



Evolution Notes 240717 114335

Life Sciences (John Mbhendle Secondary School)



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EVOLUTION

- Evolution - a general term that may be defined as change over time
- **BIOLOGICAL EVOLUTION** – genetic changes in a population that are inherited over successive generations due to natural selection
- Biological evolution results in the **formation of new species**

EVOLUTION – HYPOTHESIS OR THEORY?

- **HYPOTHESIS** – an informed assumption that provides an explanation of a specific phenomenon that can be tested.
- **THEORY** – a well substantiated explanation supported by evidence that makes sense of a natural phenomenon.
- A theory develops and is changed or replaced as new evidence is discovered
- Evolution is a scientific theory since various hypotheses relating to evolution have been tested and verified over time

EVIDENCE OF EVOLUTION

- FOSSIL RECORDS (grade 10)
- DESCENT WITH MODIFICATION
- BIOGEOGRAPHY (GRADE 10)
- GENETICS

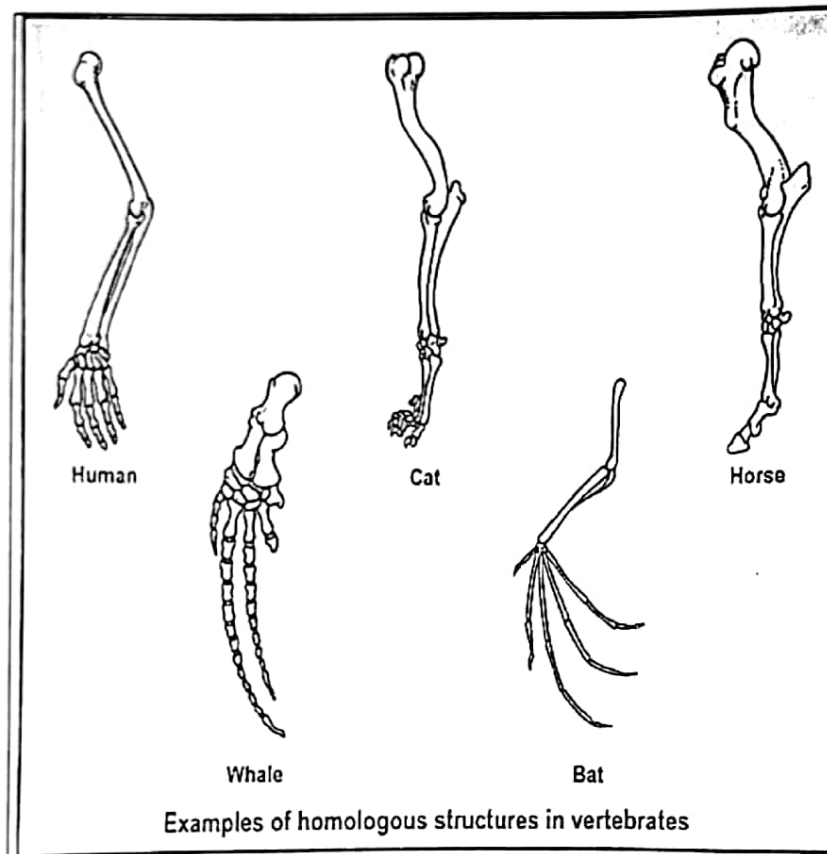
FOSSIL RECORDS

- **FOSSIL** – an organism or the remains, imprints or footprints of an organism, usually preserved in rock.
- Fossils provide evidence of the history of extinct organisms on earth.
- Fossils are studied by Paleontologists
- **Paleontology** is the study of fossils
- **Paleontologists** can determine the age of a fossil and also determine characteristics of the organisms by studying its fossil. This knowledge of these characteristics allows them to see relationships amongst different organisms.

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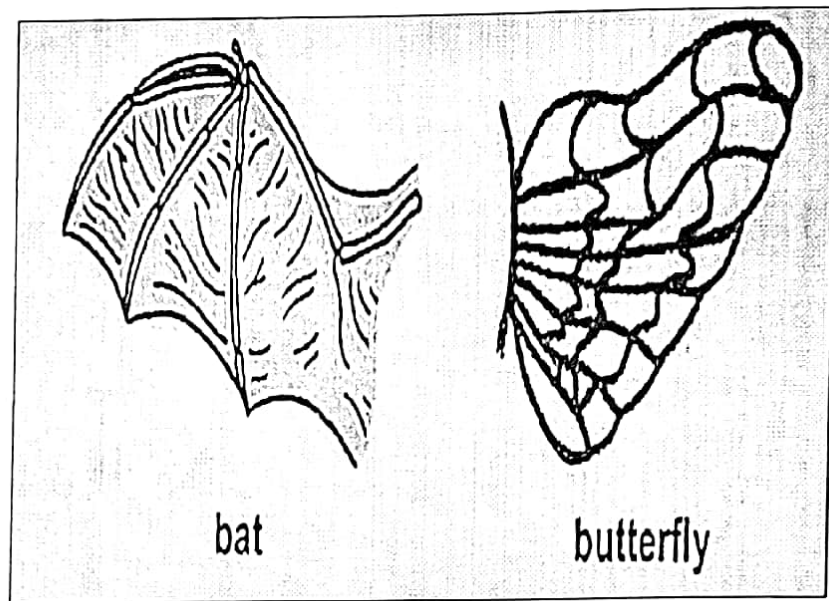
DESCENT WITH MODIFICATION

- Descent with modification describes how the body plans of organisms are modified to adapt to their different environments.



- Forelimbs of vertebrates look different and perform different functions, but show the same basic body plan.
- Similar structures with the same body plan that perform different functions are known as **HOMOLOGOUS STRUCTURES**.
- Homologous structures provide evidence of evolution because similarities may be traced back to a common ancestor.

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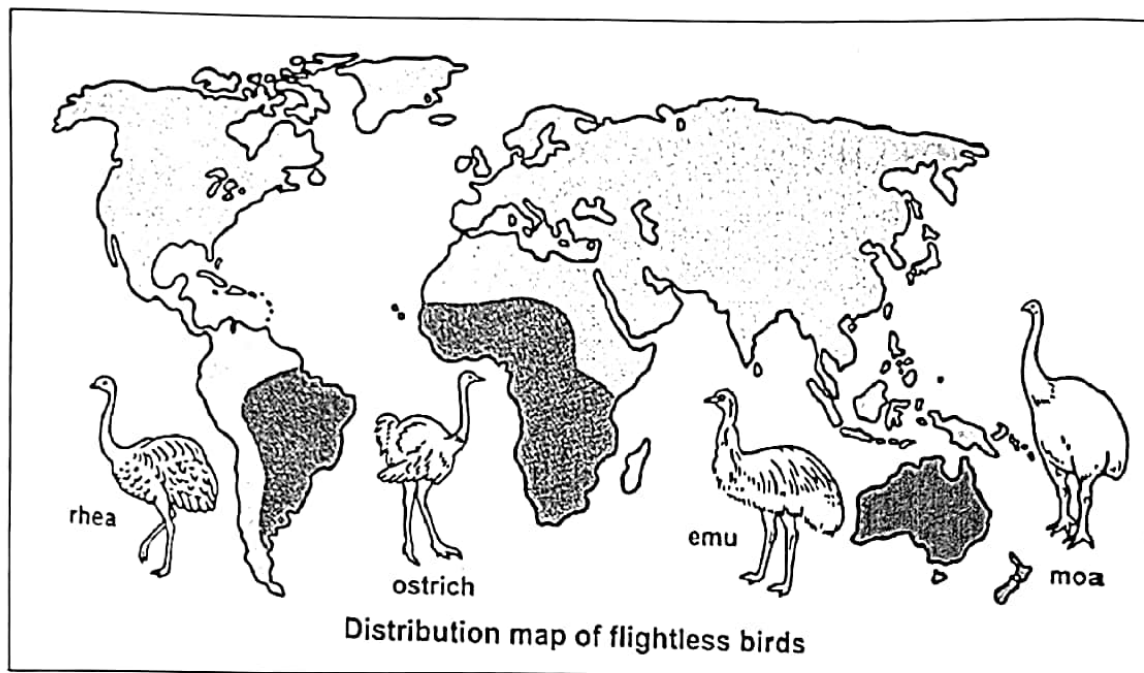


- Some body structures perform the same function in different organisms, but did not originate from a common ancestor.
- These are known as **Analogous structures**
- These structures differ but have the same function
- Therefore the theory of Descent with modification suggests that **modern species are modified descendants of earlier species and adaptations/modifications occurred to adapt to different environments**

BIOGEOGRAPHY

- **Biogeography** – is the study of the distribution of existing and extinct species in specific geographical species.
- Biogeography proves that closely related species usually occur in the same geographical region and this may suggest that they also share a common ancestor.
- Biogeographical regions, however, may be isolated by barriers, this may lead to the formation of a new species.

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- These flightless birds may have developed from a common ancestor
- The birds were separated by geographically and thus they adapted to their changing environments
- New species develop due to different mutations and selections in various environments

GENETICS

- **GENETICS** – the study of inheritance
- Genetics provides evidence that:
 - Closely related organisms have more similarities in their DNA
 - the source of variation that is necessary for evolution to occur
 - changes in genotype or phenotype are transferred to successive generations
 - gene pools of populations can change and lead to

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VARIATION

- **BIOLOGICAL SPECIES** – a group of organisms that interbreed to produce fertile offspring
- **POPULATION** – a group of organisms of the same species that live in a particular place at a particular time with the ability to freely interbreed.

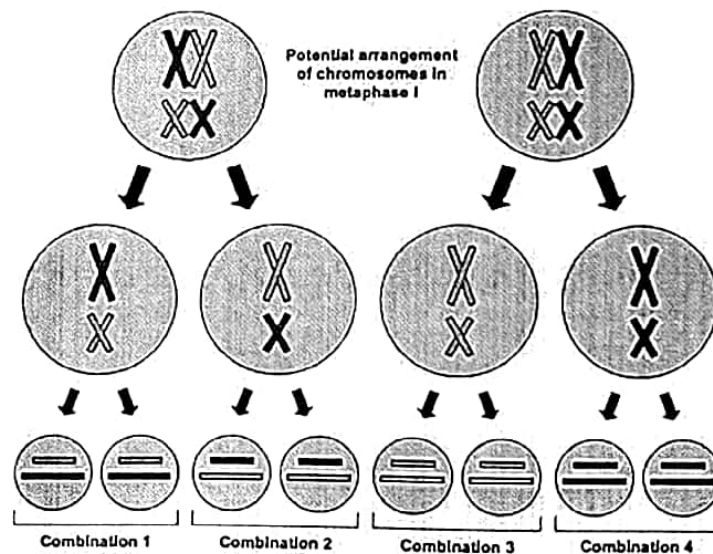
SOURCES OF VARIATION

- CROSSING OVER
- RANDOM ARRANGEMENT OF CHROMOSOMES
- MUTATIONS
- RANDOM FERTILIZATION
- RANDOM MATING

1. Crossing over

- Crossing over a process that occurs during meiosis
- Involves the exchange of genetic material during prophase I and leads to the formation of gametes with different gene combinations

2. Random arrangement of chromosomes



- Occurs during meiosis
- Involves the random assortment of homologous chromosome pairs on the equator during metaphase I also leads to greater variation in the gametes

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3. Mutations

- Mutations are the most important cause of genetic variation
- Occurs as a change in the sequence or quantity of nucleotides in DNA
- This leads to a change in the amino acid sequence of the protein synthesized.

4. Random fertilization

- Sperm cells and egg cells are different from each other due to meiosis
- Given that fertilization is random of these gametes, therefore there will be different combinations of genetic material in the offspring

5. Random mating

- Individuals within a population can mate randomly
- This leads to variation of gene combinations
- This leads to even more variation within a species

CONTINUOUS AND DISCONTINUOUS VARIATION

CONTINUOUS VARIATION

- Occurs when there is a range of phenotypes for the same characteristics
- Forms a continuous spectrum from one extreme to another
- A genetic characteristic may be controlled by more than one gene and each gene may have multiple alleles
- Examples include: height in humans, skin colour, hair length and milk yield in cows

DISCONTINUOUS VARIATION

- Phenomenon where phenotypes fit into separate categories, with no intermediate forms
- Only single pair of alleles occurs
- Examples include: human ABO blood groups, tongue rolling, finger prints and sex

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THEORIES OF EVOLUTION

LAMARKISM

Jean-Baptiste de Lamarck (1744-1829) was a French naturalist that proposed his theory of evolution in his book *Philosophie Zoologique*



LAMARKISM - Lamarck's theory of evolution

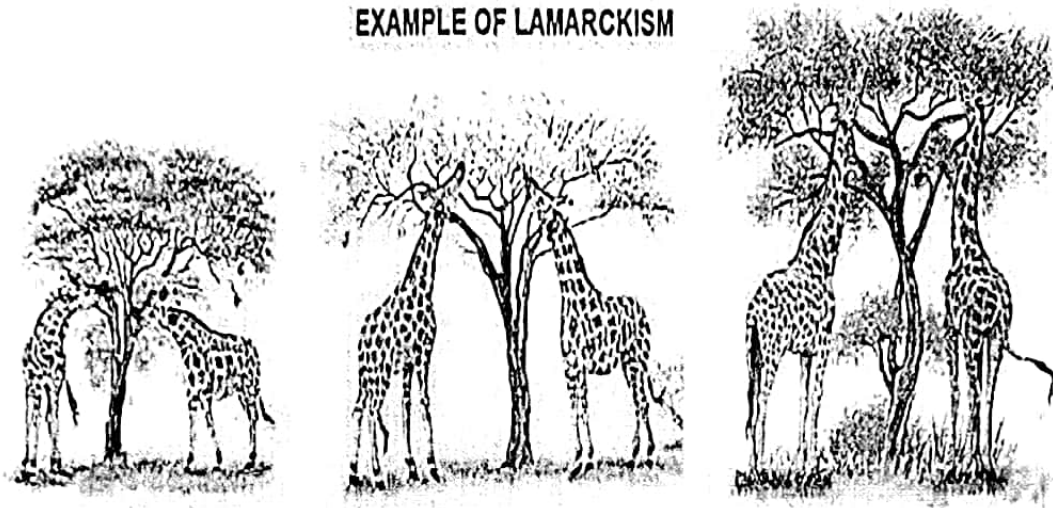
Based on two related ideas:

- **Law of use and disuse** – the use or disuse of organs may cause the organs to increase or decrease in size or even completely disappear.
- **Law of inheritance of Acquired characteristics** – during their lifetime organisms acquire certain changes in characteristics that are inherited by their offspring.
- This results in changes in populations and the formation of a new species

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LAMARKISM – Application

EXAMPLE OF LAMARCKISM



- All giraffes had short necks originally
- Giraffes frequently stretched/used their necks to reach for leaves of tall trees causing their necks to become longer
- The characteristics of long necks acquired in this way was then passed on to the next generation forming offspring with longer necks than the generation before

LAMARKISM – Reasons for rejection

- After the discovery of modern genetics, Lamarck's theory was rejected
- In the example of the giraffe, the ancestors of the giraffe possessed the gene for long, strong necks and did not acquire the gene by stretching their necks.
- Acquired genes cannot be inherited or transmitted to offspring.
- Lamarck had no understanding of genes and mutations, but he was the first scientist to suggest that 'something' passed on the characteristics of the parents to the offspring

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DARWINISM

Charles Darwin (1805-1882) was an English naturalist on the survey ship HMS Beagle that undertook a five year expedition to the southern hemisphere from 1831-1836. He made some important observations on the Galapagos islands. He published his book, On the origin of species by means of natural selection

Darwin in 1840,
after his return
from the
voyage



DARWINISM – History

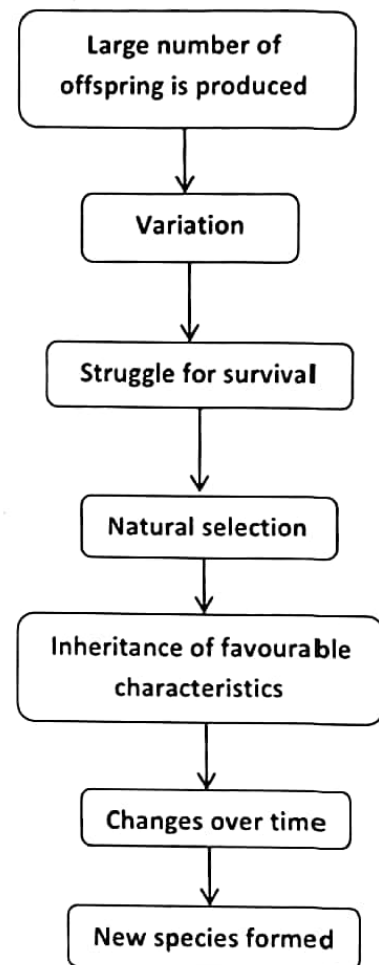
Darwin's observations:

- Individuals of a population produce more offspring than is required
- A great deal of variation occurs within a population to ensure survival of the population
- Some individuals are better adapted to a specific environment and are more likely to reproduce while weaker adapted individuals will not reproduce or may become extinct
- Characteristics are transferred from the surviving parents to their offspring

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DARWINISM – Evolution by natural selection

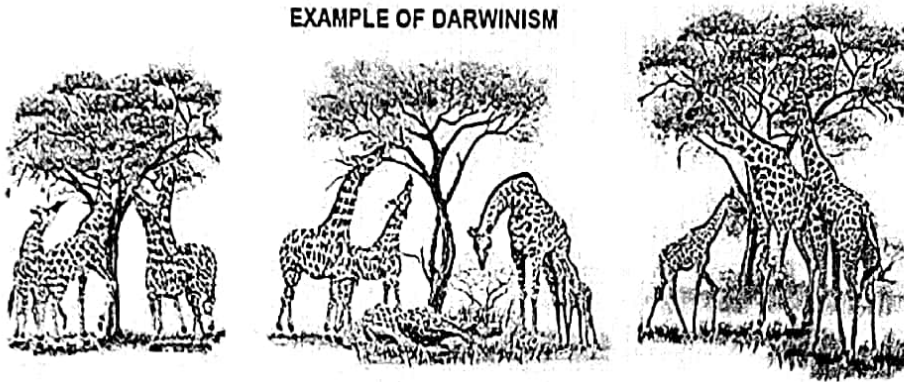
- Organisms produce a **large number of offspring**
- There is **variation** in the offspring
- Some individuals have **favourable characteristics** that give them an advantage in the environment
- When there is a **change in the environment** or increased competition, organisms with favourable characteristics that are better adapted to their environment, survive
- Organisms without these favourable characteristics are less suited to the environment and **will die**. Therefore the number of 'less fit' organisms in the population will **decrease**
- The organisms that survive, **reproduce** and thus pass on the favourable characteristic **to their offspring**
- The **next generation** will therefore have a higher proportion of individuals with the favourable characteristic
- The changes occurring in the individuals of a species over time may lead to the formation of a **new species**



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DARWINISM – Application

EXAMPLE OF DARWINISM



- As a result of genetic variation in the giraffe population some giraffes have longer necks than others
- Environmental change/competition for resources occurred causing those with shorter necks to die and those with longer necks to survive, since they could reach the leaves of tall trees
- This is termed natural selection
- The genotype for longer necks was passed on to subsequent generations
- In this way each subsequent generation had necks longer than the generation before

DIFFERENCES BETWEEN LAMARCK & DARWIN

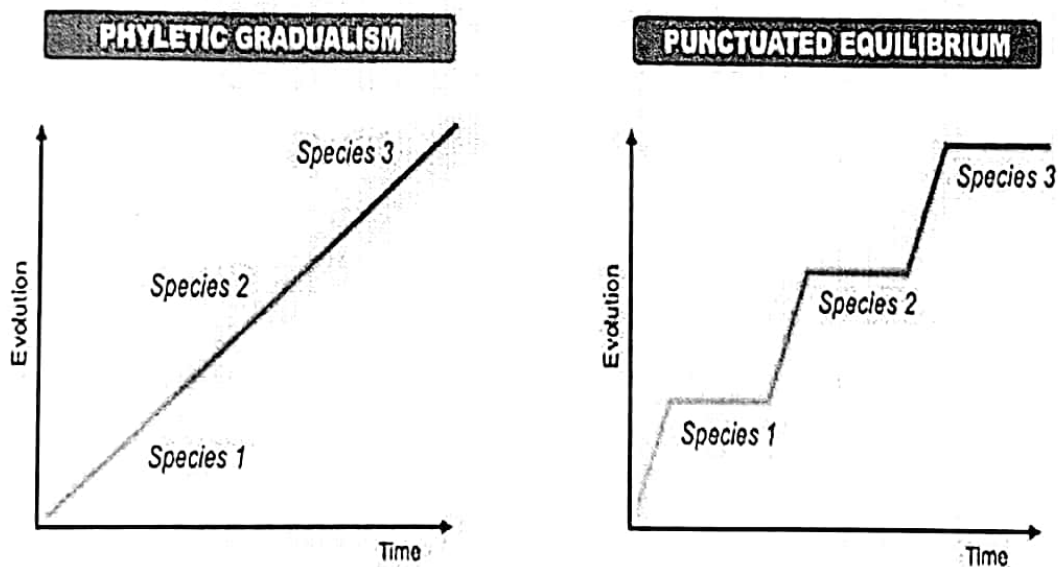
Lamarck	Darwin
Law of use and disuse	Law of natural selection
The acquired characteristics are passed on to the next generation	Inherent genetic characteristics can be inherited from parents
Organisms have an internal drive to change/deterministic	Organisms do not have an internal drive to change/nature selects the best to survive
Individuals change	Populations change
Infers that no extinction because organisms get better and better and therefore survive	Extinction occurs since organisms may have features that do not favour survival

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PUNCTUATED EQUILIBRIUM

- Niles Eldredge of the American Museum of Natural History and Stephen Jay Gould of Harvard University described Punctuated Equilibrium in 1972
- Punctuated Equilibrium and gradualism are concerned with evolutionary rate
- Evolution involves long periods of little or no change (known as equilibrium)
- This alternates with (is punctuated by) short periods of time where rapid changes occur through natural selection
- During which new species may form in a short period of time

PUNCTUATED EQUILIBRIUM AND GRADUALISM

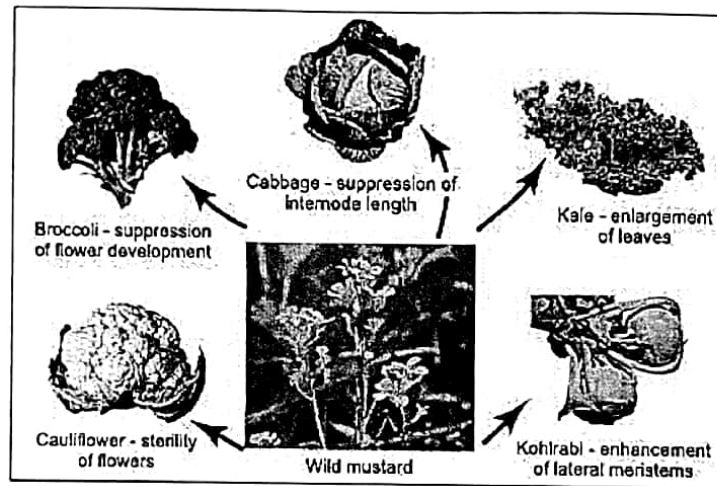


- According to Darwin evolution takes place due to an accumulation of small changes over a long period of time there are transitional fossils to show gradual change over a long period of time
- **Transitional fossils** – consist of both the ancestor species and the modern species
- Eldredge and Gould observed that sometimes evolutionary changes happens very rapidly and then long periods of stasis involving little evolutionary change. This was called **punctuated equilibrium**.

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ARTIFICIAL SELECTION

- Artificial selection – is the deliberate breeding of plants and animals for desired characteristics that would not necessarily benefit the survival of the offspring.
- Humans select the desired characteristics and therefore serve as the environmental trigger
- During artificial selection a specific organism is chosen for a specific genetic trait required by the breeder. The organism is then bred with another organism of the same species, with the same characteristic. Based on genetic mechanisms, more offspring will have the desirable characteristic



ARTIFICIAL SELECTION – Example

A domesticated species :

- By selecting cows which produce large amounts of milk and whose mothers and grandmothers were also high milk producers, and allowing them to mate with bulls whose mothers and grandmothers were also high milk producers, cows which produce more milk than their ancestors, have been developed.

A crop species:

- Farmers cultivated numerous popular crops from the wild mustard, by artificially selecting them for certain attributes. By selecting for shorter internodes, the cabbage was produced. By selecting for poor flower development, the broccoli was produced. By selecting for sterile flowers, the cauliflower was produced

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ARTIFICIAL SELECTION VS NATURAL SELECTION

Similarities:

- Variation occurs in a particular population
- Variation is hereditary in the population
- The outcome is the same, i.e the population changes over time and certain characteristics become more frequent

Differences:

NATURAL SELECTION	ARTIFICIAL SELECTION
The environments acts as the selection pressure	Humans determine which traits are selected
Selected characteristics are advantageous for survival in the natural environment	Selected characteristics are not necessarily advantageous for survival in the natural environment
Can lead to a new species	Leads to a new breed of a plant or animal

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FORMATION OF NEW SPECIES

- **SPECIES** – a group of organisms that interbreed to produce fertile offspring.
- **SPECIATION** – an evolutionary process during which new species form.
- Speciation increases the range of organisms on earth and thus increases biodiversity
- Extinction is the loss of species, therefore decreases the range of organisms on earth and thus decreases biodiversity

SPECIATION THROUGH GEOGRAPHIC ISOLATION

- If a population of a single species becomes separated by a geographical barrier (sea, river, mountain, lake) then the population splits into two.
- There is now no gene flow between the two populations.
- Since each population may be exposed to different environmental conditions/the selection pressure may be different
- Natural selection occurs independently in each of the two populations such that the individuals of the two populations become very different from each other genotypically and phenotypically.
- Even if the two populations were to mix again they will not be able to interbreed.
- The two populations are now different species.

EXAMPLES OF GEOGRAPHIC ISOLATION

1. Galapagos finches
2. Lands on different land masses (linked to continental drift)
 - Baobabs in Africa and Madagascar
 - Proteas in South Africa and Australia
3. Any example of mammals on different land masses

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GALAPAGOS FINCHES

- The finches were isolated from the original population, islands are situated so far from the mainland
- The finches multiplied and mutations occurred
- Variation in beak size occurred
- Natural selection resulted in selection of traits that enable finches to adapt
- Population began to look different from population on the mainland
- Gene pool changed over time
- Some finches flew to other parts of the island
- Finches are now isolated from each other by geographical barrier
- Once again mutations occurred in each population
- Natural selection occurred
- Finches on different islands developed separately and differed genetically
- Eventually, they were unable to cross breed
- Thus a new species is formed with different beak sizes and shapes

GALAPAGOS TORTOISES

- During continental drift the tortoise populations were isolated/separated from the original population on different islands living under different environmental conditions and through natural selection developed into new species develop phenotypically and genotypically differently not able to interbreed after a period of time

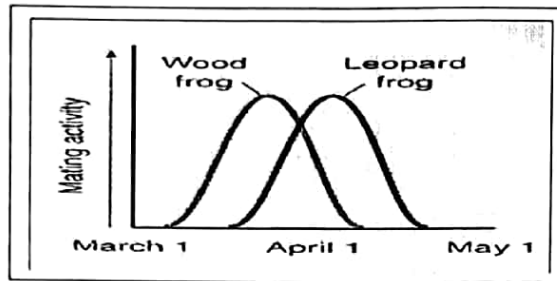
MECHANISMS OF REPRODUCTIVE ISOLATION

- Breeding at different times of the year
- Species-specific courtship behaviour
- Mechanical isolation
- Hybrid isolation
- Ecological isolation

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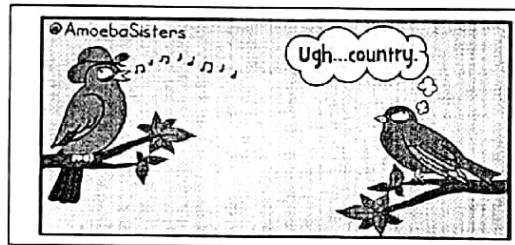
MECHANISMS OF REPRODUCTIVE ISOLATION

1. Breeding at different times of the year



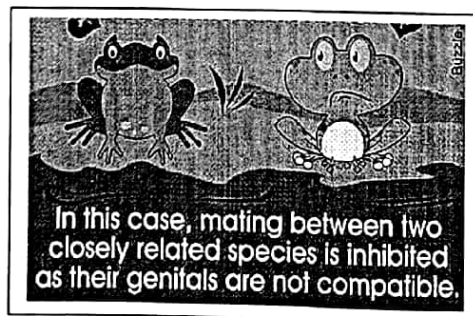
- Animal species mate and reproduce at different times of the year
- Wood frog species mates between March 1 and April 1
- Leopard frog mates between April 1 and May 1
- Two species of mayflies emerge during different weeks in springtime.

2. Species-specific courtship behavior



- Courtship rituals are species specific and only individuals of the same species will recognize the signals. The two bird species are unable to recognize each other's courtship rituals. Two similar species of birds have different mating rituals

3. Mechanical isolation



- Organisms may have structural adaptations that ensure that they are only fertilized by their own species
- The frog species have genitalia that are not compatible and hence cannot mate. Two species of orchid have different length nectar tubes and are pollinated by different species of moths.

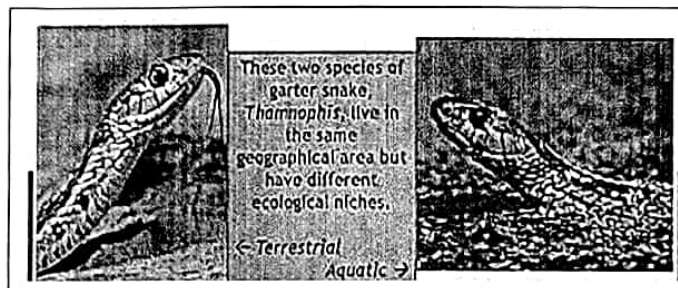
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4. Hybrid isolation



- Two different species can sometimes crossbreed and produce a hybrid offspring
- The hybrid is often infertile and unable to produce offspring
- In the image a donkey mates with a horse to produce a mule which is an infertile hybrid

5. Ecological isolation



- Organisms may live in different habitats or niches in the same environment and use different resources
- This decreases the chances of meeting mating partners
- The one snake is found on land while the other is found in aquatic environment decreasing their chances of meeting to mate

EVOLUTION AT PRESENT TIMES

- insecticides in insects
- Mosquito population had variation
- Resistant to DDT and others not resistant
- Mosquitoes that were resistant to DDT survive and reproduce offspring
- Mosquitoes that were not resistant to DDT died
- DDT also killed birds and fish that naturally prey on mosquitoes
- Gene pool of Mosquito population changed

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Resistant strains of tuberculosis-causing bacteria

- Bacteria undergo mutations
- The applications of antibiotics changes the environment and acts as a selection pressure
- The mutated resistant bacteria are selected and survive
- Most of non-resistant bacteria are destroyed by the antibiotics
- While resistant ones multiply
- The characteristic of resistance is inherited
- Eventually a new bacteria population that is resistant to a specific antibiotic

HIV resistance to antiretroviral medication

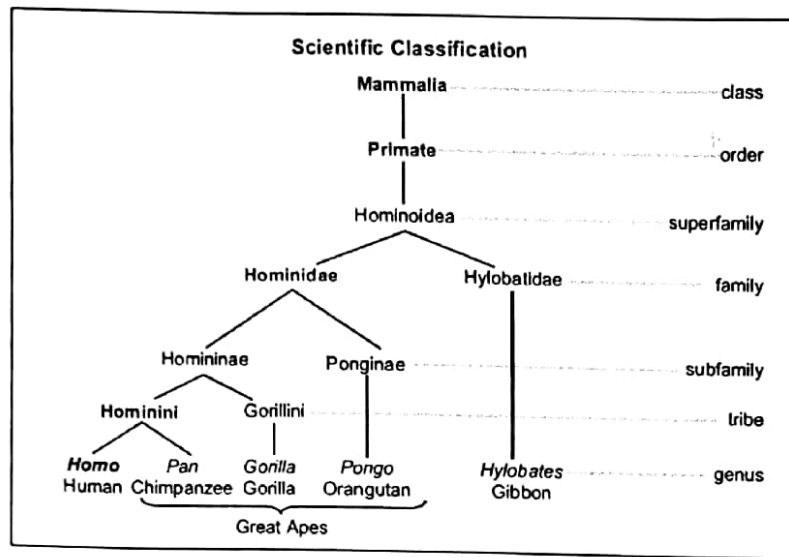
- Some viruses develop mutations that make them resistant to ARVs
- This introduces variation
- The application of ARVs changes the environment and acts as a selection pressure
- Resistant viruses are selected, survive and multiply
- A drug resistant virus population develops

Bill (beak) and body size of Galapagos finches

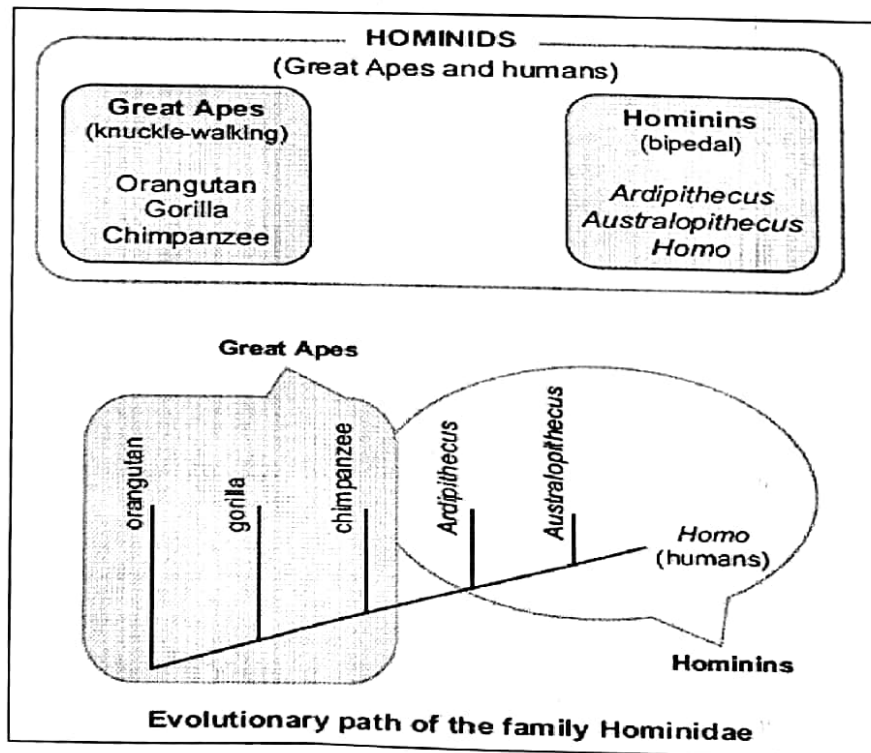
- There was variation in the size of beaks
- During normal wet seasons plants used to produce small and large seeds.
- The small seeds could be eaten by the finches with small and medium beaks.
- The large seeds could be eaten by the finches with large beaks.
- Between 1976 – 1978 there was a serious drought.
- During the drought the small seeds were depleted and larger seeds were plentiful.
- Many of the small to medium beak finch species could not survive the drought and died
- The bigger beaked finches were able to break open the coats of large seeds in order to get to the seeds.
- Therefore the finches with larger beaks had a competitive advantage during the drought period where larger seeds were available.
- Environmental selection pressure eliminated finches with small beaks due to a lack of food
- Presently only large beaked finches have been able to survive and are naturally selected due to their advantageous gene of having larger beaks.
- The genes for larger birds with strong beaks were passed on to successive generations

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EVIDENCE OF A COMMON ANCESTOR

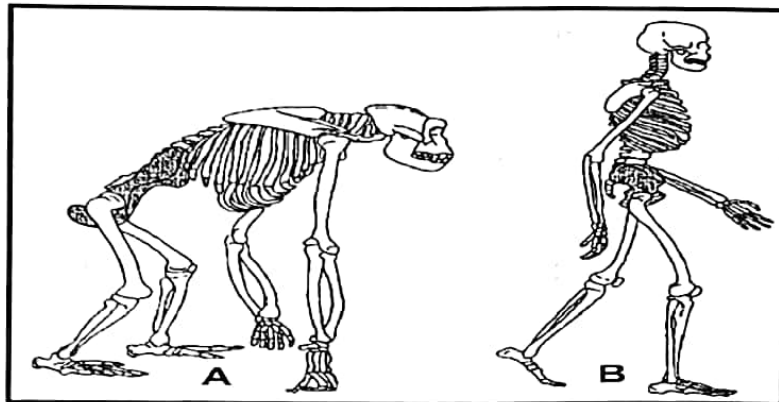


- All members of the family Hominidae are known as **hominids** (Great Apes and humans).
- **Hominines** refers to humans and their fossil ancestors.
- **hominid** refers to the Great Apes as well as humans and their fossil ancestors.
- **Great Apes** are also often referred to as African Apes



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Comparing African apes and Humans



Similarities between African apes and Humans

- Long upper arms
- Freely rotating arm
- Elbow joints allowing rotation of forearm
- Opposable thumbs
- Flat nails instead of claws/bare finger tips
- Large brains/skulls compared to their body mass
- Eyes in front/binocular vision/stereoscopic vision
- Eyes with cones/colour vision
- Sexual dimorphism/distinct differences between male and female
- Olfactory brain centres reduced/reduced sense of smell
- Portions of the brain centre that process information from hands and eyes enlarged

Anatomical differences between African apes and humans

The skull

African apes	Humans
Smaller cranium/brain	Large cranium/brain
Face sloping	Flat face
Brow ridges pronounced	Brow ridges not pronounced
Larger canines	Small canines
Large spaces between the teeth	Smaller spaces between the teeth
Jaw with teeth in a rectangular/U shape	Jaw with teeth in a round shape
More pronounced jaws/prognathous	Less pronounced jaw
Poorly developed chin	Well-developed chin
Foremen magnum at the back of the skull	Foremen magnum at the front/bottom of the skull
Long and narrow pelvis	Short and wide pelvis
C-shaped spine	S-shaped spine
Quadrupedal	Bipedal
Flat feet	Curved foot arch
Opposable toes on feet	No opposable toes on feet

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Evidence that indicates hominids may have shared a common ancestor:

- Fossil evidence
- Genetic evidence
- Cultural evidence

1. Fossil evidence

Bipedalism

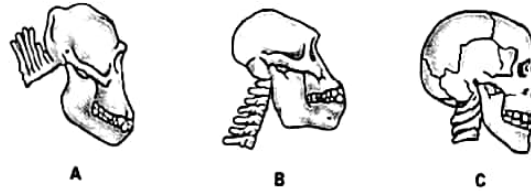


Chimpanzee (quadrupedal)

Human (bipedal)

-Apes are four-footed (quadrupedal) with gorillas and chimpanzees demonstrating a particular manner of walking, i.e. knuckle-walking.
-Humans, however, are bipedal and walk upright
-Hominid fossils show evidence of a transition from quadrupedalism to bipedalism

Position of foreman magnum



A. Chimpanzees: foramen magnum is at the back of the skull

B. Early Homo species: foramen magnum is closer to the front for stable upright walking

C. Homo sapiens: foramen magnum is directly above the spine to balance the head above the vertebrae

Vertebral column



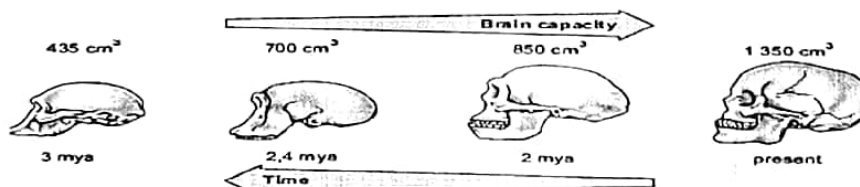
The human vertebral column is S-shaped for flexibility and shock absorption. The vertebral column of apes is C-shaped.

Pelvic girdle



The human pelvic girdle has become larger, shorter and wider to support the greater weight due to the upright posture. The pelvic girdles of apes are long and narrow.

Brain size



-Hominid fossils indicate that the size of the cranium increased in most fossils over time. We may conclude that, in general, the size of the brain (brain capacity) increased over time.

-The more complex human brain gave rise to:

- *well developed hand-eye coordination (to make and use tools)
- * the capacity for language
- *the use of fire

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Prognathism

Gorilla
(Ape)

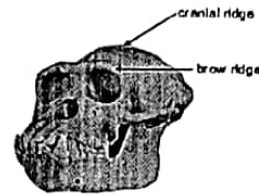


Australopithecus
(Fossil ancestor)



Homo sapiens
(Human)

- Apes have large, protruding jaws (snout or muzzle) without a chin. Their jaws protrude beyond the upper part of the face, which results in a sloping face.
- As the teeth become smaller over time, so the jaws become less protruding (reduced prognathism) and more rounded. The face appears flatter and less sloping
- Humans have a narrow, flat face with rounded jaws and a protruding chin. The forehead appears more vertical as a result of the larger cranium that contains a larger brain

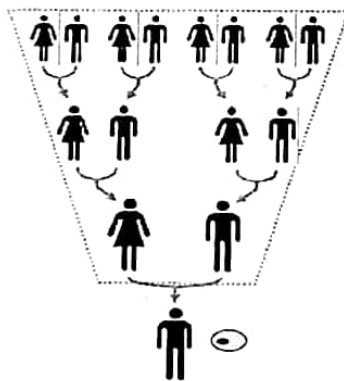
Cranial and brow ridges

Chimpanzee skull with prominent cranial and brow ridges



Human skull with completely reduced cranial and brow ridges

- Apes have prominent cranial and brow ridges for attachment of well-developed chewing muscles
- Cranial and brow ridges are completely reduced in humans

2. Genetic evidence**Chromosomal DNA**

Chromosomal
DNA is inherited
from all ancestors

- Chromosomal DNA occurs in the nuclei of all cells and contains all the genetic information pertaining to the characteristics of the organism.
- Chromosomal DNA is transferred by both parents (mother and father) to their offspring, thus chromosomal DNA is inherited from all ancestors.
- A comparison of the chromosomal DNA of living hominids may determine how closely related they are.
- The more similarities found in the DNA, the

Mitochondrial DNA (mtDNA)

Cladogram that indicates when the evolutionary paths of living hominids possibly separated

- By comparing the mtDNA of living hominids, scientists can attempt to determine when the evolutionary paths of humans and African apes separated.
- If there are many differences, the separation occurred earlier.
- This means there was more time for mutations to occur so there is more variation.
- If there are fewer differences, the separation occurred more recently.
- There was thus less time for mutations to occur and there is less variation.
- In this way, scientists determined that a common

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closer the relationship.

-Although every person is unique, 99,9% of all human DNA is identical, with only a small variation in 0,1%.

-This small genetic variation between people also serves as evidence of the close relationship between all humans.

-Humans and apes share 96 - 98% of the same DNA.

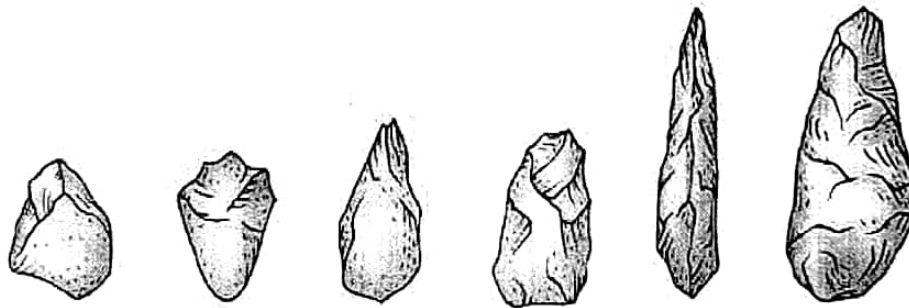
-98% of human DNA corresponds with chimpanzee DNA, which makes them the closest related hominid to humans.

-The above-mentioned evidence supports Darwin's initial idea that humans and apes share a

ancestor for all living

hominids may have existed 15 mya and that the evolutionary paths of humans and chimpanzees separated about 6 mya.

3. Cultural evidence: tools



Different hand axes in Acheulian tool culture

-The production and use of tools and other cultural practices like fire-making, burial rites, art and hunting techniques are suggested as further evidence of common ancestors for living hominids.

-The development of speech and language is another cultural change that distinguishes modern humans from primates.

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ADVANTAGES OF BIPEDALISM

- Allows total awareness of the environment in sensing danger/looking for food
- Enables hands to be free to carry tools or offspring/throw/protect
- Exposes a large surface area for thermo-regulation/lose body heat to surroundings in hot conditions/reduce overheating therefore reduce need for water
- More effective for locomotion
- Display of male/female sex organs as part of courtship behaviour

MAJOR PHASES IN THE HOMINID EVOLUTION (from 6 mya to present)

The main hominin genera within the hominid group are the following:

- Ardipithecus
- Australopithecus
- Homo

Taung child (Australopithecus africanus)  Taung skull -In 1924 the fossil skull of a hominin was found by Professor Raymond Dart at Taung, northwest of Kimberley. -It was the skull of a child of about 3 - 4 years old.	Mrs Ples (Australopithecus africanus)  Mrs Ples In 1947 a complete adult skull and various bones were found by Dr Robert Broom in the Sterkfontein Caves in South Africa.
Lucy (Australopithecus afarensis) -<u>Lucy</u> is a fossilised female skeleton found by Donald Johanson at Hadar in the Afar valley, Ethiopia in 1974. -The skeleton dates back 3,5 million years. -The shape of the pelvis indicated that Lucy was female. Australopithecus sediba (2 - 1,7 mya)	Little Foot (Australopithecus species) -In 1994 the ankle and foot bones of an australopithecine fossil was discovered in the Sterkfontein Caves by the palaeoanthropologist Dr Ron Clarke. -The fossil was named <u>Little Foot</u>. -The rest of the skeleton was found in 1997.

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In 2008 two fossils, those of a young woman and boy, were discovered in the Cradle of Humankind in the Malapa area by Professor Lee Berger and his 9-year-old son, Matthew.

HOMO SPECIES

Homo habilis



- Australopithecus africanus probably gave rise to Homo habilis.
- In 1960 a Homo habilis fossil was discovered in Tanzania.
- The body of Homo habilis was smaller than that of Australopithecus and it was ape-like.
- Homo habilis was the first group that used stone tools.
- The name Homo habilis literally means 'handy man'.

Homo erectus



- Homo erectus literally means 'upright man' and they lived 1,8 - 0,3 million years ago.
- They were probably the first hominins to migrate from Africa to Europe and Asia.
- Homo erectus made and used stone and bone tools.
- They were successful hunters and the first species that learnt to use fire.

Homo neanderthalensis



- Although their brains were larger than Homo sapiens, language was not well developed and their technological development was limited.
- They were hunters, wore clothes made from animal skins, built shelters in caves and used fire.
- They buried their dead, which is an indication of some

Homo sapiens



- This group is considered to be the direct ancestors of modern humans.
- Presumably, Homo sapiens appeared about 200 000 years ago.
- Their clothes were made mainly from leather and plant material.

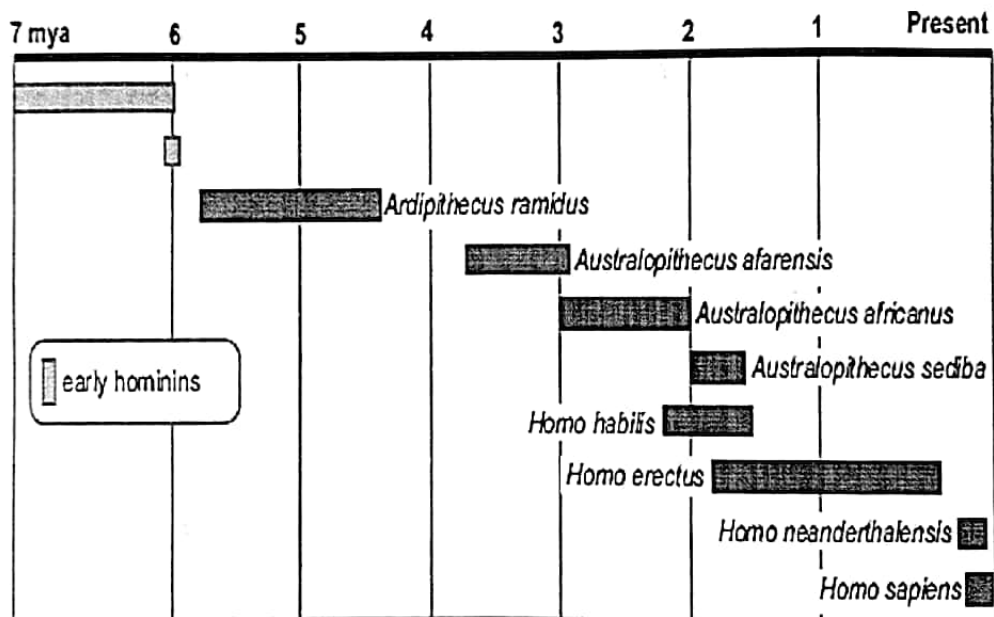
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form of 'spiritual life' or advanced culture

- They lived in tents and formed communities.
- As hunters they followed the annual animal migrations in the summer.
- They developed agriculture and cultivated the land.
- They wore jewellery and decorated their bodies with paint.
- They developed rituals that were linked to hunting, births and deaths

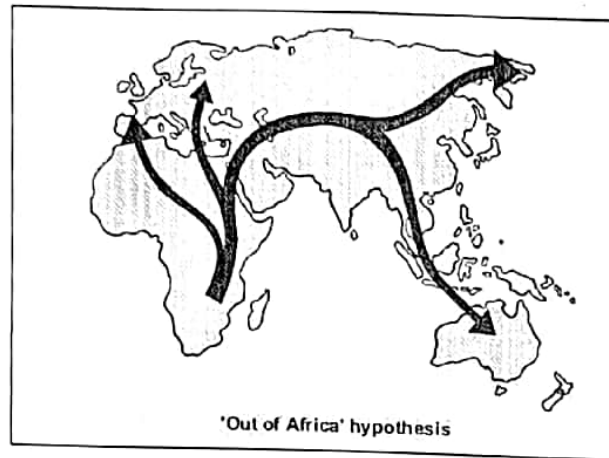
Differences between genera *Australopithecus* and *Homo*

- The brain of *Homo* was much larger and better developed. *Homo* could make and use tools, make fire and develop language.
- The skull of *Homo* was more human-like with less prominent brow ridges, a flatter face, smaller teeth and a more rounded jawbone



Timeline to illustrate evolution of hominins

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'OUT OF AFRICA' HYPOTHESIS**Fossils and artefacts of hominins found in Africa**

- The oldest fossils of Australopithecines/Homo habilis/ bipedal have only been found in Africa
- The oldest fossils of Homo erectus have been found only in Africa
- Fossils of Ardipithecus were found ONLY in Africa/Rift Valley/Ethiopia/South Africa
- The OLDEST fossils of Homo sapiens were found in Africa

Genetic links as evidence for the 'Out of Africa' hypothesis

1. Chromosomal DNA (excluding Y-chromosomes)
 - Analysis of Y chromosome shows that the oldest male ancestors of humans are from Africa
 - The Y chromosome shows the paternal line
2. Mitochondrial DNA
 - Mitochondrial DNA is inherited only from the maternal line
 - Analysis of mutations on this mitochondrial DNA shows that the oldest female ancestor were located in Africa and that all humans descended from her/mitochondrial Eve
 - Any mutation on this DNA can be traced along the maternal line only
3. CULTURAL EVIDENCE
 - The OLDEST/most primitive artefacts (tools, cutlery, art etc.)
 - were found in Africa

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