Evolution - Evidences of Evolution - Part 2

Objectives

After going through this lesson, the learners will be able to understand the following:

- Evidences from Morphology And Comparative Anatomy
- Evidences from Embryology
- Evidences from Paleontology
- Evidences from Biogeography
- Evidences from Taxonomy
- Evidences from Biochemistry And Physiology
- Evidences from Genetics

Content Outline

- Introduction
- Evidences from Morphology And Comparative Anatomy
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Introduction

The term “evolution” comes from the Latin *evolver*, meaning “to unfold.” Evolution is a series of inter -relations connecting all forms of life. Evolution is the gradual mechanism by which present biological diversity of lifeforms appear from primitive organisms. There is countless evidence available from different academic divisions of biology that authenticate and support the theory of evolution. The ‘origin of species’ states that all living things on earth are a result of descent with alteration from a common ancestor. Scientists from many disciplines have aggregated a great deal of substantial evidence that supports the theory of evolution. This evidence includes; the fossil records of animals and plants that lived in the past. It provides a history of life suggesting where, when and how organisms lived in the past,

and in some cases helps to pin down directly the origin of species. The other evidence comes from studies of comparative anatomy, embryology, molecular biology and biochemistry including studies of biogeography. These studies provide evidence for evolution through a shared ancestor. In this module we try to understand for ourselves what is the evidence that is available to prove the theory of evolution and how convincing they are for us to make us believe that evolution really took place. We would also study in depth various evidence including Fossils, Comparative Morphology, Anatomy and Embryology along with evidence from Biochemistry, Genetics, Taxonomy and Biogeography.

Evidences from Morphology and Comparative Anatomy

Morphological and anatomical studies of various organisms imply that they are constructed on the same body plan and are interconnected structurally. These similarities can be discussed as follows:

- Homology
- Analogy
- Vestigial Organs

- **Homology and Homologous Organs:** It is the similarity between organs of different animals based on common ancestry or common embryonic development, built on the same basic pattern, but performed discrete functions and have different appearance. The term Homologous was given by Richard Owen (1804-1892). There are several examples some of them are: -

    - **Limbs of reptiles, birds and mammals:** arms, wings, legs and flippers vary greatly in form and function yet all are constructed from the same basic bones, each of these limbs has adapted in ways that enable organisms to survive in different environments. This also represents evolution of new forms in several directions from common ancestral types (Divergence).
    - **Homology in brain structures:** varying from fish to mammals, the brain is made up of very similar parts-olfactory lobes, cerebral hemispheres, optic lobes, cerebellum, and medulla oblongata.
    - **Mammals share many homologies that distinguish them from other vertebrates.** For example, Dolphins may look similar to fishes but homologies show that they are

mammals. They have lungs rather than gills and obtain oxygen from air rather than water.

- **Thorns and tendril of some plants:** A thorn of *Bougainvillea* and a tendril of passion flower *(Passiflora)* or tendril of *Cucurbita* are homologous organs in plants. They look different and help the plant in climbing in different manners but all of them arise from axillary position and are modified branches. Thus they also have different functions but have the same origin.

Thus, presence of homologous organs in different organisms affirms common ancestral relationship between different groups and the different appearance in form and function is due to divergent evolution i.e the process by which a species evolves into two or more descendant or different forms.

- **Analogous Structures:** The analogous organs have similar appearance and perform the same function but have totally different basic structure and origin. Example: The wings of a bat, butterfly, and bird all serve the same purpose of flying in the air. However, in all the three cases the basic body structure is totally different. The wings of an insect are a thin flap of chitin along with a muscle that is present near its base. In case of birds there is the presence of feathers attached to the bones of the forelimbs. In case of bats the wing is formed of a fold of integument (patagium). The similar body shape between distantly related groups represent the phenomenon of convergent evolution i.e when two different species do not share a common ancestor but have developed similar characteristics through adaptation to similar environmental conditions. Example the humming bird and humming moth they both are very similar in size, they both obtain nectar from the similar species of flowers, and they also have wings that help them to fly, however we humming bird belongs to birds and humming moth belongs to insects , some more examples of analogy are the eye of the octopus and mammals or the flippers of Penguins and dolphins. One can say that it is the similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but toward the same function. In the case of plants Sweet potato (root modification) and potato (stem modification) is another example for analogy.

- **Vestigial Organs:** These are organs or structures that appear not to have any function and are claimed by evolutionists to be leftover remnants from an evolutionary ancestor. Because they appear to be useless they are not only presented as evidence for evolution,

but as evidence against creation, because no intelligent creator would make useless organs. Human body has several vestigial organs some of these are nictitating membrane, muscles of the pinna, segmental muscle of abdomen, vermiform appendix etc. In plants vestigial organs include Staminodes and non- pistils called pistiloides are vestigial organs that occur in the male flower of cucurbitaceae.

Embryological from Evidences

Embryology is the study of embryonic development. It also provides evidence for evolution as embryo formation in widely-divergent groups of organisms tends to be conserved. Structures that are absent in the adult of some groups often appear in their embryonic form. Disappearing by the time they become adults. For example, Homology in the embryo of all the vertebrates exhibit remarkable similarity and makes it difficult to differentiate between a human embryo, embryos of chick, lizard, frog or fish in early stages. The similarity includes similar forms and structures like presence of notochord, gill cleft, tail, rudiments of eyes, ears etc. Some of the more closely related vertebrates resemble more and for a longer period. The way in which the notochord is replaced by the vertebral column and development of limbs is also very similar in them. Homeobox (Hox) genes that regulate the expression of hundreds of other genes appear to determine the path that embryo development follows. Depending on the Hox genes parts of the organism develop differently. Similarities in Hox genes give strong indications of the presence of a relatively recent common ancestor.

Evidence from Fossils (Paleontology)

The history of evolution is traced chiefly through the presence of remnants of prehistoric plant and animal life. These records give us undeniable evidence for the changes that have occurred to organisms through time. Nevertheless, considering the fossil records alone, there may have been some rifts due to incomplete data collection. The term fossil (Latin *fosillium* means something dug out) refers to remains or impressions of organisms that lived in the past and got fixed in the sedimentary rocks. The fossils include teeth, bones, shells, impressions left on soft mud etc. The study of past life based on fossil records is called paleontology. *Leonardo da Vinci* is considered the father of paleontology while *George Cuvier* is called the father of modern paleontology. One of the interesting observations Cuvier noted was that fossil impressions in sedimentary rocks in different layers have specific forms of fossils.

Determination of age of rocks and fossils

The age of the fossil can be determined by following methods: -

- **Relative Dating Method-** The distribution of fossils in the rocks of different ages. It is considered that fossil forms become more and more complex as we proceed from earliest to recent rocks. Fossils records also conclude that evolution has taken from simple to complex in a gradual manner. For example the rocks of the early era (archaeozoic and proterozoic) contain very few fossils and those simple marine invertebrates . This shows that life first evolved in the sea and earliest forms of life were soft bodied and simple

- **Radio–Carbon-Dating-** The age of the fossils can be determined by radioactive dating technique in which the radioactive isotope of C^{12} is used to determine the age of up to 45,000 years old fossils. While radioactive U^{238} or K^{40} is used to obtain the age of very old rocks. Fossils contain isotopes of elements that accumulated in the organisms when they were alive. For example, a living organism mostly contains carbon isotope, carbon-C^{12} and carbon- C^{14}. When the organism dies, the accumulation of carbon 12 stops and the quantity of carbon-12 in its tissues does not change over time. However, the carbon-14 that was present in its tissue at the time of death slowly decays and decreases to one half every 5.6 X 10^3 years until about 40,000 years. Thus, measuring the ratio of carbon-14 to carbon-12 in a fossil, will help to determine the fossil's age. Also radio-carbon dating can only be used to determine the age of the fossils that are not older than 40,000 years.

Paleontology also provides evidence for the number of organisms that existed on earth for some time and then got extinct. These include the dinosaurs, *Archaeopteryx*, trilobites and ancestor of man etc. Fossils also provide the missing link for example Seymouria- It is considered to be the missing link between amphibia and reptilian, similarly toothed bird *Archeopteryx* is the missing link between reptiles and birds. *Archeopteryx* is also called as the lizard bird as it has mixed characters of both the reptiles like the presence of claws on fingers, toothed jaws and non-pneumatic bones and that of bird like presence of feathers, forelimbs modified into feathered wings and bipedalism.

Evidences from Biogeography

Biogeography is the study of geographical distribution of organisms. The geographical distribution of animals is called Zoogeography and the geographical distribution of plants is

called Phytogeography. Wenger in 1972 proposed that earth at one point of time was a single landmass called Pangea . The Pangea then broke into Northern Laurasia and Gondwanaland. Northern Laurasia formed North America, Greenland and Eurasia. Gondwanaland formed South America, Africa, India, New Zealand, Antarctica and Australia.

Some 135 million years ago tectonic changes brought India in contact with Eurasia while South America came to lie in contact with North America. The Six realms were created by Sclater (1858) and Wallace (1876) on the basis of geographical distribution of animals and plants.

The Six realms are:

- Nearctic (Northern America),
- Neotropical, Central and South America
- Palaearctic, North Asia, Europe and North Africa,
- Ethiopian, South Africa
- Oriental, India, Ceylon, Malaysia, Philippines, Indonesia
- Australian, Australia, New Zealand and adjoining islands.

The six realms were separated from one another by major barriers like oceans, deserts, mountains etc. and have different climatic conditions.

Bio geographical evidence may be explained as follows:

Diversity in flora and fauna

- In many cases countries which are very near to each other having similar climatic conditions differ in flora and fauna for example - Madagascar is only 260 miles from the east coast of Africa but its inhabitants are markedly different.
- The fauna of Northern Africa and South Europe which are widely separated by the Mediterranean Sea is much more identical than the above case.
- The similarities in fauna of North Africa and South Europe is because these were connected together for a long time and living forms from one Island could migrate to another. The similarity in the flora and fauna in these continents could also be because life has evolved there together.

Discontinuous distribution of closely related species

The existence of closely similar species descending from common ancestor in widely separated geographical places, leading to significant difference between them is known as discontinuous distribution. In some cases, closely related species exists in widely separated places with no representatives in the intermediate territory example

- *Tapirs* are found in tropical America and Malayan Island.
- The camel occurs in Asia whereas its nearest ally Lama is found in South America.
- Elephants were found in Africa and India and not in places with identical climate such as Brazil
- Alligator occurs only in southeastern United States and Eastern China

Restricted distribution

Some unique organisms are confined to some parts of the world and are not found in other areas. This phenomenon of occurrence of certain unique species in certain areas due to habitat isolation is known as restricted distribution.

- Monotremes or egg laying mammals occur only in Australian Island
- Marsupials the pouched mammals exclusively found in Australia and New Zealand .

Evidences from Taxonomy

The science of describing and classifying organisms is known as the taxonomy. It has been concluded that resemblances in living organisms are because these have arisen from common stock and differences in them are due to adaptations to different types of environment. It provides several pieces of evidence to suggest the occurrence of evolution.

- **Arrangement of taxonomic groups-** of different economic groups of plants and animals can be arranged in a sequence from simple to complex forms which indicates the path of evolution.

- **Connecting links**– While classifying organisms we often come across certain organisms which exhibit characteristics of more than one group such organisms are often called as connecting links for example *Peripatus* is a connecting link between annelida and arthropoda. Similarly, *Balanoglossu*s is a connecting link between chordates and non-chordates.

- **Resemblance amongst organisms-** Classification is based on information of groups and subgroups. The grouping is carried out on the basis of resemblances in morphological, anatomical, biochemical, cytological and other traits.

Evidences from Biochemistry and Physiology

Certain organisms can be related to each other based on the physiological and biological processes occurring inside the body. The evidence based on similarity of biochemical reactions between the organisms are known as biochemical evidences for example:

- **Enzymes-** Many enzymes are similar in plants and animals. The similarity between the enzymes is due to similar modes of action and their similar chemical nature. For example the enzymes that catalyze the catabolic reactions that produce energy are almost similar in all organisms. Trypsin is an enzyme that splits protein and it is found universally in all animals from Protozoa to Mammals.
- **Hormones-** Some hormone secretion of the ductless glands show up close similarity between the vertebrates. These hormones are similar with respect to their chemical nature; the mode of action and the target organ.

- **Blood and lymph-** the component of blood is similar in all vertebrates. Blood and Lymph perform similar functions in different animals which indicate a close relationship between them.

- **Blood proteins-** Various mammals show blood proteins that are almost similar. However, the blood protein of the mammals can be easily distinguished from the blood protein of the other vertebrates.Blood protein tests like haematin crystal precipitation test show that man is closely related to apes when compared with monkeys. This was discovered by doctor George HF Nuttal helps establish the serological relationship between different organisms. A close relationship between different carnivores like cats, dogs and bears and between lizards and snakes was established using this test.

- **Blood Group-** Human beings have different blood groups A, B AB and O. Apes also show A and B blood groups.

- **Cytochrome C-** the protein is universally present in the mitochondria of all living organisms. It is found in the electron transport chain of mitochondria and acts as an electron carrier. The sequence of amino acids in this protein in different organisms was determined by R. E. Dickerson. Variation in the sequence of the amino acids was noticed in the different organisms; these variations have established the phylogenetic relationship.

Evidence From Genetics

In living organisms the genetic material is DNA which is inherited generation after generation, though there are mutations that happen at the level of genes still it has been established that genes remain quite constant indicating their common ancestry. Genetic triplet code is the same from bacteria to humans. Similarly, genetic information flows from DNA to RNA during transcription and from RNA to polypeptides during translation. Central dogma is universal with the exception of retroviruses where a central dogma reverse operates in the formation of DNA.

Summary

Diversity of life forms on earth has been changing over millions of years. It is generally believed that variations in a population result in variable fitness. Other phenomena like habitat fragmentation and genetic drift may accentuate these variations leading to appearance of new species and hence evolution. Homology is accounted for by the idea of branching descent. Study of comparative anatomy, fossils and comparative biochemistry provides evidence for evolution.