

EVOLUTION

Meaning of Evolution and Current Concepts

- Evolution is the development of organisms from pre-existing simple organisms over a long period of time.
- It is based on the similarities in structure and function that is observed in all organisms.
- All are made up of cells, and similar chemical compounds are present.
- This indicates that all organism may have had a common origin.
- Evolution seeks to explain the diversity of life and also to answer the question as to the origin of life, as well as its present state.

The Origin of Life

- Human beings have tried to explain how life began.

Currently held views are listed below:

- Special creation -life was created by a supernatural being within a particular time.
- Spontaneous generation life originated from non-living matter all at once. e.g. maggots arise from decaying meat.
- Steady state - life has no origin.
- Cosmozoan - life on earth originate from elsewhere, outer space.
- Bio-chemical evolution-life originated according to chemical and physical laws.
- Only special creation and chemical evolution will be discussed.

Special Creation

- The earliest idea is that of special creation which is recorded in the old testament (Genesis 1: 1-26).
- It states that God created the world and all living things in six days.
- Some hold the six days literally, while others say it may represent thousands of years.
- According to his theory, the earth and all organisms were created mature.
- Similarities in structure and function denote the stamp of a "common Designer"
- Evidence for this view arises from observations of life itself.
- Faith explains it all.
- By faith we understand that the universe was created by the command of God.
- Several scientists hold this view and their research confirms accounts in the old testament of a universal flood explains the disappearance of dinosaurs as vegetation decreased.

Chemical Evolution

- The following is the line of thought held in this view to explain origin of life:
- The composition of atmospheric gases was different from what it is today:
- There was less oxygen, more carbon (IV) oxide, hence no ozone layers to filter the ultra-violet light.
- The high solar energy reached the earth and brought together hydrogen, carbon (IV) oxide and nitrogen to make organic compounds.
- These were: hydrocarbons, amino acids, nucleic acids, sugars, amino acids and proteins.
- The proteins coalesced and formed colloids.
- Proteins and lipids formed a "cell membrane" that enclosed the organic compounds, to form a primitive cell.
- The cell was surrounded by organic molecules that it fed on heterotrophically.
- This took place in water.
- From this cell progressively autotrophs evolved.
- That were similar to blue-green algae.
- They produced oxygen and as more oxygen was evolved ozone layer formed an blocked ultra violet radiation.
- This allowed formation of present day photo-autotrophs.

Evidence for Organic Evolution

- Most of the evidence for evolution is **indirect** .
- i.e. it is based on studies carried out on present-day animals and plants.
- **Direct evidence** is obtained from studying the remains of animals and plants of the past.

Fossil Records

- The study of fossils is called paleontology.
- Fossils are remains of organisms that lived in ancient times.
- Most fossils are remains of hard parts of the body such as bones, teeth, shells and exoskeletons.
- Some fossils are just impressions of the body parts, e.g. footprints, leaf-venation patterns, etc.
- Fossils are usually found in sedimentary rocks which have been formed by deposition of sediments over millions of years.
- The deeper the layer of sediments, the older the fossils found in that layer.
- Modern man, *Homo sapiens*, evolved from ape-like creatures 25 million years ago.

- These evolved to upright, tool using creature called *Australopithecus afarensis* which had a cranial capacity of 400-500 cc.
- This evolved through several intermediates; *Homo habilis* and *Homo erectus* to modern day human.
- *Homo sapiens* has a cranial capacity of 1350 - 1450 cc.
- *Homo sapiens* is more intelligent.
- Main features in human evolution include bipedal posture, is an omnivore and has an opposable thumb.

Limitations of the Fossil Evidence

- Only **partial preservation** was usually possible because softer parts decayed. The fossil records are therefore incomplete.
- **Distortion** - parts of organisms might have become flattened during sedimentation.
- **Subsequent geological activities** e.g. erosion, earthquakes, faulting and uplifting may have destroyed some fossils.

Geographical Distribution

- Until about 250 million years ago, all the land masses on earth formed a single land mass (Pangaea).
- This is thought to have undergone continental drift, splitting into different continents.
- Consequently, organisms in certain regions became geographically isolated and did not have a chance to interbreed with other organisms in other regions.
- Such organisms underwent evolution in isolation and have become characteristically different from organisms in other regions.
- For example, pouched mammals (e.g. kangaroo, wallaby, koala bear) are found almost exclusively in Australia.
- The opossum is the only surviving representative of the pouched mammals in North America.

Comparative Embryology

- During the early stages of development, the embryos of different vertebrates are almost indistinguishable.
- Fish, amphibian, bird and mammalian embryos have similar features, indicating that they arose from a common ancestor.
- Similarities include:
- Visceral clefts, segmental muscle blocks (myotomes) and a single circulation.

Comparative Anatomy

- Comparative anatomy is the study of organs in different species with the aim of establishing whether the organisms are related.
- Organisms which have the same basic features are thought to have arisen from a **common ancestor**.
- The vertebrate **pentadactyl limb** evolved in different ways as an adaptation to different modes of life.
- e.g. as a flipper in whales, as a wing in bats and as a digging hand in moles.
- Such organs are said to be **homologous**, i.e. they have arisen from a common ancestor but they have assumed different functions.
- This is an example of **divergent evolution**.
- The wing of a butterfly and that of a bird are said to be **analogous**.
- i.e. they have originated from different ancestors but they perform the same function.
- This is an example of **convergent evolution**.

Cell Biology

- All **eucaryotic cells** have organelles such as mitochondria, membrane-bound nuclei, ribosomes, golgi bodies.
- Thus indicating that different organisms have a common ancestor.
- The presence of chloroplasts and cellulose cell walls indicates that green plants have a common ancestor.
- Blood pigments are conjugated proteins with a metal group.
- Similar pigments are found in different animal groups.
- e.g. haemoglobin is found in all vertebrates and in annelida (earthworm).
- This shows that all animals have a common origin.

Mechanism of Evolution

- The mechanism of evolution can be described as a process of **natural selection acting on the heritable variations that occur among the members of a population**.
- A population consists of a group of individuals of the same species.
- Each individual has a set of hereditary factors (genes).
- All the genes in a population constitute a gene pool.
- When reproduction takes place, genes pair with one another randomly.
- Genes which occur in great numbers in the gene pool, will occur in greater numbers in the next generation.

- Several theories have been proposed over the years to explain how evolution took place.

Lamarck's theory

- Lamarck had observed that if a part of the body of an organism was used extensively, it became enlarged and more efficient;
- If a part of the body was not fully used, it would degenerate.
- By use and disuse of various body parts, the organism would change and acquire certain characteristics.
- He suggested that these characteristics would then be passed on to the offspring (next generation).
- In 1809, Lamarck published his book "**Theory Of Evolution**".
- He proposed that new life forms arise from use and disuse of parts of existing organisms and through the inheritance of acquired characteristics.
- Lamarck's theory has been disapproved in that although use and disuse of parts does lead to acquired characteristics, such characteristics are not inheritable since they are effects produced by the environment and not by genes.

Evolution by natural selection

- In 1859, Charles Darwin published his theory of evolution' in a book called 'origin of species by means of natural selection'.
- Darwin's theory was based on the following evidence; the population of a given species remains constant over a long period of time.
- The number of young ones is more than the number of adults.
- More offsprings are produced than can possibly survive.
- Variation occurs within a given population, i.e. all members of the same species are not alike.
- On the basis of these observations.

Darwin made the following conclusions;

- There is a struggle for existence among individuals in a given population.
- Individuals who are not suitably adapted (e.i. who have unfavourable variations) are less able to pass their characteristics to the next generation.
- Natural selection operates on the population, selecting those individuals with favourable variations;
- i.e. environment favours individuals that are more adapted.
- They win competition e.g. for food and survive. i.e. "**survival of the fittest**".
- They attain sexual maturity and pass on the characteristics to their offsprings.

Natural selection

- Peppered moth (Industrial melanism)
- The peppered moth, **Biston betularia**, exists in two distinct forms;

- A speckled white form (the normal form) and the melanic, dark form.
- The moths normally rest on the tree trunks and branches where they are camouflaged against predators.
- The first melanic moths were observed in 1848 around Manchester in Britain.
- Since that time, their numbers have increased tremendously, out-numbering the speckled white form.
- The increase in the population of the melanic form is correlated with environmental changes brought about by industrialization and pollution.
- Smoke and soot from factories have darkened the tree trunks over the years.
- This has resulted in the preservation of the mutation in ***Biston betularia*** leading to the evolution of the melanic form.
- This form is almost invisible against the dark background of the tree trunks and is less subject to predation than the speckled form.
- The peppered form is more abundant in areas away from the soot and smoke of factories.
- This is because it is well camouflaged by the lichen-covered tree trunks against which it rests and is therefore not easily detected by predators.
- The existence of two or more distinct forms within a species (as exemplified by *Biston betularia*) is called **polymorphism**.

Resistance to Drugs

- Certain strains of organisms have developed resistance to drugs and antibiotics.
- Following continued use of such drugs and antibiotics, some of the individuals in a population of bacteria or other microorganisms survive and are able to pass their characteristics to the next generation.
- When a patient fails to take full dosage of the antibiotics prescribed the pathogen develops resistance to the drugs hence become difficult to control.
- Some mosquitoes have developed resistance to certain pesticides.

Practical Activities

Comparison of Vertebrate Limbs

- Limbs of various vertebrates are provided:
- e.g. fish- Tilapia, amphibian-frog reptiles, lizard; bird - domestic fowl (chicken), mammal- rabbit.
- Their anatomy can be studied.
- The following can be noted:
- That all limbs have five sets of bones;
- A single upper bone- the femur in hind limb and the humerus in fore limb
- Two lower limb bones -i.e. the tibia & fibula in the hind limb & ulna & radius in the forelimb.

- Small bones - i.e. ankle (tarsals) and wrist bones (carpals)
- The bones making the foot and hand are metatarsals and metacarpals respectively.
- The bones of toes and of fingers i.e. phalanges
- Observe the various modifications of these bones in the various animals.
- Limbs of different mammals e.g. rabbit, cow, donkey reveal that the anatomy is adapted to mode or type of movement .
- e.g. the horse has a single digit.
- An outdoor activity to observe various styles of movement in different mammals can be studied.
- It is noted that some move on tips of toes (donkey) others on the whole leg (rabbit).

Comparison of Wings of bird-and insect

- Wings of birds and insects (grasshopper, butterfly or moth) are obtained.
- A hand lens or a dissecting microscope is used to observe the specimens.
- The differences in their anatomy is noted.
- Insect wings are membranous while those of birds are made up of feathers that interlock.

Education tour to Archeological site/local Museum

- Visits to the local museum yield important information that greatly supplement study of evolution.
- The National museum in Nairobi has many fossils.
- Visit to the various archeological sites that exist in Kenya is recommended.

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