

## EVOLUTION

- ✓ Evolution attempts to explain the origin, diversity and unity of life.
- ✓ It's a gradual change of living organisms from simple life forms to more complex forms over a long period of time.
- ✓ The origin of life
- ✓ Theories to explain origin of life

### **Special creation**

- ✓ This is a belief that is held by all the world's major religions and also found in folklore.
- ✓ This theory narrates that the whole universe and all that it contains was created by the action of a supreme being (God). To "create" means to bring into existence something out of nothing.
- ✓ This belief holds the following views on the origin and nature of life;
  - -That life was brought into existence by a Supreme Being
  - -That life forms were created in a perfect form and have remained unchanged over time.
  - -That this knowledge is based on faith and cannot be disputed
  - -The belief cannot be contradicted by science since it is not scientifically testable.

### **Chemical evolution**

- ✓ This theory suggests that life probably began through a catalytic effect of light bringing together elements to form simple molecules such as water (H<sub>2</sub>O), Ammonia (NH<sub>3</sub>) and Methane (CH<sub>4</sub>).
- ✓ It can be theorized that, millions of years ago simple molecules such as hydrogen, oxygen, nitrogen etc in the universe combined in various proportions to form different simple compounds such as water and ammonia.
- ✓ Further combinations of such compounds resulted in the formation of complex molecules e.g. DNA. Successive replication of the molecules led to the formation of simple forms e.g. viruses and bacteria.
- ✓ The period during which the chemicals combined to form the 1<sup>st</sup> living organisms is called the period of chemical evolution of life.
- ✓ This theory holds the following views on the origin and nature of life;
  - -Life came into existence through combinations of chemicals.
  - -The initial life forms were simple and have changed over the years to form the present complex organisms. This is the principle of organic evolution.
  - -Scientific evidence in the form of experiments, artifacts and fossils back this theory.
- ✓ It's theorized that the universe came into existence some 15 billion years ago. Our solar system seems to have been formed about 6 billion years ago.
- ✓ Our planet earth is supposed to have been formed 4 billion years ago from the debris of a burnt out star.
- ✓ Since then, it has undergone cooling and structural changes on its outer crust providing an environment for the development of living organisms.

## **Evidence for organic evolution**

## (i) Fossil records

- ✓ Fossils are remains of ancestral forms that were accidentally preserved in some naturally occurring material e.g. sedimentary rocks.
- ✓ The study of fossils is called palaeontology.
- ✓ The most common method of fossil formation is petrification i.e. changing into rock. This is usually possible for hard body parts such as bones, teeth etc
- ✓ The fossils give direct evidence of the type of animals and plants that existed at a certain geological age.
- ✓ The earliest fossils are of Monera, then Protoctista, Fungi, plants and finally animals.
- ✓ The age of fossils can be determined through radioactive dating. For recent fossils, carbon-14 ( $C^{14}$ ) is used hence called radioactive carbon dating.
- ✓ The age of very old fossils is obtained by determining the age of the rocks where the fossils are found using the potassium-argon method.
  - **Limitations of fossil records**
- ✓ There are several missing fossil records (missing links) due to;
  - -Some parts or whole organisms decomposed.
  - --Some were scavenged upon
  - -Not all had conditions suitable for fossilization.
- ✓ Distortion of parts during sedimentation which may give wrong impression of the structures.
- ✓ Destruction of fossils by geological activities such as earthquakes, faulting etc
  - **Fossil record of humans**
- ✓ In his book “The Descent of man” Charles Darwin proposed that man descended from ape-like creatures. The earliest primate stock from which man is supposed to have evolved is **Proconsul** (20million years ago). The proconsul gave rise to **Pongidae** and **Hominidae**.
- ✓ **Pongidae** gave rise to the present day **apes** while **Hominidae** gave rise to the **human** species.
- ✓ The earliest hominids belonged to the genus **Australopithecus**. It seemed to have had an almost upright gait. No evidence of culture (fire-making, tool making) has been associated with it.
- ✓ Its representatives discovered recently include;
  - -**Australopithecus anamensis**- from L. -Turkana dated 3.9 million years old.
  - -**Australopithecus afarensis**- Also called “Lucy” found in Hadar Ethiopia dated 3.6 million years old.
  - -**Australopithecus africanus**- dated 3 million years old and **Australopithecus robustus** dated 2 million years old. Both were found in South Africa.
  - -**Australopithecus boisei**- dated 1.3 million years old and was found by Mary Leakey at Olduvai Gorge in Tanzania.
  - -**Zinjanthropus boisei** (nut –cracker man) dated 1.8 million years old found at Olduvai Gorge in Tanzania.
- ✓ The next genus was **Homo**. The species in this genus are;
  - **Homo habilis** (Handy man)
- ✓ Discovered by Richard Leakey and Kamoya Kimeu at Koobi Fora (eastern part of L. Turkana) dated 2-1.5 million years old
- ✓ There is evidence of tool making e.g. hand axes.

- ✓ Cranial capacity (brain size) 700cm<sup>3</sup>.
    - *Homo erectus* (erect man)
  - ✓ Discovered in Africa, Asia and Europe.
  - ✓ There is evidence of;
    - Tool making
      - -Use of fire
      - -Some mode of communal life and work.
  - ✓ Had a prominent brow-ridge over the eyes.
  - ✓ Small stature
  - ✓ Small brain size (775-1200cm<sup>3</sup>)
  - ✓ Recently a skeleton of *Homo ergaster* nick named “Turkana boy” has been found dated 1.56 million years old.
  - ✓ Fossils of *Homo neanderthalensis* (Neanderthal man) has been found in Germany dated 300,000 years old.
    - *Homo sapiens* (Rationalising man)
  - ✓ The present day species of humans is thought to have arisen some 130,000 years ago.
  - ✓ Another fossil form of Homo sapiens called “Cro-Magnon man” dated 40,000 years in Europe is almost identical to modern man.
    - **Characteristics**
  - ✓ High intellectual capacity
  - ✓ Ability to vocalise sound or communicate through language.
  - ✓
  - ✓ Express moral judgements and develop ideas.
- Structural differences between apes and humans**

<b>Ape</b>	<b>Human</b>
Cranium enlarged; brain size 500cm <sup>3</sup> ; low learning capacity	Cranium greatly expanded; brain size 1350cm <sup>3</sup> ; high intellectual capacity
Large incisor and canine teeth useful in defense and killing prey; omnivorous	Small incisor and canine teeth unsuitable for self-defense or for killing prey; omnivorous
Locomotion quadrupedal (on 4 limbs)	Locomotion bipedal (on 2 limbs)
Forelimbs used for arboreal locomotion and walking; opposable thumb	Forelimbs (hands) used for manipulation e.g. tool making; opposable thumb
Hind foot has opposable toe for grasping branches	Non-opposable toe in foot; used mainly for stability on the ground

## (ii) Comparative Anatomy

- ✓ This is comparing the form and structures of different organisms. Those organisms which show similarities suggest that they have a common or related ancestry.
- ✓ Where one basic structural form is modified to give rise to various different forms the phenomenon is called **divergent evolution**.
- ✓ **Adaptive radiation**- This is where the divergent forms originating from a single ancestral form may become adapted to different ecological niche in a given habitat.

### Examples of adaptive radiation

#### I. Homologous structures

- ✓ They are those parts that have a common embryonic origin but may be modified to perform different functions e.g. form and anatomy of the forelimb differ in various vertebrate groups while the basic pentadactyl (5 digit) structure is retained.
- ✓ **Examples of homologous structures**
  - (a) **Forelimbs in vertebrates**
    - ✓ The forelimb of a bat is modified to form a wing for flight.
    - ✓ The forelimb of a horse is elongated to enhance speed in running.
    - ✓ The forelimb in whale/turtle is modified to form a swimming flipper.
    - ✓ Forelimb of man modified for grasping/holding
  - (b) **Beak structure in birds**

Beaks in birds have a common embryonic origin and basic structure. Depending on the type of food and mode of feeding this basic structure is modified in length, shape and size e.g.

    - Short stout beaks are common in seed eaters e.g. weaver birds.
    - Long slender beaks for nectar feeders e.g. sunbirds.
    - Strong hooked beaks for carnivorous birds e.g. eagles
  - (c) **Foot structure in birds**

They are modified for various functions and habitats although they have a common embryonic origin e.g.

- a. -The webbed feet of ducks are used for wading.
- b. -Heavy clawed feet of eagles are used for grasping and tearing prey.

## **II Convergent evolution**

This is where different structures are modified to perform similar functions. E.g.

### **(i) Analogous structures**

They are those structures that have different embryonic origin but have evolved to perform similar functions due to the exploitation of the same kind of environment.

#### **Examples of analogous structures**

##### **a. Wings**

The wings of birds and those of insects have different embryonic origin but both are adapted for flight.

##### **b. (ii) Eye structure**

The eye structures of humans and that of octopus are similar but their embryonic origin is different.

## **III Vestigial structures**

They are those structures that have in the course of time ceased to be functional and therefore have become reduced in size or rudimentary.

#### **c. Examples of vestigial structures**

Appendix in man has no digestive function while in herbivores e.g. rat, its well developed and functions as the cellulose-digesting part of the alimentary canal.

The python and the whale have no externally visible hind limbs but their original presence is evidenced by the existence of a rudimentary pelvic girdle.

The kiwi (flightless bird) of New Zealand has reduced wings beneath the body plumage.

A vestigial tail is present in humans in the form of a much reduced coccyx.

The nictitating membrane in the eye of the mammals is now reduced and functionless; but in birds and fish it can move over the eye and act as the 3<sup>rd</sup> eyelid.

## **(iii) Comparative embryology**

- (j) The embryos of different vertebrate groups (fish, birds, amphibians, reptiles and mammals) are morphologically similar during the early stages of development. This relationship is as a result of their common ancestry. The closer the resemblance between the early stage embryos, the closer is their evolutionary relationship. This theory is called recapitulation theory. It can also be stated as “ontogeny recapitulates phylogeny”

## **(iv) Geographical distribution of organisms**

The theory of “continental drift” supposes that at one time the present continents formed one large single land mass which later broke up and the parts drifted away from each other.

Before drifting occurred there had been migration of animals from the centre of the land mass mainly from Asia to Australia. After the drift, animals with a common ancestry became isolated and evolved into different species.

#### **a. Examples**

Amazon forest in South America is inhabited with monkeys with long tails while in African forests there are the short-tailed monkeys.

The panthers and the jaguars in the forests represent the cat family while in Africa we have the leopards and cheetahs and in Asia there are the tigers.

The llamas of the Amazon forest and modern camels of Africa and Asia are thought to have had a common ancestry in North America. It's believed that from their common points of origin, they migrated into different continents thus became isolated and evolved into different species.

The process of initial migration and subsequent isolation by physical barriers such as oceans, dry deserts and mountains seems to have given rise to a wide variety of animal and plant types.

### **(v) Cell biology**

The cells of all higher organisms show basic similarities in their structure and functions. Thus all these cells contain cell membranes and organelles such as ribosome, Golgi bodies, mitochondria etc.

- (k) They also have some biological chemicals in common e.g. ATP and DNA. This strongly indicates that all cell types have a common ancestral origin.
- (l) Also plant cells contain cellulose cell wall, cell sap, chloroplast etc. all these features are absent in animal cells.
- (m) Among animals blood pigments are of universal occurrence. These include haemoglobin (vertebrates and invertebrates), haemocyanin (molluscs and crustaceans) and chlorocruorin (annelids).

### **(vi) Comparative serology**

- (n) Experiments with serum (serological tests) are used to show phylogenetic relationships e.g.
- (o) -If human serum is injected into a rabbit, the proteins in the serum act as antigens. The rabbit produces antibodies against the human proteins. When blood with antibodies is drawn from the rabbit and mixed with serum from different animals, an immunological reaction occurs forming a precipitate. The amount of precipitate formed varies from one animal to the other. The greater the amount the closer the phylogenetic relationship between the animal and the human being.

# Mechanism of evolution

## Lamarck's theory (Theory of use and disuse)

(p) This theory was proposed by Jean Baptiste de Lamarck (1815). He proposed that when the environment demanded the need for a particular structure in an organism, the organism develop it in response to the demand. This led to the natural use and disuse of structures producing changes in the individual during its life time.

He further proposed that these changes or structures that were acquired during the life time of an individual were then transmitted to their offspring and subsequent generations resulting in the emergence of new forms or new species.

### a. Examples

(q) He cited the example of development of the long neck of the giraffe which developed as a result of stretching upwards by some short-necked ancestral forms towards the higher levels of vegetation in competition with other browsers for food. The longer neck trait developed was passed on to successive generations giving them advantage over the short-necked forms.

The appearance of flightless birds e.g. ostriches, kiwi etc. their reduced and functionless wings resulted from their disuse in an environment not requiring flight.

**NB** This theory was rejected because phenotypically acquired characteristics which do not affect the genotype of an individual cannot be inherited.

## Darwin's theory of Natural selection

This theory was proposed by Charles Darwin (1859).

### a. Main features of the theory

He observed that variations arose by chance and from within the individual. Through sexual reproduction the characteristics are transmitted to successive offspring. Some of the variations confer an advantage to the individual while others are disadvantageous.

He proposed that in nature there exist a phenomenon known as "Natural selection" which "selects" those individuals best suited to an environment. He observed that the number of offspring by far outnumber the parental generation but due to eliminating factors such as predation, diseases, competition for food, breeding conditions etc only a few survive to adulthood and are able to reproduce. He explained that in nature there exists a "struggle for existence" and those best suited for an environment survive. He called this "The survival of the fittest".

He proposed that "Natural selection" is a chance occurrence. Neither the environment nor the individual controls the direction of change.

Those individuals that are selected for reproduction thus transmit the variations to their offspring. The gradual accumulation of small variations

from generation to generation over a long period of time leads to the emergence of new forms of species.

### **Natural selection in action**

Strains or varieties could offer evidence of evolution in progress e.g. i

#### **Peppered moth (*Biston betularia*)**

This moth occurs in Britain. They occur in two forms i.e. speckled white form and black melanic form.

Before the industrial revolution, the speckled white form was well camouflaged against tree trunks with similar pattern and colouration. But around 1848 during industrial revolution the environment was darkened by soot. Due to this change the black melanic form blended well against the bark of trees which had been darkened by soot and smoke.

These darker forms were better protected in the industrial area against predation from birds than the lighter forms.

In the smoke and soot polluted areas there is greater frequency of black melanic form while in the soot free areas the speckled white form predominates. Thus the agent of natural selection was selective predation on the unprotected forms.

#### **e.g. ii Sickle cell trait**

It's known that there is a high frequency of this mutant gene in places where malaria incidence is high. This is because those who are heterozygous HbA<sup>H</sup>HbS have immunity to malaria a situation called heterozygous advantage.

#### **e.g. iii Resistance to drugs, pesticides and antibiotics**

Some pathogens and pests usually survive and reproduce even when they are exposed to the antibiotics and pesticides repeatedly. These instances show that within the population some individuals possess the gene for resistance or acquire it through mutation hence survives the chemical. Those that survive transmit this characteristic to their offspring thus establishing a new population of resistant forms.

-Mosquitoes possess a gene that makes them synthesise an enzyme against DDT.

-The control of plasmodium has been made difficult due to the ability of the plasmodium to rapidly change its coat surface antigens. This makes the plasmodia resist the drug meant to kill them.