Evolution

Presented by Mr. kosgei felix

Evolution

It was coined from a Greek word evolve which means gradual change.

Definition

Evolution :is the process by which complex live forms gradually develop from simple life forms over a long period of time.

Importance of studying Evolution

It attempts to explain:

- Origin of life
- The diversity and unity of life. That is, how living organisms are related and
- inter-dependent.

Theories of origin of life

There are several theories which try to explain the origin of life. They include:

- Special creation theory
- Spontaneous generation (Abiogenesis) theory
- Life from life (biogenesis) theory
- Chemical evolution theory
- Organic evolution theory

Special creation theory

- It proposes that the whole universe and all its contents was created by a supreme being called God.
- It is a belief held by all the major religions which include Christianity, Islam, Hinduism, Judaism, e.t.c.
- The **knowledge and evidence** of this theory are based on faith and therefore cannot be contradicted by science since they cannot be scientifically tested.

Spontaneous Generation (Abiogenesis) theory

It states that living organisms suddenly arouse from non-living matter e.g.

- Egyptians believed that fish and snakes came from mud.
- Greeks believed that rats arouse from garbage .
- Some scientists suggested that bacteria arouse from nutrient media.
- This theory was disapproved by Louis Pasteur (19^{th}) who showed that bacteria and fungi only grew in non-sterile conditions.
- From this experiment, the theory of biogenesis came up.

Life from life (Biogenesis) theory

- It was believed that **life begins** from the pre-existing life forms e.g maggots from meat.

Chemical Evolution theory

- ✓ It postulates that life came into being through a combination of chemical elements such as hydrogen, oxygen, nitrogen, carbon, e.t.c. which were in existence in the **ancient world.**
- ✓ Through **catalytic effect** of **frequent lightning, high energy radiations** such as U.V radiations and **high temperature** and **pressure prevailing** at that time, these elements were **combined to form simple molecules** such as Ammonia, Methane, Hydrogen and water vapour.
- ✓ The **simple molecules** then combined to form **complex molecules** such as **lipoproteins, polysaccharides**, and **self-replicating molecules** similar to **DNA** (**the genetic material of living cells**).
- ✓ Successive replication of these molecules and further development led to formation of **simple cellular organisms** resembling the present day **bacteria** and **viruses.**
- ✓ The simple life forms underwent a series of changes over a long period of time giving rise to present generation of living organisms.

Evidence That Chemical Evolution Occurred

Note: *In 1953, an American scientist called* ***S.L Miller*** *was able to produce four of the 20 known naturally occurring amino acids in the laboratory by passing electrical sparks through a mixture of* ***hydrogen, Methane, water vapour*** *and* ***ammonia*** *under high temperature and pressure.*

This is evidence that chemical evolution occurred.

Organic Evolution

- It is based on the idea of descent with modification
- It is based on the concepts of chemical evolution theory.
- It is the gradual development of complex life forms from simple life forms over a long period of time.

Organic evolution is the process by which changes in the genetic composition occur in response to environmental changes

Organic evolution is therefore based on three ideas:

- The living world is changing, not a static place
- Change is gradual
- Closely related species have evolved from one basic ancestor

Evidences of Organic Evolution

1. Fossil Records/Study (Paleontology)

- ✓ Fossils are remains of living organisms that existed long ago and have been naturally preserved over a long period of time.
- ✓ The remains include hard plant and animal parts such as bones, teeth, shells, woody parts.
- ✓ They also include impressions of body parts e.g foot prints, leaf venations, e.t.c.
- ✓ The preservation is done in sedimentary rocks and plant resins. The sedimentary rocks are usually arranged in strata, with old fossils in the lower strata and the recent/younger fossils occurring in the upper strata.
- ✓ Through radio-isotope dating technique, the age of fossils can be determined.

Continuation.....

Fossil records are used to construct a complete evolutionary history of a species which reveals:

a) The **extinction of some organisms** due to presence of fossils of organisms that no longer exist today such as dinosaur, H. habilis.

b) The **existence of transitional forms between groups of organisms** to show progressive change from primitive forms to complex modern forms.

Explain how fossils records are used as evidence of organic evolution

- Many fossils represent organisms that have become extinct e.g. Dinosaurs , flying reptiles
- Fossils founds in lower layers of the soils are less complex than those found at the upper showing that organisms become more complex with time
- The numbers of early organisms were small but have been increasing over the years
- Early forms of life was confined in water as earliest fossils represent only aquatic organisms which were later followed by terrestrial forms
- Increased population forced some of the organisms t change in form and occupy different ecological habitats , hence the emergence of terrestrial plants and animals

Human Evolution

- Man, apes and monkeys belong to the order primates.
- As a result, they are believed to have evolved from **ape-like creature** called proconsul, which belonged to the order primates.
- The proconsul existed 20 million years ago. It gave rise to two families; Hominidae (**Humans**) and pongidae (**Apes**).
- Hominidae is divided into two genera; Australopithecus and Homo.
- Australopithecus existed 4 million years ago together with some members of the genus homo but all its members together with some members of the genus homo got **extinct.**

The only hominids that exist today are modern man.

What evolutionary characteristics make the modern man (Homo sapiens) better adapted to his environment?

- Having well developed and large brain capacity (1350- 1450cm$^{2)}$ giving high intellectual capacity for thinking and reasoning
- Having pre-hensile hands for grasping tools and carrying out various activities such as driving and digging
- Having two eyes at the front to give a wide angle of binoculars view. He is not blinded completely when one of the eyes is damaged
- Being bipedal (locomotion on two limbs) make him fast in movement i.e. Running
- Having an upright posture makes him see far , can detect danger from far and escape early
- Development of speech for effective communication with each other. Has the ability to vocalize sound
- Having a non- opposable toe on the feet for stability on the ground when walking

Limitations of Paleontology

- Missing links of fossil records to link with ancestral forms. This is because some fossils have been destroyed by scavengers, or decomposition. Other fossils have not been discovered.
- Distortion of some fossil parts during fossilization resulting into wrong impression of structures. Due to sedimentation
- Destruction of fossils by geological activities such as earthquakes, faulting, folding, e.t.c therefore giving inadequate information. This results into false conclusions being drawn.

2. Comparative Anatomy

- Comparative anatomy refers to the Comparison of basic internal structures of various species of organisms.
- The Study of internal structures of organisms points towards a common or varied ancestry of such organisms.

There are three types of structures/organs in terms of anatomical evolution.

These are:

- ✓ Homologous
- ✓ Analogous
- ✓ Vestigial Structures.

Homologous structures/organs

- These are structures/ organs with common embryonic origin or ancestry but have been modified in the course of evolution to perform different functions.
- This is as a result of the organisms **exploiting different environments** (occupying different ecological niches). Organisms with homologous structures are said to have undergone adaptive radiation or divergent evolution.

  Example is Pentadactyl limbs in vertebrates
- The **forelimbs of vertebrates**, though varied in various species, share a common basic pentadactyl plan/framework

Examples of homologous structures

a) Pentadactyl limbs in vertebrates:

Bat wings are for flying

,human hands for grasping and manipulating

,flippers of whale for swimming.

a) Beaks of birds

b) Feet of birds

c) Mouth parts of insects:

- ✓ Piercing and sucking mouth parts e.g. mosquitoes
- ✓ Sponging and sucking mouth parts e.g. houseflies
- ✓ Cutting and chewing mouth parts e.g. grasshoppers

Homologous structures

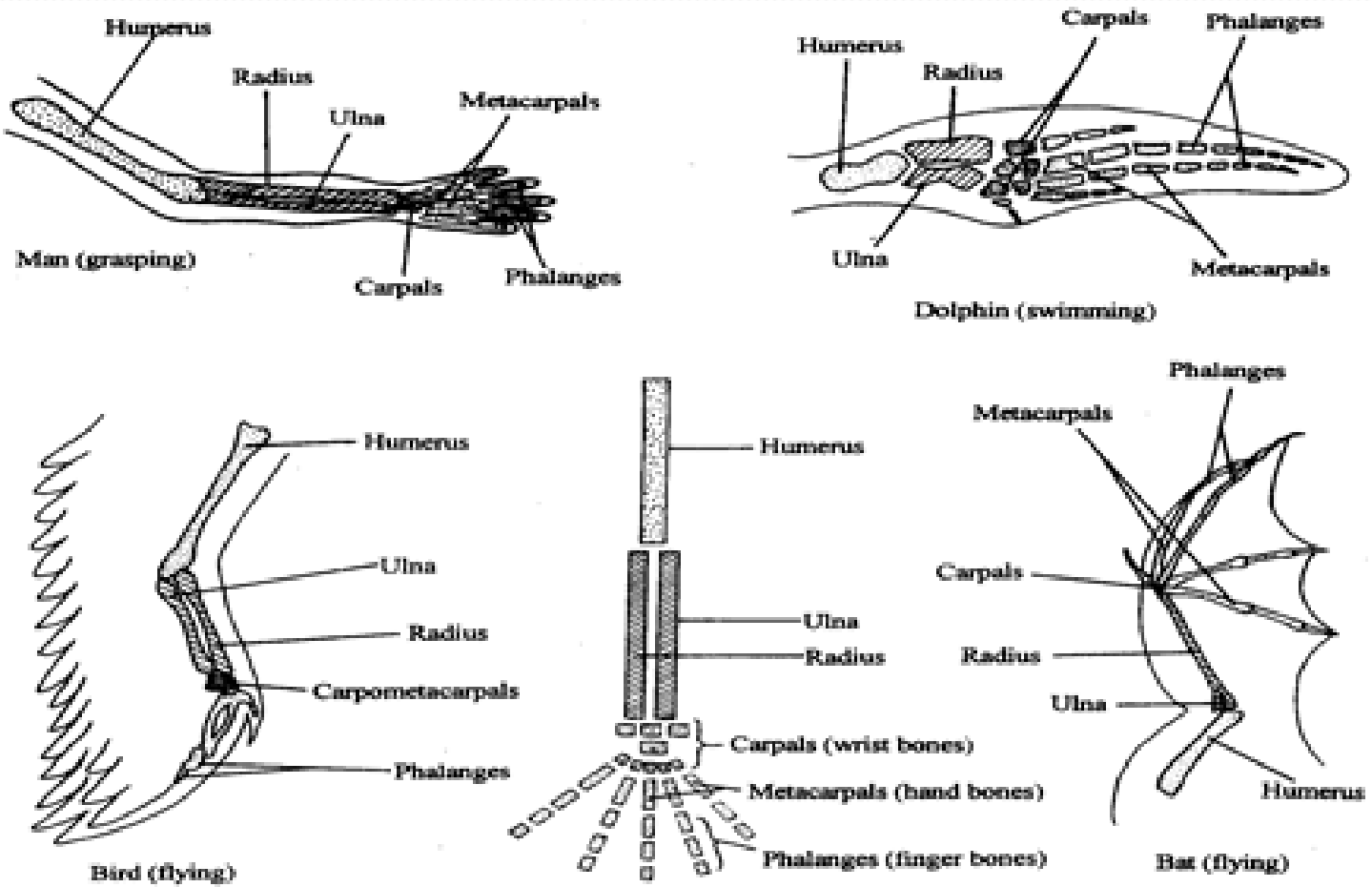


Fig. 22-13 A comparison of the structure of the forelimb skeleton of several vertebrates to illustrate what is meant by homologous organs. The diagram in the middle shows the pentadactyl limb plan

Analogous structures/ organs

Structures/ organs with varied embryonic origin or ancestry but have been modified in the course of evolution to perform similar functions due to the exploitation of same kind of environment.

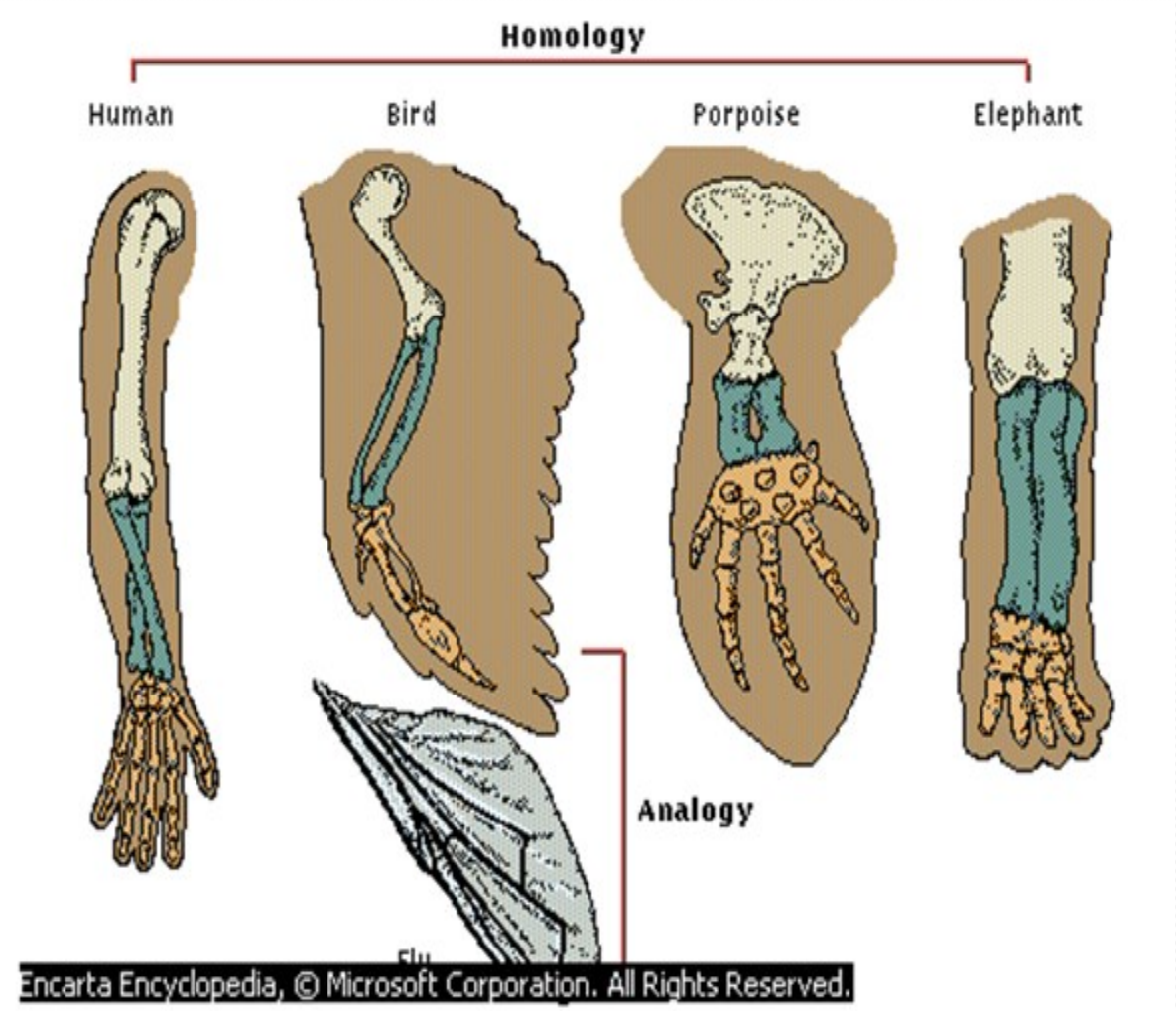
Such structures appear **morphologically similar** though **anatomically varied.**

Organisms with analogous structures are said to have underwent convergent evolution.

Examples

- **(i) Wings of birds and those of insects** – wings of birds have a pentadactyl framework while those of insects are supported by toughened veins composed of cuticle which originate from the exoskeleton.
- **(ii) Eyes of molluscs** (e.g. octopus) and those of vertebrates
- (iii) **Fins of fish** and **flippers of whale**

Homologous and analogous structure



Vestigial structures/ organs

These are structures/ organs that have greatly reduced in size and become functionless due to disuse over a long period of time.

- They might have been functional in the ancestral forms but due to the changes in the environment, they lost their usefulness.
- Examples include:
- Ear muscles
- Caecum and appendix
- Body hair
- Coccygeal vertebrae
- Nictitating membrane

3. Cell biology/ cytology

- This is the study of cell.
- Researches in cell structure and function have shown that basic similarities exist between cells from almost all kinds of living things.
- Thus **all eukaryotic cells** contain the same organelles as mitochondria, ribosomes, endoplasmic reticulum etc. And other biological chemicals like ATP, DNA and RNA.
- These similarities indicate that all cell types have a common ancestral origin

4. Geographical distribution of organisms on earth

- The distribution of living things on the world shows that **regions with similar climates** and **topography** are **not necessarily inhabited by similar species** of organisms. It is believed that millions of years ago, the world was one giant land mass surrounded by huge ocean (pangae).
- Later on the **land mass split**, members of the same species occupying the different regions became isolated. Through mutation and natural selection, each group evolved independently adapting to a different set of environmental conditions.
- This being that the organisms which are found in different and isolated places look different suggests that special creation may not have taken place.

Continuation....

Study of geographical distribution of organisms reveals that different geographical regions with similar climatic conditions and same latitudes consist of different flora and fauna e.g.

(i) Short tailed monkeys of Africa and long prehensile tailed monkeys of Amazon-America

(ii) Jaguars and panthers of Amazon, leopards and cheetahs of Africa and tigers of Asia

(iii) Buffaloes of Africa and Bison of America

5. Comparative embryology

- This is the study of development of embryos of different organisms. **A similarity between embryos in animals is an indication of the common ancestry**.
- Recapitulation theory suggests that **embryos of organisms that are closely related resemble each other up to a certain development stage**. *"ontogeny recapitulates phylogeny" meaning an organism repeats its ancestral history during embryological development*. Like during the **early stages of development**, the embryos of different vertebrates are almost the same e.g. **Fish, amphibians, birds and mammalian embryos have similar features,** indicating that they arose from **a common ancestor**

Illustration of embryology

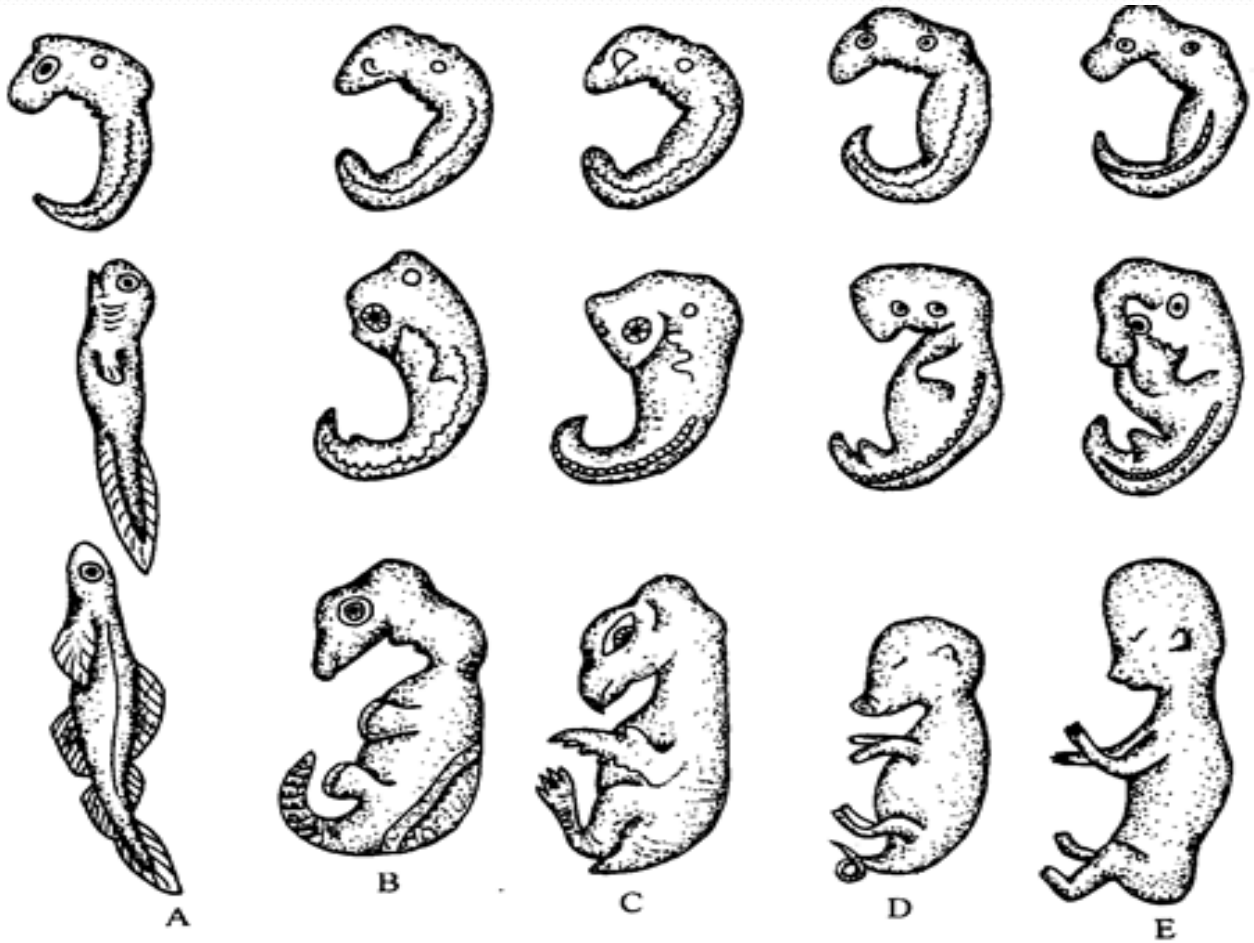


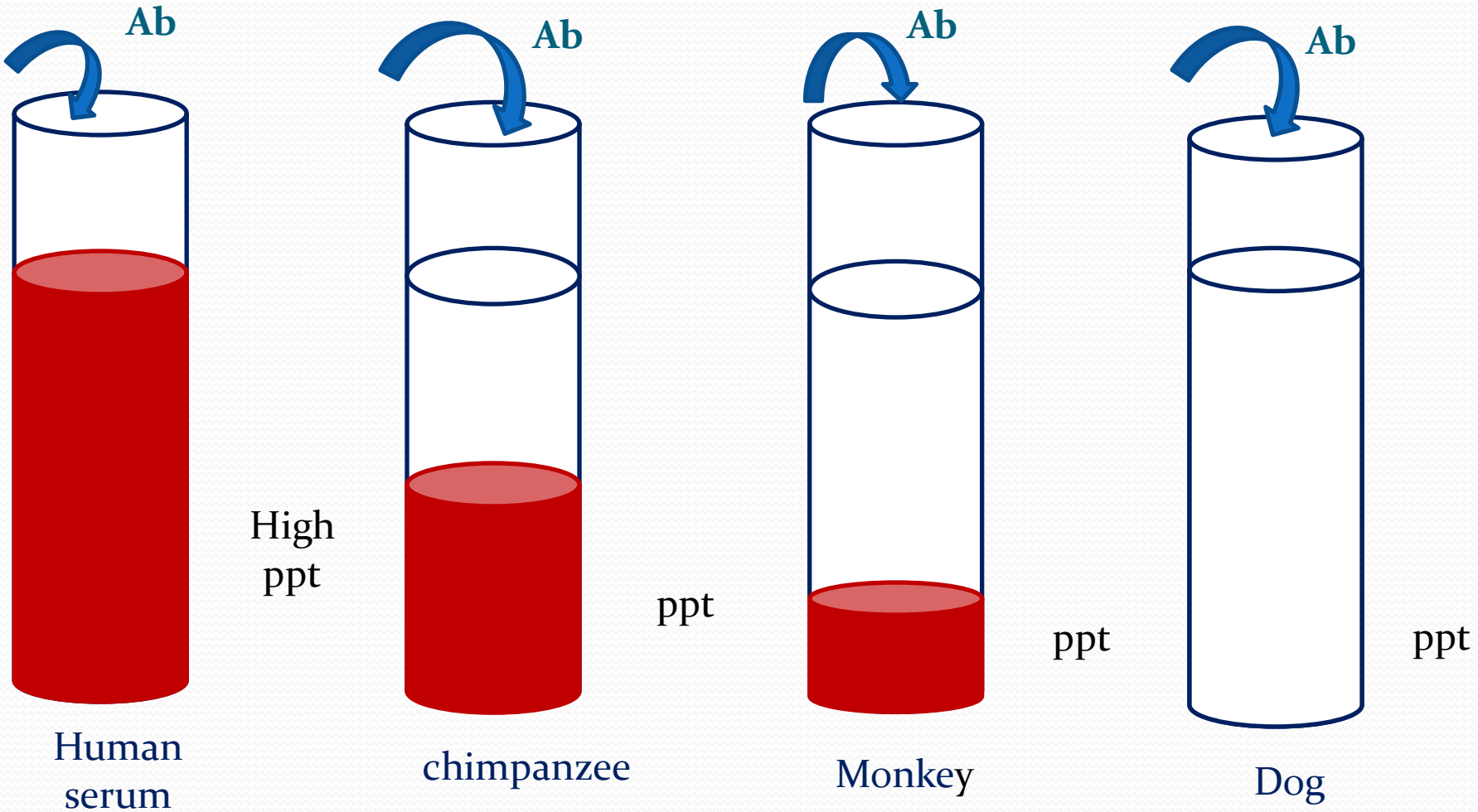
Fig. 22-15 Comparison of the embryonic development in a variety of vertebrates. Each column represents three stages of the development in (A) Fish (B) Tortoise (C) Domestic fowl (D) Pig (E) Man. Note the remarkable similarity in the early stages of development.

6. Comparative Serology

- Species that are closely related contain more similar blood proteins e.g in chimpanzee and man are biochemically similar.
- When antibodies produced in a rabbit are mixed with serum from different animals immunological reactions occurs forming precipitate.
- The greater the amount of precipitate the closer the phylogenetic relationship.
- A **lot of precipitate** is produced with anthropoid apes like a chimpanzee showing a close relationship but none with a distant animal like a dog
- This suggests evolution from a common ancestor.

comparative serology

Antibody(Ab)
produced in a rabbit
against human **serum**



7. Taxonomy

Modern classification involves grouping of organisms on the basis of similarities and differences among organisms in terms of structure, physiological functioning and phylogeny (evolutionary history) of organisms e.g. man and apes belong to the order primates whose ancestor is proconsul.

Mechanisms of Organic Evolution

These are ways/processes on how the evolution is thought to have occurred.

They are theories that explain how organisms have been gradually changing and forming new species from pre-existing ones.

There are two theories i.e.

- Lamarck's theory also known as the theory of use and disuse
- Darwin's theory of natural selection.

(a) Lamarck's Theory of Use and Disuse

He carried out studies and proposed that particular body structures develop in organisms when need arises.

According to him, the environmental conditions dictate the development of a specific structure.

- He believed that adaptation of organisms to the environment was the chief cause of evolution.
- The function required determines the type of the structure to develop. The organism s therefore undergoes developmental changes during its lifetime. These **changes are subsequently passed on to the off spring**. The offspring are then supposed to form new species due to these changes base on these;

Lamarck explained the long necks of modern giraffes in the following manner;

Ancient giraffes were fewer in number and had shorter necks than those living today. When they increased there was **competition for food in the form of tree leaves**. This made them to **stretch their necks** so as to reach for leaves on the higher branches. The result of this was an elongated the giraffes necks

Lamarks theory is based on three propositions;

- Theory of need: plants and animals change because they need to change.
- The development of organs has a direct relationship to their work. The size of an organ is proportional to its use or disuse
- All that has been acquired or altered in the organization of an organism during its life- time transmitted to the next generation

Limitations of Lamarck's Theory

- It is true that the environment can shape the **phenotype** of an organism e.g. Muscles of **body builders** increase due to their **continuous use**.
- However, from the knowledge of genetics, the **acquired characteristics cannot be inherited** (**phenotype**) since they do not affect the **genotype.**

(b) Darwin's Theory of Natural Selection

- According to Charles Darwin, **variations** are the raw materials for evolution.
- New species are formed from pre-existing ones as a result of gradual accumulation of **advantageous variations** over a long period of time. The main features of natural selection are

Features of natural selection;

a) All organisms produce more offsprings but only a few survive to adult hood
b) Every organism faces a constant struggle to survive.
c) Variations occur within members of a population.
d) Individuals with advantageous variations/ are better adapted to the environment/ selected for (survival of the fittest)
e) Individuals that are better adapted reproduce and transmit the variations and hence their traits on to their offsprings.leading to emergence of new species (speciation)

What is meant by natural selection?

- This is a process by which individual organisms that are better adapted to survive, grow and reach maturity through reproduction, they pass on their favourable characteristics to their offspring's. Individuals with unfavourable characteristics are eliminated naturally or they die.
- The process works on hereditary variations. **Individuals** with favourable variations have some selective advantages over those with unfavourable variations.
- Natural agents such as climate, competition for food, reproductive capacity ,produce differential mortality that leads to greater changes of survival for individuals with selective advantage.
- These individuals pass on their advantageous genetic variations to their offspring's through reproduction.

Describe organic evolution according to the theory of natural selection by Charles Darwin. (20mks)

- Variations occur in a population and from within some individual members.
- Some of the variations are advantageous (Beneficial variations) thus making an organism to be well adapted to the environment while others are disadvantageous.
- Through sexual reproduction, these characteristics (variations) are transmitted to the successive offsprings.
- The number of offsprings produced at any particular time by far exceed the parental generation. However, only a few survive to adulthood and are able to reproduce. This is due to environmental pressures e.g. predation, diseases, and competition for food/mates e.t.c. This is called 'struggle for existence'.
-

Continuation….

-
- In the struggle for existence, individuals with advantageous variations are well adapted to the environment and therefore are selected to survive and reproduce, While those that have disadvantageous variations are poorly adapted hence perish (die out or migrate) and do not transmit their characteristics to the next generation. This is called ‘survival for the fittest’.

- The individuals that are selected for reproduction transmit the beneficial variations to their offsprings. These variations gradually accumulate from generation to generation over a long period of time leading to emergence of new forms of species. This is called speciation.
- *Note: speciation is a result of accumulation of variations in a population and the rate at which variations occur in a population determine the rate of speciation.*

Explain how new species of organisms develop by the process of evolution

- For a new species to emerge, (a deme) small genetic units of a population) must first become completely isolated from others over a long time
- Any new variations that arise in the population will not thus flow to the other demes
- Variations together with the evolutionary forces of natural selection and genetic drift (drop in gene frequency) then act on the isolated deme to favour the emergence of new species

Factors that favour speciation

a)Geographical isolation –

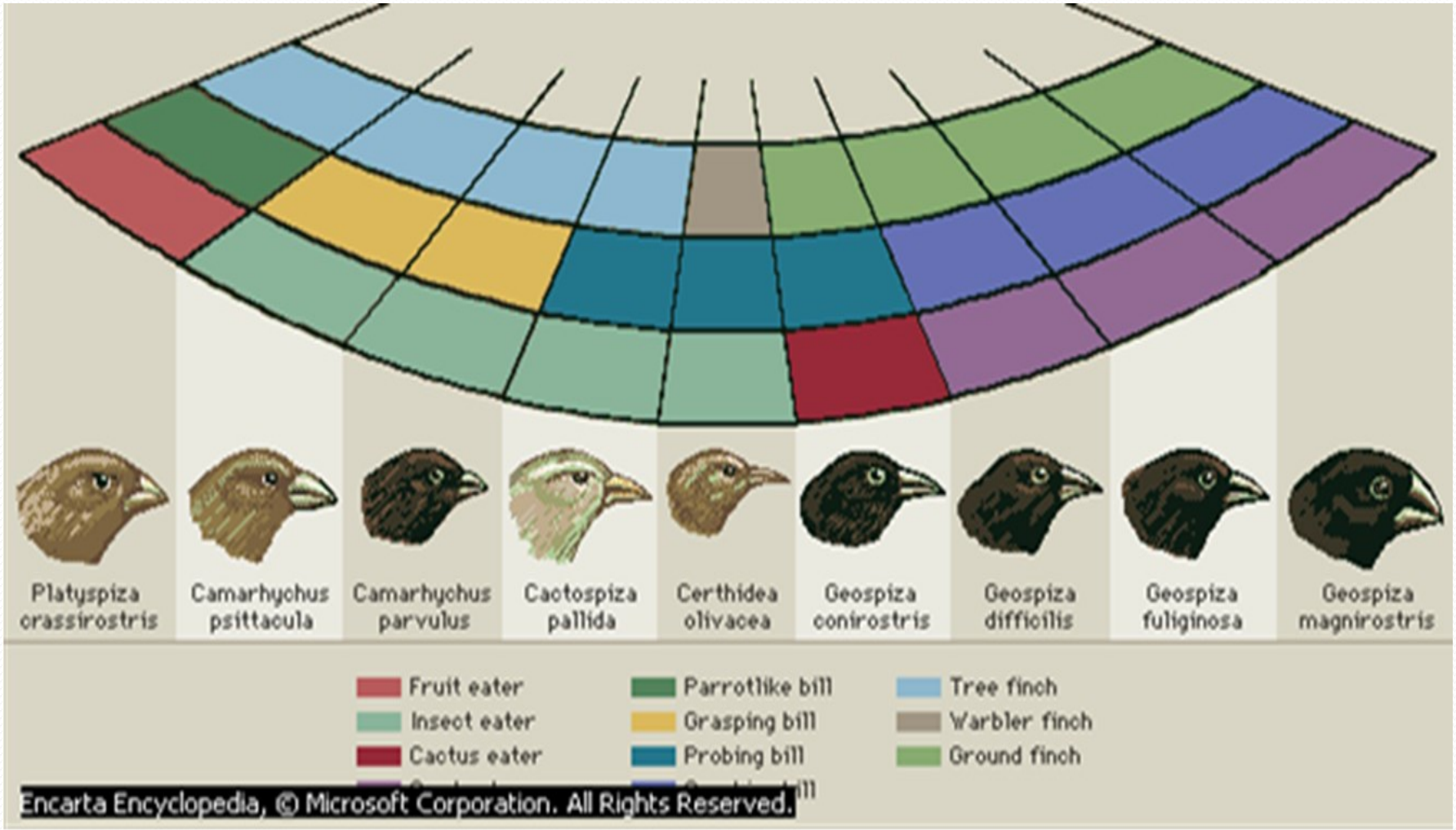
Refers to separation of populations by natural geographical barriers

physical barriers such as mountains , deserts and seas hinder interbreeding between demes/ population since they restrict movement of individuals from a deme/ population to another e.g. Unique fauna of Austria and Galapagos island was due to geographical isolation.

This lead to the emergence of different beaks among the finches adapted for different feeding modes

- Note; Galapagos is a Spanish word meaning island

Evolution of Galapagos finches beaks



- **b)Ecological isolation** – these are barriers that arise as a result of a deme occupying a different type of habitat from the original type for reason of ; breeding , escape from enemies or feeding
- **c)Reproductive isolation** – these include genetic changes which bring about barriers to successful mating among individuals of a given population.
- Genetic differences within the gametes of individuals may lead to failure of fertilization or / infertility or result in infertile offspring's e.g. In man , individuals with 45 or 47 chromosomes instead of normal 46 chromosomes are infertile .
- Inheritable structural changes in genitalia of individuals in a deme may hinder the mating process. Fertilization and viable offspring's will only result from genetically similar individuals

- **d)Behaviour isolation** – these include changes in courtship Behaviour, song sounds and nesting habits proceeding mating. If some courtship Behaviour activities are not recognized by a prospective mate, then the individuals are not likely to mate. Changes in social Behaviour may restrict interaction with other individuals of the same population hence there will be no likelihood of mating.
- **e)Artificial selection and selective breeding by man**
- Man selects animals and plants varieties with desirable qualities or characteristics and allow them to interbreed while those with undesirable qualities are prevented from mating hence become eliminated. Genetic manipulations bringing about polyploidy in plants have been used to develop crop varieties with desirable characteristics
-

Natural Selection in Action

Evolution is a **gradual process** over many years making it impossible to observe species being formed.

- However, **formation of strains** and **varieties** within **species** are **indicators of speciation** in progress.

Examples of natural selection in action include;

- ✓ Industrial melanism,
- ✓ Sickle cell trait,
- ✓ Resistance to drugs, pesticides and antibiotics

a)Industrial melanism (peppered moth)

The peppered moth; *Biston betularia*,

- They exist in two distinct forms: a **speckled white form (the normal form)** and a **melanic, dark form.**
- The moths normally rest on the trunks and branches of trees where they camouflaged against predators
- The first melanic moths were observed in 1848 around Manchester in Britain. Since that tie the number has increased tremendously outnumbering the speckled white form. The increase went together with the increase in industrialization.
- 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 mutation in **Biston betularia** leading to evolution of their **melanic form**. The dark background of the tree trunks made the white moths move conspicuous (easily seen) while the **black form blended well with the dark tree trunks**. It **became harder for predators to see the black moth**. The **white moth was therefore more likely to be eaten than the black one**. During industrialization, the black form was therefore more likely to survive. The surviving moths eventually moved to areas where the trunks were not coated with smoke. The black form gradually became dominant

Biston betularia(peppered moth)

b)Resistance to drugs, pesticides and antibodies

Long exposure to the drugs makes some organisms to undergo mutation and develop new strains whose protein coat cannot be destroyed by the antibodies so produced. Through **reproduction the populations of the new strains increase** whereas the individuals that would not have undergone mutation are eliminated or die. Eventually there emerges a population of the new strains that are resistant to drugs

c)Sickle cell trait

There is high frequency of this **mutant gene** in places of where malaria prevalence is high.

This due to heterozygous individual being resistant to malaria a situation called heterozygous advantage. These individuals are selected for.

Explain the role of mutations in evolution

- Mutation can be **advantageous** or **disadvantageous** to an individual organism.
- Those organisms with **advantageous** will be naturally selected to survive and the existing environmental conditions because they will be better adapted. Such individuals will grow to maturity and through **reproduction**, pass over their favourable characteristics to their of springs which will become better adapted to the environment than their parents.
- Those individuals with the **disadvantageous mutations** will be eliminated or die before maturity, hence will not be able to pass on their unfavourable characteristics to any offspring. This leads of emergence population that are better adapted to the existing environmental conditions than their parental population, hence evolution would have taken place
-

Mechanisms of Evolution

- Chromosomal and gene mutation – which are transmitted from parents of offspring's. This brings about changes / variations in a population , hence evolution
- Cross- over – occurs during prophase i of a meiotic cell division – occurs when homologous chromosomes pairs up and their chromatids break and rejoin at certain points. When they separate or segregate into a daughter cells (gametes) they will have a gene sequence different from the original chromosomes. Different combinations of genes are reproduced leading to variations
- Interbreeding- between individuals of adjacent populations changes the frequency resulting in variations in the populations.
- Migration – immigration and emigration of animals tends to alter the gene frequency
- Environmental changes- certain environmental changes may affect individuals in a population in such away they are not able to pass their characteristics to the next generation. The gene frequency in the new generation will differ from the proceeding one.

The end

- Thank You For Your Time