ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL -9

Class: XII Sub: BIOLOGICAL SCIENCE Date: 18.07.2020

Topic - EVOLUTION (Part 2)

EVOLUTION OF LIFE FORMS (BIOLOGICAL EVOLUTION)

According to the theory of organic evolution, all living forms have evolved from some common ancestor. This is called monophyletic origin. Through the process of gradual modifications, adaptations and natural selection, over a million and half different species have evolved from the common ancestral form. This process is called evolution or organic evolution. This is described as descent with modification. The salient features of doctrine of evolution are :-

- Unicellular organisms were the first to appear.
- Multicellular organisms evolved from them.
- Early forms were simple in structure and evolved gradually into more and more complete forms. For example, present day seed plants have evolved from simple seedless plants and vertebrates have evolved from invertebrates.

EVIDENCE FOR BIOLOGICAL EVOLUTION

The doctrine of biological evolution is supported by evidences drawn from the study of different branches of biology – Paleontology, Morphology or Comparative Anatomy, Vestigial organs. Embryology, Molecular biology, Cytology, Geographical distribution, Taxonomy and Genetics.

I. Evidences from Morphology and Comparative Anatomy

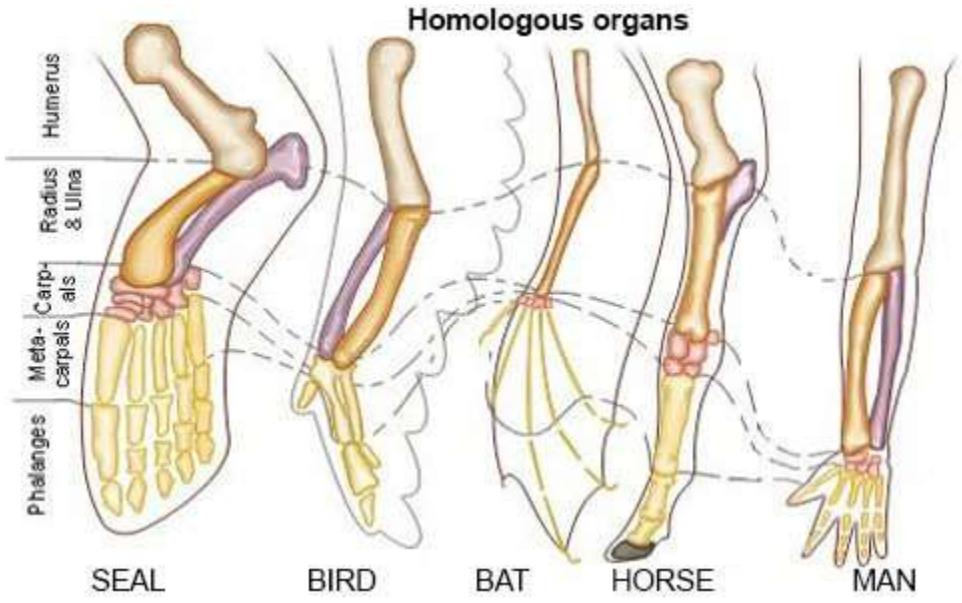
Comparative study of morphology and anatomy of various organs and organ systems reveals that both similarities as well as differences exist in the structure of body organs due to the similarities and differences in their functions. Presence of basic structural and functional similarities in the organ systems of organisms indicates their common ancestry. It is illustrated by homologous organs, analogous organs, vestigial organs and atavism.

(i) Homologous organs and Homology

Homologous organs are different functions, but are built on the same basic pattern and have the common origin. Therefore, homology is the similarity in the basic structure of organs of different animals based on common ancestry or common origin. The concept of homology was introduced by Richard Owen.

Exmple 1. Homology of Forelimbs : The forelimbs of seal or whale are modified for swimming, of bat and bird for flight, of horse for running, of frog for leaping and forelimbs of man for grasping. Thus, the functions of forelimbs in these animals are entirely different and so also their external appearance. But these are constructed on the same pentadactyl pattern, consisting of the same bones (humerus, radius-ulna, carpals, metacarpals and phalanges), muscles, nerves and blood vessels arranged on the same pattern. This homology can be explained only on the basis that all of them have evolved from the common ancestors.

Homology can also be traced in the structure of skull, brain, nerves muscles, heart and blood vessels of different vertebrates.



Example 2. Homology in Plant Parts : (a) Leaf Modifications : Thorns of *Bougainvillea* (Garden Glory) and tendrils of *Passiflora* (Passion flower) or *Cucurbita* are homologous structures. Both are modified shoots and are located in the axil of leaves. These help the plant in climbing.

Conclusions: Presence of homologous organs confirms:

- Common ancestry and inter-relationship among different groups.
- Occurrence of divergent evolution that the individuals from the same group have undergone adaptive modifications in different environments and have become different. Homologous organs provide evidence for descent with modification.

(ii) **Analogous Organs and Analogy**

Analogous organs perform the same function and have almost similar appearance, but they develop in totally different groups and are different in fundamental structure. Therefore, analogy is the superficial similarity in appearance between organs of different animal groups because they carry out the same function. These represent convergent evolution.

Example 1. Analogy in Wings: Wings of an insect (Dragonfly), bird (Eagle), mammal (Bat) and reptile (Pterodactyle) perform the same function of assisting in flight, but differ considerably in their structures. The wings of an insect are mere expansions of body wall without any skeletal support. The wings of Pterodactyle and bat are skin folds supported by fingers and the wings, but the sings of a bird are modified forelimbs with feathers attached to the limb bones. This shows that these organs have acquired superficial resemblance, because they carry out the same function but their basic architecture is different.

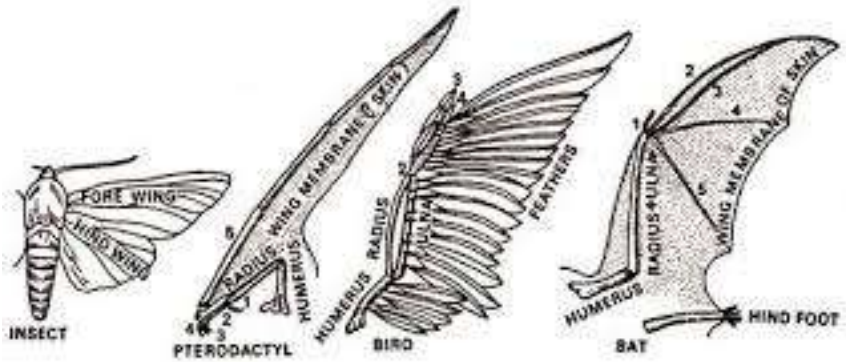


Fig. 21 . Analogy between wings of insects and vertebrates

Table : Difference between Homologous and Analogous Organs

Homologous Organs	**Analogous Organs**
1. They have same basic structural plan.	1. They have totally different structural plan.
2. They are found in closely related organisms which arise from some common ancestor.	2. They are found in totally unrelated organisms.
3. They differ in appearance.	3. They have similar appearance.
4. They are modified to carry out different functions.	4. They develop to carry out the same function.
5. They lead to adaptive radiation or divergent evolution.	5. They lead to convergent evolution or adaptive convergence.

Example 2. Potato and Sweet potato have similar tuberous appearance due to storage of food, but Potato is stem and Sweet Potato is root.

iii. **Vestgial Organs**

Vestigial organs are rudimentary or poorly developed organs or body parts that are nonfunctional and useless to the possessor, but were functional in the ancestors and are fully developed and functional in related forms canines, wisdom teeth, vermiform appendix, mammae in male, clitoris in women, caudal vertebrae (coccyx), abdominal muscles, hair coat, etc. On the body are only a few examples of vestigial organs in human body.

Vestigial Organs in Plants : Vestigial organs occur in plants also such as scale leaves of *Ruscus* and underground stems, cutinized stomata in cacti and rudimentary flagella in cycad sperms.

Significance of Vestigial Organs: Vestigial organs were fully developed and functional in the ancestors, but with the change in habit, these were not needed by the organisms and have gradually reduced to vestiges. The widespread occurrence of vestigial organs provided evidence for the occurrence evolution.

The vermiform appendix in human is the remnent of the appendix and caecum which is large and functional in all herbivores. It helps in the digestion of cellulose. The presence of nonfunctional appendix in man indicates that ancestors of man (Primates) were herbivorous and had functional appendix: man being omnivorous does not require caecum or appendix. So, it has undergone reduction in size during the evolution or man from primates.

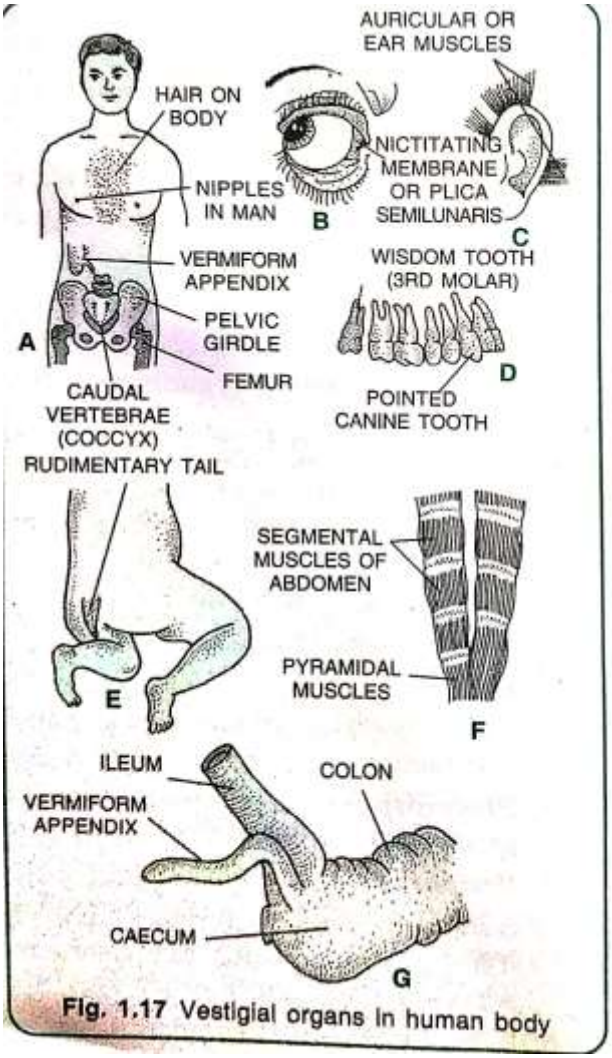


Fig. 1.17 Vestigial organs in human body

4. **Atavism or Reversion**

Atavism is reappearance or functioning or certain ancestral characters or organs after several generations, which has either completely disappeared or greatly reduced.

- Long and dense hair on the body of some persons.

- Power of moving pinna in some persons.
- Presence of a short tail in some human babies.

ii. **Evidences from Connecting Links**

Some plants and animals exhibit characters of two different groups, one of them is primitive and other one advanced. Such organisms form a bridge between the primitive and advanced groups. Such living organisms are called connecting links.

(i) **Prototherian mammals**, *Echidna* (spiny anteater) and duck-billed Platypus are egg-laying mammals. Their eggs are large, yolky and shelled-like those of reptiles, but they have mammalian characters like hair and mammary glands. Thus, they form a link between reptiles and mammals.

Significance of Connecting Links : Connecting links provide evidence for the process of evolution and theory of descent with modification.

(iii) **Evidences from Embryology**

1) **Similarity in the Early Development of Animals**: The early developmental stages of all the multicellular animals are similar. All start their life from a fertilised egg called zygote. It undergoes cleavage and develops into morula, blastula and gastrula. In gastrula, three germinal layers, i.e., ectoderm, mesoderm and endoderm, are formed. These germinal layers give rise to the same types of parts in all the animals. Later, development in different groups diverges. The nearer the relationship in the adults, the greater is the similarity in their development. This supports the common ancestry of all animals.

2) **Resemblance among Early Vertebrate Embryos**: The embryos of Fish, Salamander, Lizard, Pigeon, Rabbit and Man during early stages of development resemble each other so closely that it is even difficult to distinguish them. They all possess:

- Similar head with rudiments of eyes and ears.
- Pharyngeal clefts or gill clefts, notochord and embryonic tail.
- Limbs which develop as limb buds.
- The notochord which is replaced by vertebral column in all vertebrate embryos.

The similarity in embryos of divergent forms of vertebrates indicates their common ancestry and the degree of similarity in embryos indicates the degree of evolutionary relationship of adults.

3) **Temporary Embryonic Structures**: The embryos of certain animals develop some temporary nonfunctional structures which disappear or reduce before hatching before birth. For example, (a) Visceral clefts or gill clefts develop in the embryos of all land vertebrates, but are not present in the adult. (b) The embryos of all vertebrates develop notochord which is replaced by vertebral column in adults.

4) **Recapitulation Theory and Biogenetic Law** : The recapitulation theory was proposed by Von Baer (1828). It was revised and renamed Biogenetic Law by Ernst Haeckel (1868). According to recapitulation theory, every organism during its development

repeats or recapitulates in an abbreviated form in the evolutionary history of its race. An organism repeats its ancestral history during its development is shown by following examples:

(a) The development of frog includes tadpole larva which is aquatic and has fish-like characters like gills, gill slits, tail with a tail find and lateral line sense organs. This suggests that frog has evolved from some fish-like ancestor.

Some examples from plants are:

(ai) Gymnosperms are not dependent on water for fertilization. But flagellated sperm and water dependency for fertilization as found in pteridophytes occurs in primitive gymnosperms like *Cycas* and *Gingko*. This shows phylogenetic relationship between gymnosperms and pteridophytes.

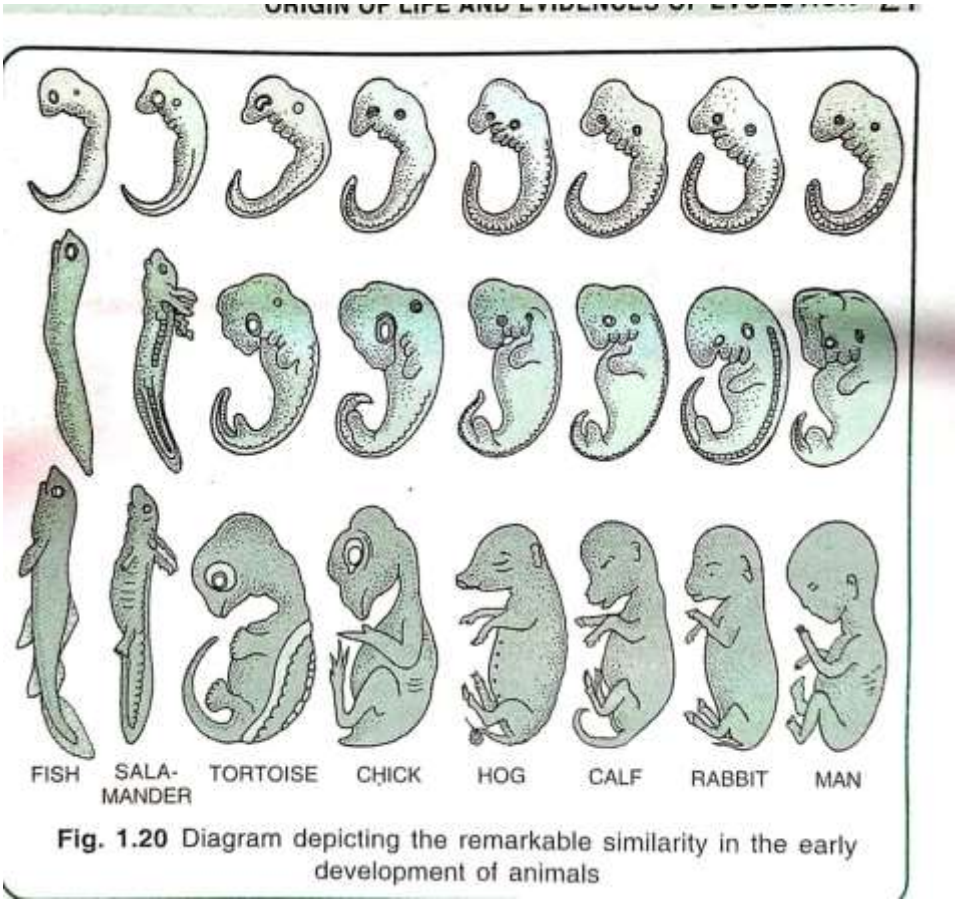


Fig. 1.20 Diagram depicting the remarkable similarity in the early development of animals

(iv) **Evidence from Molecular (Genetic) Biology**

The most convincing evidence of common ancestry comes from the basic similarities seen at the molecular level in the chemical composition, genome, universal genetic code, enzymes, hormones, blood proteins and various biochemical activities amongst diverse groups of organisms.

1. **Evidences from Cytology and Genetics**

The basic structure of a cell is the same in almost all the organisms. All animal cells have similar organelles such as cell membrane, endoplasmic reticulum, Golgi complex,

ribosomes, mitochondria and nucleus. All the plants cell wall, chloroplasts, ER, mitochondria, ribosomes and nucleus.

(i) **The structure of nucleus**, chromosomes, chromosomes, chromatin and DNA is the same in all living beings. The chemical composition of DNA is basically the same in all living beings except for the difference in the sequence of nitrogenous bases. The universality of genetic code in all living organisms is an overwhelming evidence that all organisms are related or have common origin.

2. **Evidences from Biochemistry and Physiology**

(i) **Molecular Homology** : It is the similarity in the molecular structure of important biomolecules. The remarkable similarity in important macromolecules in the organisms of different groups indicates degree of closeness between them. For example, 98.2% homology is found in the base sequences of DNA of man and chimpanzee and 100% molecular homology occurs in the amino acid sequence of their cytochrome C.

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