ORIGIN OF LIFE

ORIGIN OF UNIVERSE

- Most accepted theory to explain the origin of universe is the Big-Bang Theory which was proposed by Abbe Lemaitre in 1931.
- According to this theory, universe had an explosive beginning. Universe originated about 15 billion years ago by a big bang (thermonuclear explosion) of a dense entity.
- The universe expanded and hence the temperature came down. Large scale collision between protons, neutrons and electrons gave rise to atoms of hydrogen.
- Hydrogen fused into progressively heavier atoms of different kinds of elements found today. This was the beginning of a long cosmic evolution.
- The original gaseous cloud spread out into space and divided into larger and smaller masses, forming stellar systems and stars. Even today, most of the stars are merely masses of red hot gases.
- First galaxies were formed which again broke to form stars and stars broke to form our planets including earth.

ORIGIN OF SOLAR SYSTEM

- According to **Nebular Hypothesis** our solar system was probably created about 4.5 to 5 billion years ago when the gaseous cloud called **solar nebula** was formed.
- As this cloud condensed, the central mass formed the **Sun,** and the peripheral ring of cloud which continued rotating around the central mass, formed the **planets** such as Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Asteroids are formed in between the planets Mars and Jupiter.

ORIGIN OF EARTH

- The earth formed about 4.6 billion years ago. The cooling and condensation of hot gases enable aggregations of cold dust and particles to clump into solid matter which was later differentiated into three main parts :-
- **Crust.** It is the outer-most solid, rocky surface of the earth. It varies widely in thickness from 12-60 km.
- **Mantle.** It is the middle part of earth which is solid and consists of iron and magnesium silicates. It has thickness of 2900 km.
- **Core.** It is the central part of earth, which is differentiated into semisolid outer core of 2080 km thickness, probably molten solid inner core of 1370 km thickness. The heavy metals such as iron and nickel sank into the central part of the earth.
- Earth originally had only two components, solid mass called lithosphere surrounded by a

gaseous envelope termed atmosphere. The liquid component, known as hydrosphere, appeared later when the earth cooled down to a temperature below 100°e.

THEORIES OF THE ORIGIN OF LIFE

- Many theories have been put forward to explain the origin of life. Some important theories about origin of life are described below.

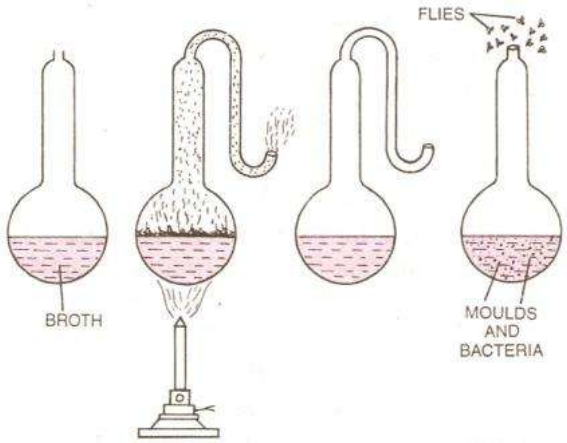
Ancient Theories of Origin of Life

- **Theory of Special Creation.**
- The greatest supporter of this theory was Father Suarez. According to this theory life was created by supernatural power.
- Special creation theory lacks scientific evidences, on account of which it is *not accepted.*

- **Theory of Spontaneous Generation (Abiogenesis or Autogenesis).**
- This theory states that life originated from nonliving things in a spontaneous manner. This concept was held by early Greek philosophers like Thales, Anaximander, Xanophanes, Empedocles, Plato, Aristotle, etc.
- In ancient Egypt, it was believed that the mud of the Nile could give rise to frogs, toads, snakes, mice and even crocodiles when warmed by the sun.
- Van Helmont (1577-1644) held that human sweat and wheat grains could give rise to organisms. He placed a dirty shirt in a receptacle containing wheat bran and found that after 21 days the gases from the shirt and wheat had formed living mice.
- These beliefs have no scientific grounds and hence are *discarded.*

- **Evidences against the Theory of Spontaneous Generation.** The theory of spontaneous generation was disproved by many scientists. They proved that new organisms can be formed from pre-existing ones, *i.e., omnis vivum ex ovo or vivo* ('Biogenesis' of Harvey T. H. Huxley). Noted scientists who experimentally challenged the theory were Francesco Redi Lazzaro Spallanzani and Louis Pasteur.
- **Redi's Experiment.** Francesco Redi took the flesh and cooked it so that no organisms were left alive. Then he placed flesh in three jars, of which, one was uncovered, the second was covered with parchment and the third one was covered with fine muslin. He kept these jars for a few days and observed that maggots developed only in the un-covered jar though the flies also visited other jars.
- **Spallanzani's Experiment.** Spallanzani (1765) disproved the spontaneous generation of microorganisms. He experimented that animal and vegetable broths boiled for several hours and soon after sealed, were never infested with microorganisms. From this experiment he concluded that high temperature had killed all living organisms in the

broths and without them life could not appear. When the broths were left exposed to air, were soon invaded by microorganisms.



- **Pasteur's Experiment.** Louis Pasteur, a French scientist took broths in a long necked flask and then he bent the neck of the flask. He boiled the *broths* in the flask to kill any microorganisms that might be present in them. The curved neck acted as a filter. If the flask with *'swan neck'* (curved neck) is kept for months together, no life appeared, as the germ laden dust particles in the air were trapped by the curved neck which serves as filter. If the swan neck was broken off, the broths developed colonies of *moulds* and *bacteria.* Thus, he showed that the source of the micro-organisms for fermentation or putrefaction such as for milk, sugar and wine, etc., was the air and the organisms did not arise from the nutrient media. Thus Louis Pasteur (famous for **"Germ Theory of Disease and Immunology")** finally disapproved abiogenesis and proved biogenesis.
- But according to **biogenesis,** life originated from pre-existing life which does not explain the origin of life. So biogenesis is also disapproved.

- **Cosmozoic Theory or Theory of Panspermia.**
- This theory was proposed by **Richter** (1865). According to this theory, **'protoplasm'** reached the earth in the form of spores or germs or other simple particles from some unknown part of the universe with the cosmic dust, and subsequently evolved into various forms of life.
- **Helmholz** (1884) speculated that 'protoplasm' in some form reached the earth with falling meteorites.
- **Arrhenius** (1908) postulated the (= **Panspermia Theory)** and stated that organisms existed throughout the universe and their spores etc., could freely travel through space from one star to the others. In fact, panspermia theory is the alternative name of cosmozoic theory.
- **Evidences against Cosmozoic Theory.** Living matter cannot survive the extreme cold, dryness and ultra-violet radiation from the sun required to be crossed for reaching the earth.

- **Theory of Catastrophism.**
- **Georges Cuvier** and **Orbigney** were the chief advocates of this theory. According to this theory **catastrophic revolution** occurs upon earth from time to time which completely destroys all organisms (living beings).

- New organisms, then, suddenly form from inorganic matter. Each creation consists of life quite different from that of the previous one. In fact, this theory is merely a modification of theory of special creation. This theory is also not accepted.

Modern Theory or Oparin-Haldane Theory of Origin of Life

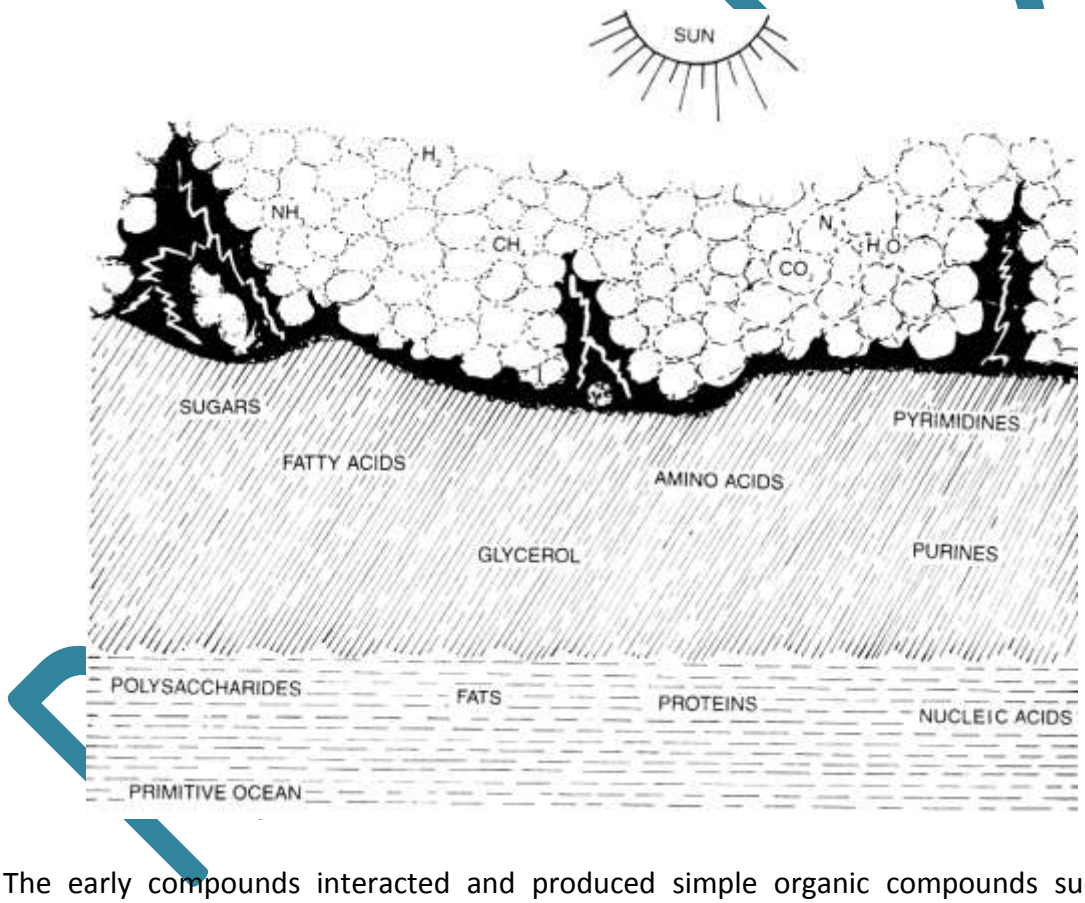
- According to this theory life originated on early earth through physico-chemical processes of atoms combining to form molecules, molecules in turn reacting to produce inorganic and organic compounds. Organic compounds interacting to produce all types of macromolecules which organised to form the first living system or cells.
- Thus according to this theory 'life' originated upon our earth spontaneously from non-living matter. First inorganic compounds and then organic compounds were formed in accordance with ever-changing environmental conditions.
- This is called chemical evolution which cannot occur under present environmental conditions upon earth. Conditions suitable for origin of life existed only upon primitive earth. Oparin-Haldane theory is also called **chemical theory or naturalistic** theory.
- **A.I. Oparin** was a Russian Scientist. He published his book **"The origin of Life"** in 1936 and an English edition in 1938. **J.B.S. Haldane** was born in England but migrated to India in July 1957 and settled in Bhubaneshwar, Orissa. He was biologist, biochemist and geneticist. Both Oparin (1938) and Haldane (1929) gave similar views regarding the origin of life.

- *Modem views regarding the origin of life include* ***chemical evolution*** *and* ***biological evolution****:*
- **Chemical Evolution**
- **(i) The Atomic Phase.** Early earth had innumerable free atoms or all those elements *(e.g.,* hydrogen, oxygen, carbon, nitrogen, sulphur, phosphorus, *etc.)* which are essential for the formation of protoplasm. Atoms were segregated in three concentric masses according to their weights.
- The heaviest atoms of iron, nickel, copper, etc. were found in the **centre** of the earth.
- Medium weight atoms of sodium, potassium, silicon, magnesium, aluminum, phosphorus, chlorine, fluorine, sulphur, etc. were collected in the **core** of the earth.
- The lightest atoms of nitrogen, hydrogen, oxygen, carbon etc. formed the **primitive atmosphere.**

- **(ii) Origin of Molecules and Simple Inorganic Compounds.** Free atoms combined to form molecules and simple inorganic compounds. Hydrogen atoms were most numerous and most reactive in primitive atmosphere. First hydrogen atoms combined with all oxygen atoms to form water and leaving no free oxygen. Thus primitive atmosphere was **reducing atmosphere** (without free oxygen) unlike the present oxidising atmosphere

(with free oxygen). Hydrogen atoms also combined with nitrogen, forming **ammonia** (NH_3). So water and ammonia were probably the first compound molecules of primitive earth.

- **(iii) Origin of Simple Organic Compounds (Monomers).** The primitive atmosphere contained gases like CO_2, CO, N, H_2, etc. The nitrogen and carbon of the atmosphere combined with metallic atoms, forming **nitrides** and **carbides.** Water vapour and metallic carbides reacted to form the first organic compound, **methane** (CH_4). Later on **hydrogen cyanide** (HCN) was formed.
- *Torrential rains must have fallen.* As the water rushed down, it must have dissolved away and carried with it salts and minerals, and ultimately accumulated in the form of oceans. Thus ancient oceanic watercontained large amounts of dissolved NH_3, CH_4, HCN, nitrides, carbides, various gases and elements.



- The early compounds interacted and produced simple organic compounds such as **simple sugars** *(e.g.,* ribose, deoxyribose, glucose, etc.), **nitrogenous bases** *(e.g.,* purines, pyrimidines), **amino acids, glycerol, fatty acids,** etc. Some external sources must have been acting on the mixture for reactions. These external sources might be:

(i) *solar radiations* such as ultra-violet light, X-rays, etc.,
(ii) Energy from *electrical discharges* like lightning,
(iii) *High energy radiations* are other sources of energies (probably unstable isotopes on the primitive earth).

- There was no ozone layer in the atmosphere. The oceanic water rich in mixture of organic compounds was termed by J.B.S. Haldane (1920) as **'hot dilute soup** of organic substances'. The 'hot dilute soup' is also called **'prebiotic soup'.** Thus the stage was set for combination of various chemical elements. Once formed, the organic molecules accumulated in water because their degradation was extremely slow in the absence of any life or enzyme catalysts.

THEORIES OF EVOLUTION

Four theories have been put forward to explain the mode of evolution, *i.e.,* origin of species.

1. Lamarckism or Lamarck's theory of the inheritance of acquired characters.
2. Darwinism or Darwin's theory of natural selection.
3. Hugo de Vries' mutation theory
4. Modern concept of evolution.

LAMARCKISM

Lamarckism or theory of inheritance of acquired characters was the first theory of evolution, which was proposed by **Jean Baptiste de Lamarck**, a French biologist. This theory was published his famous book **"Philosophic Zoologique"** in 1809.

Lamarck believed that species are not constant and existing species were derived from the pre-existing species. According to him organisms become adapted to their environment during their lifetime and pass on these adaptations to their offspring. At that time, this idea was in total conflict with prevailing view of fixity of species and Lamarck was challenged by most of the biologists of that time.

PROPOSITIONS OF LAMARCKISM

Lamarckism includes four main propositions:-

(i) Internal Vital Force - Living organisms and their parts tends to increase in size continuously due to internal vital force or inner want.

(ii) Effect of Environment and New Needs - Environment influences all types of organisms. A change in environment brings about changes in organisms. It gives rise to new needs. New needs or desires produce new structures and change habits of the organisms.

(iii) Use and Disuse of Organs - If an organ is constantly used it would be better developed whereas disuse of organ results in its degeneration.

(iv) Inheritance of Acquired Characters - Modifications which are acquired during the life time of an individual due to internal vital force, effect of environment, new needs and use and disuse of organs, are transferred to affect the future generation. This process continues and after several generations, the variations are accumulated up to such extent that they give rise to new species.

EXAMPLES IN SUPPORT OF LAMARCKISM

Lamarck substantiated his theory by giving the following examples:-

(i) Evolution of Giraffe. The ancestors of giraffe were bearing a small neck and forelimbs and were like horses. But as they were living in places with no surface vegetation, they had to stretch their neck and fore-limbs to take the leaves for food, which resulted in the slight elongation of these parts. Whatever they acquired in one generation was transmitted to the next generation with the result that a race of long necked and long fore-limbed animals was developed.

(ii) Webbed Toes of Aquatic Birds. Aquatic birds like ducks have been evolved from the terrestrial ancestors. Since they had to go to water due to lack of food, etc. some structures like web between the toes developed in them, so that they could live in water easily. The wings were not used for flying as they were not needed, and later on they got reduced.

(iii) Disappearance of Limbs in Snakes. The snakes have been evolved from lizard like ancestors which were having two pairs of limbs. These lizards like ancestors of snakes felt insecure from the mammals of that time, because the latter were more powerful and numerous in numbers. To escape from the mammals, the ancestors of the snakes started living in narrow holes or crevices and in thick jungles. To accommodate their body in narrow spaces they could not use their limbs, that is why the limbs were reduced and finally disappeared, while their body became longer and cylindrical.

(iv) Flat Fishes. They are flat and bear both the eyes on one side and live at the bottom of the water. During the embryonic stage their eyes are present laterally, one eye on either side. The bodies of these fishes is not flat at this stage but later on both the eyes are shifted to one side and the body becomes flat to withstand the pressure of water.

(v) Flightless Birds. The ancestors of these birds *(e.g.,* Ostrich) were capable of flying, but due to some environmental factors they had plenty of food and were well protected. So they did not use their wings and that is why the latter became vestigial.

(vi) Retractile Claws of Carnivorous Mammals. The ancestors of carnivorous mammals such as lions, tiger etc. had ordinary claws for tearing the flesh of their preys. As the latter gained in running, the carnivorous mammals also had to run fast for which claws were a hindrance. The animals, therefore, developed retractile claws.

(vii) Deer. The ancestors of deer were not having so much speed in running, but as they needed protection from other animals of that time they started running, due to which present speed was achieved by the deer and consequently their limbs got developed and the body became streamlined.

(viii) Cave Dwellers. The ancestors of cave dwellers had normal eye sight. On account of living under continuous dark conditions, the animal lost their power to see.

(ix) Emergent Hydrophytes. The effect of environment and inheritance of acquired characters is clearly seen in emergent hydrophytes like *Ranunculus aquatilis.* Here the submerged leaves are dissected while the emerged ones are simply lobed. When the plant is grown out of water, all the leaves are undissected. In the submerged environment all the leaves are dissected.

CRITICISM OF LAMARCKISM

1. The first proposition of the theory does not have any ground because there is no vital force or inner want in organisms which increases their body parts. The increase in size has been noted in many life forms, but many times evolution shows reduction is size too. Many plants contradict this Lamarckian principle by showing such reduction in size during their evolution. Many ferns and conifers were gigantic trees but they became extinct, whereas many flowering plants were smaller in size but they are highly evolved. Moreover, persons constantly busy in reading and writing and using their eyes more than others often developed impaired sight, which again contradicts thus Lamarckian principle.
2. As regards the second proposition, the environment can affect the animal but it is doubtful that a new need or desire forms new structures in organism. If the development of new organ or structure depends upon the desire why man who has long desired to fly like birds has not developed the wings.
3. The third proposition, the use and disuse of the organs is correct up to some extent as far as growth of an organ within the lifetime of an individual is concerned. For example, constant use of a muscle would lead to its better development.
4. The fourth proposition regarding the inheritance of acquired characters is most disputed. This principle has been tested by many biologists who have devised many types of experiments for it and have found it entirely incorrect. Mendel's **Laws of Inheritance** and Weismann's **Theory of Continuity of Germplasm** (1892) discarded Lamarck's concept of inheritance of acquired characters.

THEORY OF CONTINUITY OF GERMPLASM

August Weismann (1834-1914), a German biologist, was the main opposer of the inheritance of acquired characters. He put forward the theory of continuity of germplasm. According to Weismann, the characters influencing the germ cells are only inherited. There is a continuity of germplasm (protoplasm of germ cells) but the somatoplasm (protoplasm of somatic cells) is not transmitted to the next generation hence it does not carry characters to next generation. Weismann cut off the tails of rats for as many as 22 generations and allowed them to breed, but tailless rats were never born.

CONCLUSION

Lamarckism is now a discarded theory and it has only historical importance, but in 1809 when it was published, it gave a way to establish the 'evolution' as main force responsible for the origin of species. It was a beginning of a new line of thinking wide away from prevailing idea of 'fixity of species'. Although the mechanism of evolution suggested by Lamarck is incorrect because he faced many intellectual constrains and he simply followed the accepted wisdom of his time, but his suggestion that evolution is responsible for origin

of different life forms on earth is very much valid. Lamarck deserves credit for being an influential early proponent of the concept of biological evolution.

DARWIN'S THEORY OF NATURAL SELECTION

HISTORICAL ASPECT

During years 1831-1836, **Charles Robert Darwin** travelled on **H.M.S. Beagle** for a voyage of world exploration and explored the fauna and flora of a number of continents and islands including the **Galapagos Islands.** Birds of Galapagos Islands influenced Darwin to think about the evolutionary change. These birds were called finches (Darwin's Finches).

In 1838 he came across with a book **An Essay on the Principles of Population** written by Thomus Robert Malthus and was published in 1799.

In 1798, **T.R. Malthus**, put forward a **Theory of Human Population Growth**.

1. He stated that population grows geometrically when unchecked; whereas the means of its subsistence like food grow only arithmetically.
2. Naturally, after some time an imbalance would occur in the population and the environment.
3. When the imbalance reaches a certain value, some factors like hunger, epidemics, floods, earthquakes, war, etc. will bring the population to a desired level. Such a population "crash" is called catastrophic control of population.

Darwin was much influenced by Malthus theory of human population growth. Darwin considered that like in humans, competition exists among all living things. Darwin came to know that humans have been modifying wild plants and animals to suit their requirements.

Finally in November 1859 Darwin published his observations and conclusion in the form of book titled ***On the origin of species by means of Natural Selection: The Preservation of Races in the Struggle for life.***

THE PRINCIPLE OF NATURAL SELECTION

The principle of natural selection stems from some important observations and three inferences:

Observation	Inferences
1. Organisms multiply in geometric ratio. 2. Most populations are normally stable in size.	1. Struggle for existence.
i. Struggle for existence.	2. Survival of the fittest & natural

ii. Variation and heredity.	selection.
i. Survival of the fittest. ii. Continues changes or adaptation.	3. Origin of a new species.

SALIENT FEATURES OF DARWIN'S THEORY OF NATURAL SELECTION

The main features of the theory of Natural Selection are as follows:

1. Over production (Rapid Multiplication): All organisms possess enormous fertility. They multiply in geometric ratio. For example, Insects lay hundreds of eggs. A cod-fish lays several hundred eggs at a time. A female rabbit gives birth to six young ones in one litter and produces four litters in a year.

2. Limited Resources (Food and Space): Despite of rapid multiplication of all types of species, food and space and other resources remain limited. They are not liable to increase.

3. Struggle for Existence: The struggle for existence occurs mainly to get hold of resources. It can be of three types:

(i) *Intraspecific Struggle:* It is the struggle between the individuals of the same species. For example, human warfare and *Cannibalism*.

(ii) *Interspecific Struggle:* It is the struggle between the members of different species. For example, a fox hunts out a rabbit, while the fox is preyed upon by a tiger.

(iii) *Environmental Struggle:* It is the struggle between the organisms and the environmental factors, such as drought, heavy rains, extreme heat or cold, earthquakes, diseases, etc.

4. Appearance of Variations: Due to the variations in population some individuals would be better adjusted towards the surroundings than the others. These adaptive modifications are caused through the struggle for existence.

5. Natural Selection or Survival of the Fittest: The organisms which are provided with favourable variations would survive, because they are the fittest to face their surroundings, while the unfits are destroyed. Originally it was an idea of **Herbert Spencer** (1820-1903) who used the phrase *'the survival of the fittest'* first time while Darwin named it as *natural selection.*

6. Inheritance of useful variations: The organisms after getting fitted to the surroundings transmit their useful variations to the next generation, while the non-useful variations are eliminated.

7. Speciation (Origin of new species): Darwin considered that useful variations are transmitted to the offspring and appear more prominently in succeeding generations. After some generations these continuous and gradual variations in the possessor would be so distinct that they form a new species.

CRITICISM & OBJECTIONS AGAINST THE NATURAL SELECTION THEORY

1. **Inheritance of Small Variations:** Besides useful variations, sometimes small variations which are not useful are also inherited, like small wings in flightless birds.
2. **Over-Specialization of Some Organs:** Some organs like tusks of elephants, antlers of deer have developed so much that they often give hindrance to them. This theory cannot explain these facts.
3. **Vestigial Organs:** According to the Natural Selection Theory, vestigial organs should not be present, when they have no function.
4. **Arrival of the Fittest:** The theory only explains the survival of the fittest but, is unable to explain the arrival of the fittest.
5. **Degeneration of Organs:** The theory does not account for the degeneration of certain organs in animals.
6. **Discontinuous Variations:** The theory fails to explain the cause of sudden changes in the body. *The main drawback of Darwin's theory was lack of the knowledge of heredity* and that is why he could not explain that how the variations are caused. Darwin himself was conscious of the inadequacies of his theory, when he remarked that, "*I am convinced that natural selection has been the most important but not the exclusive means of modifications.*"

THE MUTATION THEORY OF EVOLUTION

Hugo DeVries based on his extensive studies on the 8 varieties of Evening Primrose, *Oenothera lamarckiana* noted that new characters originated by sudden changes in the wild type and were heritable. The plants with new characteristics transmitted these characteristics to their progeny. Each of the form was called *mutant* by DeVries and the new characteristics were called '*mutations*'. The theory formulated on the study of these forms was named '*Mutation Theory of Evolution*' which established that *"New species originate as a result of these large, discontinuous variations which appear suddenly and full-fledged and form the new species at once."*

The main features of Mutation Theory are as follows:

1. Mutations arise from time to time amongst the individuals of a naturally breeding population or species. The individuals with mutations are known as mutants. These mutants are markedly distinct from their parents.
2. Mutations are large and sudden and are very different from fluctuating variations of Darwin, which are small and directional.
3. Mutations may occur in any direction.
4. Mutations are heritable.

5. Mutations establish new forms, races, or species. Mutations are the primary forces behind speciation.
6. Mutations are subjected to natural selection.
7. Mutants found unsuitable are likely to be destroyed by natural selection.
8. Since mutations appear full-fledged, there is no question of the significance of incipient stages in the development of an organ.

CRITICAL EVALUATION OF THE MUTATION THEORY OF EVOLUTION

DeVries work was exposed to severe criticism soon after proposal. Darwinists contended that evolution resulted from gradual fluctuating inheritable differences over a long series of generations, whereas mutation is involved in sudden appearance of species differences.

Extensive cytological studies showed that mutants of *Oenothera* are mostly polyploids rather than gene mutants. Later, Blakeslee working on *Datura* and T. H. Morgan on *Drosophila* showed that origin of species as described by DeVries in *Oenothera* is by no means exceptional but is a common thing among plants.

Morgan (1909) showed that mutations are of all magnitudes in *Drosophila.* Today mutations are observed among bacteria, bacteriophages and viruses as well as in man and other living organisms. With increased knowledge of mutations it has become clear that mutations alone cannot account for evolution, but these furnish the raw material on which other forces can act to bring about the evolutionary change.

MODERN CONCEPT OF EVOLUTION

The modern evolutionary synthesis is a union of ideas from several biological specialties. This synthesis has been generally accepted by most working biologists. The synthesis was produced over about a decade (1936–1947), and the development of population genetics (1918–1932) was the stimulus. This showed that Mendelian genetics was consistent with natural selection and gradual evolution. The synthesis is still, to a large extent, the current paradigm in evolutionary biology.

Julian Huxley invented the term, when he produced his book, *Evolution: The Modern Synthesis* (1942). Other major figures in the modern synthesis include R. A. Fisher, Theodosius Dobzhansky, J.B.S. Haldane, Sewall Wright, E.B. Ford, Ernst Mayr, Bernhard Rensch, Sergei Chetverikov, George Gaylord Simpson, and G. Ledyard Stebbins.

The modern synthesis solved difficulties and confusions caused by the specialisation and poor communication between biologists in the early years of the twentieth century. Discoveries of early geneticists were difficult to reconcile with gradual evolution and the mechanism of natural selection. The synthesis reconciled the two schools of thought, while providing evidence that studies of populations in the field were crucial to evolutionary

theory. It drew together ideas from several branches of biology that had become separated, particularly genetics, cytology, systematics, botany, morphology, ecology and paleontology.

Modern evolutionary synthesis is also referred to as the new synthesis, the modern synthesis, and the evolutionary synthesis.