THEORIES OF EVOLUTION:

- Evolutionary biology includes both the origin of life and the diversity of living organisms on the earth. Various concepts explain the process of evolution, but the important concepts or theories that explain the scientific basis of organic evolution are Lamarckism, Darwinism, Mutation theory and modern synthesis theory.

LAMARCKISM OR INHERITANCE OF ACQUIRED CHARACTERS:
- Jean Baptiste de Lamarck: Jean Baptiste de Lamarck (1774 -1829), a French biologist is well known for his concept, inheritance of acquired characters in organisms for the formation of new species, which he explained in his book *Philosophic Zoologique* in 1809.

I. Salient features of Lamarckism:
- He observed that
  i. Species change under changing external influences,
  ii. There is a fundamental unity underlying the diversity of species
  iii. The species progressively develop.
- Based on these observations he assumed:
  1. Living organisms and their parts tend to increase in size continuously due to internal forces of life,
  2. New organs (characters) are developed in order to meet the needs of the new want and are main tained (acquired characters).
  3. The development of organs and their use are proportional to the activities of these organs. Use and disuse of organs result in variations.
  4. Every new character that has been acquired in the life of an individual is preserved and transmitted to the next generation by them (inheritance of acquired characters).
- Thus, Lamarck proposed that variations in organisms were the result of the influence of environment.
- When the environment of an organism changes, its needs also change. Changed needs lead to either special use of organs or disuse of organs.
- Organs that are used more increase in their size and organs which are not used continuously degenerate, Such acquired traits are inherited to next generation.

Examples of Lamarckism:
- Lamarck cited the examples of giraffe and snakes to explain use and disuse of organs. An original deer like ancestor found the supply of grass and herbs inadequate.
- It started feeding on the leaves of trees. In the process of reaching the leaves of higher branches, its neck got stretched and the forelegs were raised. As a result the neck became longer along with that forelimbs. Lamarck cited this example for the use of an organ.
- The ancestors of snakes were the four-limbed animals. They adapted to burrowing habit in course of time. During this adaptation they lost their limbs gradually.
- Hence the snakes of the present day are without limbs. Lamarck cited it as an example of disuse of an organ.

II. Germplasm theory:
- August Weismann 1890 the German biologist, performed the decaudalisation experiments on mice and disproved Lamarckism and pangenesis theory of Darwin.
- He cut the tails of white mice for more than 20 generations and observed the effect on the length of tail in coming generations.
- In all the generations the length of the tail was found to be normal. Hence, he believed that the acquired character was not inherited.
- August Weismann proposed the theory of germplasm, or germinal selection.
  1. He differentiated the protoplasm into somatoplasm and germplasm. Somatoplasm is in the somatic cells (other than the sex cells). It does not play any role in heredity. Germplasm is the protoplasm in the sex cells. It plays an important role in heredity.
  2. The changes that occur in the nonreproductive cells or somatic cells are not transmitted where as the changes that occur in the reproductive cells are transmitted.

III. Neo-Lamarckism:
- Lamarckism is the first scientific assumption that recognised the "adaptation to the environment as a primary product of evolution".
- The followers of Lamarck (Neo-Lamarckians) like Cope, Cannon, Osborn, Packard, Spencer, McBride tried to modify Lamarckism to make it acceptable. These neo-Lamarckians considered that adaptations are universal.
- Organisms acquire the new structures due to their adaptations to changed environmental conditions. They argue that the sex hormones influence the somatic cells of an organism.
The external conditions affecting the somatic cells stimulate the body cells to produce specific secretions. These secretions reach the sex cells through the blood. Such variations can be inherited by offspring.

Kammarer observed in *Proteus anguinus*, which is a cave dweller the development of normal eyes and colour of the skin when exposed to daylight. This character is inherited to the next generation.

**DARWINISM OR NATURAL SELECTION**:

Charles Robert Darwin:

- Charles Robert Darwin (1809-1882) was an English naturalist born on 12th February, 1809 at Shrewsbury, England. He was appointed a Naturalist in 1831 upon a world survey-ship of British Government H.M.S. Beagle.
- He went on voyage for five years (1831 to 1836) and explored the fauna and flora of a number of continents and islands. The idea of *evolution of new species by natural selection* influenced his mind in the journey.
- Darwin was much influenced by three publications namely the essay of T.R. Malthus, 1798, titled *On the principles of populations* which states that populations increase geometrically and the food sources increase arithmetically, the book written by Sir Charles Lyell entitled *Principles of Geology* which explained the gradualism (earth has changed slowly and gradually through ages) and uniformitarianism (fundamental laws operate today on the earth in the same way as they did in the past) and the paper titled *On the tendency of varieties to depart from original types* sent to him by Alfred Russel Wallace.
- Darwin presented the summary of his theory in a joint paper titled, 'Origin of species, in 1858 to the Linnean society.
- Again in 1859, Darwin published his findings in detail in his book titled *The Origin of Species by Natural Selection* or *The Preservation of Favoured races in the struggle for life*.

I. Darwin's theory of Natural Selection:

- Darwin's theory of natural selection is based on several facts and observations.
  1. **Over production or enormous power of fertility:**
     - Every organism tends to increase in geometrical proportions in its population, e.g. *Paramecium* divides by binary fission three to four times in a day.
     - At this rate, the mass of protoplasm equals to 10,000 times of the volume of the earth at the end of 9000th generation. *Salmon* produces 28 millions eggs and *starfish* one million eggs in a season.
     - If all the eggs hatch and the larvae come to reproductive stage, all the seas will be filled with them in a few generations.
     - A pair of elephants, the slowest breeder, in the absence of checks may have 29 million descendants at the end of 800th generation.
  2. **Constancy in population of each species in nature**:
     - However, an abnormal increase in the population of any species is not observed in nature. The population of each species remains more or less constant because the offspring die in large number before they become reproductively active.
     - The food and other sources do not increase in the same rate of population increase. As a result there is a danger of population over running the food and other facilities. Consequently, more number of individuals are eliminated, because available resources support only a limited number of organisms.
     - A great competition exists wherein the individual tries to become better than the other to protect itself from the danger of being eliminated.
  3. **Struggle for existence**:
     - Over population results in severe competition. Darwin called it struggle for existence. These struggles are of three types.
     - i. **Intraspecific struggle:** It is the struggle found among the individuals of a species. It is most severe check of the rate of reproduction. This struggle is for food and mating.
     - ii. **Interspecific struggle:** It is found between different groups of animals. It is most common because most of the species have same food habits.
     - This competition is for food and other needs. Usually the lower animals are more effected by this then the larger ones.
     - iii. **Struggle with the environment:** Living organisms struggle with the adverse environmental conditions like floods, cold waves, heat waves, earthquakes etc.
     - The gigantic reptiles, dinosaurs, struggled very much in cretaceous period and perished.
  4. **Universal occurrence of variations**:
     - Variations exist in all organisms. These variations may be **useful** or **harmful** or useless. Harmful variations make the organism unfit in the struggle for existence.
     - The variations may be **favoured** or **unfavoured** by the nature. **Beneficial** variations are favoured by the nature.
Useful variations are quite significant and make the organism fit in the struggle for existence.

Such variations are inherited by the progeny, so that the progeny has better chances of survival.

5. **Natural selection**:

- According to Darwin during the struggle for existence, the organisms with beneficial variations alone will survive.
- Darwin hypothesised that these variations are sorted out by nature through competition.
- The organisms which are selected by nature are said to be the fittest.
- This idea of **survival of the fittest** was proposed by Herbert Spencer.
- Variations which are useful to the individual in a particular environment would increase that individual's ability to reproduce and leave fertile offspring. These are favoured by nature.
- Less favourable variations would be at disadvantage and organisms possessing them are reproductively less successful. Differential reproductive success exists among organisms.
- The concept of differential reproductive success of various forms is more accurate.
- Over period of time, the criterion for the success is the reproductive success.
- The organism that fails to reproduce cannot be represented in future generations however fit it may be in the struggle for existence.

6. **Origin of species**:

- Darwin concluded that the struggle for existence leading to the survival of the fittest allows the successive generations to become better adapted to the environment.
- All the modifications caused by variations and selected by nature are accumulated from generation to generation till a generation is produced that is more adapted and has more chances of survival.
- Darwin considered that a permanent racial change is the product of fluctuating variations. He also believed that evolution is a gradual, rather than a sudden, biological event.
- Thus, as per natural selection, **new species** are evolved due to cumulative effect of fluctuating variations.

II. **Objections to Darwinism**:

- Darwinism is considered to be the best explanation for the biological event, organic evolution. Yet some objections are levelled against Darwin's Natural Selection.
  1. Natural selection stresses upon the small fluctuating variations, but these are mostly nonheritable. Thus Darwin did not distinguish between heritable and nonheritable variations. He also did not distinguish between somatic and germinal variations.
  2. Natural Selection can not explain the occurrence of vestigial organs, because they have no selection value.
  3. Darwinism explained the **survival of the fittest**, but did not explain the **arrival of the fittest**.
  4. Natural selection does not account for how an organ can be successful in its initial stages of formation. These stages of formation do not have the selection value, unless the organs are perfected in course of time.
  5. It does not explain the over specialisation of some organs like the antlers of extinct Irish deer and large special tusks of Jefferson mammoths. In some cases these organs led to the extinction of their possessors.
  6. Natural selection does not explain the organs formed by coadaptations like electric organs in electric rays and mimicry in Kallima (butterfly). The effectiveness of these organs depends on the perfection, wherein the perfection is due to coadaptation.
  7. Darwin did not consider the importance of macrovariations in evolution. He called them as **sports of nature**.
  8. If the new species are formed due to the cumulative effect of fluctuating variations in the generations, transitional forms might be available. However such forms were not found in most cases.

III. **Experimental verification of Natural Selection**:

**Industrial melanism:**

- A classical example of natural selection in the wild is the case of peppered grey moth *Biston betularia* which was abundant before industrial revolution all over England.
- These moths showed colouration with two phenotypes, grey and black. The black forms were more and grey forms were less in the industrial period particularly in the industrial cities like Birmingham.
- Biologists proposed this change in the population of peppered moth was due to the pollution caused by the industrial revolution. Prior to industrial revolution the grey moths succeeded to camouflage the light trunks of the trees.
- With the industrial revolution more soot was released due to the burning of coal. Tree barks became black. Grey moths were easily identified and were more predated by the birds.
- Grey moths decreased in number and dark moths increased in the population. Therefore natural selection favoured the melanic moths to reproduce more successfully.
Natural selection of darker forms in response to industrial pollution is known as industrial melanism. Bernard Kettlewell, a British ecologist, tested the hypothesis experimentally.

He reared the grey and dark forms of populations with equal numbers. He released the moths in two sets - one in Birmingham (polluted area) and the other in the Dorset (unpolluted area).

Kettelwell recaptured more dark forms in the polluted area and more grey forms in the unpolluted area. This explains the differential survival of the moth.

The release of smoke was reduced in the later periods. Consequently frequency of dark forms in the population declined and the light forms slowly increased.

Reduction in the pollution is related to reverse evolution of gray moths.

**SEXUAL SELECTION:**

There are many evolutionary consequences related to the adaptation of sexual mode of reproduction.

This includes the competition among the individuals for mates. So, animals developed the secondary sexual characters.

Darwin considered the theory of sexual selection to explain the development of secondary sexual characters in the animals.

These secondary characters can not he explained by natural selection, because these are not useful in the struggle with the environment.

These nonadaptive secondary sexual characters like brilliant colours, ornaments etc. appear mostly in males, because females chose the males with these characters for mating.

**ARTIFICIAL SELECTION:**

Artificial selection is a man made selection.

According to Darwin it is the commonest method of producing new races of animals by man. This process has been adopted for production of better races of domestic animals by man.

A animal breeder selects the animals among highly variable individuals with desired characters and breed them until the desired character is perfected in the progeny.

Artificial selection focuses on one trait rather than overall fitness of the animal.

**MUTATION THEORY:**

Mutation is a sudden, random, discontinuous and heritable change independent of the environment in the genetic make up of an individual.

The term mutation was coined by Hugo de Vries, a dutch botanist in 1901. Darwin called such variations as sports or saltations, where as Bateson called them discontinuous variations.

Hugo de Vries observed evening primose Oenothera lamarckiana, which is a biennial plant of 5 to 6’ height. The wild variety showed different characteristics in different forms O. brevistylis -small style, O. levifolia -smooth leaves, O. gigas -the giant form, O. nanella -the dwarf form etc. These characters are inherited to the progeny.

Each of them is called mutant and the characteristics are called mutations. Mutation is the whole truth of evolution to Hugo de Vries, who proposed mutation theory.

It states that new full-fledged species originate at once as a result of large, discontinuous variations which appear suddenly.

**Salient features of mutation theory:**

1. Mutations arise from time to time among the individuals of a naturally breeding population.
2. Mutants are markedly different from parents.
3. Mutations are large, sudden and differ from fluctuating variations of Darwin.
4. Mutations are subjected to natural selection.
5. Mutations are discontinuous, not cumulated in generations.
6. Mutations are full-fledged so there are no intermediate stages in the course of evolution.

**Importance of mutations in evolution:**

De Vries stressed on the randomness of variation, where as Darwin considered the adaptiveness of the variation in evolution.

De Vries stated that new species arise by sudden jump, called mutation, where as Darwin considered that new species arise by the cumulation of gradual fluctuating variations in a series of generations.

T.H. Morgan observed mutations in Drosophila melanogaster and confirmed the mutation theory.