching descent

→ Darwin's theory is based on certain observation which are factual -

- Natural resources are limited.
- Population are stable in size.
- Variation between member of population.
- Most of variation are inherited.

Key points of theory -

i). Overproduction
ii). Resources are limited.
iii). Intraspecific competition.
iv). Some member have certain variation which help in better adaptation in environment.
v). These member produce more progeny than others.
vi). Survivors form a population with characteristic and hence new species form.

Examples -

ⓐ Industrial Melanism
ⓑ Microbes colony under given medium
ⓒ Man made selection
ⓓ Evolution by Anthropogenic action.

Industrial Melanism -

In England, before industrialisation it was observed that there were more white winged moth. Before industrialisation trunk were covered with lichen which is whitish in colour. white moth has an advantage so, predator could not spot them and their number increase.

During industrialisation, smoke polluted the environment and lichen disappeared, white moth easily visible in background. so predator capture them and these number decreases. So, black moth have advantage of colour and predators can't spot them.
This phenomenon is called industrial melanism.

Microbial colony -

A colony of bacteria grow in a given medium. Then, medium was changed → only those microbe survive who have variation to utilise this changed medium. These bacteria out grows others and appears a new species.

→ rate of appearance of new form is linked to life cycle or life span.

Nature select those organism which are better adapted to survive in given environment.

Selective Breeding and Domestication -

Man has bred selected plants and animals for the agriculture, horticulture, sport or security.
Human created new breed by selective breeding and domestication within few hundred years.

It means nature can create new species by natural selection of organism over MYA.

Evolution by Anthropogenic Action -

i) Excess use of herbicide, pesticide has result in selection of resistant varities in much lesser time scale.

ii) Industrial melanism.

3. Mutational Theory :

→ Given by Hugo De Vries. He worked on Evening Primrose.

→ According to him - Large difference arise suddenly in population i.e. Mutation. These mutation cause evolution. It is known as Saltation

→ Single step large mutation cause evolution.

Mechanism of Evolution -

[compare b/w Darwin theory and De Vries Theory].

1). According to Darwin small continuous variations cause evolution whereas De Vries believe that mutation cause evolution.

2). Darwinian variation are small and directional but mutational variation is large and directionless.

3). Darwin thought evolution was gradual process while in mutation, it is single large step.

4). Main force.

Darwin - Natural selection.

De Vries - Mutation.

Hardy - Weinberg Law :-

British mathematician G.H. Hardy and German Physician W. weinberg proposed the concept of genetic structure of non-evolving population. It is known as Hardy-Weinberg equilibrium.

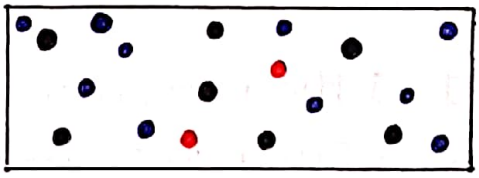
'This states that allele and genotype frequencies in a ideal population will remain constant from generation to generation in the absence of other evolutionary influences.'

For an ideal population condition are -

i) Random mating occur
ii) No mutation
iii) No migration
iv) No natural selection
v) Large population.

→ It describe a gene pool whose allelic frequency is constant under certain condition.

Gene pool - Total genes and their alleles in a population.



Gene pool
- AA
- Aa
- aa

Allele
- A
- a

Allelic Frequency -

Genotype	AA	Aa	aa		
Number of Individual	7	10	2		Total
Number of A allele	14	10	0	=>	24
Number of a allele	0	10	4	=>	14
					38

Frequency of A (P) $= \frac{24}{38} = 0.63$

Frequency of B (q) $= \frac{14}{38} = 0.37$

$P+q = 0.63 + 0.371$

$P+q = 1$

→ According to Hardy weinberg – sum total of all the allelic frequencies is 1.

$$p+q = 1$$

where p and q are allelic frequencies of A and a respectively.

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

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

where p^2 is frequency of AA.

q^2 is frequency of aa

2pq is frequency of Aa

→ It is a population follow Hardy-weinberg, it shows genetic equilibrium or no evolution.

→ Change in frequency of genetic equilibrium cause evolution.

Factors affecting Hardy – weinberg equilibrium –

1). Gene flow
2). Genetic drift
3). Mutation
4). Genetic Recombination
5). Natural selection.

1). Gene Flow :

It is the movement of genes into or out of a population. Such movement occur due to migration.

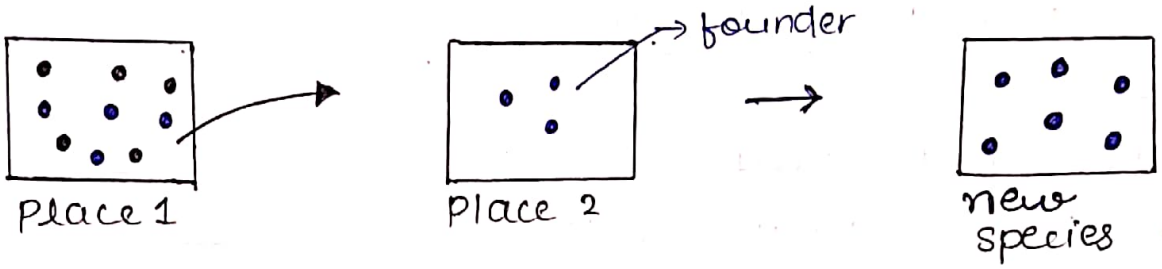
2). Genetic Drift :

It is an evolutionary force operating in small population in which there is change in allelic frequency BY CHANCE. It occur due to –

i) Founder Effect
ii) Bottle Neck Effect.

i) Founder Effect :-

when a few individual or a small group migrate from main population. In this small migrant group some genes may be absent or occur in such low frequency that may be easily lost. Due this they have unique frequency, so form new species.



ii) Bottle Neck effect :-

It happens when size of population is highly reduced by event like natural disaster. It kills most of the individual and leaving behind a small, random member. So gene frequency changes. This leads to formation of new species.

3. Mutation :

Sudden change in genetic structure of organism. It can changes gene frequencies.

↳ Mutation cause discontinuous variation which can cause formation of new species.

4. Genetic Recombination :

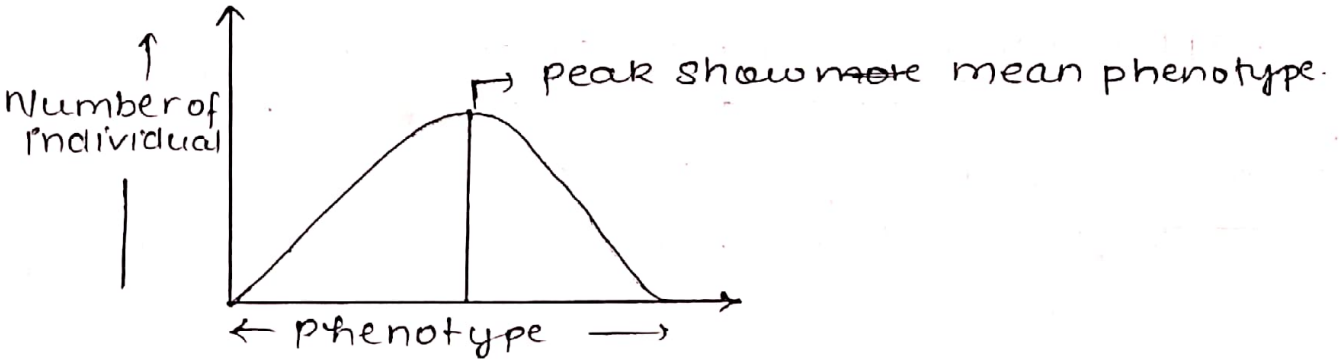
Crossing over during meiosis cause formation of new combination along with parental combination. It can produce new variation.

5. Natural selection -

It is the process in which heritable variation enabling better survival in given environment Due to it these organism reproduce and form more progeny.

Types of Natural selection -

i). Stabilising Natural selection
ii). Directional natural selection
iii). Disruptive Natural selection.



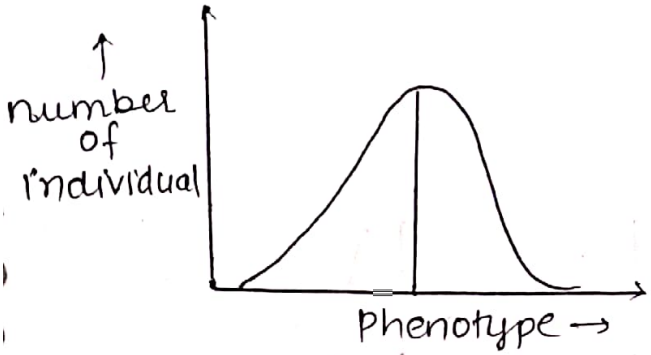
1) Stabilising Natural selection :-

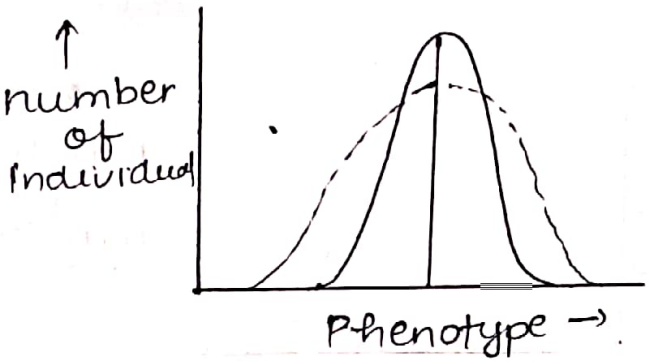
Type of natural selection in which more individual acquire mean character.

- operates in constant environment
- mean is selected
- both extreme are rejected
- mean phenotype remain same.
- Peak gets high and narrow
- Most common.

Eg. Birth weight in human infants -

5.5 lb	7.3 lb	10 Lb
[Death]	[Survive]	[death]



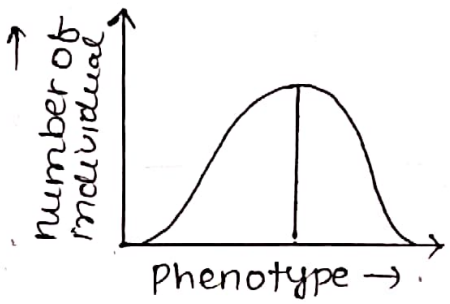


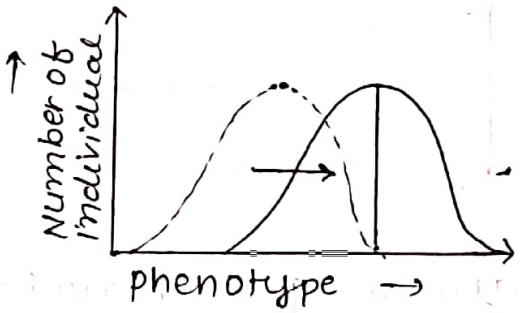
2). Directional selection –

Type of natural selection in which more individual acquire value other than mean character value.

- ▷ operates in changing environment
- ▷ one extreme is selected
- ▷ other extreme is rejected
- ▷ Mean value changes
- ▷ peak shift in one direction.

Eg. Industrial melanism

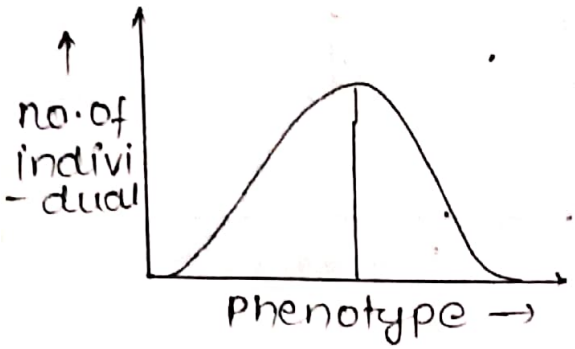


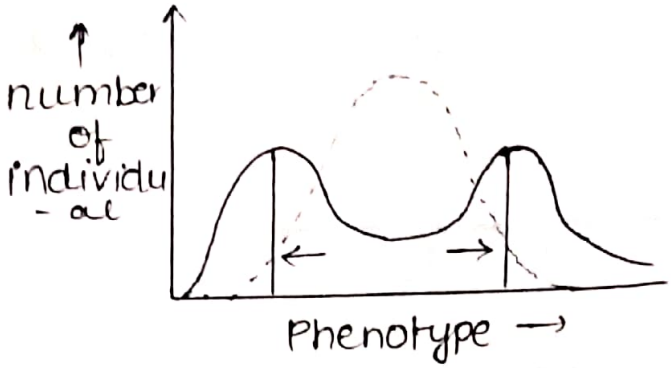


3). Disruptive Natural Selection :

Type of natural selection in which more individual acqui peripheral character value.

- ◻ operate in changing environment
- ◻ Both extreme is selected
- ◻ Mean is rejected
- ◻ 2 peaks are formed
- ◻ More important in evolution.





Geological Time Scale -

It is a representation of time based on rock record and fossil record of earth.

→ Geochronolog unit - subdivision of geologic time.

- Eon
- Era
- Period
- Epoch
- Age

} Hierarchical Geochronologic Unit

Eon :- largest geochronologic unit.

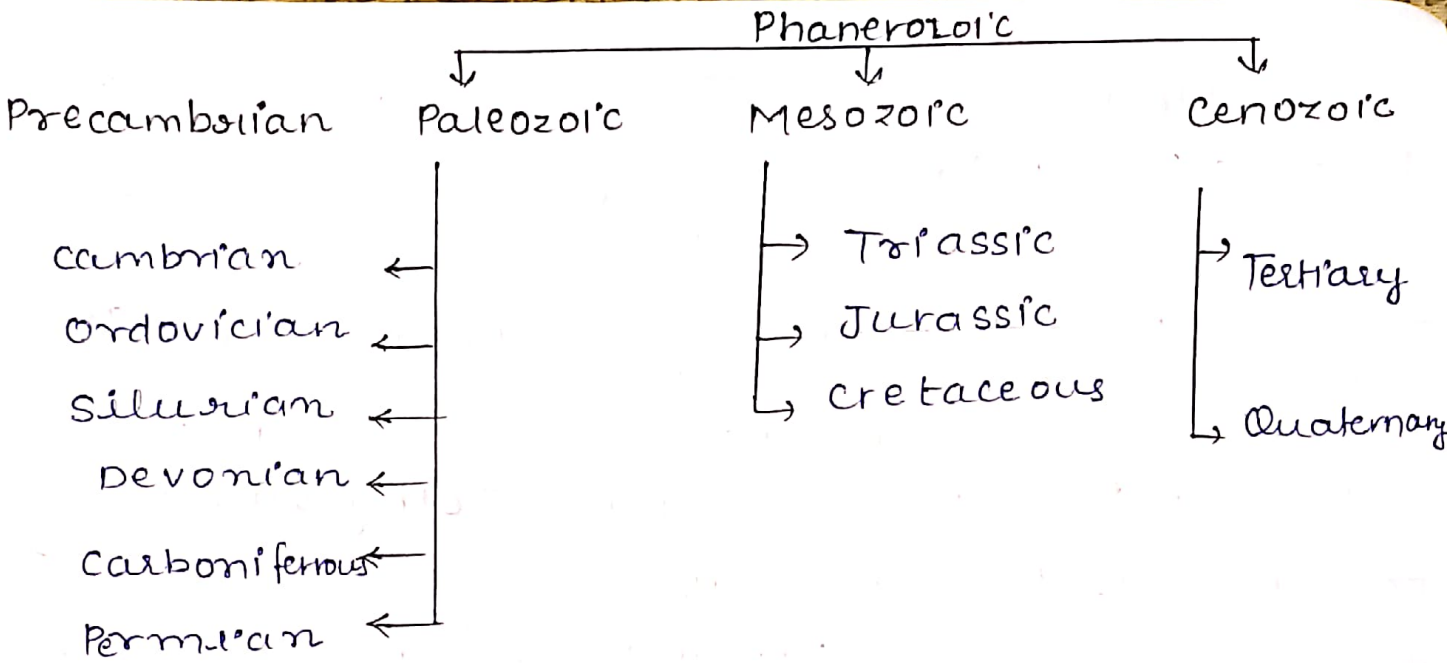
1. Archean
2. Proterozoic

} cryptozoic → no fossil record

3. Phanerozoic → have fossil record.

Era :- second largest geochronologic unit.

Phanerozoic →
- Paleozoic
- Mesozoic
- Cenozoic.



Brief Account of Evolution -

→ About 2000 MYA the first cellular forms of life appeared on earth.

→ Some of these cells had ability release O_2 [Photosynthetic Autotroph].

→ Slowly singled-celled organism become multicellular

→ By the time of 500 MYA invertibrates were formed.

→ 350 MYA vertebrates (Jawless fish) evolved.

→ First organism that invade land were plants when plants were widely spread then animals invade land.

→ Lobefins thought to be eainct but in 1938 Coelacanth caught in south africa.

→ They could move on land and go back to water.

Lobefins
↓
first amphibians
↓
Frog and other amphibians
salamender

↓

Reptiles

Reptiles lay thick-shelled eggs which do not dry up in sun unlike amphibians.

→ In next 200 MYA, reptiles of different shapes and size dominated on earth.
Some of these land reptile went back in water to evolve into fish like reptile Ichthyosaurs.

→ Land reptile -- Dinosaurs.
↳ biggest - Tyrannosaurus rex.

→ Dinosaurs disappered from earth - 65 MYA.
Reason → climatic change
↳ Evolved into birds.

→ Small sized reptiles of that era still exist today.

Animal evolution -

First cellular form → Invertebrates → vertebrate (Jawless fish) → Lobefins → first amphibian → Amphibian → Early reptile

Early reptile → Sauropsids, Synapsids

Sauropsids → Anapsids, Diapsid

Anapsids → Turtles

Diapsid → Lizard, Snake, Tuatara, Thecodonts

Synapsids → Pelycosaurs (extinct) → Therapsids (extinct) → Mammals.

→ First mammals were Shrews.

- → viviparous
- → Protect their unborn inside mother's body
- → More intelligent in sensing and avoiding danger.

→ Before continental drift south america had mammals similar to horse, hippopotamus, bear, rabbit etc. Due to continental drift when south america joins north america animals of south america were overridden by north america.

→ Same continental drift separate australia. Here pouched mammals survived because of lack of competition from other mammals.

Golden Periods:

Fish - Devonian

Amphibian - Carboniferrous

Reptile - Jurassic

Mammals - cenozoic era

Plant Evolution:

First cell → Cynobacteria → plant like protista → chlorophyte ancestor → Tracheophyte ancestor → Rhynia type plant → Psilophyton

Psilophyton → Sphenopsida (horsetail).

Psilophyton → Ferns, Cunko, conifers, Gnetales

Psilophyton → Progymnosperms → seed ferns → cycads

seed ferns → Dicot → monocot

Origin and Evolution of Humans-

First cell (2000 MYA)
↓
Invertebrates
↓
(Jawless fish)
vertebrate
↓
Lobefins
↓
Amphibian
↓
Reptile
(Synapsida)
↓
Mammals

Dryopithecus 15 MYA
↓
Ramapithecus 15 MYA
↓
Australopithecus 3 to 4 MYA
↓
Homo habilis 2 MYA
↓
Homo erectus 1·5 MYA
↓
Homosapiens neanderthalenis
(Neanderthal man) 100K to 40K YA
↓
Homo sapiens fossils
(cromagnon)
↓
Homo sapiens sapiens.

Evolutionary change.

- Bipedal Locomotion
- Increment in Cranial capacity
- Erect posture
- opposable Thumb.

① Dryopithecus (→ more Apelike) and ② Ramapithecus (→ more manlike) -

- existed about 15 MYA.
- Both were hairy and walked like gorillas and chimpanzees.

③ Australopithecus -

- 3-4 MYA
- Fossils obtained from Tanzania & Ethiopia.
- Ape-man like
- Vegetarian
- Not more than 4 Feet tall.
- Walked up-right.

④ Homohabilis -

- First Human like humanid.
- Existed 2 to 2.5 MYA
- Cranial capacity - 650 to 800 cc
- 1st to use stone made tool → tool maker / Handy man.
- Lived in caves.
- Vegetarian.

⑤ Homoerectus -

- Existed in 1.5 MYA
- Fossils discovered in Java in 1891 (Javaman).
- Large brain size around 900 cc.
- They ate meat.
- 1st to use fire for hunting, protection, cooking.

Note: Homoerectus involve -
- Java man
- Peking man → show cannibalism
- Heidelberg man

⑥ Homosapiens -

i) Neanderthal Mans -
(Homo sapiens Neanderthalenis)

- 100 K to 40 K YA
- Near east and central asia
- Cranial capacity - 1400 cc
- They used hides to protect their body and buried their dead.

ii). Cromagnon Man -
(Homo sapiens fossils)

- 50 K to 10 K YA
- Cranial capacity - 1650 cc → maximum
- Domestication and painting

iii). Modern Man -
(Homo sapiens sapiens)

During ice age between 75,000 - 10,000 YA moder Homo sapiens arose.

- Homo sapiens arose in Africa. and moved across continents and developed into distinct races.
- Craniel capacity - 1300 to 1600 cc (avg - 1450 cc).