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Biology Department

Grade 12

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Unit 4
Evolution

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4.1 The origin of life

- **What is evolution?**
- Evolution is the **change in genetic composition of a population** over successive generations, which may be **caused by meiosis, hybridisation, natural selection** or **mutation**. This leads to a sequence of events by which the population diverges from other populations of the same species and may lead to the origin of a new species.
- There are five main theories of the origin of life on Earth:

1. Special creation theory

- **Special creation theory**, in which a **'supreme being'** is believed to have **created life** or directs its creation and evolution.
  Different version of creationist
  - **Young Earth creationism**
    - ✓ Suggests that the Earth is only a few thousand years old.
    - ✓ The Earth was created in six 24-hour days.
    - ✓ According to this theory, geological events are interpreted in the light of **Noah's flood.**
  - **Old Earth creationism**
    - ✓ All life was created by God as it was in genesis but explain the earth was very old.
    - ✓ **Gap creation, progressive creation** and **evolutionary creation** are **considered as old earth**

Special creation theory…

- **Day-age and gap creationism**
  - **The day age creationist** accounts the creation of the day were not 24 hour day, but the day really meaning a billion years of a geologic time. The sequence and creation of the day is symbolic.
  - **Gap-creationists** states that life was recently created on preexisting old earth. They believe that there is a large gap (millions or billions of years) between the formation of the Earth and the creation of all organisms.
- **Progressive creationism**
  - This type of creationism **accepts the Big Bang as the origin of the Universe.**
  - It **accepts the fossil record of a series** of creations for all of the organisms.
  - However, **they denies genetic relationship between ancient and modern species,** it sees them as unique creationist.

Special creation theory…

- **Theistic evolution/Evolutionary creationism**
  - **God 'invented' evolution and created the universe** and life through evolutionary processes.
  - The theory was promoted by the Pope for the Catholic Church and is also espoused by most mainline Protestants.
- **Intelligent design**
  - Intelligent design maintains that **the handiwork of Gad can be seen in all of creations.**
  - The theory that life developed due to a **combination of natural force and intervention of supernatural being**
  - Modern **intelligent design** offer sophisticated arguments, often based on cell biology and mathematics, to give the impression of complex scientific arguments.

2. Spontaneous generation theory [redacted],

- This suggests that **life arose spontaneously from non-living matter** such as flies from rotten meat, mice from corn and bacteria from wine.
- It hypothesizes that non-living things are capable of producing life, **finally disproved by the experiments of Francisco Redi and Louis Pasteur**

3. Eternity of life theory,

- The theory of eternity of life claims that **the universe has always existed and there has been always life in the universe** and continuous exist forever, changing only in form.
- There is no beginning and no end to life on earth, so it is eternal.

4. Cosmozoan theory

- States that **life on earth initially come from somewhere else in the universe**
- Life reached the earth in the form of highly resistant spores (cosmozoa) carried by cosmological structure such as meteorites.

5. Biochemical origin theory

- States that **life have originated as a result of biochemical reactions** creating first\necessary organic molecules which then became assimilated **into 'pre-cells',** which eventually evolved **into cells.**
- It was **proposed by** a Russian biochemist **Alexander Oparin** (1924) and supported by English biologist John **Haldane.**
- Thus this theory called **Oparin-Haldane theory**

- **Both Oparin-Haldane suggest that:**
  - The **primitive atmosphere** of the Earth was a **reducing atmosphere** with **no free oxygen**.
  - There was a **supply of energy**, such as **lightning or ultraviolet ligh**t etc
  - Uv and lightening would provide the energy for reactions to synthesise a wide range of organic compounds, such as **amino acids, sugars and fatty acids**.

❖Oparin suggestion

- Oparin suggested that the **simple organic compounds** could have undergone a series of reactions leading to more and more complex molecules.
- He proposed that the molecules might have formed colloidal aggregates, or **‘coacervates’,** in an aqueous environment.
- The coacervates were able to absorb and assimilate organic compounds from the environment in a way similar to the metabolism of cells.

- **Haldane suggestion**
  - **Primitive sea served as a site of chemical reaction** powered by solar energy.
  - The sea became **‘a hot dilute soup’** of organic monomers and small polymers. A hot dilute soap called this the ‘**prebiotic soup’,**
- **Oparin’s coacervates** and **Haldane’s prebiotic soap** came to symbolise the Oparin–Haldane biochemical origin of life.

Evidence biochemical origin of life

- **Stanley Miller** proposed **spark discharge experiment** In 1953
- He passed electric sparks repeatedly through a mixture of gases containing methane **(CH_4), ammonia (NH_3), water (H_2O)** and **hydrogen (H_2)** that represent the primitive atmosphere of the Earth.
- He was able to produce organic compound including;
  - **amino acids** – essential to form proteins
  - **pentose sugars** – needed to form nucleic acids
  - **hexose sugars** – needed for respiration and to form starch and cellulose
  - **hydrogen cyanide** – nitrogenous bases found in nucleotides can be synthesised in the laboratory using HCN as a starting point

Problem of Miller experiment

- Both **left-handed and right-handed amino acids were produced**. However, only ‘left-handed’ amino acids found in living things
- **Nitrogenous purines** (adenine and guanine) **were not synthesised** under the same conditions as pyrimidine (thymine, uracil and cytosine) synthesised.
- Miller could not produce polymers from monomer

Evolution of autotrophs

- Most geochemist agree on the composition of **primitive atmosphere** to be consisting of
  - **Nitrogen (N_2),**
  - **Carbon dioxide (CO_2),**
  - **Water vapor (H_2O),**
  - **Hydrogen sulphide (H_2S),**
  - **Ammonia (NH_3),**
  - **Methane (CH_3)**
  - **Hydrogen (H_2).**

Evolution of autotrophs….

- So **primitive atmosphere were reducing atmosphere** as opposed to today's oxidizing atmosphere oxygen.
- The level of **oxygen has increased after the evolution of photosynthetic organisms.**
- The age of the earth is estimated to be about **4.5 billion years.**
- The first organism heterotrophic prokaryotic **appeared 3.5-4 billion years**. May be posse RNA instead of DNA as genetic material.

Evolution of autotrophs….

- These first life forms might have given rise to 3 lines;
  - **Archaebacteria;** prokaryotes that survive locally or in unusual habitats
    - **Example;** thermophilic bacteria, sulpho-bacteria, methano-bacteria and halophilic bacteria
  - **Eubacteria:** the vast majority prokaryotes today;
    - **Example:** ordinary bacteria and cyanobacteria (blue-green bacteria)
  - **Eukaryotes;** modern unicellular or multicellular that are almost all are aerobic
    - **Example:** protoctistans, fungi, plants, animals

Evolution of autotrophs….

- The **reducing atmosphere** was gradually changed to **oxidizing one about 2.4 billion** years ago as **the level of oxygen started to rise because of photosynthesis**
- Cyanobacteria releasing oxygen 3.5 billion years ago but the level stayed low as it was absorbed by the huge iron existing on earth.
- **Cyanobacteria are photoautotrophs** (use sun light as source of energy), **chemoautotrophs** are the other category of autotrophs (**use chemical reaction as source of energy**)
- **Chemoautotrophs are believed to be one of the first organisms to inhibit earth.**
  - The primitive sulphobacteria use hydrogen sulphide as the energy source, methanobacteria use methane.

Evolution of autotrophs….

➢ **4. 6 billion years ago**	➢ Formation of earth
➢ **4 billion years ago**	➢ Evolution of prokaryotes
➢ **3.5 billion years ago**	➢ Cyanobacteria begin to produce oxygen
➢ **3.5-2.1billion years ago**	➢ Bacteria were the only life forms
➢ **2.4-2.1 billion years ago**	➢ Concentration of oxygen begin to rise
➢ **0.9 billion years ago**	➢ Fungi like organism rise
➢ **0.6-0.7 billion years ago**	➢ Evolution of animals

4.2 Theories of evolution

- Theories of evolution try to explain the **mechanism in which new species gradually arise from the existing species of population.**
- For many years in Europe, the Christian belief that the Earth and all species had been created about 6000 years ago.
- In the mid-1700s, George Buffon challenged this idea, suggesting that:
  - The Earth was much older than 6000 years, and
  - Organisms changed over time in response to environmental pressures and random events.
- The following are major theory of evolution:

Lamarckism ‘theory of transformation’

- Proposed by Jean-Baptiste Lamark at the beginning of 19th century
- In 1809, he published a paper entitled **‘Philosophia Zoologique’.** In this paper he describes a ***two part mechanism by which species gradually change.***
- **The two part of the theory are**
  - Use and disuse, and
  - Inheritance of acquired traits.

Use and disuse

- It suggests that **continually using a structure or process results in more enlarged structure or process** or **little use or disuse of a structure or process lead to size reduction or less development**
- **Example**;
- **Elongation of giraffe's neck**
  - According to Lamarck, a giraffe's necks become longer due to the strain over its life time to reach high branches, and this is a 'natural tendency towards perfection.
- **Webbed toes of water bird**
  - Lamarck suggested that from years of straining toes of water birds to swim. Water birds gained elongation and webbed toes to swims batter.
- **Smaller and undeveloped wing of penguins**
  - Lamarck also believe that disuse would cause traits to become reduced
  - For example the wing of penguins would be smaller than those of other birds. This because penguins do not use them to fly.

Inheritance of acquired traits

- Lamarck believed that **traits changed or acquired during an individual's lifetime could be passed down to its offspring**.
- Giraffes that had acquired long necks would have offspring with long neck. This type of inheritance, sometimes called **Lamarckian inheritance.**
- **Lamarck's inheritance of acquired traits was disproved by genetics.**
- However, Lamarck's **believe species started out simple and constantly move toward complexity** (closer to perfection) is still acceptable and explained through genetic change.

Darwinism

- Charles Darwin and Alfred Russell Wallace in 1858 published a paper called **'origin of species by Natural Selection'.**
- Darwin visited five of the Galapagos Islands found about 600 miles away from the cost of Ecuador in south America
  - He studied finches /type of bird/ found in the island
  - **Darwin observed similarity between finches on the island** with those of nearby cost of south America
  - According to him **"ancestral finches" migrate to the island** from south America
  - **'Ancestral finches' evolved into different species such as Fruit eaters, Insect eaters, Cactus eater and seed eaters** depending on the type and size of beaks
  - Darwin called such change **"decent with modification"** current equivalent term is **"Adaptive radiation"**
- Darwin belief that this modification is the key evidence for the theory of evolution by natural selection.

- **Darwin theory of natural selection (Adaptive radiation) has 4 core ideas.**
  - **Fecundity /Over reproduction/:** all species tend to produce more offspring than can possibly survive.
  - **Variation;** there is variation among offspring.
  - **Struggle for survival:** as there is limited resource , there will be struggle among the offspring for survival
  - **Survival of the fittest**: those members of species that are better adaptation to the environment will survive.
- Darwin proposed that those organisms that were best adapted to the environment would have an advantage:
  - be able to reproduce in greater numbers than other types
  - pass on their advantageous adaptation to the offspring.

Comparison of Lamarck's theory with Darwin's theory

Aspects of theory	Lamarckian theory	Darwinian Theory
➢ **Variation**	➢ Change of the environment bring change of organism	➢ Natural heritable variation
➢ **Survival**	➢ Development of new features for survival. E.g. Long neck	➢ Environment selects with adaptable features
➢ **Inheritance**	➢ Acquired traits pass to the offspring	➢ Advantageous variation pass to the offspring
➢ **Evolution**	➢ New species form over time	➢ New species form over time

Neo-Darwinism

- It is the revised version of Darwin's theory of evolution by means natural selection
- It combines **Darwin's original theory** with **genetic theory** and **ethology/animal behavior/**
- **Alleles of genes** determine features of organisms.
- **A population evolves** into new species when its **gene pool is changed**.
- **Gene pool** refers to all alleles of all the gene found in the organisms

Neo-Darwinism…

- If an **allele is advantageous** in an organisms in its environment. The following will happen:
  - The advantageous allele of the gene will survive to reproduce in greater numbers.
  - The advantageous allele will pass to the offspring in greater number.
  - The frequency of the advantageous allele will be higher in the next generation.

Neo-Darwinism…

- Mutations introduce new variation into populations. Any gene mutation can confer one of the following 3 fates to the organisms. The gene can be
  - **Neutral:** mutation will have generally no harm or benefit to organism. Depend on the environment, its frequency may increase slowly, remain stable or decrease.
  - **Advantageous:** confers a selective advantage; the frequency of the allele will increase over time
  - **Disadvantageous;** the frequency of such a gene will decrease, and eventually disappear from the population.
- Behavioral pattern of organisms important for the survival of organism, it can also be neutral, advantageous or disadvantageous and may be used as a factor by natural selection.

4.3. The evidence for evolution

1. Palaeontology

- **Palaeontology** come from two the greek words
  - **Palaios** =ancient
  - **Logos**=study– is the study of ancient life is mainly based on fossils (direct evidence about past life)
- **Fossils** (Latin word *fossus*= ‘having been dug up’) are the remains or traces of animals, plants and other organisms from the remote past.
- They can group into two categories:

1. Palaeontology…

- **Category 1:** the remains of the dead organism or the imprint left from the remains, including:
  - **Bones**, **teeth**, **skin impressions, hair**, **the hardened shell** of an ancient invertebrate such as a trilobite or an ammonite and an **impression of an organisms**
- **Category 2:** trace fossil that was made by the animal while it was living. These includes:
  - **footprints**
  - **burrows**
  - **coprolites** (animal faeces)
- The **first type of fossils** can be **the actual organism or part of an organism.** For example, a spider has been trapped in tree resin, completely unchanged, inside the amber for millions of years.

Stages of fossil formation

1. Death without decomposition

- To start with, organisms must die in or so close to water that it is covered by water immediately after, or shortly after, death.
- The water insulates the remains from many of the elements that contribute to decomposition.
- Bacteria will still decay the soft body parts over a long period but leave any hard body parts unaltered.

2. Sedimentation

- Sediments burry the remaining hard part of the organism through a time.
- Sedimentation further insulates the body of organism from complete decay.
- The nature and quality of the fossil are influence by nature and chemical composition of the sediments.
- A more detailed fossil is formed by very **fine-grained particles, like clays, than coarser-grained sediments like sand.**
- The chemical make-up ~~of~~ the sediments affects the colour the fossil will be.
  - Iron-rich sediments could give a reddish colour fossil.
  - Phosphates rock gives a grey or black fossil.

3. Permineralisation

- Over time, this pressure turns the sediments into rock.
- If water rich in minerals percolates (seeps) through the sediments, the mineral particles stick to the particles of sediment, effectively gluing them together into a solid mass.
- An important point here is that these minerals are probably not the same minerals that make up the sediments (now rock).
- Over the course of millions of years, these mineral particles dissolve away the original hard parts of the organism, replacing the molecules of exoskeleton with molecules of calcite (calcium carbonate) or another mineral.

Permineralisation…

- In time, the entire shell is replaced by mineral particles and these also are compressed into rock in the shape of the original organism.
- As this rock is not the same as the surrounding rock, it is visible as a fossil in the exact shape of the original organism.

4. Uplift

- Earth movement such as folding and earthquake expose rocks that may contain fossils. Rain and wind can know erode the rock expose the fossil

Fossils dating

- Age of fossil can determined either stratigraphy (relative dating) or absolute dating.

1. Stratigraphy (Relative dating)

- In sedimentary rock layer (strata), the oldest strata (fossils) are found in the lowest layers and more recent rocks and fossils in layers above them, with the most recent being nearest to the surface.
- The names ‘Tertiary’, ‘Cretaceous’ and ‘Jurassic’ are the names of some of the geological periods of time.

2. Absolute (actual dating)

- Use a radioactive element to determine the actual age of rocks or fossils.
- Basically, the amount of radioactive element in a fossil is measured and compared to the estimated amount of the organism before death.
- There are two techniques:
  - ✓radiocarbon dating, or
  - ✓Potassium–argon dating.

Radioactive carbon (C^{14})

- Radioactive carbon atoms **(C^{14}) decay into** non-radioactive **nitrogen atoms (N).**
- **Half-life** is the time required to decay half of radioactive element.
- Half-life C^{14} is about 5,730 years
- The ratio of carbon 14 (radioactive carbon) to carbon 12 (ordinary carbon) in living things is about 1 to 1 trillion
- After 5730 years, only 50% of the original C^{14} atom will remain, and the ratio C^{14} to C^{12} is will be 0.5 to 1 trillion

Radioactive carbon…

% of original C^{14}	Half life	Ratio of C^{14} to C^{12}	Years
➢ **100**	➢ 0	➢ 1 to 1 trillion	➢ 0
➢ **50**	➢ 1	➢ 0.5 to 1 trillion	➢ 5730 ×1= 5730yrs
➢ **25**	➢ 2	➢ 0.25 to 1 trillion	➢ 5730×2=11,460yrs
➢ **12.5**	➢ 3	➢ 0.125 to 1 trillion	➢ 5730×3=17910yrs
➢ **6.25**	➢ 4	➢ 0.0625 to 1 trillion	➢ 5730×4=22920yrs

Potassium–argon dating

- Radioactive potassium atoms **(K^{40})** decay into argon atoms **(A^{40}).**
- Works in the same way radiocarbon dating, but the half-life in this case is 1.3 million years.
- This makes potassium–argon dating suitable for dating rocks and fossils older than 60 000 years old.

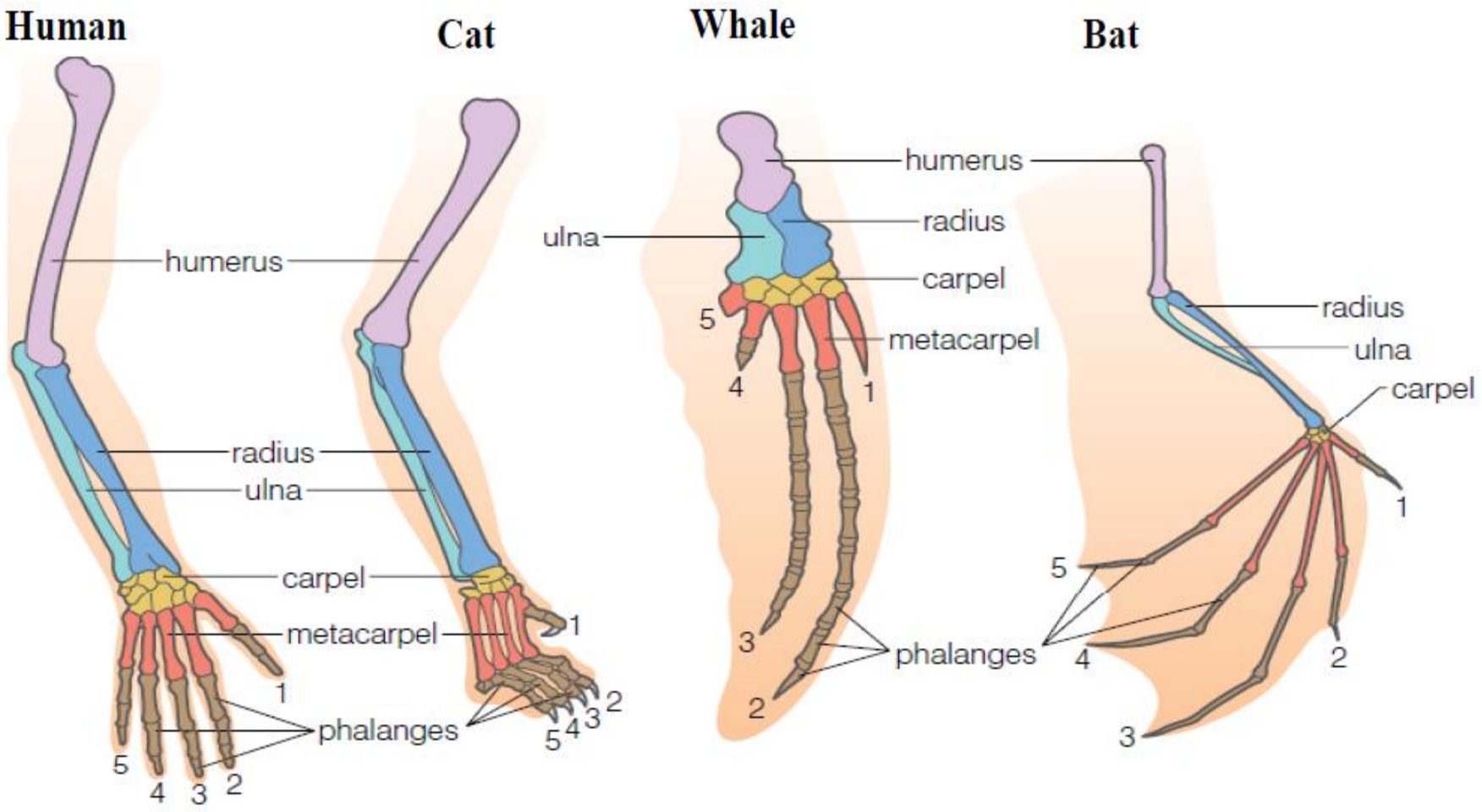
Comparative anatomy

- This is the study of anatomical similarity and difference between organisms
- It comprise analogous and homologous structure
- **Analogous structure**
  - The same function but different anatomy and morphology.
  - They are **not evidence for common ancestor**; hence they have **different evolutionary origin**.
  - Example:
    - The wing of insects and bird used for flying but different body plan
    - mammalian and insects leg used for waking

Homologous structures.

- Have **the same basic anatomy and a common evolutionary origin** but they may **serve for different function**
- Organism with homologous structure are **evolutionary related, and probably the same common ancestor.**
- Example;
  - Pentadactyl (having 5 digits) on 4 limes of mammals
- Each possesses the same number of bones, arranged in almost the same way, while they have different external features and they function in different ways:
  - arm for manipulation in humans
  - leg for running in cats
  - flipper for swimming in whales
  - wing for flying in bats

Example of homologous structures pentadactyl limb



Comparative embryology

- Comparative embryology deals with the development vertebrates embryos before birth or hatch.
- In early vertebrate embryo development, all have gill slit and tails
- Vertebrate embryo resembles at early stages, shows a common ancestor according to the theory of evolution
- However, the ‘gill slits’ are not gills; they connect the throat to the outside, but in many species they close later in development.
- However, in fish and larval amphibians they contribute to the development of gills.
- The embryonic tail does not develop into a tail in all species.
- In humans, it is reduced during development to the coccyx, or tailbone.

Comparative biochemistry

- Organism that share similar molecule and chemical pathways are closely related evolutionary
- Comparative biochemistry studies two type of molecule have been used so far. These are :
  - **DNA:** base sequences of DNA from different organisms is compared
  - **Proteins:** amino acid sequence of different organism are compared
  - **Cytochrome-c** (found in the electron transport chain of respiration) and
  - **Haemoglobin:** found in RBC to transport oxygen
- Species that are closely related have the most similar DNA and proteins; those that are distantly related share fewer similarities.
- Human share 98% of our DNA with chimpanzees but only 50% with banana

Plant and animal breeding

- **Selective breading-** is a technique of choosing organism with desired traits:
- It is a technique used to produce organisms with a desired traits (for example, high milk yield or large number of seeds per pod), by allowing only those organism to reproduce.
- For example selective breeding of the wild pig (wild boar) into the many different varieties of the domestic pig.
- The new varieties produce by human selective breading then will be selected by natural selection (in which environmental pressures) should also be able to produce new varieties and, eventually, new species over a long period of time

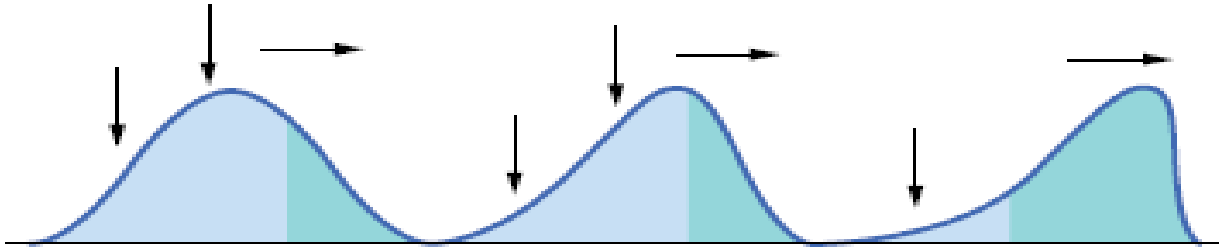
4.4. The processes of evolution

- **Natural selection** is the process by which those members of a species which are best adapted to their environment will survive and reproduce in greater numbers than others less well adapted. They will pass on their advantageous alleles to their offspring and, consequently the frequency of these alleles will increase in their gene pool. The advantageous types will, therefore, increase in frequency in successive generations.
- Natural selection is the „driving force“ behind evolution. It gradually brings about changes in populations the same species that may lead to different **species.**

- **Type of Natural selection**
  - **Directional selection**
  - **Stabilising selection**
  - **Disruptive selection**

Directional selection

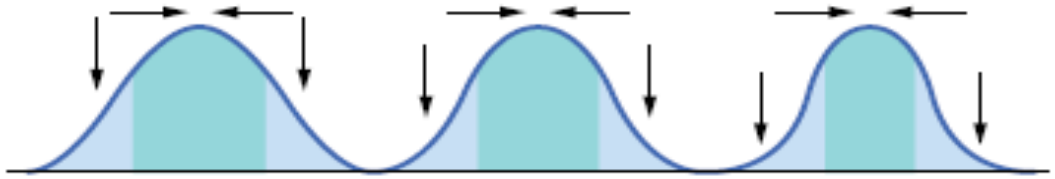
- A type of natural selection in fever of one extreme feature of a population
- It works against other features
- For example, if a fox population establish in a very cold environment those individual a longer and thicker fur foxes will be favored
- Thinner fur in foxes is an advantage in a hot climate.
- The mean range of frequencies of alleles will shift toward favored feature
- The fox with favored feature must be result of mutation and new combination of allele



(a) directional selection

Stabilising selection

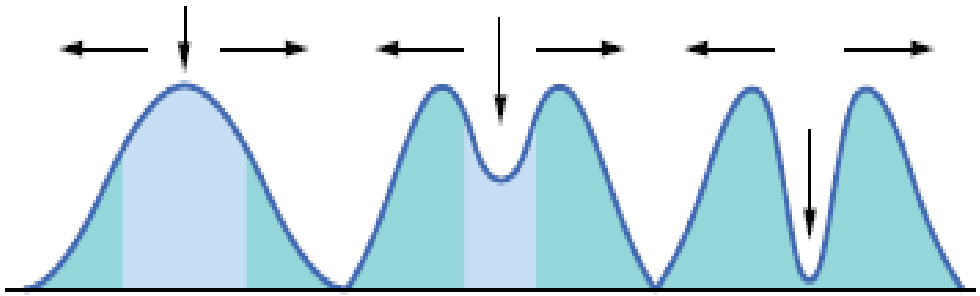
- Works in fever of intermediate (mean) feature against both extremes
- Make the population more uniformly adapted.
- E.g. Birth mass in humans very heavy or very light babies usually die before birth



(b) stabilising selection

Disruptive selection

- Individuals at both extremes of a range have favored, against those of the mean feature.
- As a result, the frequency of those individuals at the extremes of the range will increase over time and those in the middle of the range will decrease over time.
- Adaptation of Darwin‟s finches for food source.
- The longer beak finch are able to obtain insects out of trees bark than the average length beak finches and may not able to crush seed effective as that of shorter beak finches do.



(c) disruptive selection

Mechanism of speciation

- Speciation is the process by which new species are formed from population of new species.
- If populations of species are reproductively isolated from each other by some other mechanism, they start to mutate independently.
- Mutation that occur in one population do not pass to the other, eventually fail to interbreed, and evolve into distinct species over a long period of time.
- two main ways of formation of species:
  - **Allopatric speciation, and**
  - **Sympatric speciation.**

Allopatric speciation

- Allotropic speciation is a process by which different population of a species develop into distinct species due to physical /geographically/ isolated that lead to reproductive isolation,
- It occurs when a population from an existing species becomes geographically isolated and the isolated population develops into a new species
- Examples of geographical barrier
  - a river changing its direction of flow
  - a mountain range being created
  - Creation of a land mass within water bodies separating into two.

Sympatric speciation

- Sympatric speciation is process of formation of new species as a result of reproductive isolation caused by seasonal, temporal and behavioral isolation mechanism
- It occurs when a population from an existing species develops into a new species without becoming geographically isolated from other members of the original species
  - **seasonal isolation:** two populations reproduce at different times of the year
  - **temporal isolation:** two populations reproduce at different times of the day
  - **behavioral isolation:** two populations have different courtship patterns
- Example: hybridisation and polyploidy have both been important in the evolution of modern wheat from wild grasses

Polyploidy and its importance

- A cell can have a single set of chromosome (haploid), two set of chromosomes (diploid) or many set of chromosome (polyplid) per cell.
- Polyploidy occurs when an organism has more than two set of homologous chromosomes.
- Polyploidy are rare in animal and not important for their evolution.
- Polyploidy has been important in plant evolution because it has allowed infertile hybrids to become fertile again.
- When different species form hybrids, very often the hybrid cannot produce offspring because all the chromosomes cannot form bivalents (homologous pairs) in meiosis.
- So they cannot form sex cells and cannot reproduce.
- If the chromosome number were to double, then all chromosomes are able to form homologous pairs. Meiosis and sex-cell formation can take place and the hybrid is now fertile.

Divergent and convergent evolution

- **Divergent evolution /Adaptive radiation/**
  - Divergent evolution is a process by which population of species evolve into different species due to different selection pressure in different environments.
  - If different selection pressures are placed on populations of a particular species, a wide variety of adaptive traits may result.
  - Divergent evolution leads to the development of a new species.
  - Examples of divergent evolution (adaptive radiation) include:
  - the evolution of the different species of finches on the Galapagos Islands
  - the evolution of the different forms of the pentadactyl limb

Convergent evolution

- Convergent evolution is a process in which unrelated organisms evolve similar structures adapted for the same function.
- It occurs when similar selection pressure is imposed on different species occupying similar niche.
- Example
  - Convergent evolution of the giant armadillo, giant pangolin, giant anteater and spiny anteater. They are not related evolutionarily, but all dig narrow cracks in the ground and feed on ants
  - The wing of a bird, a bat shows convergence.

4.5 The evolution of humans

- According to the theory of evolution, there has been **'line of evolution'** for million years that has given rise to :
  - Old world monkeys (e.g. baboon and proboscis monkey)
  - New world monkeys(e.g. marmosets and monkey)
  - Hominoids (apes and humans)
  - Human belong to primates. We have two features in particular that distinguish us from other primates. These are:
    - **Bipedalism** – the ability to truly walk on just two legs.
    - **a very large brain,**

The evolution of humans…

- Statements like ‘humans evolved from chimpanzees’ are inaccurate but humans and chimpanzees both evolved from a common ancestor that lived about 6 million years ago.
- Chimpanzees, Bonobo and Human have common ancestors about 6 million years ago.
- Gorilla, Chimpanzees and human have common ancestors about 8 million years ago.
- Orangutan, Gorilla, Chimpanzees and human have common ancestors about 13 million years ago
- There are two group of human..
  - **Hominin;** All humans belong to the **genus** *Homo*. *Homo sapiens*, *Homo neanderthalensis*, *Homo erectus* and *Homo hablis*
  - **Hominid** a group of species that includes all the species belonging to the genus Homo along with other species such as *Ardipethecus ramidus* and *Australopithecus afarensis* (Lucy)

The significant about Lucy and Ardi

- Lucy and Ardi are important fossils in explaining the evolution of modern humans and chimpanzees from a common ancestor.
- **Lucy (*Australopithecus afarensis*)**
  - Lucy was discovered by Donald Johanson and Tom Gray in 1974 at Hadar in Ethiopia.
  - Lucy is a fossil dated at about 3.2 million years.
  - She was bipedal (waking upright on two leg) and partly arboreal (tree dwelling) hominids
  - **The fossil Luci was significant for showing bipedalism came before big brains.**

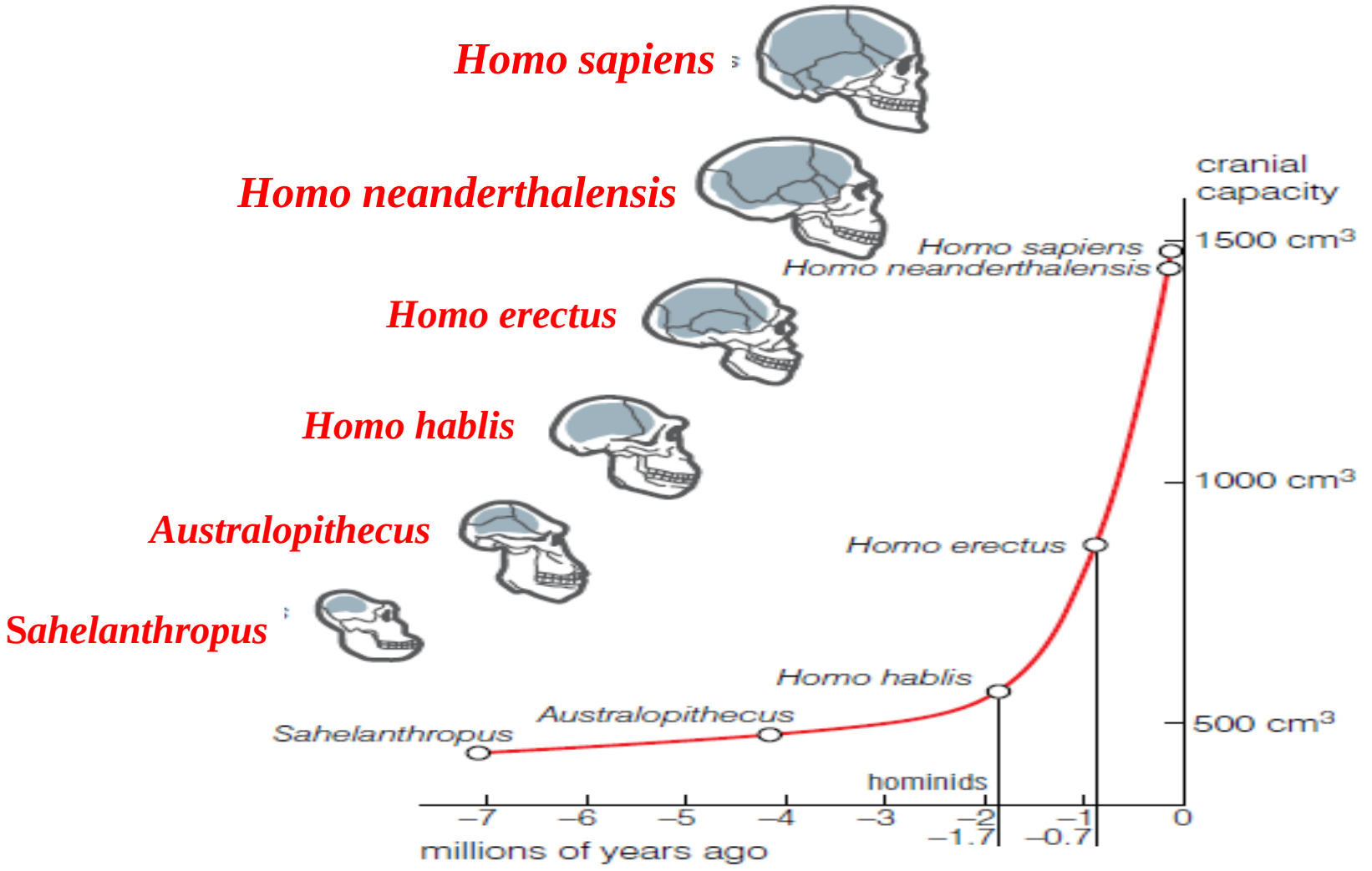
❖ Ardi (*Ardipithecus ramidus*)

- The Ardi fossil was first discovered in 1992, in the Afar dessert in Ethiopia
- Ardi was 4.4 million years old, she is the nearest fossil to the ‘common ancestor’ of humans and chimpanzees
- The **fossil Ardi was significant** because it **proves that the common ancestor of humans and chimpanzees could not have resembled a chimpanzee**, this is because chimpanzees are not truly bipedal.

Change of brain size during human evolution

- During the course of human evolution, the brain has got bigger.
- Moreover, the brain has increased in size as a proportion of body mass.
- For example;
  - *Australopithecus species have* a brain that is between 0.7% and 1.0% of their body mass.
  - Modern humans are between 1.8% and 2.3% of their body mass.
  - The brain of *Homo sapiens* uses 25% of the resting energy requirement, compared with 8% in the great apes.
  - A larger brain, longer legs, nimble fingers and straight spine allows humans to:
    - Faster running in a more upright posture
    - planning in advance to avoid attack
    - development and utilization tools and weapons

Change of brain size…



- **The cranial capacity of different hominids increased in the order**(*Sahelanthropus-H. sapiens*)
  - *Homo sapiens*
  - *Homo neanderthalensis*
  - *Homo erectus*
  - *Homo hablis*
  - *Australopithecus*
  - *Sahelanthropus*

Are we still evolving?

- According to fossil evidence, Homo spines appeared in Africa and migrated to other parts of the world.
- Different selection pressures in the different environments resulted in the different human populations evolving along different lines.
- For example cold regions, body features that gave a survival advantage by helping to conserve heat were selected for. These included:
  - a shorter, squatter body shape; to reduces the surface-area-to volume ratio and so minimize heat lost
  - increased layer of adipose tissue under the skin to act as insulation
  - increased hairiness; to reduces heat loss by convection

3 different races of human

- Based on the recent genetic analysis, human classified into 3 different races.

1. African (Negroid)-Africa and Melanesians of the South Pacific.

2. Eurasian (Caucasoid),has.3 subdivisions e:

- **Nordic** –people from Scandinavian and Baltic countries, Germany, France, Britain
- **Mediterranean** –includes people from Southern France, Spain, Italy, Wales, Egypt, Jews, Arabs, Afghanistan, Pakistan, India
- **Alpine** –includes countries from the Mediterranean to Asia

3. East Asian (Mongoloid), most numerous of the present-day populations and split into three groups:

- Eastern Siberians, Eskimos and the Northern American Indians
- Japanese, Koreans and Chinese
- Indonesians and Malays

- Central African pigmies, the Bushmen and the Australoids are not included in the above classification