CLASS – 11

BIOLOGY

Chapter – 8

CELL: THE UNIT OF LIFE

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EVOLUTION:

- It is the change in the inherited characteristics of biological populations over successive generations.
- It give rise to diversity at every level of biological organization, including species, individual organisms and molecules such as DNA and proteins

Origin of Life:

- The origin of life is considered a unique event in the history of universe
- The Universe is about 20 billion years old and includes huge cluster of galaxies, which contain stars and clouds of gas and dust.
- The Big Bang theory explains origin of universe which states that the universe arose from a huge explosion unimaginable in physical terms) of large entity.
- As the universe expanded, the temperature decreases; hydrogen & helium were formed sometime later which get condensed under gravitation & formed the galaxies of the present day universe.
- In the solar system of the milky way galaxy, earth was supposed to have been formed about 4.5 billion years back

The Earth:

- Earth was formed 4.5 billion years before.
- Water vapour, methane, ammonia & carbon dioxide were released from the molten mass.
- The UV rays from the sun broke up water into hydrogen & oxygen and then the lighter hydrogen gas escaped from the surface while oxygen combined with other compounds (methane, ammonia etc.) to form water, carbon dioxide etc.
- As the water vapour cooled, the water fell as rain & filled all depressions to form oceans & other water bodies.
- From the oxygen, ozone layer was also formed.
- Life started appearing (origin of life) about 500 million years after the formation of earth i.e., about four billion years ago

Theories of Origin of Life:

- Various theories were proposed to explain the origin of life:
  1. Theory of Special Creation
  2. Theory of Panspermia/ Cosmozoic theory
  3. Theory of Spontaneous Generation
  4. Theory of Chemical Evolution

Theory of Special Creation:

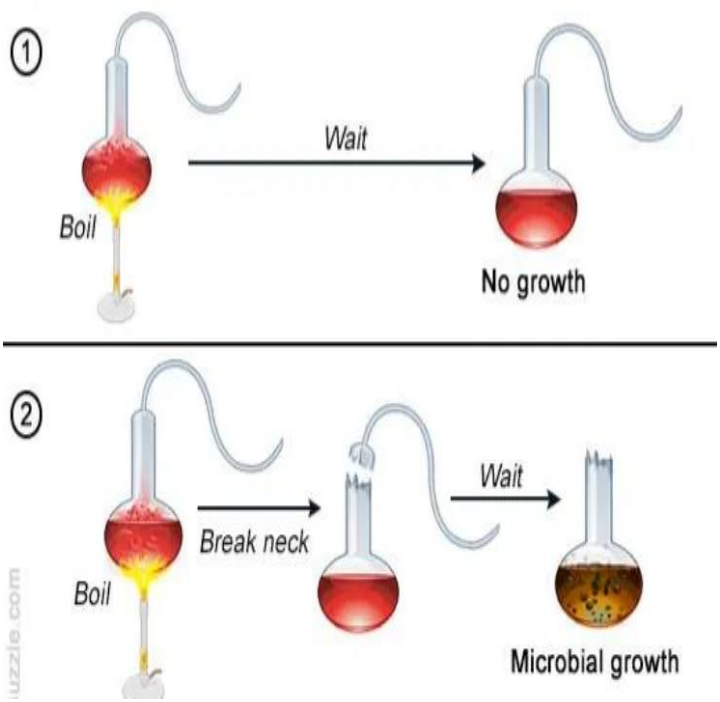
- Conventional religious literature talks about the theory of special creation.
- According to which God, the supernatural being created the earth, light, plants and animals.
- This theory has three suggested views:
  - I. All living organisms (different species or types of plants & animals) that we see today were created as such
  - II. The diversity of life forms was always the same since the time of creation & will remain the same in future also.
  - III. Earth is about 4000 years old.
- All these ideas underwent drastic changes during 19th century when Charles Darwin showed that the existing life forms share similarities to varying degree among themselves and also with those life forms that existed millions of life ago.
- Extinctions also took place during at different phase of geological history

Theory of Panspermia/ Cosmozoic theory:

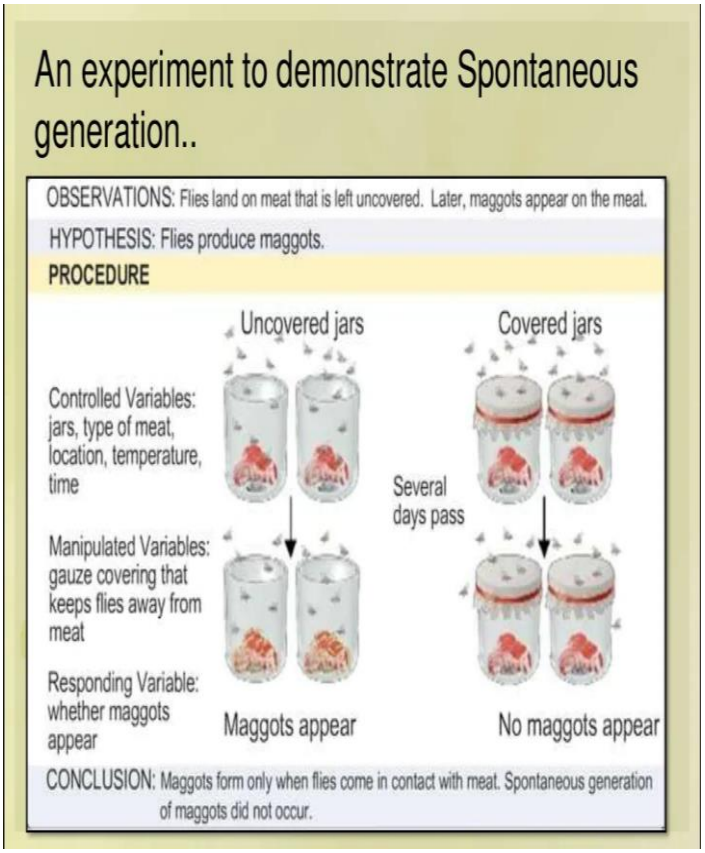
- Some scientist believes that life has come on earth from other planets or outer space.
- In regard early Greek philosophers thought units called 'spores' or 'pansperms' came on earth along with meteorites & they might have evolved into present day forms.

Theory of Spontaneous Generation:

- It was also believed that living organisms (life) arose from decaying matter like straw.
- Louis Pasteur demonstrated that life can arise only from pre-existing life and showed that no life arose from the heat- killed yeast broth that was kept in pre- sterilized closed flask, while new organisms arose from the heat- killed yeast that was kept in the flask left open in the air.



Experiment to demonstrate Spontaneous generation:

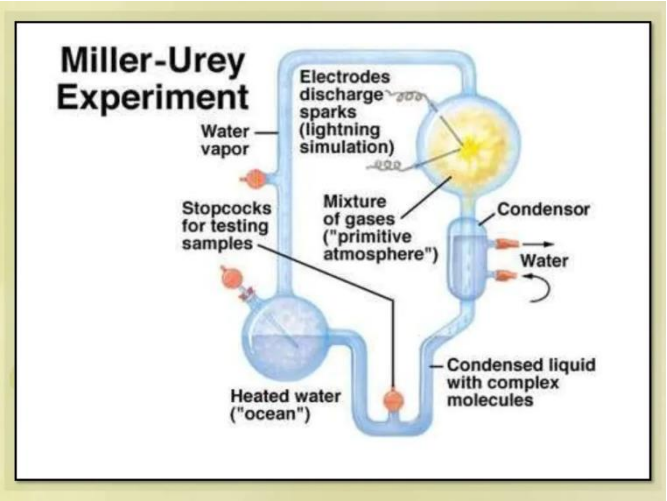


Theory of Chemical Evolution:

- This theory was proposed by Oparin & Haldane.
- They proposed that first life form could have come from pre- existing non- living organic molecules (like RNA, proteins, etc.) and that formation of life was preceded by chemical evolution, i.e., formation of diverse organic molecules from inorganic constituents.
- The conditions on earth that favoured chemical evolution were very high temperature, volcanic storms & reducing atmosphere that contained methane, ammonia, water vapour etc.

Experimental Proof for Chemical Evolution of Life:

- Stanley Miller & Urey created conditions similar to the primitive atmosphere in the laboratory using glass apparatus & tubes.
- They created electric discharge using electrodes in a conical flask (i.e. containing methane, ammonia, hydrogen & water vapour) at 800ºC and due to that water containing chamber was heated to provide water vapour.
- After a week, they observed the formation of amino acids.
- In similar experiments, many other scientists observed the formation of sugar, nitrogen bases, lipids, amino acids & even pigments.
- Analysis of the meteorites also revealed the presence of similar compounds, indicating the occurrence of similar processes elsewhere in the space.
- The chemical evolution of life was more or less accepted.



Origin of First Life:

- The first non- cellular form of life could have originated three billion years ago and they would have been giant molecule like RNA, proteins or polysaccharides.
- These capsules were able to replicate/ reproduce.
- The first cellular forms of life must have appeared about less than 2 billion years ago, they must have been single cells and all life forms have appeared in water bodies.
- This is theory of abiogenesis, i.e., the first form of life arose slowly through evolutionary forces from non- living molecules and accepted by the scientists.
- Once formed, these single cells must have evolved into the diverse complex organisms of today.

Evolution of Life:

- Several assumptions were to propose evolution of life of which the first was religious literature which tells us about the theory of special creation.
- This theory has three connotations.
  I. All living organisms (species or types) that we see, today were created as such.
  II. The diversity was always the same since creation and will be the same in future also.
  III. The earth is about 4000 years old.
- These ideas were strongly challenged during the nineteenth century by Charles Darwin based on his observations made during a sea voyage in a sail ship called H.M.S. Beagle round the world.
- He concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago and also said extinctions of different life forms took place also new forms of life arose at different periods of history of earth.
- Organism has undergone gradual evolution due to variation of characteristics which enable some to survive better in natural conditions (climate, food, physical factors, etc.) would outbreed others that are less-endowed to survive under such natural conditions.
- It was referred as fitness of individual/ population which means reproductive fitness (i.e. who are better fit in an environment, leave more progeny than others) which will survive more and hence are selected by nature.
- He called it natural selection and implied it as a mechanism of evolution.
- Alfred Wallace, a naturalist who worked in Malay Archipelago had also come to similar conclusions that Darwin had.
- All the existing life forms share similarities and share common ancestors. However, these ancestors were present at different periods in the history of earth (epochs, periods and eras).
- They also concluded is that earth is very old, not thousand of years as was thought earlier but billions of years old.

Geological History of Earth:

- Due to advancing studies on evolution scientists were able to conclude that Earth is billions of years old.
- The geological time scale is divided into eras, periods & epochs.
- Rocks are formed by sedimentation a cross-section of earth's indicates the arrangement of the sediment one over the other during the long history of earth.
- Different sediments (of different ages) contain different life forms, which probably died during the formation of the particular sediment.
- Certain organisms got extinct during these phases (Eg.- Dinosaurs).
- Those found towards upper layer resemble modern organisms, while others in deeper layers were the simpler & older forms

Evidences for Evolution:

- Evidences for evolution come from, Palaeontology, Embryology, Comparative anatomy and morphology, Molecular homology & Biogeography.

Palaeontology:

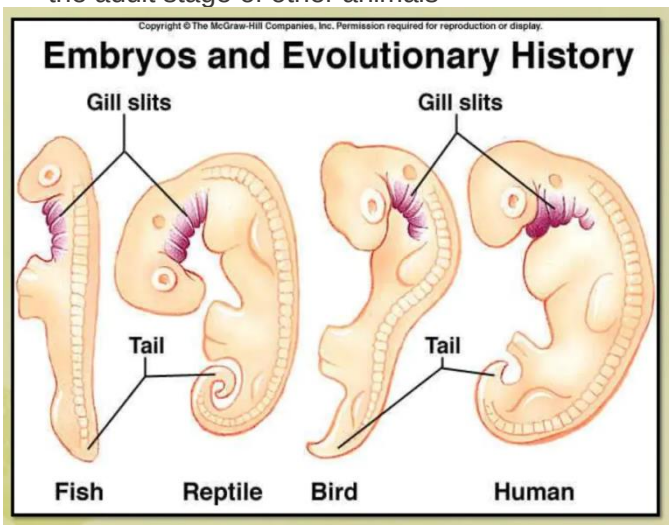
- Study of fossils found in the rocks to support organic evolution.
- Study of fossils from different sedimentary layers indicates:
  I. The geological time period in which the organisms existed.
  II. The life forms varied over time & certain life forms are restricted to certain geological life-span.
  III. The new forms of life that have appeared at different times in the history of earth.

Embryology:

- It is a study based upon the observation of certain common features during embryonic stages of all vertebrates.
- Ernst Haeckel proposed biogenetic law which states that 'ontogeny recapitulates phylogeny', i.e., developmental/ embryological stages of organisms (ontogeny) recapitulate their evolutionary history (phylogeny).
- Vertebrate embryos shows similarities which are: 1. All vertebrate embryos develop a row of gill slits, but they are functional only in fish & not

found in any other vertebrates 2. Notochord is present in all vertebrate embryos .

- But this proposal was disapproved by Ernst Von Baer; he noted that embryos never pass through the adult stage of other animals

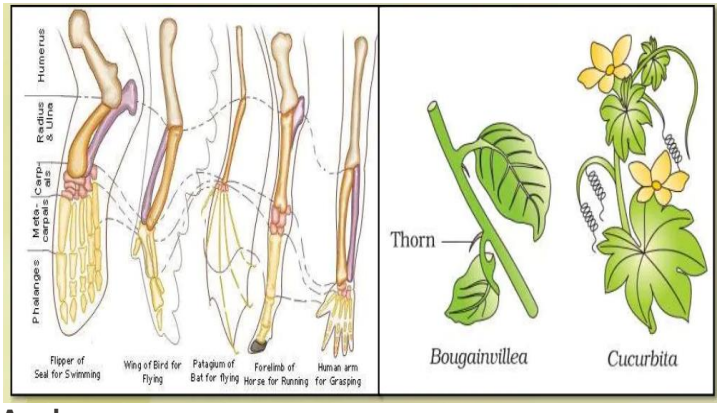


Comparative Anatomy & Morphology:

- Comparative anatomy and morphology shows both similarities & differences among the present day organisms & those existed long before.

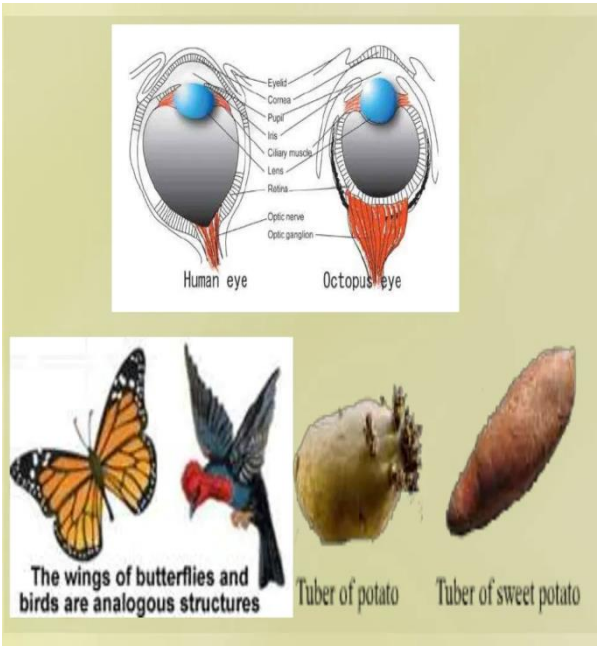
Homology:

- It is the relationship among organs of different groups of organism that show similarity in the basic structure and embryonic development, but perform different functions.
- Homology of organs of different organisms indicates their common ancestry.
- Found in the bones of forelimbs of whales, cheetah, birds, amphibians and human; they have similar basic anatomical structure with the bones humerus, radius, ulna, carpals, matacarpals & phalanges.
- The thorns of Bougainvillea & tendrils of Cucurbita represents homology
- Homology/ homologous organs are the result of divergent evolution, i.e., the evolutionary process where the same structure develops along different directions due to adaptations for different needs.



Analogy:

- It is the relationship among organs of different groups of organisms performing the same function, irrespective of structural or anatomical differences.
- Eg.- Eyes of octopus & those of mammals; wings of butterfly & those of birds; flippers of whales or dolphins & those of penguins; tubers of sweet potato (root modified) & those of potato (stem modified).
- It is the result of convergent evolution, i.e., the evolutionary process, where anatomically different structures in different groups of organisms evolve towards the same function.
- It is the similar habitat conditions that have selected similar adaptive features in different groups of organisms towards the same function.



Molecular Homology:

- Molecular homology refers to the similarities in the biomolecules of different groups of organisms.
- The sequences of nucleotides in nucleic acid & many proteins are similar in apes & humans.
- The biochemical similarities point to the same/ common ancestry of diverse organisms.

Biogeography:

- The differential geographical distribution of different organisms also indicates common/ shared ancestry in that restricted region.
- Habitat isolation has probably restricted these organisms to particular geographical regions on the earth.

Theory of Natural Selection:

- Darwin made a sea voyage round the world in a sail ship, named H. M. S Beagle.
- Based on the observations he made during this voyage, he concluded the following:

I. The existing living organisms share similarities to varying degrees not only among themselves but also with the life forms that existed millions of years ago.

II. There has been gradual evolution of life forms during different periods of geological history and there has been extinctions also.
III. Any population has built- in variations in characteristics. iv. Individuals with those characteristics which enable them to survive better (fitness of the individual) in the natural conditions, would overcome the others, who are less adapted under the same natural conditions

- This fitness of individual, according to Darwin refers ultimately and only to reproductive fitness. • Such fit individuals leave more progeny (with more fit individuals) than others and are selected by nature (natural selection) to survive and reproduce to increase their population size.
- Branching descent and Natural selection are the two key concepts of Darwinian theory of evolution.
- Darwin considered natural selection as a mechanism of evolution.
- Alfred Wallace was a naturalist during Darwin's time concluded:

I. New life forms arise & evolve in due course of time.
II. All the existing forms of life share certain similarities & common ancestors.
III. These ancestors lived at different periods in the history of earth.
IV. The geological history closely correlates with the biological history.

- The rate of appearance of new life forms is linked to the life- cycle or lifespan of organisms; e.g., Microbes that divide fast (with a generation time of 20 minutes or so) speciation can occur within a few days, whereas in larger animals it would take millions of years as their life span are in years
- The term fitness has a genetic basis for getting selected & to evolve.
- Adaptive ability is inherited & has a genetic basis • Fitness is the end result of the ability to adapt & get selected by nature.
- Natural selection is based on certain observations, which are factual; they are as follows:

I. Natural resources are limited; so populations are stable in size except for seasonal fluctuations.
II. Members of the population show variation of every characteristic-no two members of a population are identical, even though they show similarities.
III. Theoretically population size will grow exponentially, if everybody reproduced to the maximum capacity- it is seen in growing bacterial/ microbial populations.
IV. The population size in reality is limited, it is due to competition among individuals for resources & only those which are betted adapted could survive and reproduce at the cost of others who are less adapted to that habitat.

- The insight of Darwin was that he asserted that the heritable variations which make resource utilization better in some individuals will enable them to reproduce & leave more progeny over a period of time; over many generations, there would be change in the population characteristics leading to origin of new forms/ species i.e., speciation

Evidence to prove Natural Selection:

1. **Industrial Melanism:**

- In a collection of moths made in 1850s (before industrialization) it was observed that there were more white-winged/ dull grey winged moths on trees than dark-winged or melanised moths.
- White-colored lichen covered the trees - in that background the white winged moth survived but the dark-coloured moth were picked out by predators- camouflage.
- However, in the collection carried out from the same area, but after industrialization, i.e., in 1920, there were more dark-winged moths in the same area, i.e., the proportion was reversed.
- This was explained that 'predators will spot a moth against a contrasting background'.
- During post industrialization period, the tree trunks became dark due to industrial smoke and soots. Under this condition the white-winged moth did not survive due to predators, dark-winged or melanised moth survived-camouflage.
- The obtained study was compared with areas where industrialization did not occur e.g., in rural areas, the count of melanic moths was low.
- Conclusion: In a mixed population, individuals that are better adapted, can survive & reproduce in large numbers & increase their population size & no variants was completely wiped out.

2. **Resistance to chemicals:**

- Use of pesticides/ insecticides has resulted in resistant varieties of organisms in a less time, e.g., DDT resistance in mosquitoes.
- It is also true for microbes (bacteria); many antibiotic resistant varieties of disease causing bacteria are appearing in a very short period.
- These are examples of evolution due to anthropogenic actions (produced by human).
- This shows that evolution is not a direct process but is a stochastic process (chance/probability), that is based on chance events in nature & mutation in the organisms.

Artificial Selection:

- Man has domesticated many wild animals & plants.

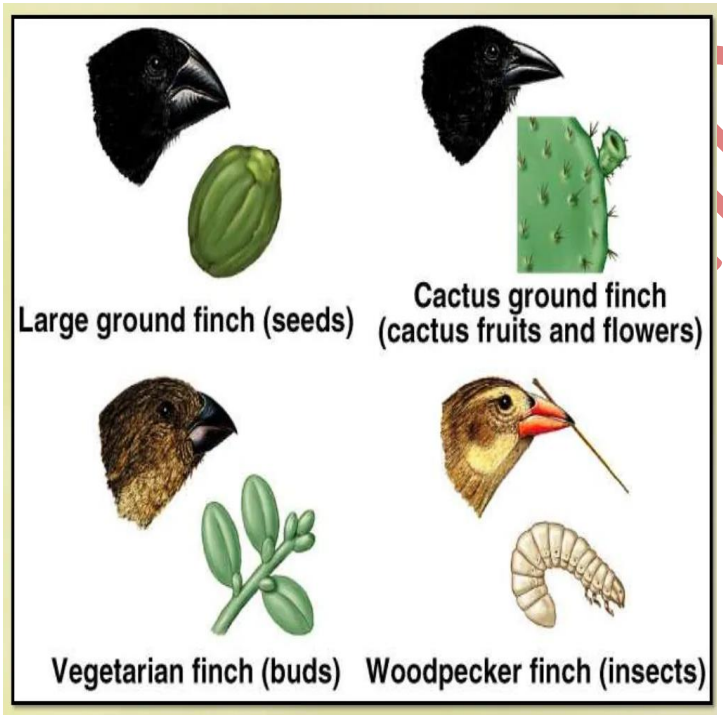
- He has also selected many plants & animals and carried out intensive breeding programs to raise new varieties of plants and animals for agriculture, horticulture, sport or security.
- He has raised a number of high- yielding breeds of animals (like cows, buffalo, poultry birds etc.) & crops (like varieties of wheat, rice, maize, pulses, etc.)

Adaptive Radiation:

- Adaptive ration is an evolutionary process in which an ancestral stock gives rise to new species in a given geographical area, starting from a point & literally radiating to other geographical areas or habitats.

I. **Darwin's finches**.

- These were small black birds which Darwin observed in Galapagos islands.
- There were many varieties in the same island.
- He reasoned that after originating from a common ancestral seed eating stock, the finches must have radiated to different geographical areas & undergone adaptive changes, especially in the type of beak.
- Living in isolation for long, the new kinds of finches emerged that could function & survive in the new habitats.

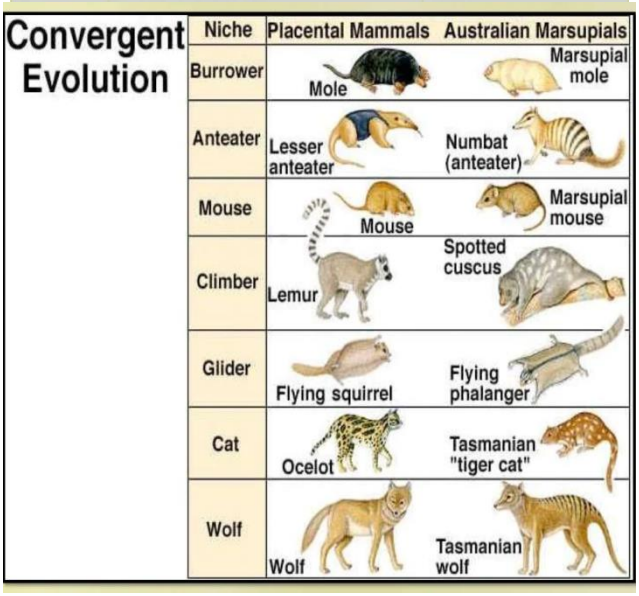


II. **Australian marsupials**:

- A number of marsupials (pouched mammals) each different from the other, evolved from an ancestral stock within Australia.
- When more than one adaptive radiation appeared to have occurred in an isolated geographical area with different habitats, it can be called as convergent evolution.
- Placental mammals of Australia show parallel evolution as they have evolved from other marsupial mammals, each of which closely resemble & look similar to a corresponding marsupial.

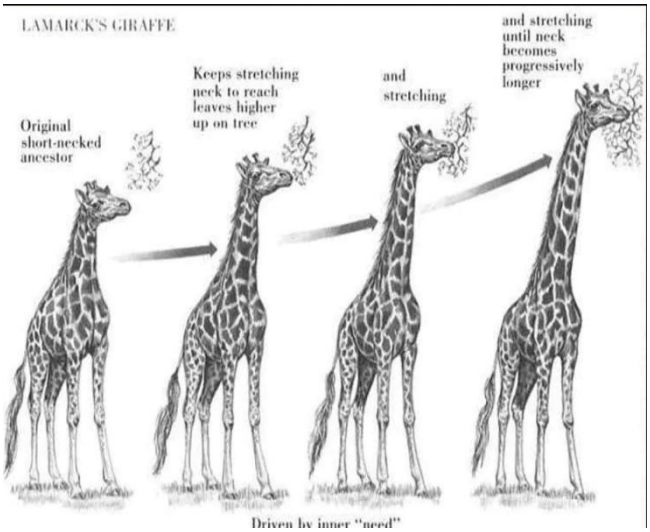
- Parallel evolution of Australian Marsupials & Placental Mammals are given below:

S.No	Australian Marsupial	Placental Mammal
1.	Marsupial mole	Mole
2.	Numbat (banded ant eater)	Ant eater
3.	Marsupial Mouse	Mouse
4.	Spotted cuscus	Lemur
5.	Flying Phalanger (sugar glider)	Flying squirrel
6.	Tasmanian tiger cat	Bobcat
7.	Tasmanian Wolf	Wolf



Lamarck's Theory of Evolution:

- According to Lamarck, the evolution of life forms had occurred by the use & disuse of organs.
- Organs that are used more develop more while those that are not used, become vestigial in the long run.
- The character/ adaptation developed by an organism during its life time is passed on to the progeny.
- He gave the long neck of giraffe as an example; according to him, it is an outcome of the attempt to stretch their neck continuously to eat leaves from tall trees.
- As they passed on this acquired character of long neck to succeeding generations, giraffes came to acquire long neck over long period of time.



Mutations-The Cause of Evolution:

- Hugo de Vries proposed the mutation theory of evolution; he worked on evening primrose.
- He defined mutation as large heritable change occurri ng suddenly in the characteristics of a population.
- According to him mutation caused speciation and called it as saltation, i.e., single- step large mutation.
- He differed from Darwin in the following ways:

I. De Vries' mutation are random & directionless, while Darwinian variations are small & directional.

II. De Vries believed that such large, single-step mutation (called saltation) caused speciation, but evolution for Darwin is gradual & occurs over a number of generations.

Hardy- Weinberg principle:

- This principle states that under certain conditions of stability, the alleles frequencies of a population are stable & remain constant from generation to generation in sexually reproducing organisms, this stability is called genetic equilibrium or Hardy- Weinberg equilibrium.
- The sum total of all the allelic frequencies is one & it is represented as: (p+q)2 or p2+2pq+q2= 1
- Disturbance in the genetic equilibrium is considered as evolutionary change.
- Five factors affects Hardy- Weinberg equilibrium namely- Gene Migration, Genetic Drift, Mutation, Recombination & Natural Selection

1. **Gene Migration:**

- When some individuals of a population migrate to other populations, or when certain individuals come into a population, the gene frequencies of the given population change, i.e., some genes are lost in the first case & added to the second.
- If this migration occurs a number of times, gene flow occurs.

2. **Genetic Drift:**

- Random changes in the allele frequencies of a population occurring by chance, constitute genetic drift.
- The change in allele frequency may become so drastically different that they form new species.
- The original drifted population becomes the founder & the change in the phenotype & genotype of the progeny, constitute the founder effect.
- This is clear with microbial experiments, where he pre- existing advantageous mutants get selected & over a few generations speciation occurs

3. **Mutations:**

- Mutations are random & occurs at very slow rate.
- They create considerable genetic variation for speciation to occur.

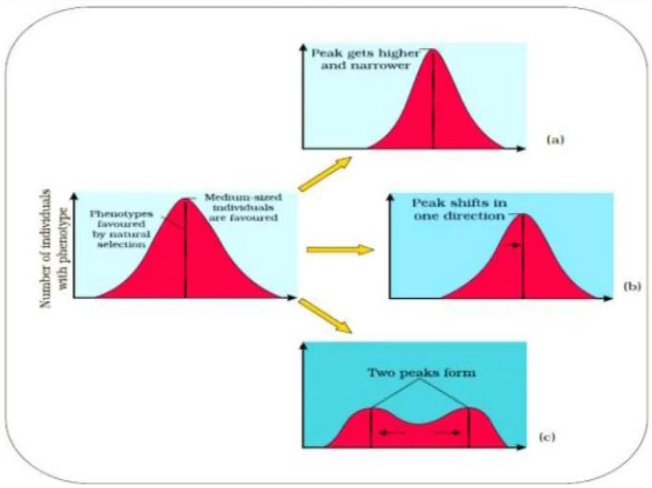
4. **Recombination:**

- New combination of genes occur due to crossing over in meiosis during gametogenesis.

5. **Natural Selection:**

- Natural selection is the most critical evolutionary process that leads to changes in allele frequencies & favours or promotes adaptation as a product of evolution.
- Coupled to increased reproductive success, natural selection makes the population look entirely different from the original population, i.e., speciation.
- Natural selection process depends on the traits favoured & produce one of the three following effects:

1) **Stabilization**- in which more individuals acquire mean character value, i.e., variation is much reduced.
2) **Directional change**, in which more individuals acquire value other than the mean character value.
3) **Disruption**, in which more individuals acquire peripheral character value at both ends of the distribution curve.



History of Evolution of Animals:

- About 2000 million years before, the first cellular form of life appeared on the earth.
- Slowly these single- celled organisms evolved into multicellular organisms.
- Invertebrates were formed around 500 million years before. • Jawless fish must have evolved around 340 million years ago.
- At around the same time, fish with stout & strong fins, that could move on land & go back to water, must have appeared.
- The coelacanth or lobefins were the ancestors of modern day frogs & salamanders.
- These amphibians evolved into reptiles that lay thick- shelled eggs which do not dry up in the sun; this made the reptiles more successful than amphibians
- In the next 200 million year or so, reptiles of different shapes and sizes dominated the earth
- Some of these land reptiles moved back to water to evolve into fish like reptiles (Ichthyosaurs) at around the same time (200 million years ago).
- The land reptiles i.e., dinosaurs suddenly disappeared from the earth (mass extinction) about 65 million years ago, while some small sized reptiles continue to exist today like birds, crocodiles etc.
- When the reptiles disappeared, mammals started dominating the earth.
- The first mammal was like shrew
- There were mammals like horse, hippopotamus, rabbit, bear etc., in South America but when South America joined North America (in the continent drift), these animals were over- ridden by the fauna of North America.
- Australian land mass remained isolated & the pouched mammals survived as there was no competition from any other mammal

History of Evolution of Plants:

- Some of the single celled organisms that appeared 2000 million years ago had pigments to capture solar energy and release oxygen, in the process of photosynthesis.
- Bryophytes were the first plants to colonise lands (plants colonised the land much before animals) and Sea weeds & few plants existed around 320 million years ago.
- About 200 million years before, giant ferns (Pteridophytes) were present, but they all fell to form coal deposits slowly.
- Herbaceous lycopods & arborescent lycopods evolved from Zosterophyllun of palaeozoic era.
- Psilophyton is the common ancestor of horsetails, ferns & gymnosperms
- Fossils of Lycopods & Psilophyton

Evolution of Man:

- The common ancestor of apes and man is a primate Dryopithecus, that lived 15 million years ago.
- At the same time, another genus Ramapithecus also existed.
- Both Dryopithecus & Ramapithecus were hairy and walked like gorillas & chimpanzees; Dryopithecus was more ape like, but Ramapithecus was more man-like and is the forerunner of hominid evolution.
- The human evolution is as follows:

1. Australopithecines:

- They probably lived 2 million years ago, in the east Africa grass lands.
- They has brain capacity of 450- 600 cc.
- They hunted with stone weapons but essentially ate fruits.

2. **Homo habilis:**

- This is called first human like being, the hominid
- They had brain capacity of 650- 800 cc.
- They probably did not eat meat 3. Homo erectus
- Their fossils were found in java (Java man) in 1981.
- They probably lived about 1.5 mya.
- They had a brain capacity of about 900cc.
- They probably ate meat.

3. **Homo sapiens (Primitive man)**:

- Their fossils were found in near East & Central Asia.
- He must have lived between 1, 00,000- 40,000 years before.
- Neanderthal man (Homo sapiens neanderthalensis) had a brain capacity of about 1400 cc.
- They used hides to protect the body & buried the dead.
- They moved across continents & developed into distinct races.

4. **Homo sapiens (Modern Man)**:

- Homo sapiens arose during ice age between 75000- 10000 years ago.
- He spread all over the globe & learned to cultivate plants & domesticate animals.
- Pre- historic cave art developed about 18,000 years before.
- Agriculture started around 10,000 years back.
- Human settlements and cultivations started