UNIT 6 THEORIES OF ORGANIC EVOLUTION*

Contents

6.0 Introduction

6.1 Theories of Evolution
   6.1.1 Lamarckism
   6.1.2 Neo – Lamarckism
   6.1.3 Darwinism
   6.1.4 The Mutation Theory
   6.1.5 The Modern Synthetic Theory

6.2 Summary

6.3 References

6.4 Answers/Hints to Check Your Progress

Learning Objectives

After going through this unit you will:

➢ understand the concept of organic evolution;
➢ comprehend patterns of evolution; and
➢ know about different theories of organic evolution.

6.0 INTRODUCTION

Biological evolution is one of the major concerns of Physical/Biological Anthropology. Let us first understand about evolution. Evolution simply means ‘change’. Herbert Spencer (1857) first used the term evolution to refer to the development of more complex forms of life (plants and animals) from simpler and earlier forms. Evolution is the term used in a variety of fields, but when we talk of evolution of organisms, the plants and animals, it is called organic evolution. Organic evolution or bio evolution is ‘Descent with modification’ or ‘Continuity of life with constant modifications’. Organic evolution implies that ‘the present complex and highly organized living beings have evolved from simpler and less organized living beings of the past by gradual modification accumulated through successive generations over millions of years.

It suggests that environmental conditions in nature are ever changing. Organisms have an inherent character of changing to the changing environmental conditions. This is called adaptability or adaptations. Such adaptive changes in organisms lead to the ‘Origin of new species’ (Evolution). Since changes in the organisms are due to adaptations, new species are always better adapted and more organized than their ancestors. Different members of a species, on being adapted to different environments, diversify and evolve

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along several divergent lines. All the present day species had a common ancestor at some or other time of their evolution. Individuals migrate from their place of origin to varied geographical areas in search of food or because of predators and then gradually adapt to different environmental conditions. This results in the formation of several new species from one ancestral species. Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago (Mondal, n. d.). Such similarities can be interpreted to understand whether common ancestors were shared or not.

Evolution can be classified into five different patterns: Divergent, Convergent, Coevolution, Parallel evolution and Adaptive Radiation.

- **Divergent Evolution**: It occurs when a population isolated (for a reason) from the rest of the species and becomes exposed to new selective pressures, causing it to evolve into a new species. Homologous structures are evidence of divergent evolution. For example, whales, bats, cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs. Though these forelimbs perform different functions in these animals, they have similar anatomical structure—Hence, in these animals, the same structure developed along different directions due to adaptations to different needs.

- **Convergent Evolution**: When unrelated species occupy the same environment, but they are subjected to similar selective pressures and show similar adaptations. Wings of butterfly and of birds look alike. They are not anatomically similar structures though they perform similar functions. Hence, analogous structures are a result of convergent evolution—different structures evolving for the same function and hence having similarity.

- **Coevolution**: Coevolution is the mutual evolutionary set of adaptations of two interacting species. Pollinator-plant relationships are one example. While feeding on the nectar from a flower, an insect, bird, or bat inadvertently ensures the reproductive success of the flower.

- **Parallel Evolution**: Parallel evolution describes two related species that have made similar evolutionary adaptations after their divergence from a common ancestor. North America and the Tasmanian wolf, a marsupial, of Australia present a notable example. They share a common ancestor and evolved in similar environments, thousands of miles apart.

- **Adaptive Radiation**: Adaptive radiation is the emergence of numerous species from a single common ancestor introduced into an environment. An example of this phenomenon was made famous by Charles Darwin on the Galapagos Islands. Darwin discovered 14 species of finches each filling a different ecological niche. The most striking difference among the species is the variation in their beaks, which are adapted for different diets. They all evolved from a single ancestral species and that radiated to fill 14 different niches (Goldberg and Goldberg, 2009).
Evolution is a very complex and extremely slow process. It is not possible to see one type of animals changing to another, but presence of intergrading organisms supports the concept of evolution.

Check Your Progress 1

1) Evolution can be described as:
   a) Process of gradual adaptive changes in organisms
   b) History of races
   c) Variations in races
   d) Change in genetic composition

2) Analogous structures indicate:
   a) Parallel evolution
   b) Convergent evolution
   c) Divergent evolution
   d) Natural evolution

6.1 THEORIES OF EVOLUTION

Many theories tried to explain the process of evolution, but the important theories that explain the scientific basis of organic evolution are Lamarckism, Darwinism, Mutation Theory and Synthetic Theory of Evolution.

6.1.1 Lamarckism

Jean Baptiste Pierre Antoine de Monet Lamarck (1744-1829) was a French naturalist, well known for his Theory of Evolution. Lamarck’s Theory of Evolution was published in Philosophic Zoologique in 1809 as Lamarckism and as the Theory of Organic Evolution. It is popularly known as ‘Inheritance of Acquired Characters’. It explains the origin of new species.

![Fig. 1: Lamarck (1744-1829)](https://en.wikipedia.org/wiki/Jean-Baptiste_Lamarck)

Lamarck recognized two principal factors behind the evolution of living forms: the first being an inherent tendency of organic matter to reach new levels of complexity; the second being the modifying capacity of the environment. According to Lamarck, complex living organisms are formed from simple
living organisms. The environment does not remain constant, it changes. The changes in the environment provide new needs for the organisms. In response to the new needs, organisms develop new structures. Variations in organisms arise through the effects of use and disuse. The continuous use makes a structure greatly developed and disuse makes the structure atrophied. The new structures developed by the organisms in response to the environment are called acquired characters. These acquired characters are transmitted generation after generation and by this way a new species is produced (Lamarckism From Oe, n. d.).

Lamarck’s theory has following assumptions and propositions:

6.1.1.1 Assumptions
- “Living organisms and their parts tend to increase in size continuously due to internal urge of life.
- New organs (characters) are developed in order to meet the needs of the new want and are maintained (acquired characters).
- The development of organs and their use are proportional to the activities of these organs. Use and disuse of organs result in variations.

![Basic Idea of Lamarckism](https://www.tutorvista.com)

**Fig. 2: Basic idea of Lamarckism**

*Source: https://www.tutorvista.com*

- 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)” (Theories of Evolution, n. d.).

6.1.1.2 Propositions
- **Internal urge**: Living organisms and their parts tend to increase in size continuously due to internal forces of life. Lamarck thought that change of habits may initiate the formation of a new organ or may bring the modification of the existing organ or structure.
- **Inheritance of acquired characters**: “Environmental response leads to development of new adaptive characters in an organism through internal urge or through use and disuse of organs. Such characters
developed during the life time of an organism are called as acquired characters that are not found in its immediate ancestors. The new characters that have been acquired in the life time of an organism are preserved and transmitted to the next generation. In the offspring this modification become more and more pronounced if they are exposed to similar stress of the environment. Acquired characters are thus inherited leading to morphological and anatomical changes in a species.” (Multi Language Document, n. d.).

- **New needs as a reaction to the environment**: New organs (characters) are the result of a new need. Lamarck believed that environment plays an important role in influencing the form of living organisms and their external and internal organs. The influence leads to change in their habits. The change results in unusual activity of an organ or structure. In case of animals, migration from one area to another leads to change in the environment and introduces new needs and requirements. Lamarck demonstrated several cases where individuals of the same species, grown under different environmental conditions, exhibited marked differences.

- **Use and disuse**: The constant use of an organ increases its efficiency and size and leads to its better development. On the contrary if any organ is not used for a long time it leads to the reduction in efficiency and size of the organ and ultimately to its degeneration. In support of his theory, Lamarck cited the examples like long neck of giraffe and limbless in snakes to explain use and disuse of organs. Lamarck explained the long neck of giraffe for use of organs as follows: An original deer-like animal found the supply of trees and herbs inadequate, started to feed on the leaves of trees. In the process of reaching the leaves of higher branches the neck got stretched and the forelegs were raised. This process of stretching the neck was continued for generations to reach the foliage of taller trees and as a result, the neck became longer along with their forelimbs.

![Fig. 3: Long neck of giraffe](http://hawaiireedlab.com)
An example for disuse of organs is limblessness in snake. The ancestors of snakes were the four limbed animals. In course time, the snakes adapted to burrowing habit. During this adaptation they gradually lost their limbs. Hence the present day snakes are without limbs.

6.1.1.3 Other examples of Lamarckism

- Development of webbed feet in aquatic birds, like duck is due to developing swimming habit. They are considered to have arisen from the terrestrial ancestors.
- Evolution of flightless birds from their flying ancestors. Flightlessness in kiwi is due to reduction of feathers and wings.
- Biceps in hands in blacksmiths which put their hands constant to heavy hammering.
- Presence of appendix post anal tail and trace of nictitating membrane in man.

6.1.1.4 Criticism of Lamarckism

Lamarckism was exposed to severe criticism as his principles of evolution met with much objection. One of the principles, inheritance of acquired characters has been much disputed. August Weismann (1890), a German biologist with his experiments on mice disproved the inheritance of acquired characters. He cut the tails of white mice for more than 20 generations and observed the length of the tail in the next generation. In all the generations the length of the tail was found to be normal. Hence, he believed that the acquired character was not inherited. Weismann differentiated the protoplasm into somatoplasm and germplasm. Somatoplasm is in the somatic cells while the germplasm is in sex cells. The germplasm play an important role in heredity. Weismann established that the changes that took place in the somatic cells of an organism are not transmitted; only the changes that occur in the germplasm are transmitted. His proposition that the tendency to increase in size, has been noted in many forms but many times evolution shows reduction in size. Moreover, persons constantly busy in reading and writing and using their eyes more than others often develop impaired sight. Why do their eyes not become more efficient? Lamarck’s proposition that new organs develop where the organisms feel their need also faced criticism. If the development of new organ or structure depends upon the desire then why man who has long desired to fly like birds has not developed the wings.

6.1.2 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 like Cope, Spencer, Packard, Kammerer etc., tried to modify the Lamarckism and made it acceptable. This modified version of Lamarckism is called Neo-Lamarckism. These neo-Lamarckians considered that adaptations are universal. Organisms acquire the new structures due to their adaptations to changed environmental conditions that affect the somatic cells. The variations caused in somatic cells can be inherited in the next generation. The Neo-Lamarckians provided examples in favour of inheritance of acquired characters.
Proteus anguineus, an amphibian lives in caves where there is no light. Hence it is colourless and the eyes are rudimentary. Kammerer, one of the followers of Lamarck brought this animal to day light and observed that the animal gradually developed black skin and normal eyes. These somatic characters were inherited by the next generation.

Yet another experiment conducted by Griffith and Detleofsm on rats by placing them on rotating table for several months, noticed that even after the rotation stopped, the rats showed signs of dizziness and the offspring also exhibited dizziness.

Neo-Lamarckism does not give any importance to factors like internal vital force, appetency and use and disuse of organs. The theory stresses on the direct effect of changed environment on the organisms. It established that only those modifications are transferred to the next generation which influence germ cells or where somatic cells give rise to germ cells.

Lamarckism was incomplete in itself and unable to explain all the cases of evolutionary changes, but holds good to certain extent because the body characters of the organisms are not single attributes but the result of interaction of heritable factors (genes) and the environment conditions.

Check Your Progress 2

3) Lamarck’s theory of evolution is popularly known as:
   a) Struggle for existence
   b) Inheritance of acquired characters
   c) Origin of new species
   d) Natural selection

4) Lamarck’s theory of evolution was published in:
   a) Systema Natuae
   b) Origin of New Species
   c)Philosophic Zoologique
   d) The Descent of Man

5) Who conducted the experiment of removing tails of white mice for many generations to disprove the theory of Lamarck?
   a) Charles Darwin
   b) Herbert Spencer
   c) August Weismann
   d) J. B. S. Haldane

6.1.3 Darwinism

Charles Robert Darwin (1809-1882) was an English naturalist who was appointed as a Naturalist in 1831 upon a world survey-ship of British Government H.M.S. Beagle. During his voyage for five years (1831 to 1836)
he explored the fauna and flora of a number of continents and islands of which Galapagos Islands were the important one. The idea of evolution of new species by natural selection influenced him and based on his observations Darwin published a book titled ‘Origin of Species by Natural Selection’ in the year 1859.

Fig. 4: Charles Darwin (1809-1882)

Source: https://en.wikiquote.org/wiki/Charles_Darwin

Charles Darwin (1809-1882) was an evolutionary biologist. The evolutionary theory proposed by him is called ‘Darwinism’. 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 entitled “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” (Theories of Evolution, n. d.).

Darwin’s theory of natural selection is based on the following principles:

1) **Over Production**: This principle is also called prodigality of over production. Every organism tends to increase their population in a geometric ratio. The organisms produce more number of offspring than will be able to survive and reproduce. “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” (Theories of Evolution, n. d.).

2) **Variations**: Variation is the characteristic feature of all organisms. Variations may be harmful or useful. The useful variations are favourable and inherited to the next generation. Harmful variations make the organism unfit in the struggle for existence. Beneficial variations are favoured by the nature. Such variations become the raw material for evolution and make the organism fit in the struggle for existence and
thus the progeny has better chances of survival (Theories of Evolution, n. d.).

![Central Theme of Darwinism Diagram]

**Fig. 5: Central Theme of Darwinism**

*Source: https://www.tutorvista.com*

3) **Struggle for existence:** All organisms reproduce in geometric ratio, but the food and space are not increased correspondingly. The organism should face competition for survival. Darwin called it struggle for existence. The struggle is of three types:

- Intraspecific struggle;
- Interspecific struggle and
- Struggle with the environment.

*Intraspecific struggle:* It is the struggle found among the organisms of the same species. This struggle is for food and mating. It is the most severe check on the rate of reproduction.

*Interspecific struggle:* The struggle between individuals of different species is called interspecific struggle. The best example of interspecific struggle is for food.

*Struggle with the environment:* The struggle that the organisms have with the environment for survival is called environmental struggle. Living animals struggle with the environmental factors like food, cold waves, heat waves, earth quake etc.

4) **Natural selection or survival of the fittest:** The organisms with beneficial variations will survive and those with less fit and unfavourable variations will be eliminated. 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.

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 a 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 it may be fit in the struggle for existence (Theories of Evolution, n. d.).

5) Origin of new species: The over production of animals lead to struggle for existence. The animals survived with favourable variations are 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 (Theories of Evolution, n. d.). Thus a new species originates by gradual accumulation of favourable variations in a number of generations.

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.

6.1.3.1 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” (Theories of Evolution, n. d.).

Check Your Progress 3

6) Who wrote the book “Origin of Species by Natural Selection”?
   a) Charles Darwin
   b) Jean-Baptiste Lamarck
   c) Alexander Oparin
   d) J. B. S. Haldane

7) T.R. Malthus wrote an essay on:
   a) Principles of Geology
   b) On the principles of populations
   c) On the tendency of varieties to depart from original types
   d) Theories of population
8) Natural selection of darker moths in response to industrial pollution is known as:
   a) Industrial pollution
   b) Industrial melanism
   c) Industrial selection
   d) Industrial revolution

6.1.4 The Mutation Theory
Hugo de Vries in the year 1900 proposed a new theory of evolution which is known as the Mutation Theory. This new theory did not consider natural selection as the principle force of evolution; rather it considered mutation as the main proponent of evolution. Mutations are called the spontaneous alteration of genes leading to changes in the organism and this in turn gives rise to new species. The new species originates suddenly and without any visible preparation.

The mutationists were of the opinion that most of the hereditary variables were discontinuous in nature and could be explained by the laws of Mendel. In this case, evolution would be effective if selection is operated on large mutations.

Contrary to the mutationists, the biometricians led by Karl Pearson, supported the view of Darwin and argued that the major cause of evolution was natural selection. They opined that selection acting on small differences was the primary mechanism for evolutionary change. After the acceptance of the Hardy-Weinberg equilibrium (1908), mathematical models began to be developed and a new field called “population genetics” emerged. This field was developed largely due to the efforts of scientists such as Th. Dobzhansky, R. A. Fisher, S. Wright and J.B.S. Haldane.

6.1.5 The Modern Synthetic Theory
As a result of emergence of population genetics, a framework developed for the integration of genetics into natural selection. This subsequently led to the demise of mutationism and the modern synthetic theory was conceived. By the middle of the 20th century, evolutionary biologists universally accepted this integration and the synthetic theory was widely adopted. In contrast to Weismann’s and Wallace’s Neo-Darwinian concept, the Synthetic Theory incorporated facts from fields such as genetics, systematics and paleontology. Hence, the term “Neo-Darwinian theory” should not be confused with the “Synthetic Theory” (or the phrase “Neo-Darwinian synthesis”).

The basic tenets of the Synthetic Theory were Theodosius Dobzhansky (1900-1975), Ernst Mayr (born 1904), Julian Huxley (1887–1975), George G. Simpson (1902–1984), Bernhard Rensch (1900–1990) and G. Ledyard Stebbins (1906–2000).

The proponents of the Modern Synthetic Theory laid emphasis on the population and not on the individual levels. It was observed that natural populations exhibited considerable amount of genetic variation and that selection could act on these variations. Hence, the population had the necessary variability to explain evolutionary genetic change through time and space. Modern Synthetic Theory has considered following aspects:
Mutation forms the base of the Modern Synthetic Theory. These occur in a random fashion and furnish the fuel for evolution by introducing genetic variability.

Migration, founder effect, random genetic drift and hybridization are other factors.

Synthetic theory is the concept of the “biological species” which has been proposed by Mayr in 1942.

Speciation defined by Dobzhansky as a “step of the evolutionary process (at which) forms ... become incapable of interbreeding”. Consequently a number of pre and post-mating isolation mechanisms have also been proposed.

Gradual evolution can be explained in terms of small genetic changes (“mutations”) and recombination and the ordering of this genetic variation by natural selection. The observed evolutionary phenomena, particularly macro-evolutionary processes and speciation, can be explained in a manner that is consistent with the known genetic mechanisms.

**Check Your Progress**

9) Who proposed the theory of mutation?
   - a) Hugo de Vries
   - b) Ernst Mayr
   - c) Julian Huxley
   - d) Bernhard Rensch

10) Gradual evolution can be explained in terms of small genetic changes (“mutations”) and recombination and the ordering of this genetic variation by natural selection. This statement defines:
   - a) Neo Lamarckism
   - b) Darwinism
   - c) Mutation theory
   - d) Modern synthetic theory

11) The concept of the “biological species” was proposed by:
   - a) Ernst Mayr
   - b) Theodosius Dobzhansky
   - c) Julian Huxley
   - d) Bernhard Rensch

### 6.2 SUMMARY

The term ‘Evolution’ refers to the development of more complex forms of life from simpler or earlier forms. To understand organic evolution various theories were put forth. But the important theories that explained the organic evolution are: Lamarckism, Darwinism, Mutation theory and Synthetic theory of Evolution. The Lamarckian theory mainly explained the Inheritance of Acquired Characters and Use and Disuse of Organs. The Darwinian Theory
consists of the principles such as, over production, struggle for existence and survival of the fittest. The Mutation Theory did not consider natural selection as the principle force of evolution; rather it considered mutation as the main proponent of evolution. The Synthetic Theory of Evolution is the combination of Darwinian natural selection and Mendelian genetics. Because of the developments in modern genetics, evolution can be studied as changes in gene frequencies between parents and offspring. Hence the Synthetic Theory can be studied with the help of mutation, natural selection and isolation.

6.3 REFERENCES


6.4 ANSWERS/HINTS TO CHECK YOUR PROGRESS

Answers: 1 (a), 2 (b)

Answers: 3 (b), 4 (c), 5 (c)

Answers: 6 (a), 7 (b), 8 (b)

Answers: 9 (a), 10 (c), 11 (a)