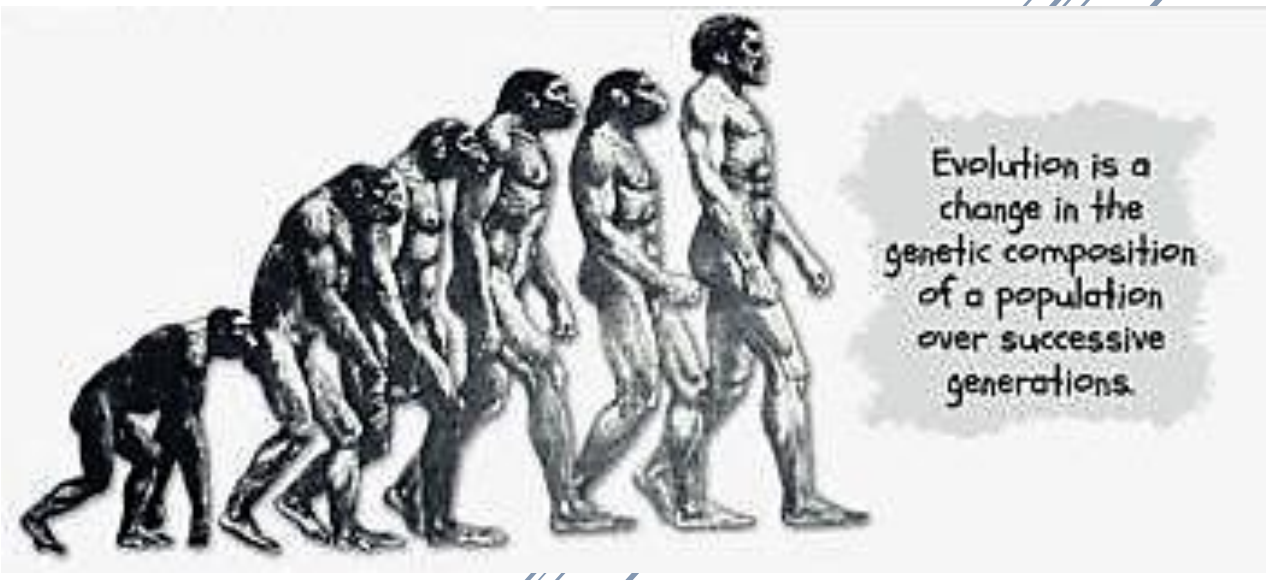
HOW TO …

LIFE SCIENCES

GRADE 12

LEARNER'S GUIDE

TERM 3



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LIFE SCIENCES Grade 12

LEARNER'S GUIDE

TERM 3

11.

EVOLUTION

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11.1 EXAMINATION GUIDELINES 2021

EVOLUTION Paper 2: 54 marks	**Terms 3**	**4weeks**

CONTENT	ELABORATION
Introduction	❑ Definition of biological evolution change in the characteristics of species over time ❑ Difference between a hypothesis and a theory ❑ The Theory of Evolution is regarded as a scientific theory since various hypotheses relating to evolution have been tested and verified over time
Evidence for evolution	❑ Role of the following as evidence for evolution: • Fossil record – Link to Grade 10 • Biogeography – Link to Grade 10 • Modification by descent (homologous structures) • Genetics

Variation	❑ Definition of a biological species and a population
	❑ A review of the contribution of each of the following to variation that exists amongst individuals of the same species:
	• Meiosis
	  ○ Crossing over
	  ○ Random arrangement of chromosomes
	• Mutations
	• Random fertilisation
	• Random mating
	❑ Types of variation:
	• Continuous variation – those characteristics where there is a range of intermediate phenotypes, e.g. height
	• Discontinuous variation – those characteristics that fall into distinct categories e.g., blood groups

CONTENT	**ELABORATION**
Origin of an idea about origins (a historical development)	❑ Ideas on evolution in the order of their origin are as follows: • Lamarckism • Darwinism • Punctuated Equilibrium
Lamarckism (Jean Baptiste de Lamarck – 1744–1829)	❑ Lamarck used two 'laws' to explain evolution: • 'Law' of use and disuse • 'Law' of the inheritance of acquired characteristics ❑ Reasons for Lamarck's theory being rejected
Darwinism (Charles Darwin – 1809–1882)	❑ Darwin's theory of evolution by natural selection: • There is a great deal of variation amongst the offspring. • Some have favourable characteristics and some do not. • When there is a change in the environmental conditions or if there is competition, • then organisms with characteristics, which make them more suited, survive • whilst organisms with unfavourable characteristics, which make them less suited, die. • The organisms that survive, reproduce • and thus, pass on the allele for the favourable characteristic to their offspring. • The next generation will therefore have a higher proportion of individuals with the favourable characteristic.

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Punctuated Equilibrium (Eldredge and Gould – 1972)	❑ Punctuated Equilibrium explains the speed at which evolution takes place: • Evolution involves long periods of time where species do not change or change gradually through natural selection (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.
Artificial selection	❑ Artificial selection involving: • A domesticated animal species • A crop species

Formation of new species	❑ Biological species concept: similar organisms that are capable of interbreeding to produce fertile offspring
	
	❑ Speciation and extinction and the effect of each on 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.
	
	❑ Speciation through geographic isolation in ONE of the following:
	• Galapagos finches
	• Galapagos tortoises
	• Plants on different land masses (linked to continental drift)
	  ○ Baobabs in Africa and Madagascar
	  ○ Proteas in South Africa and Australia
	• Any example of mammals on different land masses

CONTENT	**ELABORATION**
Mechanisms of reproductive isolation (Keeping species separate)	❑ A brief outline of reproductive isolation mechanisms that help to keep species separate: • Breeding at different times of the year • Species-specific courtship behavior • Plant adaptation to different pollinators • Infertile offspring • Prevention of fertilisation
Evolution in present times	❑ Any ONE example of natural selection and evolution in present times: • Use of insecticides and consequent resistance to insecticides in insects • Development of resistant strains of tuberculosis-causing bacteria (MDR and XDR) to antibiotics, due to mutations (variations) in bacteria and failure to complete antibiotic courses • HIV resistance to antiretroviral medication • Bill (beak) and body size of Galapagos finches

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Evidence of common ancestors for living hominids, including humans	❑ Interpretation of a phylogenetic tree to show the place of the family Hominidae in the animal kingdom ❑ Characteristics that humans share with African apes ❑ Anatomical differences between African apes and humans, with the aid of diagrams, as it applies to the following characteristics: • Bipedalism (foramen magnum, spine and pelvic girdle) • Brain size • Teeth (dentition) • Prognathism • Palate shape • Cranial ridges • Brow ridges ❑ Lines of evidence that support the idea of common ancestors for living hominids including humans: • Fossil evidence: Evidence from fossils of different ages show that the anatomical characteristics of organisms changed gradually over time. • Emphasis on evolutionary trends provided by the anatomical features of fossils of the following three genera: ○ *Ardipithecus* ○ *Australopithecus* ○ *Homo* as well as: ○ The age of each fossil found/time-line for the existence of the three genera ○ The fossil sites where they were found: emphasis on the fossil sites that form a part of the Cradle of Humankind ○ The scientists who discovered them • Genetic evidence: mitochondrial DNA • Cultural evidence: tool-making
Out-of-Africa hypothesis	❑ The Out-of-Africa hypothesis: Modern humans originated in Africa and then migrated to other continents ❑ Evidence for the 'Out-of-Africa' hypothesis: • Fossil evidence: information on each of the following fossils that serve as evidence for the 'Out-of-Africa' hypothesis: ○ *Ardipithecus* (fossils found in Africa only) ○ *Australopithecus* (fossils found in Africa only, including Karabo, Little Foot, Taung Child, Mrs Ples) ○ *Homo* (fossils of *Homo habilis* found in Africa only; oldest fossils of *Homo erectus* and *Homo sapiens* found in Africa, while the younger fossils were found in other parts of the world) • Genetic evidence: mitochondrial DNA ❑ Timeline for the existence of different species of the genus *Homo* and significant features of each of fossil type to show the differences amongst them ❑ Interpretation of phylogenetic trees proposed by different scientists showing possible evolutionary relationships as it applies to hominid evolution

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A. REVISION GUIDELINES

PAPER	TOPIC	CONTENT	KEY POINTS TO FOCUS ON DURING REVISION
P2	**EVOLUTION (54 marks) Refer to the notes and examples provided**	Evidence for evolution	• Role of the following as evidence for evolution: ✓ Fossil record ✓ Biogeography ✓ Modification by descent (homologous structures) ✓ Genetics
		Sources of variation	• Meiosis: ✓ Crossing over ✓ Random arrangement of chromosomes • Mutations • Random fertilisation • Random mating
		Lamarck and Darwin's theories	• State the general theories according to the Exam Guidelines but apply it to a given example
		Natural and artificial selection	• Describe the processes • Tabulate the differences **Emphasise:** • See Diagnostic report p165 (2021) • Learners must identify the favourable and unfavourable traits in questions on natural selection include the exact description of these traits in their responses.
		Punctuated equilibrium	• Describe
		Speciation	• Apply the example given in a paper according to the format in the Examination Guidelines • Be able to identify the geographic barrier and speciation of one species becoming different species **Emphasise:** • The terms population and species. Only a population is separated by a geographical barrier and not a species. • Clarify the following concepts in speciation: ✓ A population is separated, not a species ✓ Speciation occurs due to natural selection ✓ More than two species may be formed See Diagnostic Report p165
		Mechanisms for reproductive isolation	• Refer to Examination Guidelines
		Evolution in present times	• Any ONE example according to Examination Guidelines
		Human evolution: similarities of humans and African apes	• With the aid of diagrams, as it applies to the characteristics in the Examination Guidelines:
		Human evolution: differences	E.g • Long and narrow vs. short and wide

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PAPER	TOPIC	CONTENT	KEY POINTS TO FOCUS ON DURING REVISION
		between humans and African apes	• Large canines vs. small canines • C shaped vs. S shaped vertebral column • The significance of the evolutionary changes E.g Foramen magnum more in front and under the skull
		Trends in human evolution	• Interpretation of phylogenetic trees proposed by different scientists showing possible evolutionary relationships as it applies to hominid evolution
		Out of Africa hypothesis	• According to the examination guidelines • Focus on species found in Africa or found ONLY Africa

11.2 TERMINOLOGY – EVOLUTION

Key terminology

biological evolution	any genetic change in a population that is inherited over several generations
biological species	a group of organisms with similar characteristics that interbreed with one another to produce fertile offspring
population	a group of individuals of the same species occupying a particular habitat
punctuated equilibrium	evolution characterised by long periods of little or no change followed by short periods of rapid change
natural selection	mechanism of evolution - organisms survive if they have characteristics that make them suited to the environment
artificial selection	human-driven selective force, e.g. breeding of plants and animals to produce desirable traits
inbreeding	mating of individuals that are closely related
outbreeding	mating of individuals that are not closely related
speciation	the formation of a new species
geographic speciation	formation of a new species when the parent population separated by a geographical barrier
reproductive isolation	a mechanism that prevents two species from mating with one another and making fertile hybrids

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B. TEACHING TIPS & TOOLS

EVOLUTION

Definitions:

Definition of biological evolution:

Biological evolution refers to any **genetic change** in a **population** that is **inherited** and becomes a **characteristic** of that population over **several generations.**

Difference between a hypothesis and a theory

A hypothesis is possible prediction and or explanation and it always states both variables. A hypothesis is tested in a series of experiments or by repeated observation.

A theory is a well-substantiated (supported by evidence) explanation supported by scientific evidence that have been tested and verified over time.

Definition of a species and a population

Population

A group of organisms of the **same species**√

- that lives together in a **defined area**√

- at a **given time**√

- and i**nterbreeding**√ can take place

Species

A group of organisms that have **similar characteristics**√

- and can **interbreed**√

- to produce **fertile offspring**√

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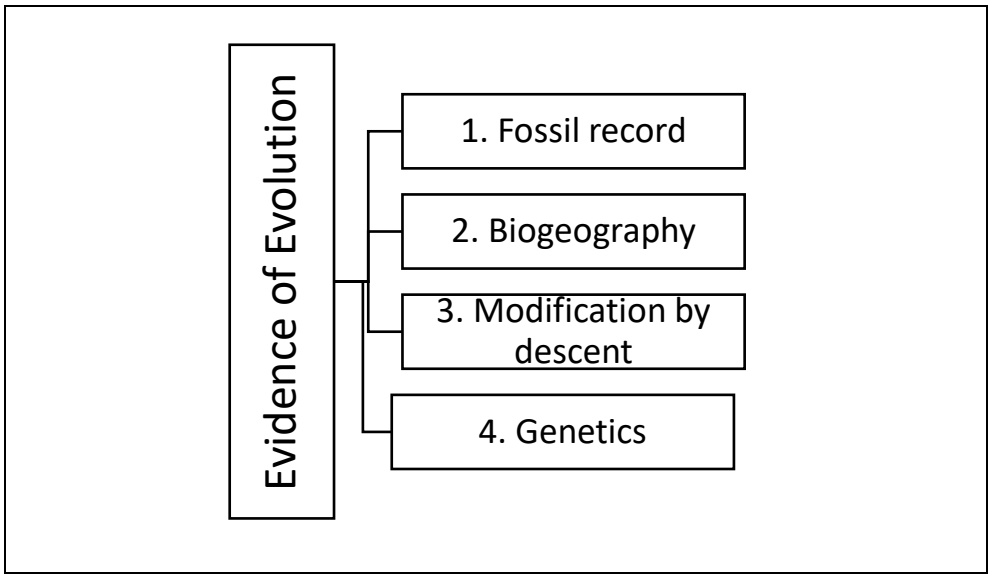
EVIDENCE OF EVOLUTION



1. **Fossil record** (Link to Grade 10)

Fossils are the remains of ancient life forms preserved usually in rock. Radiometric dating is used to determine the age of the rock in which the fossil is preserved. Scientists used the age of fossils to establish when organisms existed and to determine the characteristics of the organism by studying the fossil. Knowledge of these characteristics allows us to see relationship amongst different organisms, this is represented in a phylogenetic tree.
Fossils provide evidence of the history of extinct organism on earth and give an indication of the climate and environment millions of years ago.

Palaeontology **-** refers to the **study of fossils**

Palaeontologist **-** scientists who studies the history of life on earth through fossil records

2. **Biogeography** (Link to Grade 10)

Biogeography refers to the study of the distribution of existing and extinct plant and animal species in specific geographic regions with similar habitats and climatic conditions but separated by geographical barriers.

These studies prove that closely related species usually occur in the same geographical region which may suggest that they also share a common ancestor.

For example: Baobab trees in Africa and Madagascar

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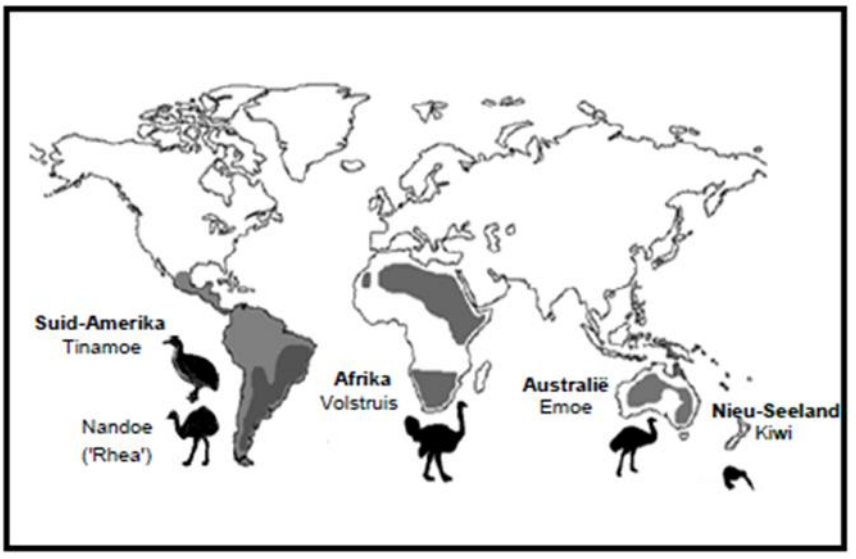
The distribution of the flightless birds: e.g. ostriches in Africa, rheas in southern America, kiwis and emus in Australia. They show great similarities although they live on different landmasses and belong to separate species.



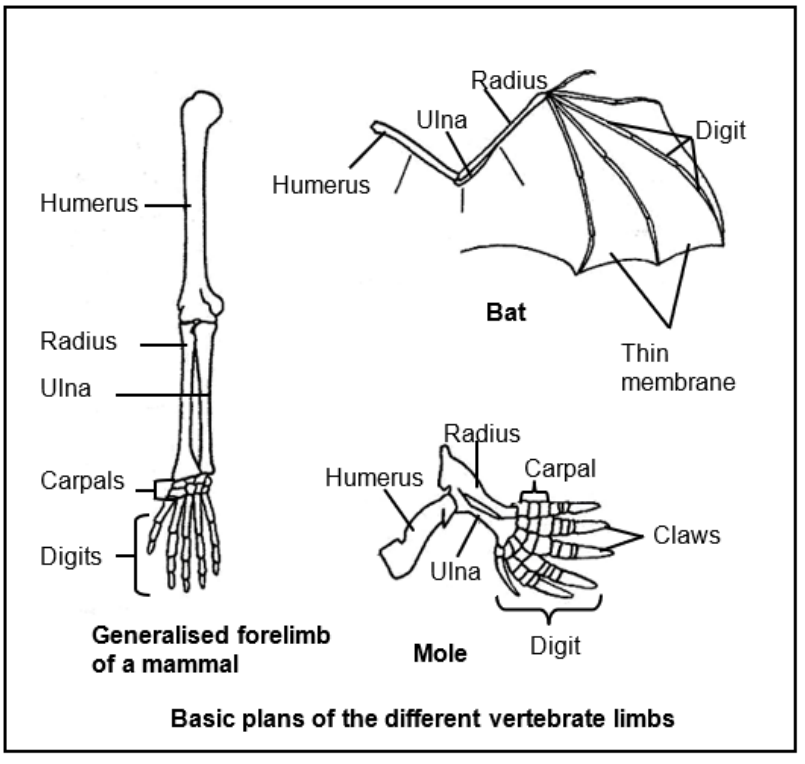
3. Modification by descent (homologous structures)

Homologous structures

Homologous structures have the same basic plan even though they perform different functions. Comparison of homologous structures among organisms to show similarities and differences e.g. homologous bone structures in the front limbs of different vertebrates, Scientist interpret homologous structures in the way that it indicates common ancestor.

Modification by descent

Is the phenomenon where the basic body plan of different plants and animals were modified over time to be better adapted to their different environments.



Basic plans of the different vertebrate limbs

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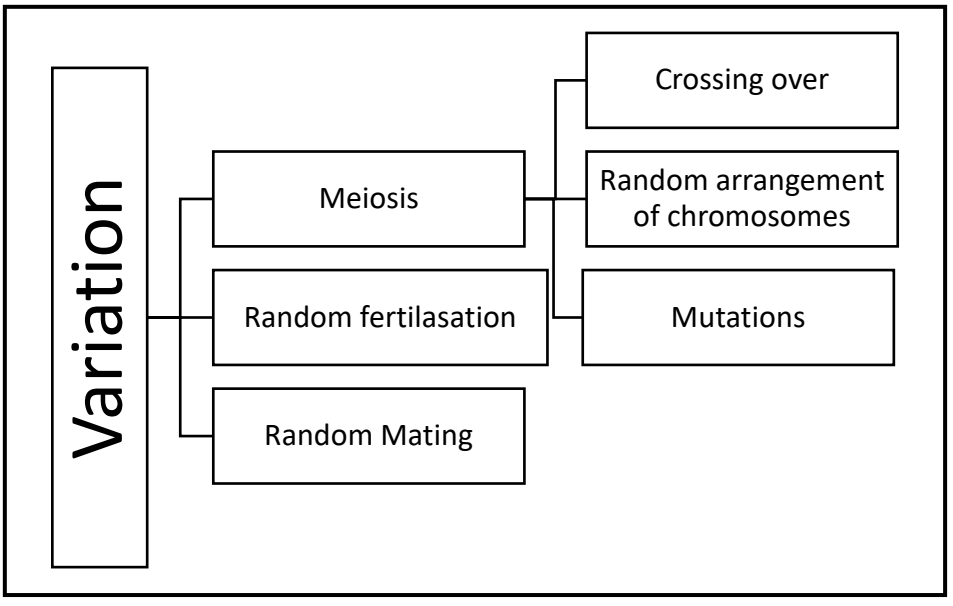
4. Genetics

Species which have very similar sequences of genes on their DNA will be closely related, and therefore developed from a more recent common ancestor.

The following features show possible common origin of different organisms:

- Identical DNA compounds
- Similar sequence of genes
- Similar portions of DNA with no function
- Identical protein synthesis

SOURCES OF VARIATION



1. Meiosis

1.1. Crossing over

- occurs during prophase I ✓
- Homologous chromosomes ✓
- non-sister – chromatids/adjacent chromatids overlap ✓
- at points called chiasma ✓/chiasmata
- Genetic material is exchanged ✓
- resulting in new combinations of genetic material from both parents ✓

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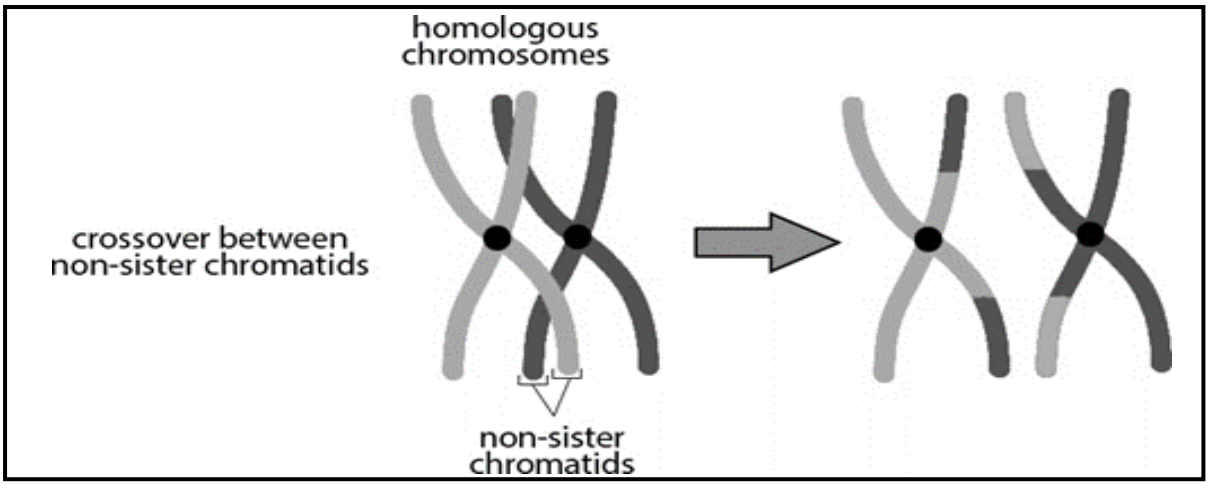
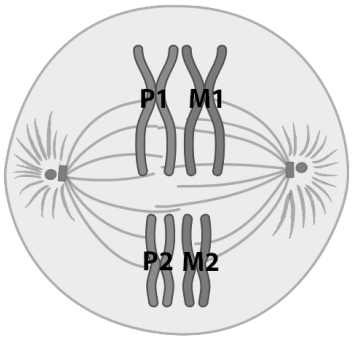


1.2. Random arrangement of chromosomes

- Homologous chromosome pairs✓ arrange randomly on the equator during Metaphase 1 ✓
- and single chromosomes✓ arrange randomly on the equator during Metaphase 2✓
- This results into genetic different gametes✓



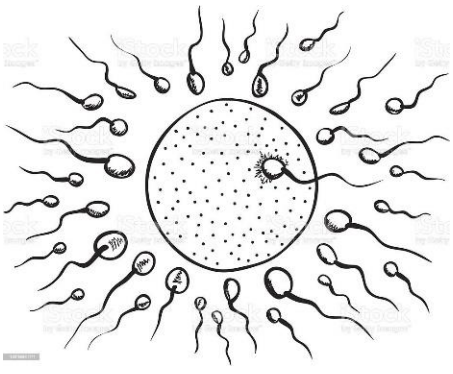
1.3 Mutations

Gene Mutation – a change in the sequence of nitrogenous bases or nucleotides of DNA

Chromosomal mutation – a change in the normal structure or number of chromosomes

2. Random fertilisation

Random fertilisation between different egg cells and different sperm cells formed by meiosis result in offspring that are different from each other.



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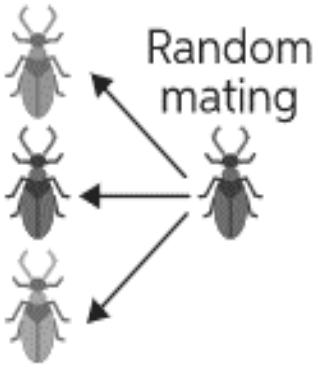
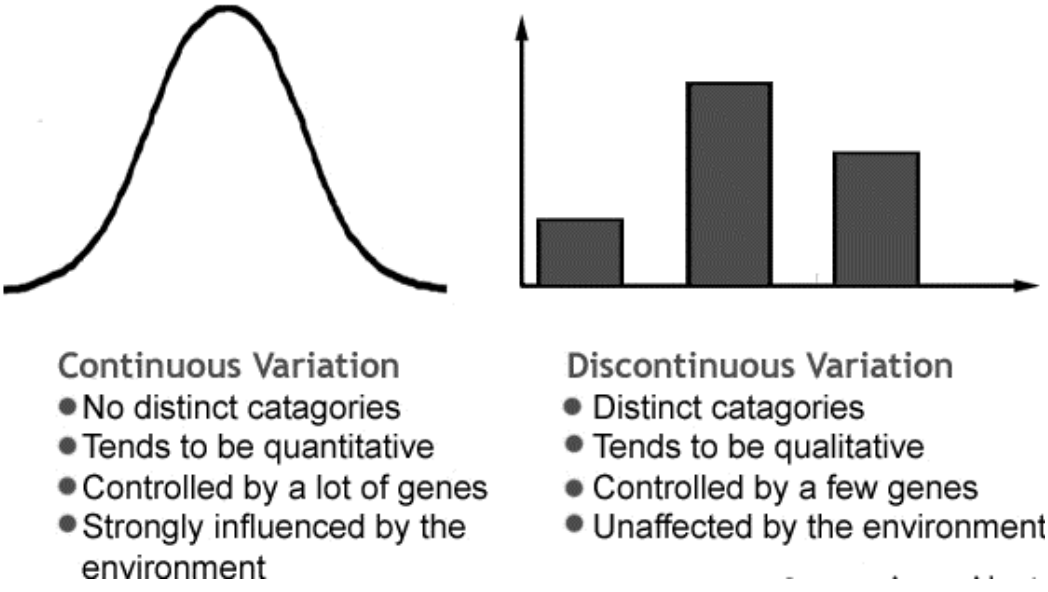
3. Random mating

Random mating between organisms within a species leads to a different set of offspring from each mating pair, where any male could mate with any female.



TYPES OF VARIATION IN A SPECIES

- **Continuous variation** – those characteristics where there is a **range** of intermediate phenotypes e.g. height
- **Discontinuous variation** – those characteristics that fall into **distinct categories** e.g. blood groups



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EVOLUTION THEORIES

1. LAMARCKISM (Jean Baptiste de Lamarck (1744-1829)

1.1 Law of use and disuse

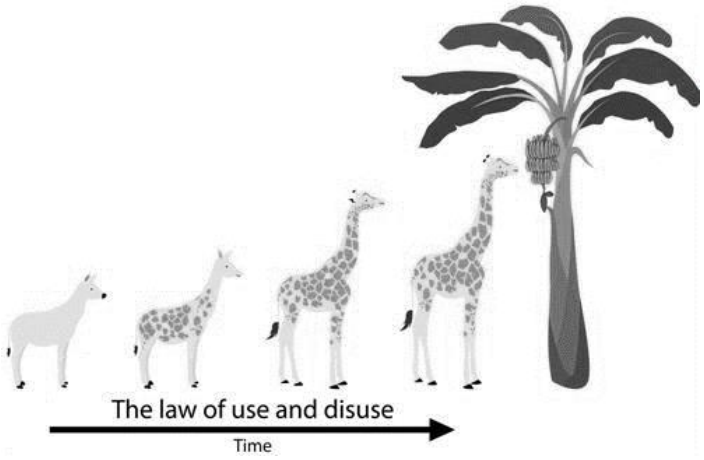
Changes in the environment create new needs that cause organisms to modify their existing organs to meet the need. Repeated use of the organ would cause it to enlarge and become more efficient. Disuse of an organ would cause it to degenerate.

1.2 Law of inheritance

The modification an organism acquired during its lifetime could be passed on to its offspring.

How to describe Lamarckism

Example:



GUIDING QUESTIONS	LAMARCK'S EXPLANATION
What was the original characteristic at the start?	All giraffes had **short necks** originally
What did the organism do?	Giraffes frequently stretched
Why did the organism do this?	Used their necks to reach - for leaves of tall trees/to feed
What was the result?	Necks become longer
What happened to this new characteristic?	The **long necks acquired** in this way could be passed on to the next generation /were inherited
What was the result of this?	All the giraffes have **long necks**

Refer to the characteristic (long necks) – do not only state …

The favourable characteristic was passed on to the next generation.

Explain why Lamarck's theory is not accepted/rejected by most scientists today.

Acquired characteristics✓are **not inherited**✓/do not cause any change to the DNA of an organism's gametes (sperms or ova) ✓

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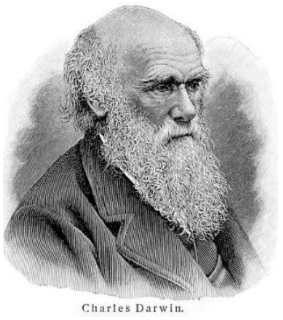
2. Darwinism (Charles Darwin (1809 – 1882)

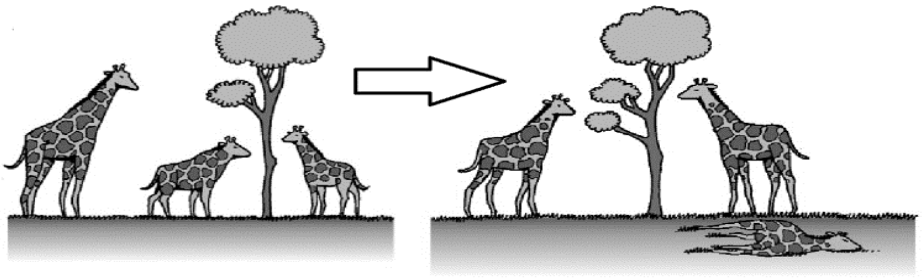


Darwin's theory of evolution by natural selection:

- There is a great deal of variation amongst the offspring.
- Some have favourable characteristics, and some do not.
- When there is a change in the environmental conditions or if there is competition,
- then organisms with characteristics, which make them more suited, survive.
- Whilst organisms with unfavourable characteristics, which make them less suited, die.
- The organisms that survive, reproduce
- and thus, pass on the allele for the favourable characteristic to their offspring.
- The next generation will therefore have a higher proportion of individuals with the favourable characteristic.

Note the difference on how to answer this from previous years.

How to describe Darwinism



Natural Selection in action

GUIDING QUESTION	DARWIN'S EXPLANATION
State the /gene characteristic that varies	There is a variation in the **length** of giraffes' necks.
Describe the variations	There were giraffes with **long** necks and **short** necks
Explain the environmental change/ selection pressure for natural selection	Leaves/ food was only available at the top of the tree/higher trees and natural selection took place between giraffes with long necks and short necks for food
State the unfavourable characteristic and why it is unfavourable	Giraffes with short necks (unfavourable characteristic) could not get food from the top of a tree/higher trees, their necks were too short
Explain what happened to this individual with the unfavourable characteristics	They died of hunger
State the favourable characteristic and why it is favourable	Giraffes with long necks (favourable characteristic) could get food from the

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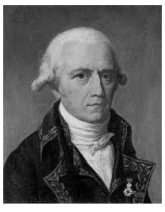
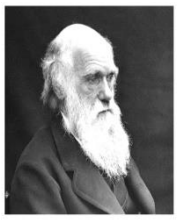
	top of a tree/higher trees, their necks were long enough
Explain what happened to this individual with the favourable characteristics	They could eat more leaves/food and survive
What happened to the favourable characteristic	The giraffes with the long necks reproduced
	The **allele for long necks** will be passed on to the offspring.
	The next generation will have higher proportion of giraffes with long necks

Differences between Lamarck's and Darwin's Theories





LAMARCK'S THEORY	DARWIN'S THEORY
Variation of offspring brought about individuals in the population that are changing	Offspring inherited the variation
Individuals want to change	Environmental factors working randomly
Change because of adaptation to environment	Natural selection – best suited to the environment will survive
Individuals in the population change	The whole population changes
Changes brought about by adaptation to the environment are inherited from parent by offspring	Characteristics are passed on from generation to generation to enable individuals to survive in the environment.

3. Punctuated Equilibrium (Eldredge and Gould – 1972)

Punctuated Equilibrium explains the speed at which evolution takes place:

- Evolution involves **long periods** of time where species **do not change** or change gradually through natural selection (known as equilibrium).
- This alternates with **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 is supported by the absence of transitional fossils indicating the period of rapid change.

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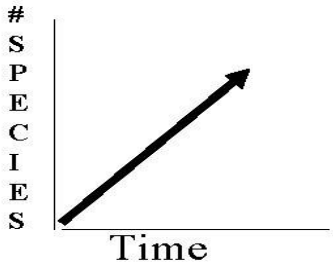
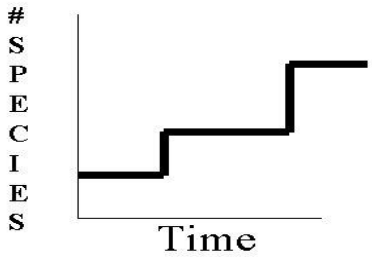
Graphs showing time frame of Evolution:

- **Gradualism:**
- **Punctuated Equilibrium**





Differences between Gradualism (Natural Selection) and Punctuated equilibrium

NATURAL SELECTION		PUNCTUATED EQUILIBRIUM
Change is continuous and slow for many years	Time period	Change occurs during brief period
New species evolve through the accumulation of many small changes over a long period of time	Change of Species	Species exist unchanged for many years and then a short period of time there is a sudden change
Constant and consistent	Change in a population	Irregular and inconsistent
Supported by transitional form	Fossil record	Supported by lack of intermediate forms

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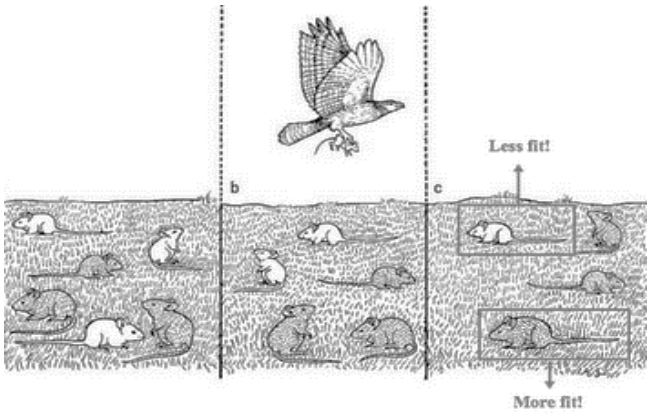
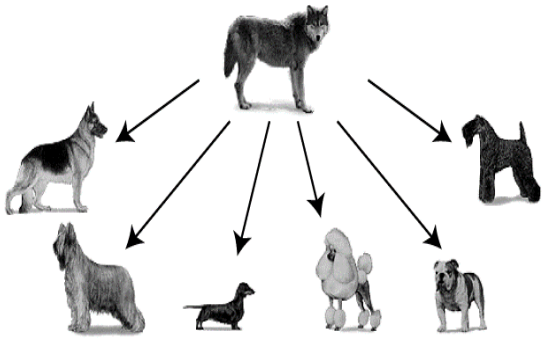
NATURAL SELECTION VS ARTIFICIAL SELECTION

Natural selection is the mechanism of evolution where natural selects the fittest individual for survival.

Artificial selection is the deliberate breeding of plants and animals for desirable characteristics that would not necessarily benefit the survival of the offspring.

NATURAL SELECTION	ARTIFICIAL SELECTION
Environment is the selective force	Human is selective force
The selected characteristics are advantageous for survival in the natural environment	The selective characteristics are not necessarily advantageous for survival, but beneficial to humans
It increases variation/ biodiversity	It decreases variation/biodiversity
Occurs in natural populations	Occurs in domestic populations
Occurs within a species	May involve one/more species
A slow process	A rapid process
Allows inheritance of beneficial traits over generations	Allows inheritance of selected traits over generations





Similarities between Natural selection and Artificial selection

- Variation occurs in the 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
- Changes occur over many generations

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SPECIATION through geographic isolation

The evolutionary process during which new species from, is known as speciation.

- 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.

NOTE HOW WE ANSWER IT BY APPLYING AN EXAMPLE

- ☐ **The BOLD is the fact that you state** according to the exam guidelines.
- ☐ **The highlighted/Grey part is what you must get out of the example in the question.**

If a population of a single species/original population
(Mention the original species in the extract that they give you and refer to where the species lived)

becomes separated by a geographical barrier
(Mention the specific barrier sea, river, mountain, lake)

then the population splits into
(Mention in how many **populations** do the original species /original population splits into according to the extract)

There is now no gene flow between the …
(Mention how many populations are there now)

Since each population may be exposed to different environmental conditions/the selection pressure may be different
(Mention the selection pressure if there is one mentioned in the example)

natural selection <u>OCCURS INDEPENDENTLY</u> in each of the two/three etc. populations

such that the individuals of the two populations become very different from each other,

genotypically and phenotypically.
(Mention the differences if the extract indicates differences)

Even if the two populations were to mix again,
they will not be able to interbreed.

The two populations are now different species, name the new species. *(mention the new species that form)*

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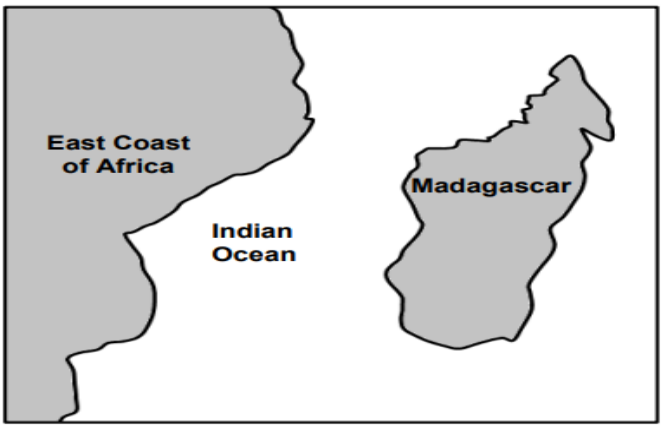
Example 1

Pottos and lemurs are small mammals. Scientists believe that pottos and lemurs share a common ancestor that existed in Africa. Presently pottos only occur in Africa while lemurs are only found in Madagascar. Madagascar is an island off the East coast of Africa as shown in the diagram below.



Describe the speciation of the pottos and lemurs

- **The BOLD is the fact that you state** according to the exam guidelines
- **The highlighted part is what you must get out of the example**

Applying the example:

If a population of a single species/original population
(Mention the original species in the extract that they give you and refer to where the species lived)

If the original population of the common ancestor/small mammals of the pottos and lemurs that existed in AFRICA

becomes separated by a geographical barrier,
(Mention the specific barrier sea, river, mountain, lake)

becomes separated by a geographical barrier the Indian Ocean
then the population splits into …
(Mention in how many **populations** does the original species /original population splits into according to the extract)

then the population splits into 2 - Africa and Madagascar

There is now no gene flow between the …
(Mention how many populations are there now)

There is now gene flow between the two population in Africa and Madagascar

Since each population may be exposed to different environmental conditions/the selection pressure may be different
(Mention the selection pressure if there is one mention in the example)

Each population may be exposed to different environmental conditions on the East Coast of Africa and Madagascar

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natural selection occurs independently in each of the two/three etc. populations

natural selection occurs independently in each of the islands

such that the individuals of the two populations become very different from each other

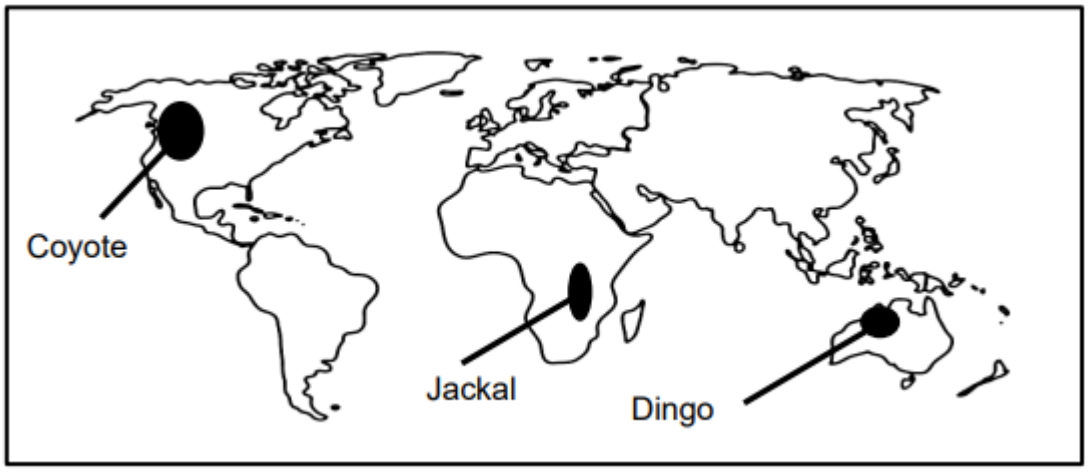
genotypically and phenotypically.

Even if the two populations of Africa and Madagascar were to mix again they will not be able to interbreed.

The two populations are now different species, Pottos and Lemurs

Example 2

The present-day distribution of three closely related species of the dog family, the coyote, jackal and dingo, is shown on the world map below.



If a population of a single species Dog family/ original population of the dog's ancestor lived on a large continent

They become separated by a geographical barrier/by continental drift/ ocean

The population splits into three

There is now no gene flow between the three populations, Jackal, Coyote and Dingo

Since each population may be exposed to different environmental conditions on the three continents/ islands

natural selection occurs independently in each of the three populations
such that the individuals of the three populations become very different from each other,

genotypically and phenotypically

Even if the three populations were to mix again,

they will not be able to interbreed.

The three populations are now different species, coyote, jackal and dingo

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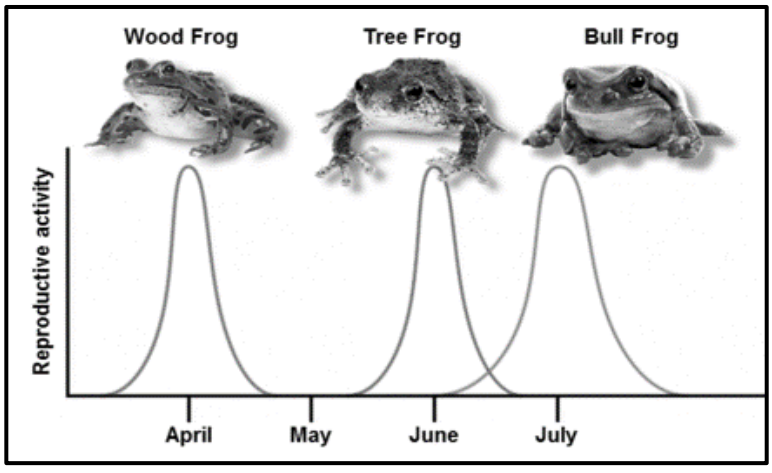
REPRODUCTIVE ISOLATION MECHANISMS

<u>NB Learners must write the whole description not just mention names like courtship!!!</u>

- **Breeding at different times of the year**

  Different species will have different breeding seasons or, in the case of plants, will flower at different times of the year, to prevent cross-pollination.



- **Species-specific courtship behaviour**

  Some animals have very specific courtship behaviours that do not attract individuals of other species, even if they are closely related species. Courtship behaviour is a physical or chemical signal that an organism is ready to mate. This can include anything from being brightly coloured, to singing elaborate mating songs or mating dances, to the secretion of pheromones to attract a mate.

The blue-footed booby (*Sula nebouxii*) performs an elaborate courtship dance.

The masked booby (*Sula dactylatra*) performs a different courtship ritual.

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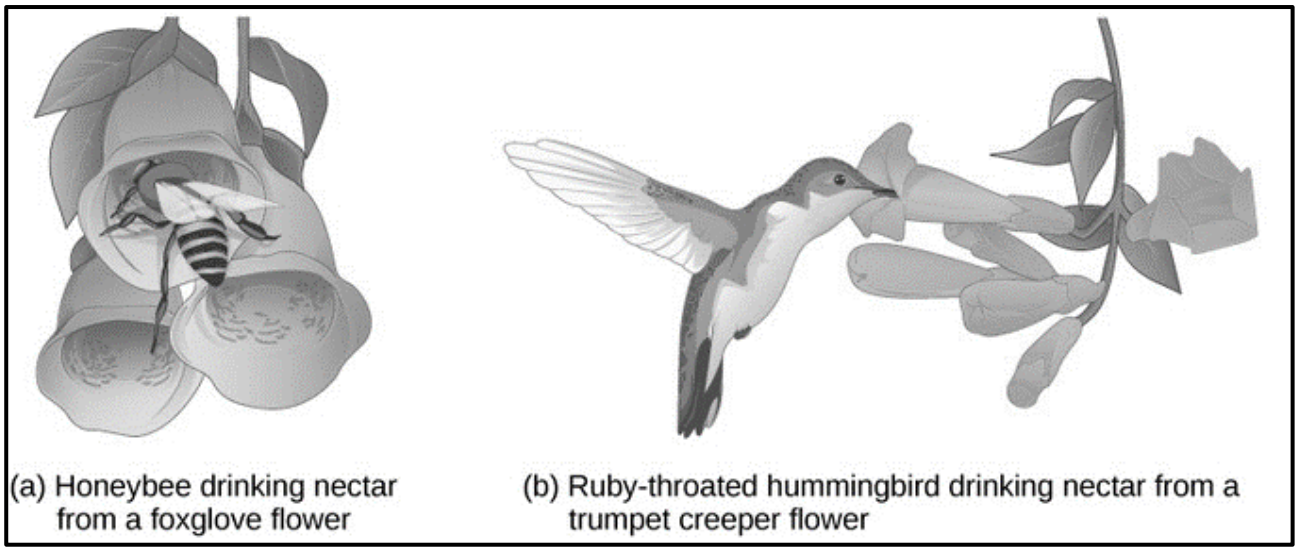
- **Plant adaptation to different pollinators**

  Many plants and their flowers are specifically adapted for specific pollinators. Some closely related species of plants have different characteristics such as flower shape, size, colour, reward type (nectar or pollen), scent and timing of flowering all play a role in attracting certain pollinators to them. Also, cross-pollination between the different species is prevented.

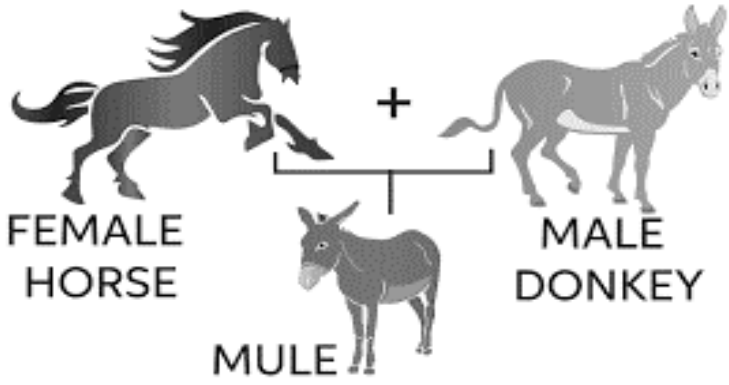


(a) Honeybee drinking nectar from a foxglove flower

(b) Ruby-throated hummingbird drinking nectar from a trumpet creeper flower

- **Infertile offspring**

  Even if two species can physically mate and produce offspring, they will still be reproductively isolated due to the fact the most hybrid offspring are infertile.



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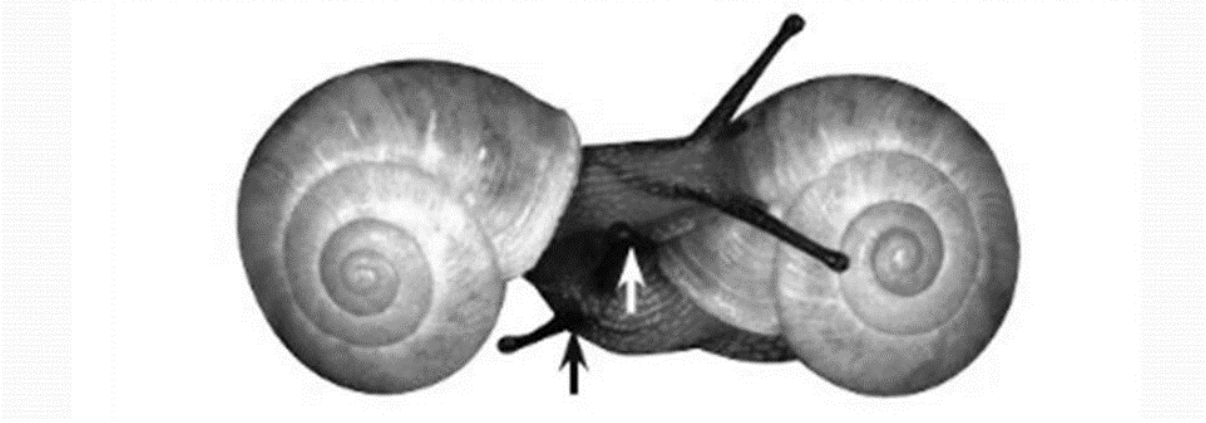
- **Prevention of fertilisation**

  Incompatible sex organs - the shape, size and location of genitals do not match those of another species.



<u>The genital opening of these snails is not aligned, and mating cannot be completed</u>

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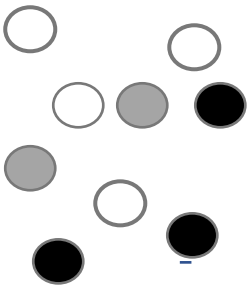
EVOLUTION IN PRESENT TIMES

Evolution is always happening. Most of the time it is impossible to observe changes in populations and species because evolution happens very slowly – thus the theory of gradualism. However, there are some cases (e.g.: rapidly producing organisms such as viruses and bacteria) that allow scientists to study how species change in response to environmental factors. Pathogens (viruses and bacteria) evolve quickly because there is lots of natural variation amongst them and the fact that mutations occur most often in rapidly reproducing organisms.

The evolution of drug resistance in bacteria

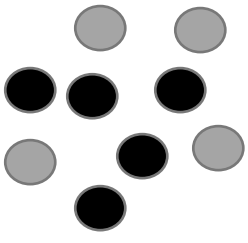
Low ---------->High

Antibiotic resistance level



Original population

- With any population there is genetic variation
- Some bacteria are more resistant to antibiotics than others
- If the amount of antibiotics taken is too low, or the full course of antibiotics is not completed
- Those who are less resistant to antibiotics will die
- Those who are more resistant will survive



- The population of resistant bacteria increase
- Continued use of antibiotics had little effect on the resistant bacteria
- The resistant bacteria reproduce and pass the resistant gene on to the next generation and increased
- Non- resistant bacteria decrease
- The antibiotics will now be ineffective

- The antibiotics acts as the selective mechanism.
- Natural selection plays a role in the evolution of antibiotic resistant bacteria.

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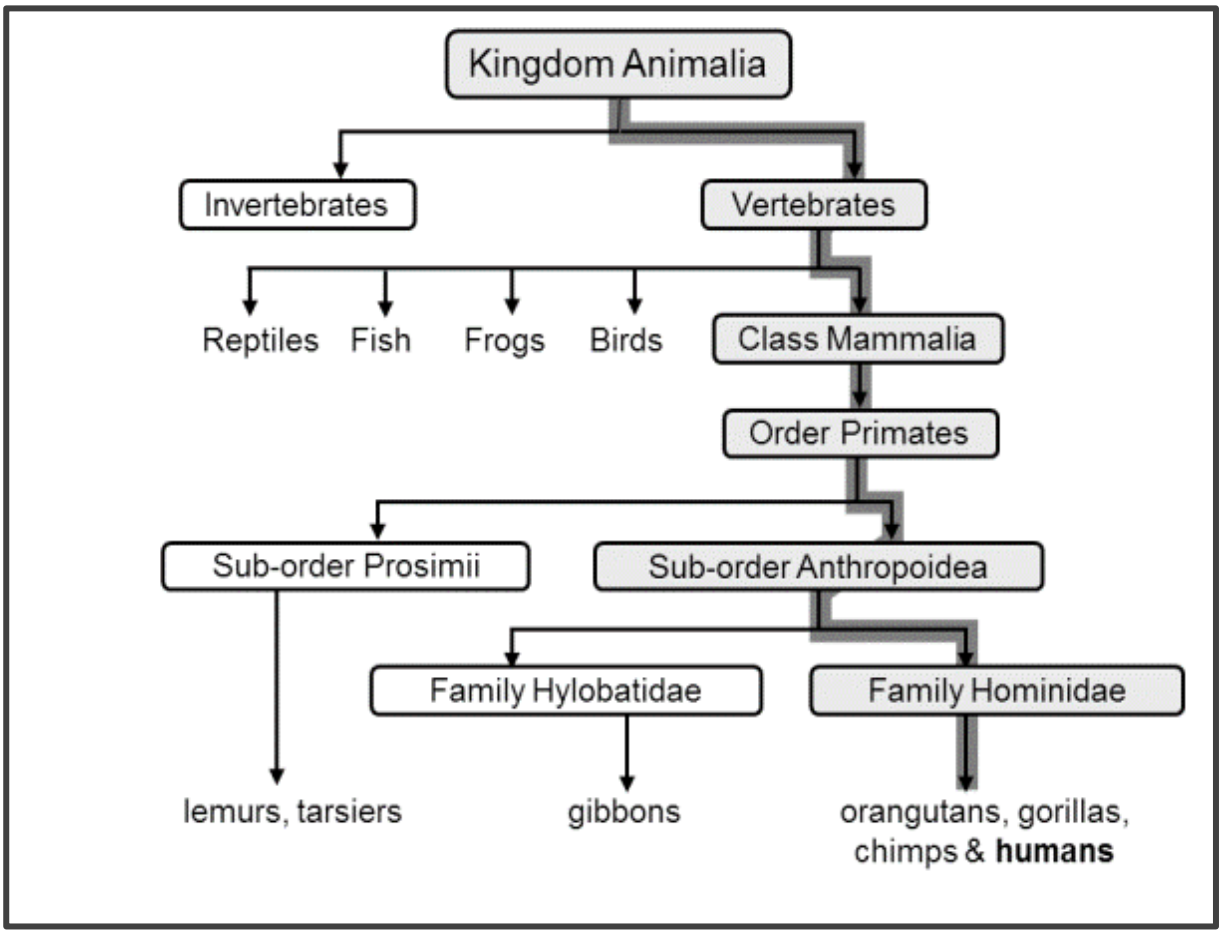
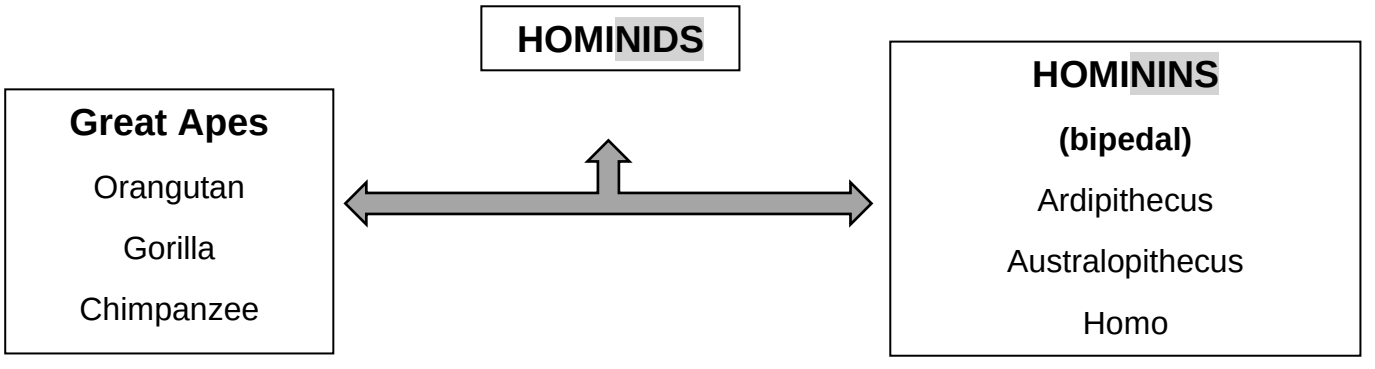
HUMAN EVOLUTION

1. The place of the family Hominidae in the animal kingdom



- Humas are mammals and belong to the class **MAMMALIA,** because their bodies are covered with hair and they suckle their young
- The order they belong to is **PRIMATES**. - Primates includes human, apes, orangutangs, gorillas an chimpanzees
- The Family **HOMINIDAE** includes **HOMINIDS**



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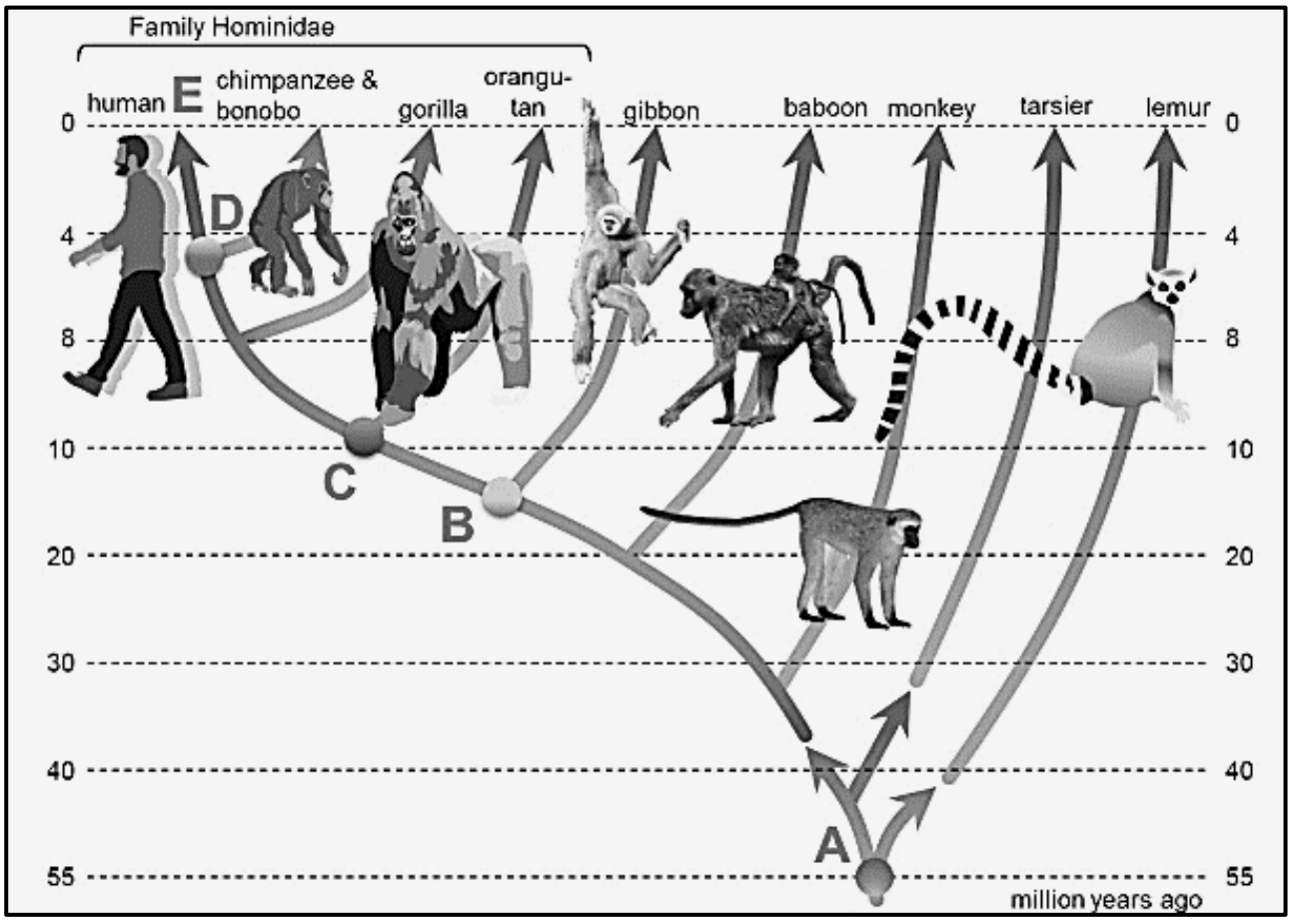

Note

Hominids refer to the <u>great apes</u> and <u>humans and their fossil ancestors</u>

Great Apes are also referred to as African Apes

Hominin – refers to <u>bipedal organisms</u>

Ardipithecus, Australopithecus and early ***Homo***- species are considered fossil ancestors of modern humans

Modern Humans are classified in the genus and species – ***Homo sapiens***

Genus – *Homo*

Species- *sapiens*

 # The genus name and species name must be <u>underlined</u> / *in italics* #

 # Read what the question asks – Give the Genus, species, family, class or order name

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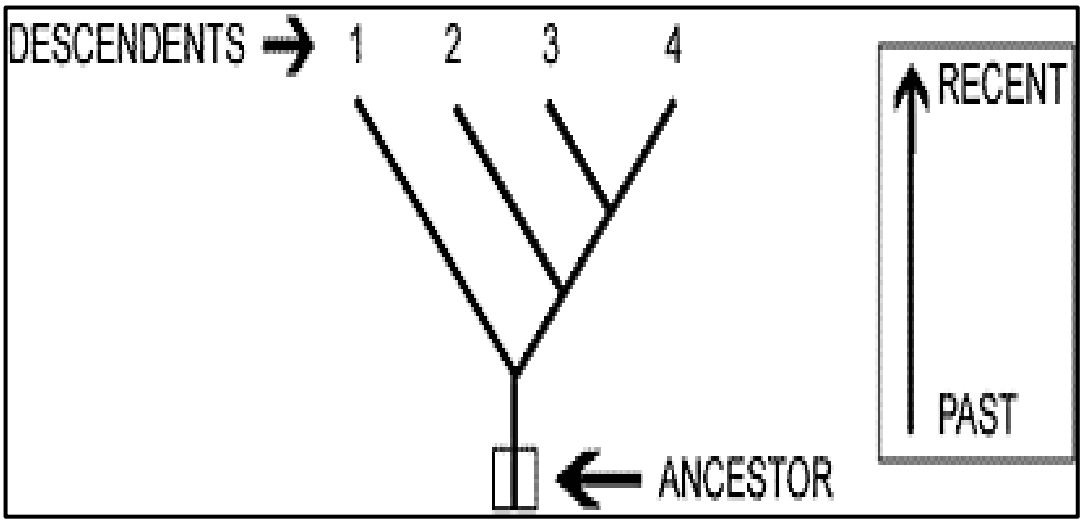
2. Interpretation of a Phylogenetic tree

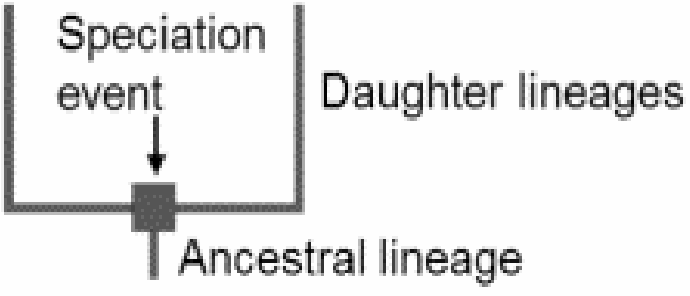
The evolutionary relationship of ancestral species and their descendants can be illustrated using a branching phylogenetic tree. A phylogenetic tree indicates which ancestors gave rise to which descendants.

How to interpretate a Phylogenetic tree:

- The root of the phylogenetic diagram represents the ancestor, and the tips of the branches, the descendants of that ancestor. To move upwards is to move forward in time.



- Speciation is represented as a branching of the tree, as a single ancestral lineage gives rise to two or more daughter lines.



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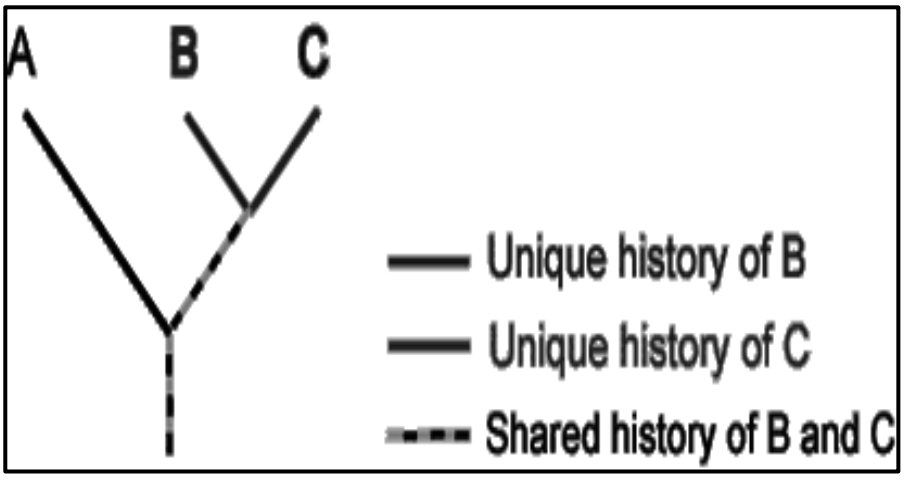
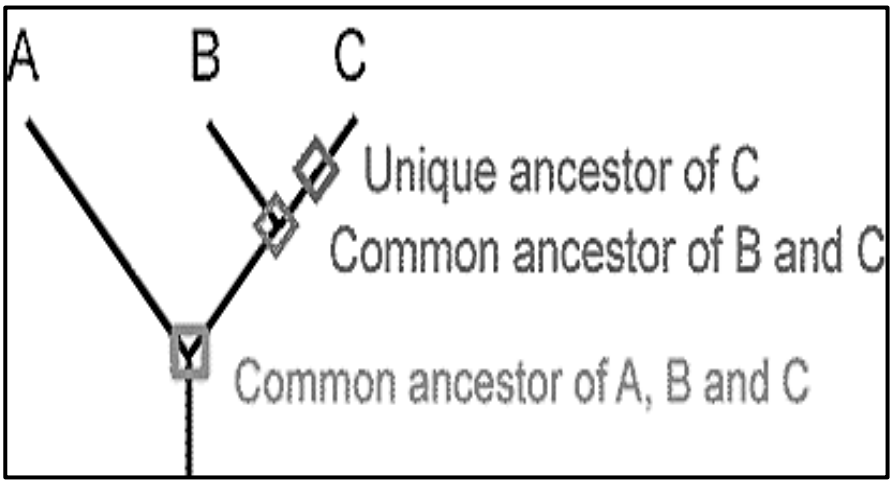
- Each lineage has a part of its history that is unique and parts that are shared with other lineages, as illustrated below …



- And each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.



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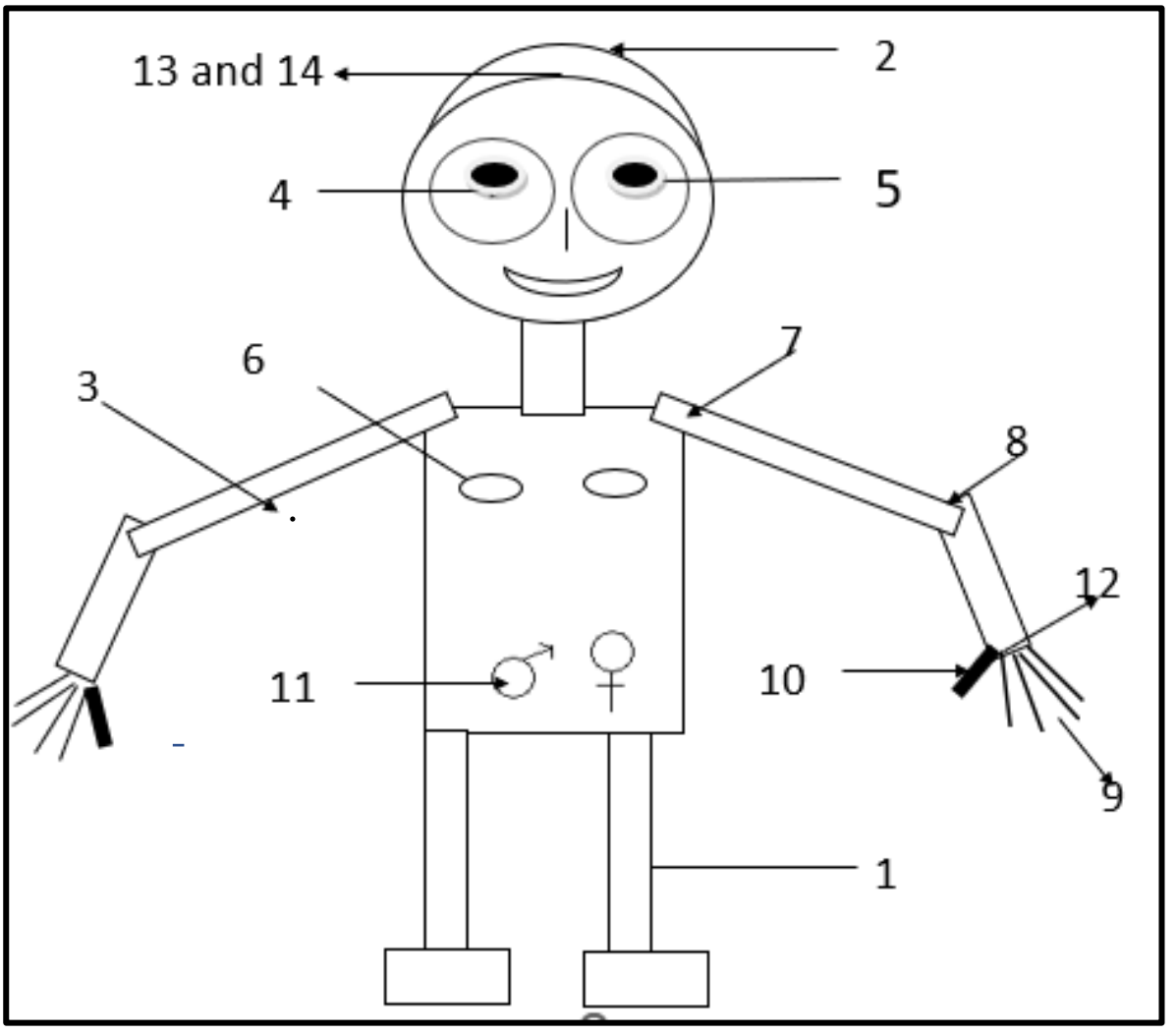
HUMANS VS AFRICAN APES

1. Characteristics that humans SHARE with other primates (African apes)



Similarities

1. **Upright posture**: the back limbs of hominids are generally stronger than their front limbs, enabling them to stand erect (upright) and use their hands for grasping; standing erect also gives a better view of surroundings and exposure of genitals to attract the opposite sex.

2. **Large brains:** relative to their body size, hominids have larger brains than other species in the Animal Kingdom. This allows them to process and store information.

3. **Long upper** arms / front limbs: apes are normally **<u>quadrupeds</u>**, and this requires longer front limbs. Longer front limbs also make it easier to grasp and swing from branches.

4. **Two eyes in the front** of the head, this provides good **binocular vision** as both eyes work together.

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5. The **eyes have cones** for colour vision that gives greater clarity.

6. **Two teats**/nipples only.

7. **Freely rotating arms**: arms can be lifted above the head to swing from branch to branch, or to pick fruit hanging relatively high above the ground.

8. **Elbow joints allowing rotation of forearm** this allows the limb to extend or flex to grasp and reach for objects. It also enables the flexing and rotation of the wrists.

9. **Bare fingertips or nails instead of claws**: Digits (finger and toes) have soft, broad, and very sensitive pads. The flat fingernails or toenails protect these pads.

10. **Opposable thumb**: the thumbs of hominids are positioned so that it can oppose other digits, enabling the hand to grip an object.

11. **Sexual dimorphism** – this refers to differences between males and females of the same species. Humans and apes are sexually dimorphic. This is linked to competition.

12. **Rotate hands at least 180º.**

13. **Olfactory brain centres** reduced/reduced sense of smell.

14. Parts of the brain that process information from the hands and eyes are enlarged.

#Note

CORRECT WAY TO STATE	INCORRECT WAY
Large brain relative to body size	Not just large brain - elephants have large brain too
Two eyes in front of the head	Two eyes
Long upper arms	Long arms
Upright posture	Can stand up straight
Two teats/nipples	Two mammary glands
Freely rotating arms	Rotating arms
Elbow joints allowing rotation of forearm	Elbows rotate

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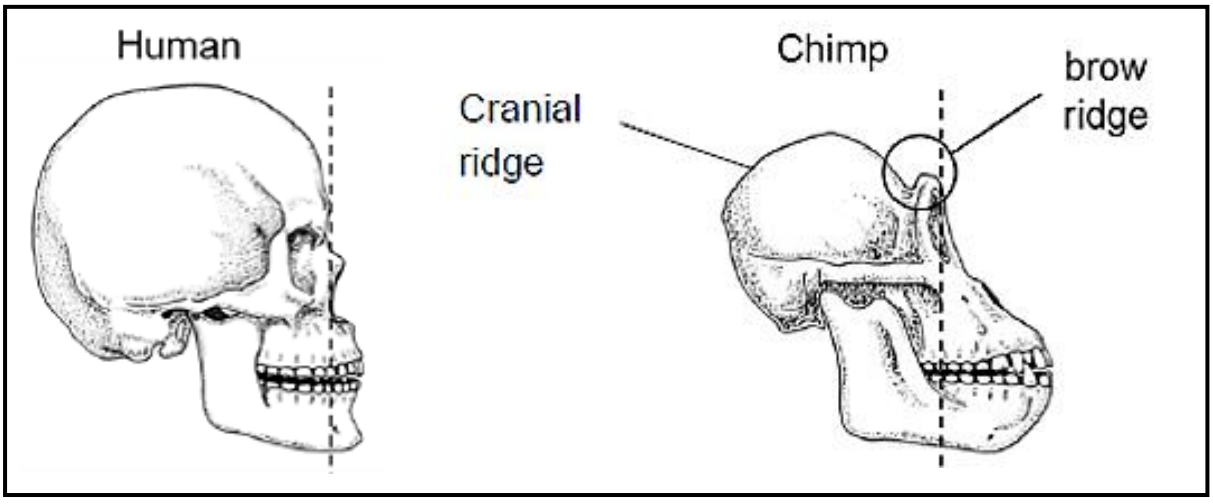
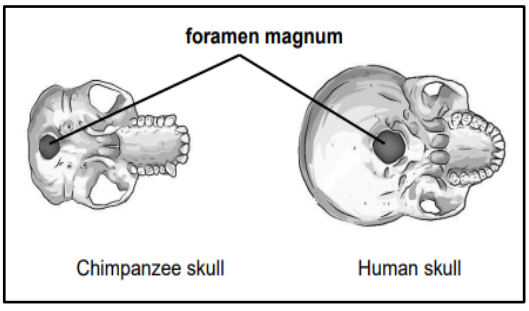
2. Anatomical DIFFERENCES between Humans and African apes



Homo sapiens	***Other primates***
Skull	
1. Larger cranium	1. Smaller cranium
2. Flat face/ Forehead slope less backwards	2. Face sloping/ Foreheads slope more backwards
3. Foramen magnum **more** forward at the bottom of the skull	3. Foramen magnum **more** backwards position at the bottom of the skull
	
4. Brow ridges are not well developed	4. Brow ridges are well developed
5. Smaller canines	5. Larger canines
6. Smaller spaces/diastema between the teeth	6. Larger spaces/diastema between the teeth
7. Palate small and round	7. Palate long and rectangular
8. Jaws with teeth on a gentle/round curve/ C-shape	8. Jaws with teeth in a rectangular/ U-shape
9. Jaws None – prognathous/ Less protruding jaw	9. Jaws Prognathous/ More protruding jaw
10. Lower jaw has a well-developed chin	10. Lower jaw has poorly developed chin
11. No cranial ridge	11. Cranial ridges at the top of the cranium

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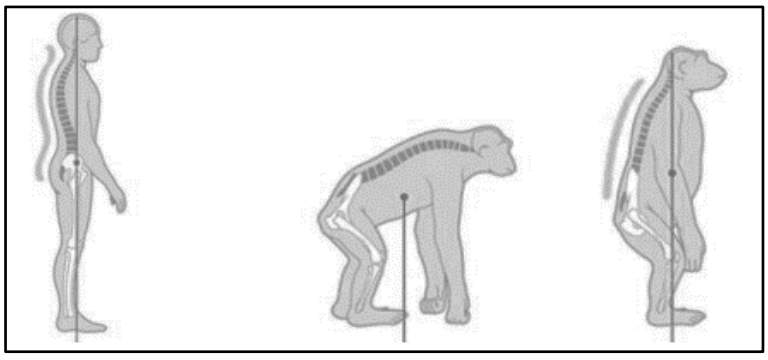
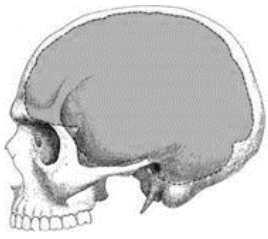
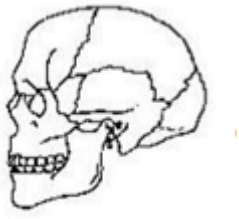
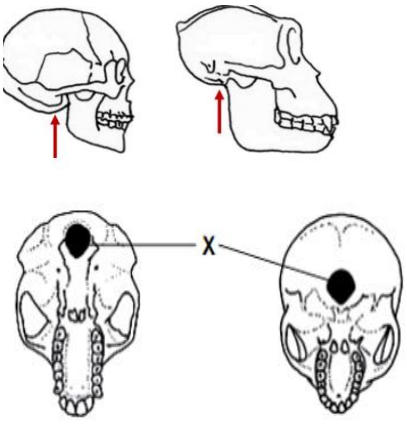
Spine	
12. Spine more curved/ S-shape	12. Less curved/ C-shape
	

Pelvic	
13. Pelvic gridle short and wide	13. Pelvic gridle long and narrow

MISTAKES made when answering anatomical differences/visible differences.

BRAIN SIZE - if the brain is not indicated in a diagram, you cannot state large brain and small brain when the question refers to visible differences.	 **Skull with brain**  **Skull without a brain**
FORAMEN MAGNUM **Human -** *more forward position* **African apes** - *more backwords position* *In both cases you must refer to more forward/backwards position at the bottom of the skull*	

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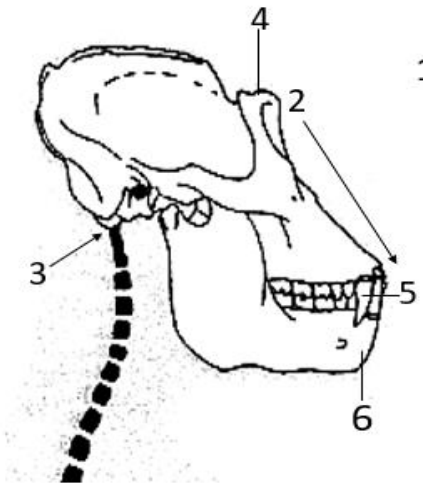
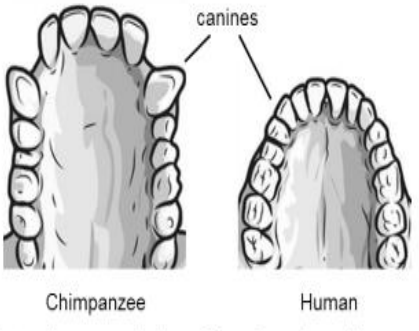
BROW RIDGES are well or not well develop. (number 4) No marks will be allocated for: • Big and small brow ridges • Visible and not visible • Prominent and not prominent	
LOWER JAW has a well-developed chin or poorly develop chin (number 6) No marks will be allocated for: • Prominent and not prominent • Big and small chin	
JAWS **In Humans** **None – prognathous** **OR** **Less protruding**	**In African apes** **Prognathous** **OR** **More protruding**
TEETH Canines are larger or smaller **It is <u>canines</u> and not <u>teeth</u>** **Not:** Big and small Larger and shorter Larger and smaller teeth	

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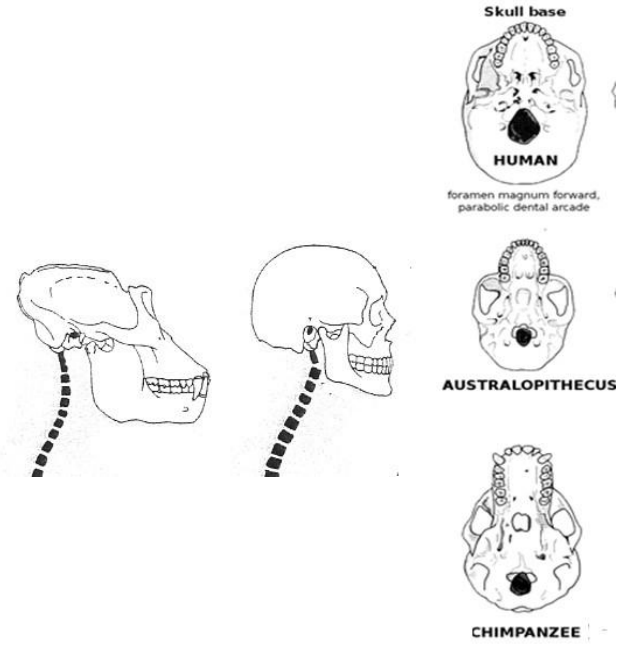
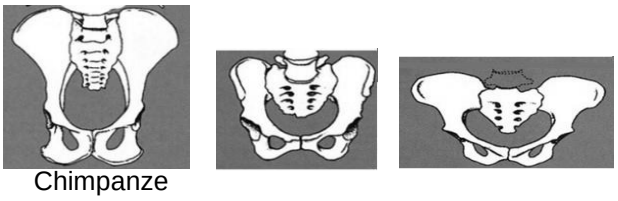
3. The significance of the structural changes that characterise the evolution of modern humans.

STRUCTURE	SIGNIFICANCE
Changes that lead to bipedalism	
1. Foramen magnum The foramen magnum was in a backward position at the bottom of the skull in the ape-like beings but in a forward position at the bottom of the skull in modern humans. 	This represents a change from quadrupedal in ape-like beings to bipedalism in modern humans, leading to the following in modern humans: • Increased awareness of the environment in sensing danger/food • Freeing of the hands to use instruments/carry objects/weapons/offspring • Exposure of a large surface area for thermoregulation /lose body heat to surroundings in hot conditions/reduce overheating • Display of sex organs /breasts as part of courtship behaviour
2. Pelvis Humans have a (wide and short) pelvis, apes have a (long and narrow pelvis)  Chimpanze	• Support greater weight due to the upright position

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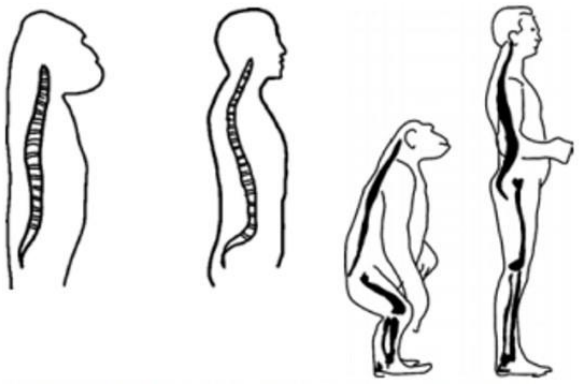
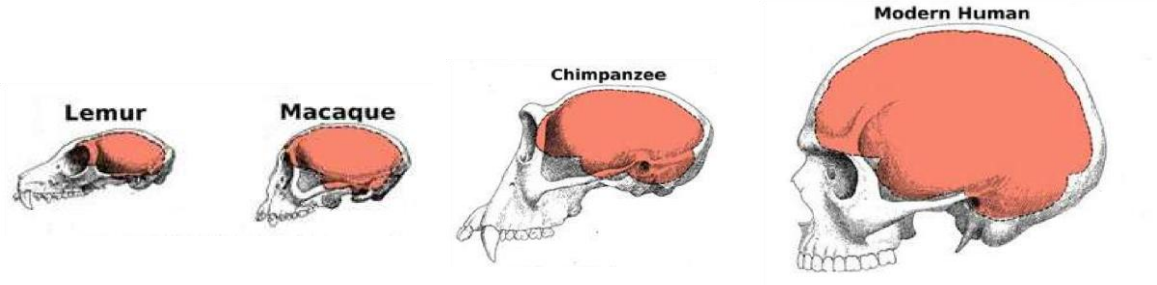
3. Spine Human's spine is more curved/ S-shaped and that of ape-like beings is less curved/ C-shaped 	• For flexibility Shock absorption
Other structural changes that characterise the evolution of modern humans	
Cranium Modern humans have a larger cranium than the ape-like beings Modern humans have a less sloping forehead than the ape-like beings Modern humans have a cranium that is more rounded than the ape-like beings	This allowed space for a larger brain in humans than in ape-like beings, making the following possible: • Better co-ordination of movement • Processing of a large amount of information • Processing information faster • Development of spoken and written languages to communicate
	

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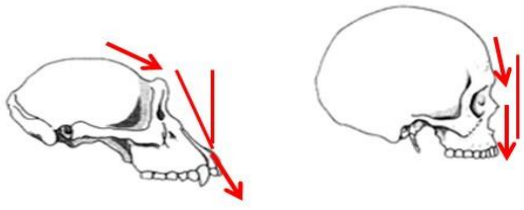
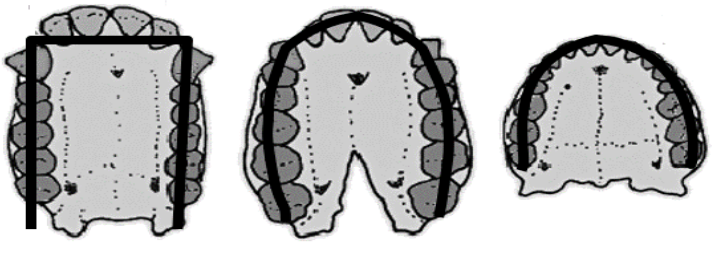
STRUCTURE	SIGNIFICANCE
Prognathism Humans have jaws that are non-prognathous compared to the jaws of ape-like beings which are prognathous African–ape has more sloping face and the modern human a flatter face 	• This corresponds with a change in diet from hard, raw food in the ape-like beings • To softer, cooked food in humans
Dentition/Teeth In ape-like beings there are gaps/diastema between incisors and canines but no gaps between the teeth in humans Humans have smaller canines than the ape-like beings Humans have flatter molars and pre-molars than the ape-like beings	• This corresponds with the decreased need to bite and tear • and an increased need to grind and chew in humans • in view of the change in diet to soft, cooked food
	
Chin In humans the chin is more developed compared to the ape-like beings	• Developed chin assists with speech in humans
Zygomatic arch In humans the zygomatic arch is less developed than in the ape-like beings	• This corresponds with the decreased need for attachment of strong muscles • due to the decreased jaw size in humans

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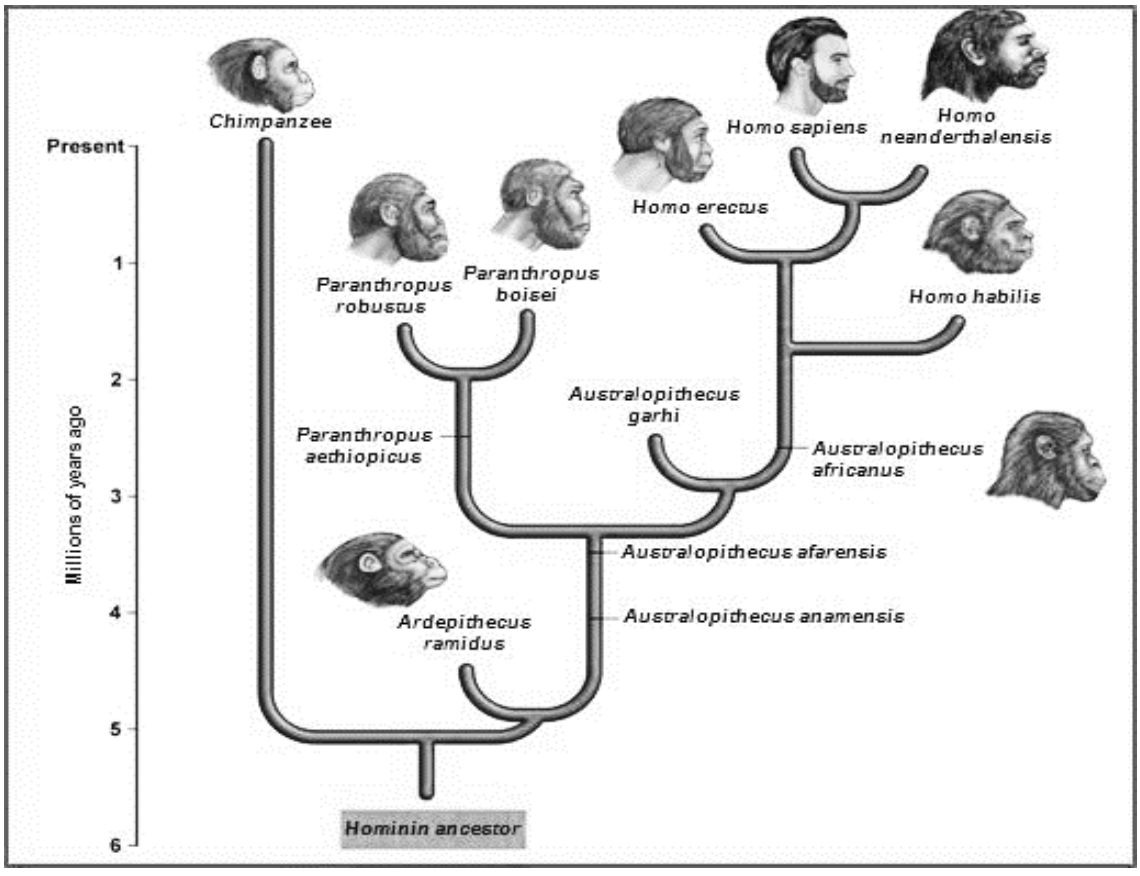
Lines of evidence that support the idea of common ancestors for living hominids including humans.



Tree phyla are used in the fossil evidence

Ardipithecus → Australopithecus → Homo

 # It is very important to know the line of fossil evidence and the fossils that are used as reference (where they are found, who discovered them etc.)

3.1 Fossil evidence:

FOSSILS THAT ARE USED AS REFERENCE	
Ardepithecus	*Ardepithecus ramidus*
Australopithecus	***Australopithecus afarensis*** – Lucy
	Australopithecus africanus Mrs. Ples Taung child Little foot
	Australopithecus sediba *Karabo*
Homo	*Homo habilis* *Homo erectus* *Homo sapience*

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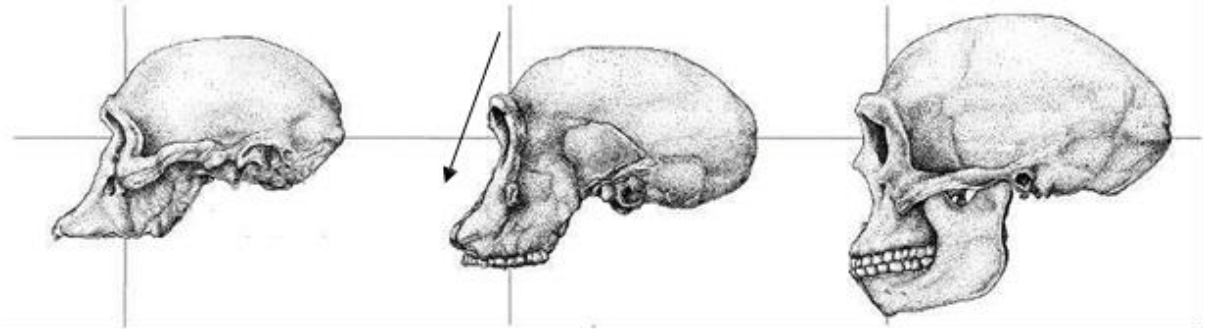
CHANGES IN STRUCTURE THAT CHARACTERISE HUMAN EVOLUTION

- Emphasis on evolutionary trends provided by the **anatomical features** of fossils of the following three genera: *Ardipithecus, Australopithecus, Homo* as well as:
- The **age of each fossil** found/time-line for the existence of the three genera
- The **fossil sites** where they were found: emphasis on the fossil sites that form a part of the Cradle of Humankind
- The **scientists** who discovered them



Australopithecus ***Homo habilis*** ***Homo sapience***

- Bipedalism (Shift of foramen magnum to a more forward position)
- A more rounded skull and increased cranium size
- A flatter face due to:
  - less sloping forehead
  - less protruding jaws (decreased prognathous)
  - a more developed chin
- A more rounded jaw
- Increased size of skeleton which means increased height
- Change in dentition

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The table below shows the characteristics of different organisms (as obtained from a study of their **fossils**) that are thought to be in the same line that led to the evolution of modern humans.

The fossils are dealt with in the order in which they appeared on Earth.

ORGANISM	WHEN ORGANISM EXISTED	FOSSIL SITE	DISCOVERED BY	ANATOMICAL CHARACTERISTICS
Ardipithecus ramidus (Ardi)	5 – 4 mya	North-East Ethiopia	Tim White	Brain size: 300–350ml Forward position of foramen magnum Very prognathous (more protruding jaws) Heavy brow ridges Pelvis structure: bipedal and tree climbing
Australopithecus afarensis (Lucy)	4 – 2,7 mya	Ethiopia, Kenya, Tanzania	Donald Johanson	Brain size: 375–550ml Forward position of foramen magnum Very prognathous Heavy brow ridges Canines large and pointed Long arms No cranial ridge
Australopithecus africanus (Mrs. Ples, Taungchild, Littlefoot)	3 – 2 mya	Mrs. Ples Taung; Sterkfontein Little foot	Robert Broom Raymond Dart Ron Clark	Brain size: 428–625 ml Forward position of foramen magnum Prognathous Brow ridges Teeth large, canines not long Long arms No cranial ridge
Australopithecus sediba (Karabo)	1,9 – 1,8 mya	Malapa Cave – in the cradle of humankind	Lee Burger	Brain size: 420 ml Less prognathous Brow ridges Large teeth, canines not long Long arms No cranial ridge
Homo habilis	2,2 – 1,6 mya	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges Human-like teeth – smaller canines Long arms
Homo erectus	2 – 0,4 mya	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter arms
Homo sapiens	200 000 years ago – present	Makapansgat in Limpopo; Border Cave in KZN; Blombos Cave in the Western Cape	Tim White	Brain size: 1200–1800 ml No brow ridges Small teeth Short arms

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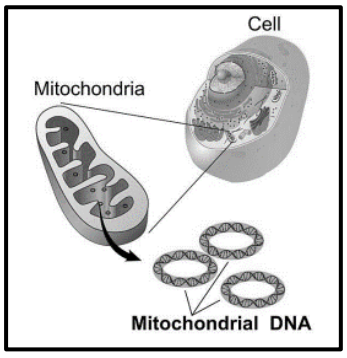
Australopithecus fossils found in the **Cradle of Humankind**:

Hominin species found in South Africa

- Mrs. Ples (*Australopithecus africanus*),
- Little foot (*Australopithecus africanus*),
- Taung child (*Australopithecus africanus*),
- Karabo (*Australopithecus sediba*) is also regarded as the missing link (between *Australopithecus africanus* and *Homo erectus*.)

3.2 Genetic evidence: mitochondrial DNA

Apart from DNA in the nucleus, DNA also occurs in the mitochondria as mitochondrial DNA (mtDNA)



- mtDNA of the sperm cell does not fuse with mtDNA of the egg cell
- mtDNA is therefore handed down from **mother to child**
- By following mutations in mtDNA, we can trace our female line of descent.
- Using mutant nucleotides of Y-chromosomes
- Spencer Wells and his colleagues have traced lineage of everyman alive to a common ancestor who lived in East Africa about 60 000 years ago.
- Analysis of mitochondrial DNA leads to ancestral female who lived in East Africa about 150 000 years ago.

Given the amount of genetic material shared between humans and other hominids (the apes), they must have had a common ancestor who lived approximately 5 – 6 million years ago.

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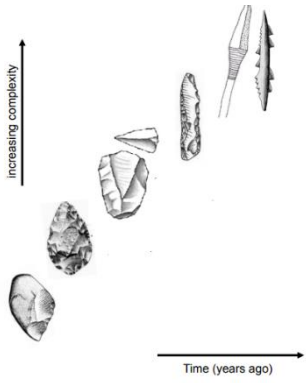
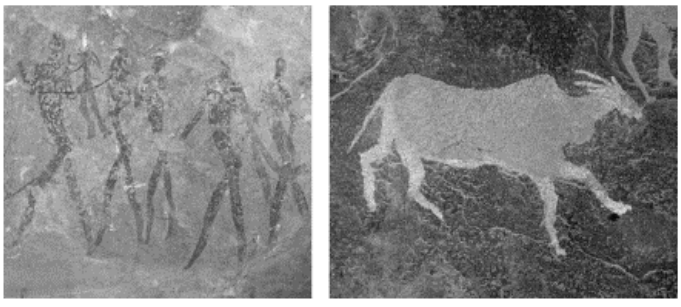
3.3 Cultural evidence: toolmaking

- A very important aspect of human evolution, separating humans from other hominids, is the development and use of tools.



- Art also contributed. The earliest known art dates from about 100 000 years ago, and the earliest cave paintings (see Figure 26 below), of which we have an abundance in South Africa, were made some 40 000 years ago



- Behaviour like burial sites

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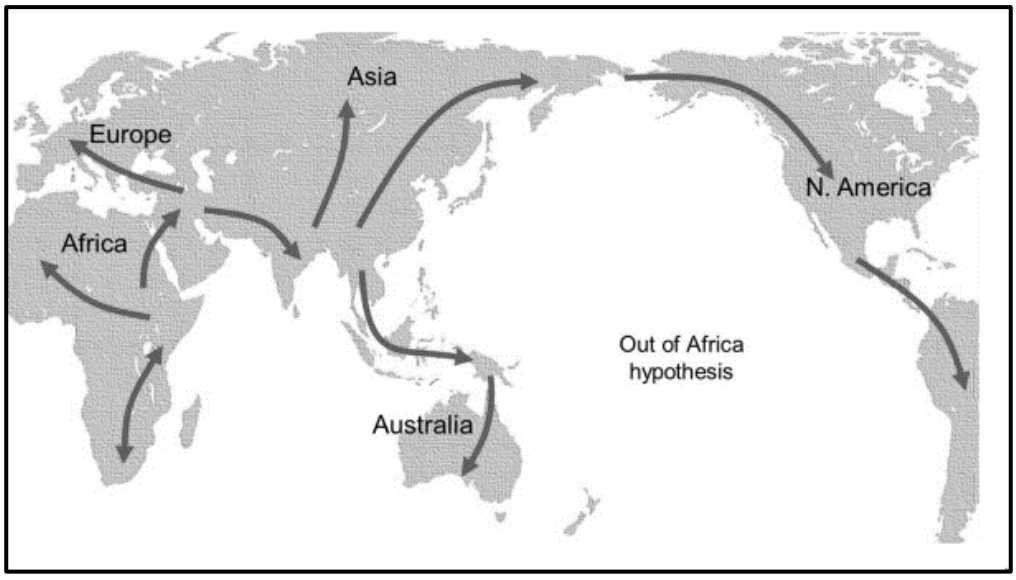
4. THE OUT-OF-AFRICA HYPOTHESIS

Modern humans originated in Africa and then migrated to other continents.



4. Evidence for the 'Out-of-Africa' hypothesis:

All modern humans **originated** in Africa and **migrated** to other parts of the world.

It must be explained as stated here

4.1 Fossil evidence:

Information on each of the following fossils that serve as evidence for the 'Out-of-Africa' hypothesis:

o *Ardipithecus* fossils found in **Africa only**

o *Australopithecus* fossils found in **Africa only** (Karabo, Little Foot, Taung Child, Mrs Ples)

o *Homo* -fossils -

- ***Homo habilis*** found in **Africa only**
- **Oldest fossils** of ***Homo erectus*** and ***Homo sapiens*** found in Africa,
- **Younger fossils** were found in other parts of the world)

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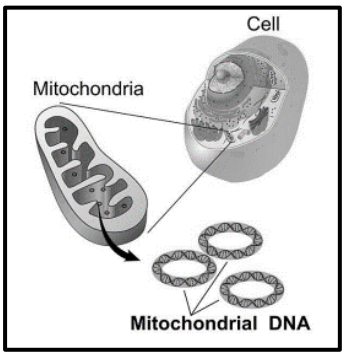
4.2 Genetic evidence: mitochondrial DNA

Apart from DNA in the nucleus, DNA also occurs in the mitochondria as mitochondrial DNA (mtDNA)

- mtDNA of the sperm cell does not fuse with mtDNA of the egg cell
- mtDNA is therefore handed down from **mother to child**



- By following mutations in mtDNA, we can trace our female line of descent.

Just something to read, not for assessment

- Using mutant nucleotides of Y-chromosomes
- Spencer Wells and his colleagues have traced lineage of every man alive to a common ancestor who lived in East Africa about 60 000 years ago.
- Analysis of mitochondrial DNA leads to ancestral female who lived in East Africa about 150 000 years ago.

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11.3 MARKING GUIDELINES

DIFFERENCES BETWEEN LAMARCKISM AND DARWINISM

LAMARCKISM	DARWINISM
Variation of the offspring occurs when individuals in the population change✓	Variation in the offspring is inherited✓
Change occurs because of adaptation to the environment✓/ Law of use and disuse	Natural selection – individuals best suited to the environment survive✓
Individuals in the population change✓	The population as a whole changes✓
Acquired characteristics are inherited by offspring✓	Characteristic are passed on from generation to generation to enable individuals to survive in the environment✓

DIFFERENCES BETWEEN NATURAL SELECTION AND ARTIFICIAL SELECTION

NATURAL SELECTION	ARTIFICIAL SELECTION
The environment ✓or nature is the selective force	Humans✓represent the selective force
Selection is in response to suitability to the environment✓	Selection is in response to satisfying human needs✓
Occurs within a species✓	May involve one or more species ✓ (as in cross breeding)

HOW LAMARCK AND DARWIN EXPLAINED EVOLUTION (IN GENERAL)

***Evolution according to Lamarck**

Lamarck explained evolution using the following two 'laws':
The law of use and disuse: ✓
- As an organism uses a structure or organ more regularly✓, it becomes better developed or enlarged in that organism✓.
- If an organism does not use a structure or organ frequently✓, it becomes less developed or reduced in size and may disappear altogether in that organism✓

The law of inheritance of acquired characteristics: ✓
- Characteristics developed during the life of an individual✓- (Acquired characteristics) can be passed on to their offspring✓

Evolution according to Darwin
- Organisms produce a large number of offspring✓
- There is a great deal of variation✓ amongst the offspring
- Some have favourable characteristics✓
- and some do not✓
- When there is a change in the environmental conditions✓/or
- there is competition
- Then organisms with characteristics which are more favourable survive✓
- Whilst organisms with less favourable characteristics die✓
- This is called natural selection✓
- The organisms that survive reproduce✓
- And thus pass on the favourable characteristics to their offspring✓
- The next generation will therefore have a higher proportion of individuals with the favourable characteristics✓

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HOW LAMARCK AND DARWIN EXPLAINED EVOLUTION (SPECIFIC EXAMPLE)
An ancestor of the elephant, *Phiomia*, had a long nose-like structure called a proboscis which evolved into the trunk of the elephant. The proboscis was used to gather leaves as food.

Explain the evolution of the elephant's trunk in terms of Lamarckism and Darwinism as well as the way in which an increase in the length of the trunk of the elephant could be achieved through artificial selection.

Lamarckism:
- The ancestral elephant stretched its proboscis✓
- to get leaves✓ in trees/further from the body
- The more it used the proboscis✓,
- the longer it became✓ **- law of use and disuse.**
- The offspring then inherited the acquired longer proboscis ✓- **law of inheritance of acquired characteristics**
- Over many generations the length of the proboscis increased✓- until it became a trunk✓ as in the modern elephant

Darwinism:
- There was a great deal of genetic variation✓ amongst the offspring of the ancestral elephant
- Some had a long proboscis✓- and some had a short proboscis
- There was a change in environmental conditions✓/competition amongst the animals for food
- They had to reach higher in the trees to get leaves✓
- The animals with shorter proboscis died✓ as they could not reach the leaves
- They did not possess the favourable characteristics for that environment
- Those individuals with the longer proboscis survived✓ as they possessed the favourable characteristics for the environment.
- The elephants with the longer trunks then reproduced✓
- and passed on this favourable characteristic to their offspring✓
- The next generation of animals had a greater proportion✓ of longer trunks
- Gradually over time the gene pool of the elephants with short trunks are eradicated✓

Artificial selection:
- Humans✓select the elephants with
- desirable characteristics✓/long trunk
- and mate them to produce offspring with longer trunks✓
- Those that are pure breeding✓ for long trunks
- are further selected to mate to produce offspring with further longer trunks✓

DARWIN'S IDEAS ABOUT GRADUALISM COMPARED TO PUNCTUATED EQUILIBRIUM
- Darwin believed that evolution takes place through an accumulation of small✓
- gradual changes that occur over a long period of time✓
- supported by transitional forms in fossil record✓
- Punctuated equilibrium suggested that evolution sometimes involves long periods of time where species do not change✓/very little change occurs
- This alternates with short periods of time where rapid changes occur✓
- New species are formed in a short period of time✓/relative to the long period of no/little change
- supported by the absence of transitional forms✓

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THE ROLE OF VARIATION IN NATURAL SELECTION
- Organisms of a particular species shows a great deal of variation✓
- Some individuals may have characteristics that are favourable✓ /any example
- Others may have characteristics that are unfavourable✓ /any example
- If there is competition✓/changing environmental conditions/ selective pressure by the environment
- organisms with favourable characteristics survive✓
- and reproduce✓
- and pass this favourable characteristics to their offspring✓
- while organisms with unfavourable characteristics will die out✓
- Over time the whole population will have this favourable trait✓

DIFFERENCES BETWEEN A POPULATION AND A SPECIES
- **A species** is a group of organisms with similar characteristics✓
- that are able to interbreed✓
- to produce fertile offspring✓
- **A population** is a group of organisms of the same species✓
- found in the same habitat ✓
- at the same time✓

SPECIATION BY GEOGRAPHIC ISOLATION (IN GENERAL)
• If a population splits into two populations ✓ by a geographical barrier
• there is now no gene flow between the two populations✓
• Since each population may be exposed to different environmental conditions✓
• 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 reproduce with each other✓ thus becoming different / new species

SPECIATION BY GEOGRAPHIC ISOLATION (SPECIFIC EXAMPLE)
Use the example of the anole lizard of the Caribbean Islands to describe how natural selection led to the process of s**peciation** that gave rise to different species of lizards.

- The original species of anole lizards was separated✓
- into different populations✓
- by a geographical barrier ✓
- which is the sea ✓
- There was no gene flow✓
- between the separated populations✓
- Each population was exposed to different environmental conditions✓/ different environmental temperatures and food availability on each island
- Because there is variation✓ amongst the lizards
- natural selection occurred independently ✓ in each population
- Each population became different from the other ✓ over time
- genotypically✓
- and phenotypically✓
- Even if the populations were to mix again✓
- they would not be able to reproduce/interbreed with each other✓

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MECHANISMS FOR REPRODUCTIVE ISOLATION

Geographic isolation causes speciation. Reproductive isolation isolates the gene pool of a species.

Examples of reproductive isolation:

• Breeding at different times of the year
• Species-specific courtship behaviour
• Adaptation to different pollinators
• Infertile offspring
• Prevention of fertilisation

THE ROLE OF MUTATIONS AND EVOLUTION IN PRESENT TIMES (IN GENERAL)

- In a population of insects✓ /bacteria/HI viruses/Galápagos' finches
- mutations are a source of variation
- which may make some organisms more resistant ✓ /better suited
- to insecticides✓ /antibiotics/antiretroviral medication/ drought
- Those individuals that are not resistant /suited will die✓ whereas
- those that are resistant/ well suited, will survive✓
- to pass the resistant allele/resistance on to their offspring✓
- This is known as natural selection✓
- As a result, individuals of the future generations will be resistant to the insecticides✓/antibiotics/antiretroviral medication/adapted to drought

HOW MOSQUITOES DEVELOP RESISTANCE TO DDT (SPECIFIC EXAMPLE)

− More mosquitoes are produced than can survive✓
− There is genetic variation✓ amongst the mosquitoes
− Some mosquitoes may be naturally resistant to DDT✓
− When DDT is applied✓
− those that are resistant survive✓
− and they then reproduce✓
− passing the allele for resistance to the offspring✓
− Those that are not resistant, die✓
− and their alleles are lost from the population. ✓
− The number of DDT-resistant mosquitoes therefore increases over the generations✓

EVIDENCE FOR EVOLUTION, HUMAN EVOLUTION AND OUT OF AFRICA HYPOTHESIS

EVOLUTION	HUMAN EVOLUTION	OUT OF AFRICA HYPOTHESIS
Fossil evidence	Fossil evidence	Fossil evidence
Genetics	Genetics mtDNA	Genetics mtDNA
Comparative anatomy (modification by descent)	Cultural evidence (tool making)	Cultural evidence (tool making)
Biogeography		

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HUMAN EVOLUTION

CHARACTERISTICS THAT HUMANS SHARE WITH AFRICAN APES.

- Large brains✓ / skulls compared to their body mass
- Bipedal✓ / upright posture / foramen magnum in a more forward position
- Olfactory brain centres reduced✓/ reduced sense of smell
- Eyes in front✓/ binocular vision / stereoscopic vision
- Eyes with cones✓ / colour vision
- Freely rotating arms✓
- Long upper arms✓
- Five digits per limb✓
- Flat nails instead of claws✓/ bare, sensitive finger tips
- Opposable thumbs✓/precision grip
- Sexual dimorphism✓ / distinct differences between males and females

ANATOMICAL DIFFERENCES BETWEEN HUMANS (*Homo sapiens*) AND AFRICAN APES

FEATURE	HUMANS (*Homo sapiens*)	AFRICAN APES
Cranium	Large cranium ✓/ brain	Small cranium ✓/ brain
Brow ridges	Brow ridges are not well✓ developed	Brow ridges are well ✓developed
Spine	More curved (S-shaped) ✓spine	Less curved (C-shaped) ✓ spine
Pelvic girdle	Short, wide pelvis✓	Long, narrow pelvis✓
Canines	Small canines✓	Large canines✓
Palate shape	Small and rounded palate✓	Long and rectangular palate✓
Jaws	Small jaws✓ less protruding / less prognathous	Large jaws✓ more protruding / more prognathous
Cranial ridges	No cranial ridge✓	Cranial ridge at the top of the cranium✓
Foramen magnum	In a forward position✓	In a backward position✓ below the skull

GENERAL TREND IN HUMAN EVOLUTION HAS BEEN TOWARDS BIPEDALISM AND A CHANGE IN DIET FROM RAW FOOD TO COOKED FOOD

The development of bipedalism:

• The backward position of the foramen magnum on the skull✓
• the narrow pelvis✓
• and the less-curved spine✓
• indicates that the ape-like beings were quadrupedal✓
• The forward position of the foramen magnum on the skull✓
• the wider / shorter pelvis✓
• and the curved S- spine✓
• indicates that modern humans are bipedal✓

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Change in the diet from raw food to cooked food:
• The large teeth, especially the canines✓
• as well as the large and long jaws✓
• which makes the skull prognathous✓
• as well as cranial/brow ridges associated with large muscles that operate the jaws✓
• indicate that the ape-like beings ate raw food that required a great amount of processing✓ /tearing, biting and chewing.
• The smaller teeth, including the canines✓
• as well as the smaller jaw size✓
• which makes the skull less prognathous✓
• as well as the absence of cranial/brow ridges due to the presence of smaller muscles for chewing✓
• indicate that modern humans rely on a diet of cooked food that does not require the same amount of processing✓ /tearing, biting and chewing.

ADVANTAGES OF BIPEDALISM
- Frees the arms✓ so that they could carry offspring✓/ tools / food / manipulate things
- Allows ability to see further✓to spot danger✓/ food
- Exposes a large surface area✓ for thermoregulation✓
- Reduces the surface area exposed to the sun✓ so less heat is absorbed✓/ less heat lost/thermoregulation
- Expose the genitals✓to attract opposite sex✓
- Efficient locomotion✓allows traveling over longer distances

ADVANTAGES OF LARGER CRANIUM
- Allows for a bigger brain✓
- Development of speech✓/ communication
- Higher intelligence✓
- Complex behaviour✓
- Quick processing of information✓
- Process large amounts of information

OUT OF AFRICA HYPOTHESIS
- All modern humans✓ /*Homo sapiens* - originated in Africa✓
- and migrated to other parts✓ of the world

EVIDENCE THAT SUPPORTS THE OAH:
FOSSIL EVIDENCE✓
- The OLDEST Fossils of *Ardipithecus* were found ONLY in Africa✓ /Rift Valley/Ethiopia/South Africa
- The OLDEST Fossils of *Australopithecus* were found ONLY in Africa✓/Rift Valley/Ethiopia/South Africa
- The OLDEST The fossils of *Homo habilis* were ONLY found in Africa✓
- The OLDEST fossils of *Homo erectus* were found in Africa✓
- The OLDEST fossils of *Homo sapiens* were found in Africa✓

GENETIC EVIDENCE✓
- Mitochondrial DNA✓
- is passed down from mother to child✓ / Is inherited only from the maternal line✓
- Analysis of mutations✓ on this mitochondrial DNA
- were traced to an ancestral female that existed in Africa✓
- and shows that all humans descended from her✓/mitochondrial Eve
- The Y chromosome shows the paternal line✓

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CULTURAL EVIDENCE✓

- The OLDEST/most primitive artefacts (tools, cutlery, art etc.) - were ONLY found in Africa

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11.4 ACTIVITIES

Evolution: Evidence of evolution

Activity 60 **Date: _____**

1. Match the definition in **Column B** to fit the term in **Column A**

	COLUMN A		COLUMN B
1.1	Biological evolution	A	Species that are closely related have a greater genetic similarity to each other than distant species and therefore share more recent common ancestor
1.2	Species	B	A group of organisms with similar characteristics that interbreed to produce fertile offspring
1.3	Population	C	The study of the distribution of existing(extant) plant and animal species in specific geographical regions
1.4	Theory	D	Similar structure with the same body plan that perform different functions
1.5	Hypothesis	E	A group of individuals of the same species occupying a specific habitat at a specific time
1.6	Fossil records	F	The study of fossils
1.7	Homologous structures	G	Any genetic change in a population that is inherited over several generations
1.8	Biogeography	H	A possible solution to a problem or explanation of a specific phenomenon
1.9	Genetic evidence	I	The basic body plan of different plant and animal groups that change over time and are then better adapted to their different environments
1.10	Decent with modification	J	An explanation of something that has been observed in nature which can be supported by facts, generalisations, tested hypotheses, models and laws
1.11	Palaeontology	K	Different fossils are found in different rock layers with the oldest fossils in the older rock layers with transitional fossils present

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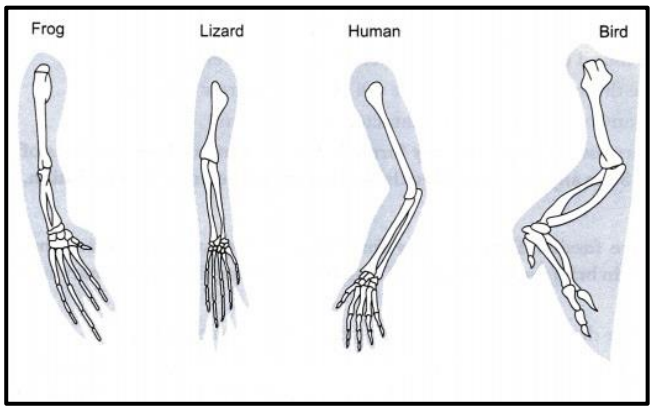
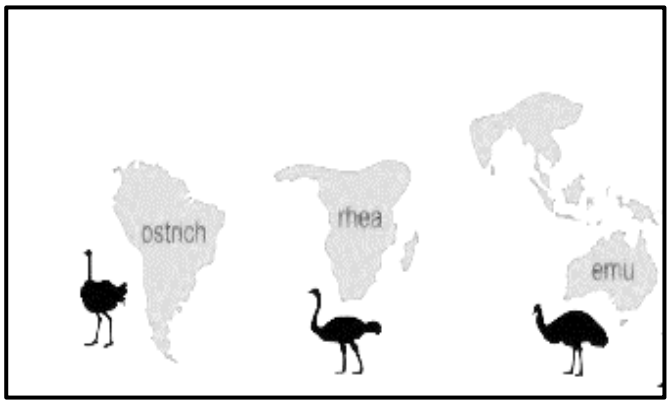
2. The theory of evolution emerged from and is explained by different lines of evidence:

A. Fossil records
B. Decent with modification
C. Biogeography
D. Genetics

Look at the diagrams below and write down the letter in the space provided, that represents the line of evidence the best.





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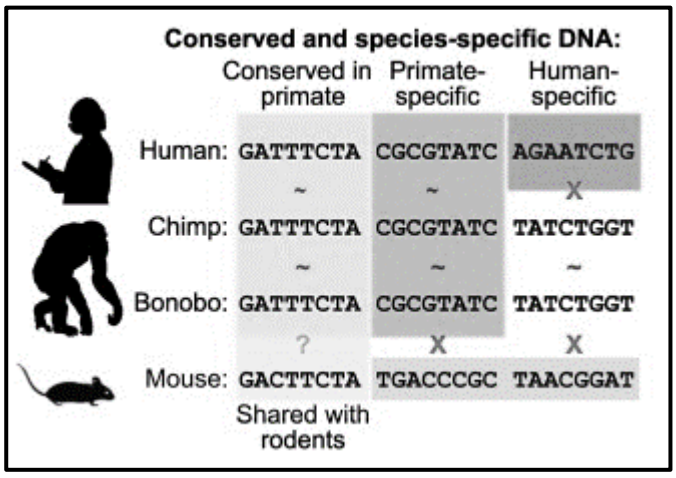

3	3.1	**Indicate what evidence do fossils provide for evolution.**	(2)
	3.2	**Explain why fossils are not a reliable source of evidence for evolution.**	(2)
	3.3	**How can homologous structures provide evidence for evolution?**	(1)
	3.4	**Explain what biogeography is.**	(2)
	3.5	**Describe the role of biogeography as evidence for evolution.**	(2)
	3.6	**Name the FOUR points that genetics are based on to provide evidence for evolution.**	(4)

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Evolution: Variation

Activity 61 **Date: _____**

1 1.1 **Name the sources of variation in a population.** (4)

1.2 **Describe how meiosis contributes to variation among individuals of the same species.** (8)

1.3 **Distinguish between Random fertilisation and Random mating.** (4)

2 2.1 **Complete the table below on the differences between continuous and discontinuous variation.** (7)

	Continuous variation	**Discontinuous variation**
Definition	Those characteristics where there is a range of intermediate phenotypes from one extreme to another	
Gene locus		Usually only one but may be a very small number
Number of alleles	Many pairs of alleles as many genes contribute to the inheritance	
Effect on phenotype	Many intermediate phenotype	
Environment influence		Environment has little to no influence
Example		

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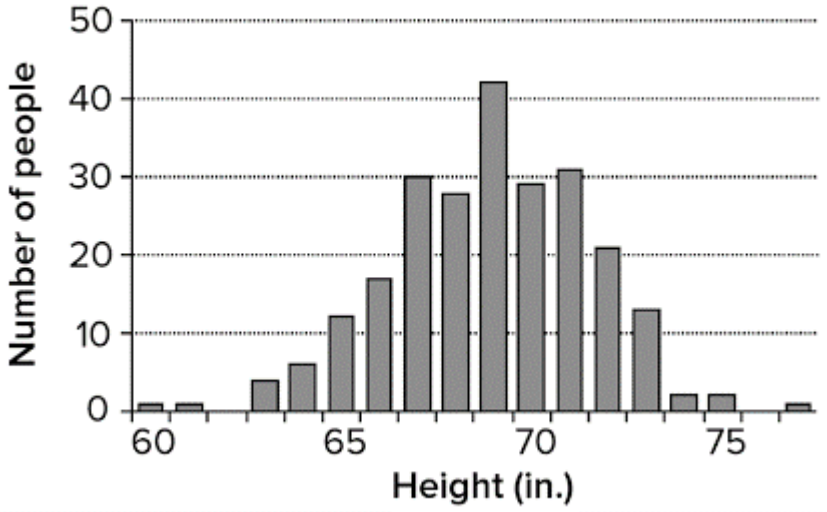
3 3.1. **The graph below illustrates different heights in humans.**

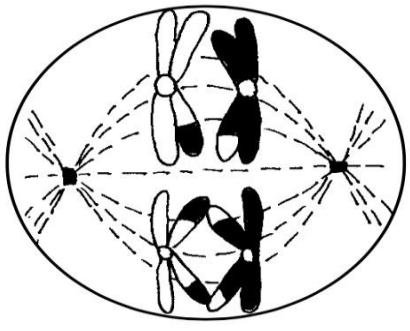


(5)

3.1.1 **What type of variation is illustrated in this graph?** (1)

3.1.2 **Explain your answer in 3.1.1** (2)

4 4.1. **The diagram below is a phase during meiosis.**



4.1.1. **Name the *process* that is illustrated in the diagram.** (1)

4.1.2 **Explain the significance of this process in 4.1.1.** (2)

5. **Explain how gene mutations can play a role in genetic variation in species.** (2)

6. **Explain random fertilisation and the role it plays in genetic variation.** (2)

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Evolution: Origin of ideas

Activity 62 **Date: _____**

1 Theories of evolution:

A. Lamarckism
B. Darwinism
C. Punctuated equilibrium

Write the letter of the correct evolution theory next to the statement below.

1.1.	Inheritance of acquired characteristics	
1.2.	Only organisms best suited to the environment will survive	
1.3.	Long periods of little changes followed by short periods of rapid change	
1.4.	If structures are not being used, then the structure would become smaller and might disappear	

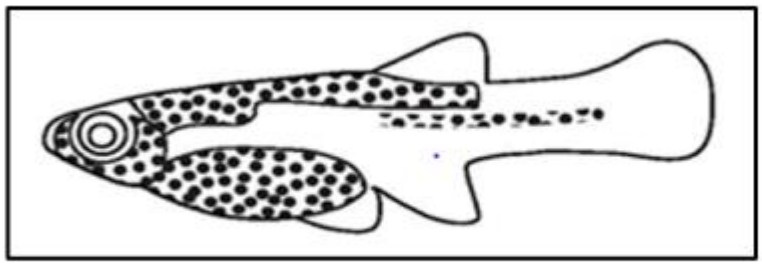
(4)

2 **Name and explain the two laws of Lamack.** (6)

3 **Describe the evolution theory of Eldrege and Gould.** (4)

4 **Describe Darwin's theory of evolution by natural selection.** (8)

5 5.1 A scientist used guppies (*Poecilia reticulata*) in an investigation to test Darwin's theory of natural selection. Male guppies have brightly coloured spots to attract females, but these spots also attract predators. It was previously observed that males living in streams where there were many predatory fish tended to have fewer spots. This reduced their risk of being eaten. Those males living in streams with fewer predators had more spots.



Guppy showing spots (adapted from www.decodedscience.org)

The procedure for the investigation was as follows:

- Equal numbers of male and female guppies were put into two ponds (pond 1 and pond 2).
- In pond 1, predatory fish that prey on guppies were introduced.
- In pond 2, predatory fish that do not feed on guppies were introduced.
- The guppies were allowed to breed for 20 months, representing several generations of guppies. (Guppies reproduce when they are about three months old.)

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The result of the investigation: The male guppies in pond 2 had significantly more spots than the male guppies in pond 1.

5.1.1 **How could the validity of this investigation be increased?** (3)

5.1.2 **Identify the:**

a) **Independent variable** (1)
b) **Dependent variable** (1)

5.1.3 **Explain why the scientist included pond 2 in this investigation** (5)

5.1.4 **Describe how Darwin's theory of natural selection can be used to explain why the guppies in pond 1 had fewer spots.** (6)

Guiding Question	**Darwin's explanation**
State the characteristic that varies	
Describe the variations	
Explain the environmental change/ selection pressure for natural selection	
State the unfavourable characteristic and why it is unfavourable	
Explain what happened to this individual with the unfavourable characteristics	
State the favourable characteristic and why it is favourable	
Explain what happened to this individual with the unfavourable characteristics	
What happened to the favourable characteristic	

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6 6.1 **The red-bellied black snake (*Pseudechis porphyriacus*) and the green tree snake (*Denderelaphis punctulatus*) are predators that sometimes feed on cane toads (Bufo marinus) that contain a toxin that may kill them. The snakes consume the toads by swallowing them whole. A decrease in the average jaw size of the snakes has been observed over a period of 70 years. Some scientists believe that this may be an example of punctuated equilibrium. With this change it was also noted that the snakes could no longer swallow the large cane toads. This has resulted in an increase in the survival of the snakes**.

6.1.1 **Define punctuated equilibrium.** (5)

6.1.2 **What characteristic of the toad species protects it from predation?** (1)

6.1.3 **Explain how the change in jaw size helped the snakes to survive.** (3)

6.1.4 **How would Lamarck have explained the development of a small jaw size in the snakes?** (6)

Guiding Questions	**Lamarck's explanation**
What was the original characteristic at the start?	
What did the organism do?	
Why did the organism do this?	
What was the result?	
What happened to this new characteristic?	
What was the result of this?	

7 7.1 **What type of characteristics does nature select during evolution?** (1)

7.2. **In nature, there is always a fight for survival due to competition, predation and adverse weather conditions. Suggest a collective term for all these factors.** (1)

7.3 **Why is the concept of natural selection so important?** (3)

7.4 **Why is natural selection not a random process?** (4)

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Evolution: Extra evolution theories

Activity 62 A **Date: _____**

1 **Brine shrimp are small arthropods found in saltwater lakes. During favourable conditions female shrimps produce eggs that hatch into live young. However, when conditions are unfavourable, the shrimp produce cysts. Each cyst contains the embryo covered with a hard, protective covering. In this state the embryo stops growing and is said to be dormant. The embryo can remain in this dormant state for many years and the cyst will only hatch at the optimum salt concentration.**
Scientists wanted to investigate which salt concentration resulted in the highest percentage of hatched cysts.

They did the following:

- Prepared salt solutions of different concentrations: 0%, 0,5%, 1%, 1,5% and 2%
- Placed 30 mℓ of each solution into one of five beakers
- Took samples of brine shrimp cysts using a dropper
- Counted the number of cysts in each sample
- Recorded this as the initial number of cysts
- Placed the samples into each of the five beakers
- Left the beakers at room temperature for 48 hours
- Recorded the number of cysts that hatched in each beaker
- Calculated the percentage of cysts that hatched

The results are shown in the table below.

SALT CONCENTRATION (%)	NUMBER OF CYSTS USED AT THE START	NUMBER OF CYSTS THAT HATCHED	PERCENTAGE OF CYSTS THAT HATCHED
0	54	0	0
0,5	34	2	6
1	40	6	15
1,5	40	1	2,5
2	53	1	X

1.1. **State TWO planning steps to consider before collecting the samples.** (2)

1.2 **State the:**
a) **Independent variable** (1)
b) **Dependent variable** (1)

1.3 **Calculate the value of X in the table. Show ALL working.** (3)

1.4 **State THREE factors that were kept constant in order to ensure the validity of this investigation.** (3)

1.5 **Which salt concentration resulted in the highest percentage of hatched cysts?** (1)

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1.6 **Use the theory of evolution through natural selection to explain how the ability to produce cysts led to the survival of the brine shrimp.**

Guiding Question	Darwin's explanation
State the characteristic that varies	
Describe the variations	
Explain the environmental change/ selection pressure for natural selection	
State the unfavourable characteristic and why it is unfavourable	
Explain what happen to this individual with the unfavourable characteristics	
State the favourable characteristic and why it is favourable	
Explain what happen to this individual with the favourable characteristics	
What happen to the favourable characteristic	

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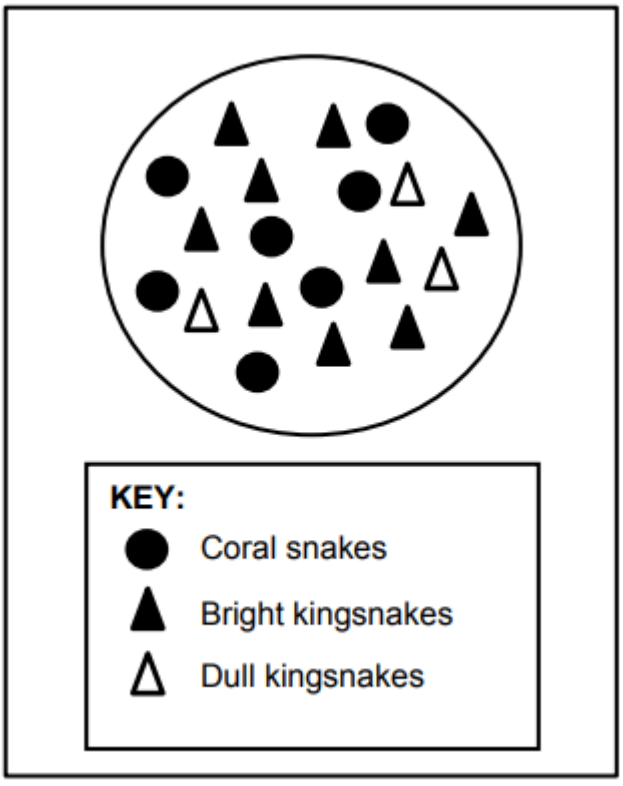
2 There are two variations in the colour of kingsnakes. Some have a bright colourful pattern and others have a dull pattern. Kingsnakes are non-poisonous to their predators. Coral snakes also have a bright colour pattern, but are poisonous to their predators. This is a defence mechanism as predators avoid them. Scientists observed that where kingsnakes shared the same habitat with coral snakes, there were more kingsnakes that had bright colourful patterns. The diagram below represents the distribution of the snakes.



2.1 **Explain how the bright colour pattern of coral snakes influences their survival.** (3)

2.2 **Use Darwin's theory of evolution through natural selection to explain why there are more brightly coloured kingsnakes in this habitat.**

Guiding Question	Darwin's explanation
State the characteristic that varies	
Describe the variations	
Explain the environmental change/ selection pressure for natural selection	
State the unfavourable characteristic and why it is unfavourable	
Explain what happened to this individual with the unfavourable characteristics	
State the favourable characteristic and why it is favourable	
Explain what happened to this individual with the unfavourable characteristics	

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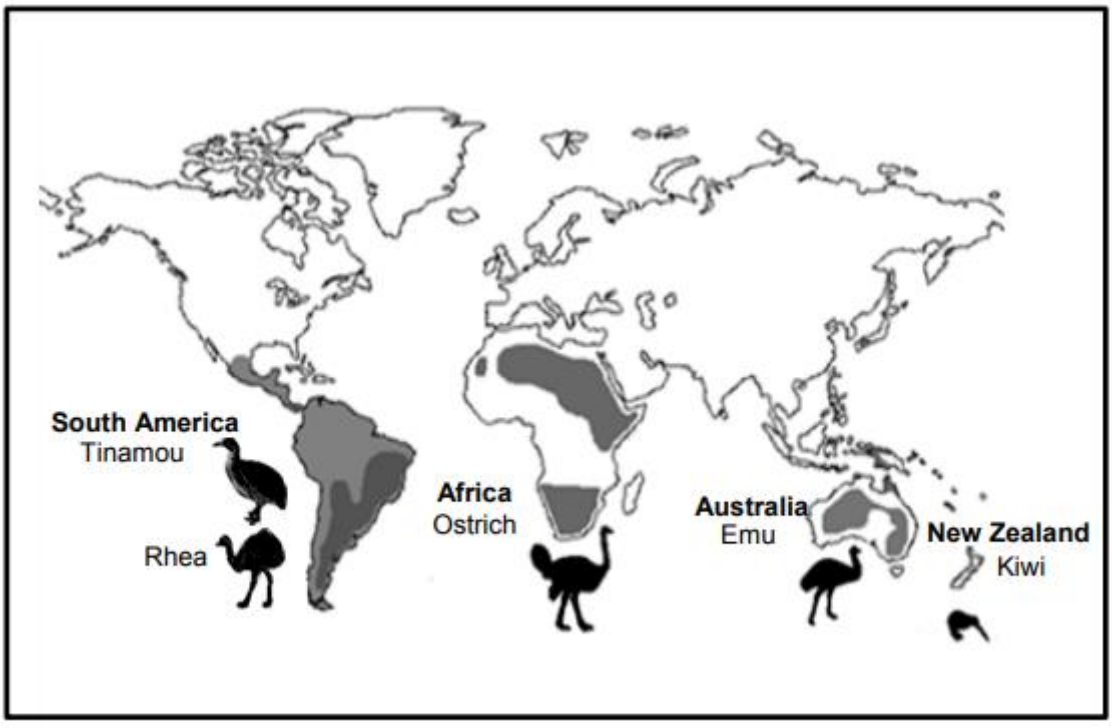
What happened to the favourable characteristic	

3 Flightless bird species that are currently distributed across different continents are shown in the picture below.



Scientists hypothesise that these species of flightless birds arose from a single common ancestor that was able to fly.

3.1 **Describe how Lamarck would have explained the evolution of flightless birds.** (6)

Guiding Questions	**Lamarck's explanation**
What was the original characteristic at the start?	
What did the organism do?	
Why did the organism do this?	
What was the result?	
What happened to this new characteristic?	
What was the result of this?	

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Evolution: Difference between Lamarckism, Darwinism and Punctuated equilibrium

Activity 63 **Date: _____**

1 **Darwin and Lamarck were both scientists who tried to understand evolution**.

Lamarck's theory of evolution was based around how organisms (e.g. animals, plants) change during their lifetime, and then pass these changes onto their offspring. For example, Lamarck believes that the giraffe had a long neck because its neck grew longer during its lifetime, as it stretched to reach leaves in high-up trees, meaning that each generation of giraffe had a longer neck than previous generations.

Darwin's theory, known as **natural selection,** believed that organisms possessed **variation** and these variations led to some being more likely to **survive** and **reproduce** than others. In terms of the giraffe, Darwin's theory would state that longer necked giraffes were more likely to survive, because they could eat leaves from taller trees, and therefore more long-necked giraffes will be born, which eventually caused all giraffes to have longer necks.

1.1 **Give:**

a) **The term that describes Lamarck's ideas.** (1)
b) **The term that describes Darwin's idea of Natural selection** (1)
c) **The name of the Scientists that are associated with the theory of punctuated equilibrium.** (1)

1.2 **Tabulate the difference between Lamarck's theory of evolution and Darwin's theory of evolution.** (5)

Lamarck's	Darwin

1.3 **Explain whose idea of evolution is more acceptable today.** (2)

2 **Distinguish between punctuated equilibrium and gradualism.** (2)

3 **What is the similarity between punctuated equilibrium and gradualism** (4)

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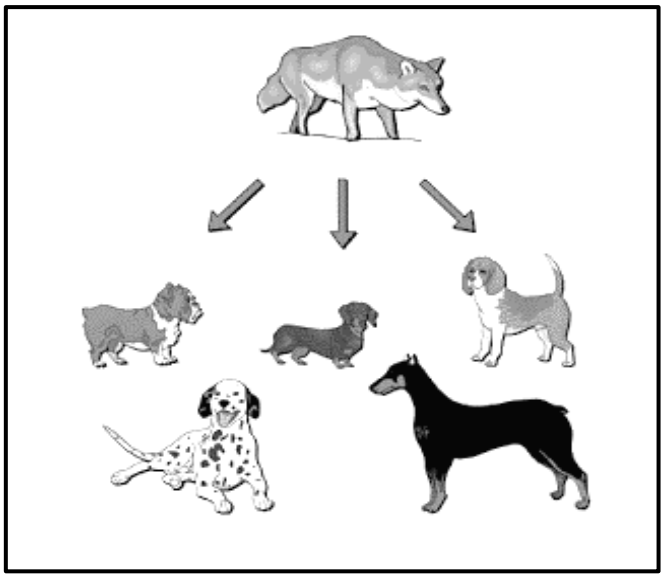
Evolution: Artificial selection

Activity 64 **Date: _____**

1 The first dog evolved from a population of wolves. Although wolves look very similar to some breeds of domestic dogs, wolves and domestic cannot interbreed.



All types of domestic dogs are capable of interbreeding to produce puppies which will eventually be capable of interbreeding with any other domestic dog.

1.1 **Explain why all breeds of domestic dogs belong to the same species.** (2)

1.2 **Domestic dogs are bred to show specific characteristics with respect to their health, personality, and appearance. Explain why this is considered as artificial selection.** (2)

1.3 **Describe how artificial selection led to different breeds of domestic dogs.** (3)

1.4 **What effect does the type of selection mentioned in 1.3 have on the survival chances of the dog species?** (2)

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Evolution: Speciation

Activity 65 **Date: _____**

1

When the Grand Canyon was formed, the population of the ancestral species of squirrels living in the area were split into two sub-populations. Over a period two species developed.

Kaibab squirrel

Abert's squirrel

One species is the Kaibab squirrel which has black fur and fluffy tail. The other is the Abert's squirrel which has grey fur and a bushy tail.

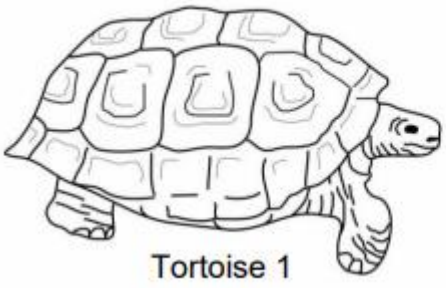
Members of these two species have a similar size, shape, and diet, but they are no longer in contact with each other and have become so different during their separation that they are now separate species.

[Adapted for http://biologydictionary.net/allopatric-speciation]

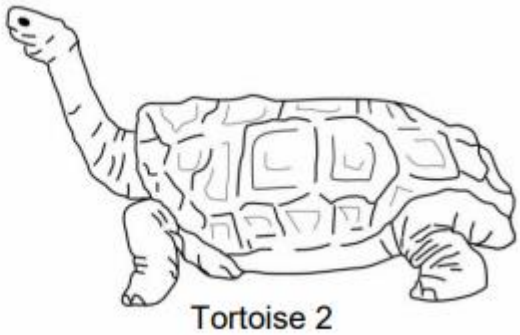
1.1. **Define the term *population*.** (4)

1.2. **Describe how speciation of the GRAND CANYON squirrels took place.** (6)

2 Darwin discovered two different species of tortoises on two different islands in the Galapagos. One had a domed shell and short neck, the other had an elongated shell and a longer neck. The two islands had very different vegetation. One of the islands (island X) was rather barren, dry and arid. It had no grass but rather short tree-like cactus plants. On the other island (island Y), there were no cactus plants but it had a good supply of water and grass grew freely. The diagram below shows the two main tortoises.



Tortoise 1



Tortoise 2

2.1 **Which tortoise would be found on island Y?** (2)

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2.2 **Describe how the two tortoise species become different.** (6)

2.3 **List FOUR sources of variation that could lead to the variation in the tortoise population.** (4)

2.4. **Explain the role of natural selection on *island X* where more of tortoise 2 are found.** (6)

Guiding Question	Darwin's explanation
State the characteristic that varies	
Describe the variations	
Explain the environmental change/ selection pressure for natural selection	
State the unfavourable characteristic and why it is unfavourable	
Explain what happened to this individual with the unfavourable characteristics	
State the favourable characteristic and why it is favourable	
Explain what happened to this individual with the favourable characteristics	
What happened to the favourable characteristic	

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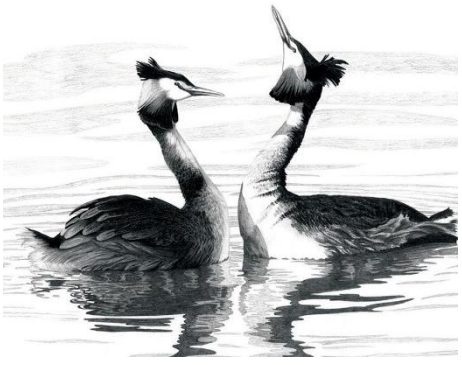
Evolution: Reproductive isolation

Activity 66 **Date: _____**

1 **Identify the reproductive isolation mechanism that is illustrated in the diagrams below.** (5)

 Insects have very specific copulatory organs.	
	
May-flower Species 1 Species 2	

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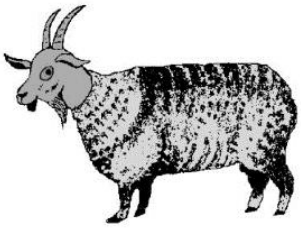 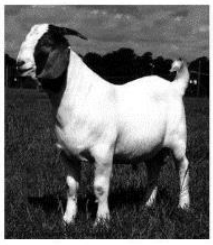 Sheep and goat hybrid dies before birth	

2 2.1. **What is meant by the term reproductive isolation?** (1)

2.2. **Describe species-specific courtship.** (2)

2.3. **Give THREE examples of species-specific courtship.** (3)

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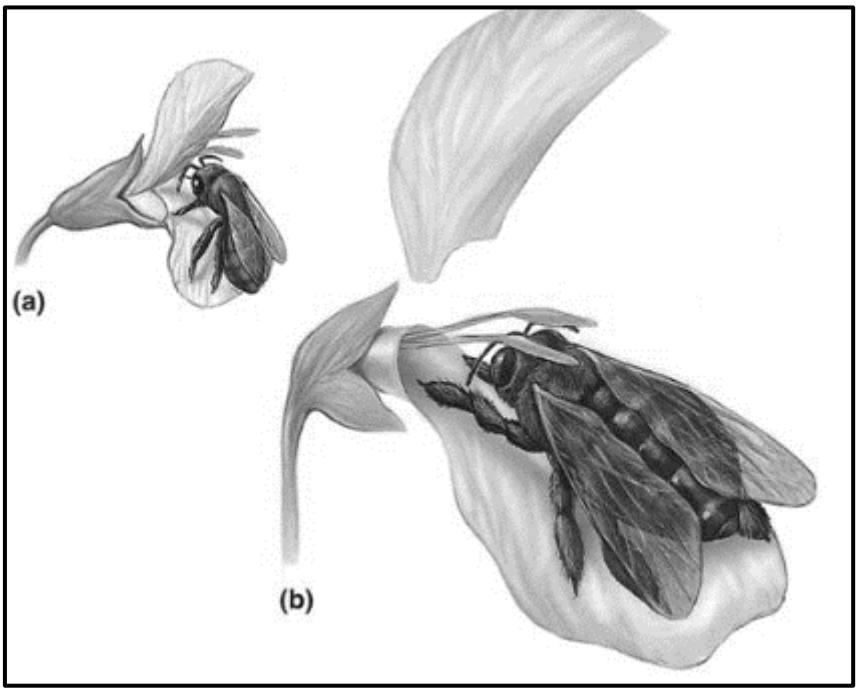
3 3.1



Differences in flower structure in black and white sage, is the selection force for different pollinating bees. Large bees do not fit on black sage petals.

3.1.1 **Identify the reproductive isolation mechanism that is illustrated in the diagram above.** (1)

3.1.2 **Explain what the significance of this isolation mechanism is.** (2)

4 4.1. **Explain the development of infertile offspring between two species.** (3)

4.2. **Give an example of infertile offspring between two species.** (2)

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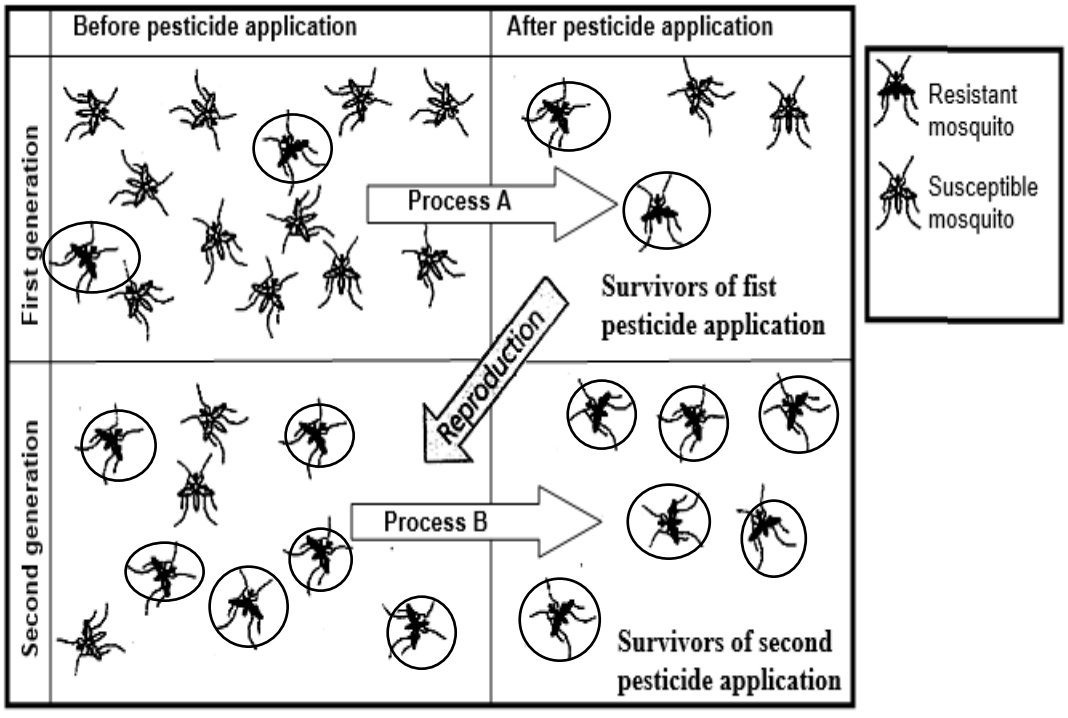
Evolution: Evolution in present times.

Activity 66 A **Date: _____**

1 **The introduction of DDT represents a change in the environment of the mosquito. Study the diagram and answer the questions.**



1.1. **Give a suitable heading for the above diagram.** (2)

1.2. **What process is represented by …?**

a) **A** (1)
b) **B** (1)

1.3 **Describe the composition of the first generation.** (2)

1.4 **Explain how these two dark mosquitoes evolved in the first generation.** (3)

1.5 **Describe the composition of the survivors of the second pesticide application.** (2)

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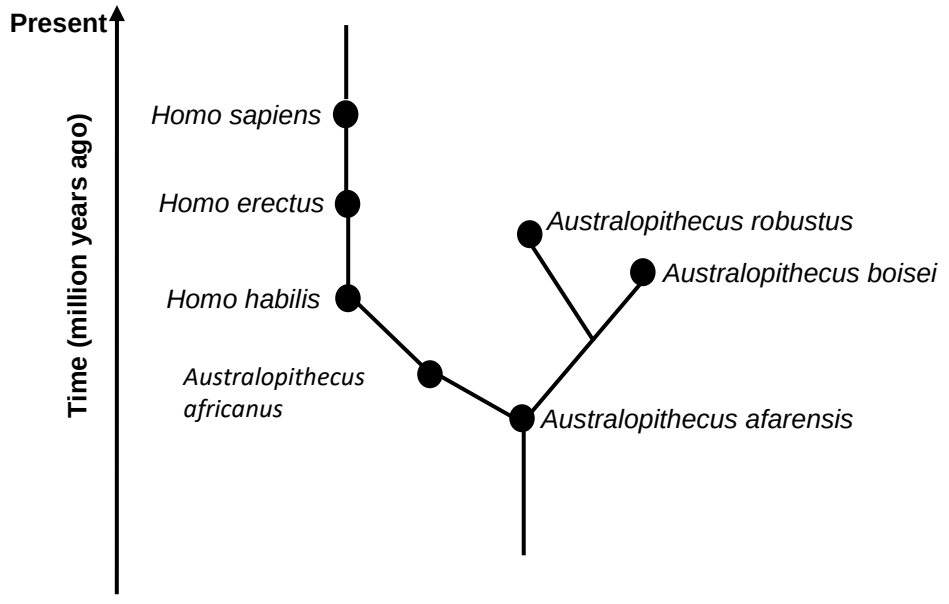
Evolution: Phylogenetic tree

Activity 67 **Date: _____**

1 **The diagram below shows possible relationships between members of Hominids.**

POSSIBLE RELATIONSHIPS BETWEEN HOMINIDS



1.1. **What is the name given to this diagram?** (1)

1.2. **How many of each of the following are represented in the diagram?**

a) Genera
b) Species (2)

1.4. **Explain why *A. robustus* and *A. boisei* are more closely related than *A. boisei* and *A. afarensis*.** (2)

1.5. **Which hominid is the common ancestor of all the hominids in this diagram?** (1)

1.6. **Give the**

a) **Family to which all humans belong to** (1)
b) **Genera to which all humans belong to** (1)
c) **Name of the ancestral of homo sapience** (1)

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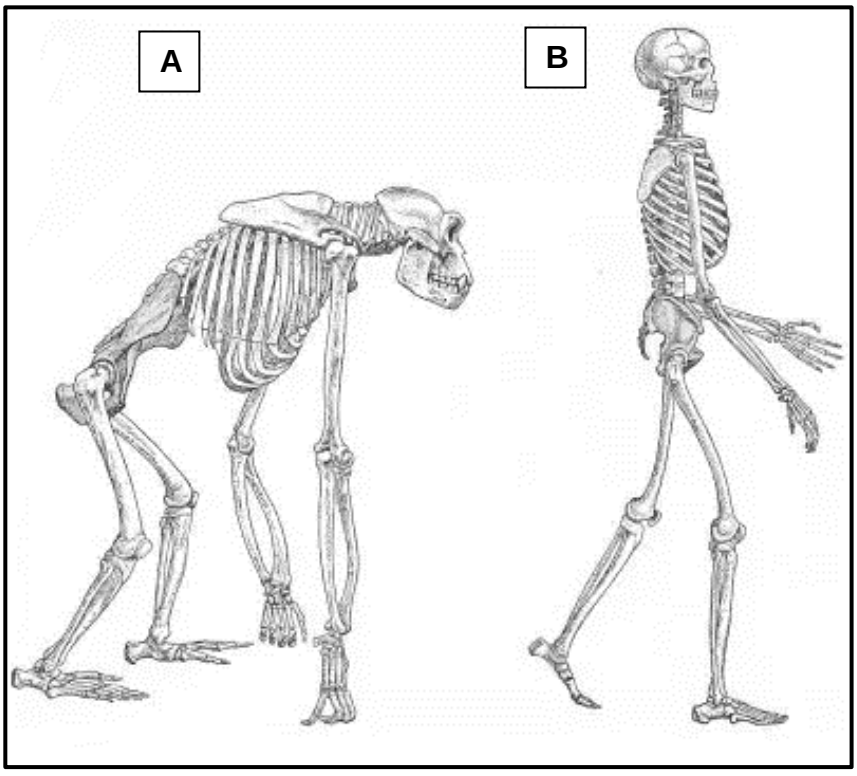
Evolution: Similarities between humans and African apes

Activity 68 **Date: _____**

1 **Skeletons of an African ape and a human.**



1.1. **Organism *A* and *B* belong to the same order and family. Give the name of the order and family.** (2)

1.2. **Give FOUR similarities they share regarding their *upper limps.*** (4)

1.4. **Which organism**

a) **belong to the hominin group?** (1)

b) **Is quadrupedal?** (1)

c) **Is Mammalia?** (2)

1.5. **How is the function of the opposable thumb of organism A and B different?** (2)

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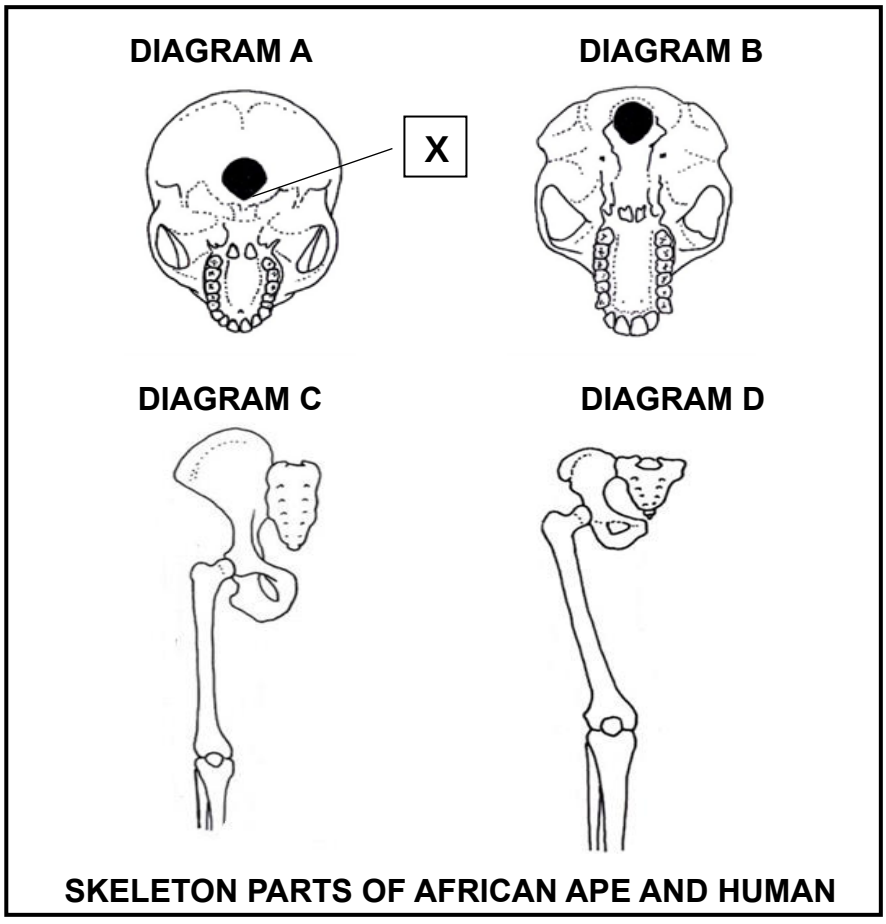
Evolution: Differences between humans and African apes

Activity 69 **Date: _____**

1 **Parts of an African ape and a human skeleton.**



1.1 .1 **Give the label for *X.*** (1)

1.1.2 **Describe the difference of the position of *X* in diagram A and B.** (2)

1.1.3 **Explain the significance of the position of *X* in diagram A.** (5)

1.1.4 **Tabulate THREE visible differences between the jaw /teeth of diagram A and diagram B.** (6)

A	*B*

1.1.5 **Explain the difference in diagram C and D.** (2)

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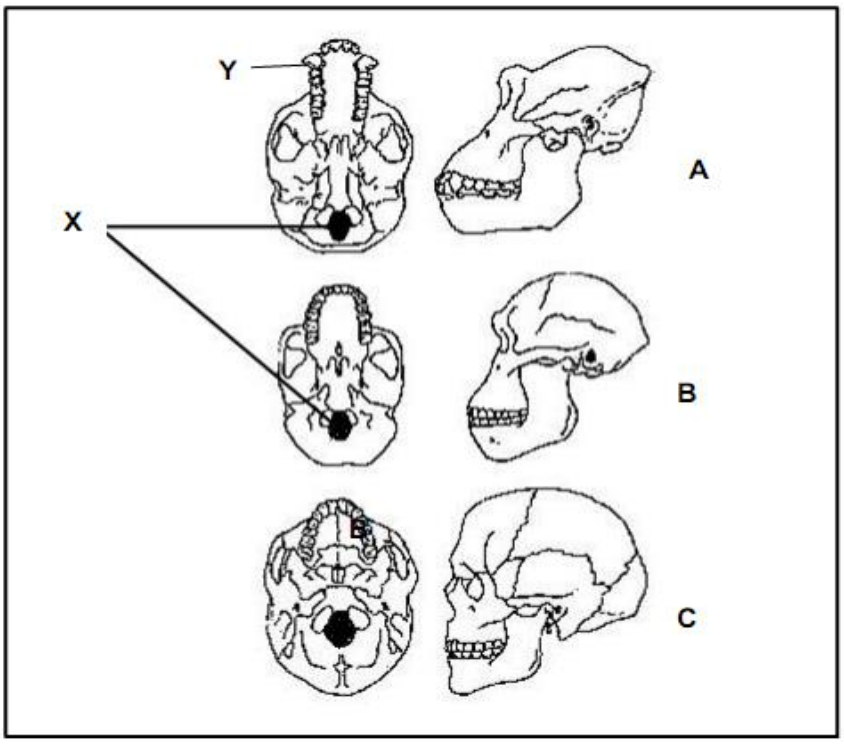
2 **Fossilised skulls of three different species of primates**



2.1.1 **Give the label for *X and Y.*** (1)

2.1.2 **Which skull belongs to … ?**

a) **Hominidae** (3)
b) **Hominin** (2)
c) **Bipedal** (2)

2.1.3 **Explain how the change in the skull from *B to C* could indicate change in intelligence.** (4)

2.1.4 **Tabulate FIVE visible differences between the skulls of *A and C.*** (10)

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Evolution: Fossil evidence

Activity 70 **Date: _____**

1 The extract below is about human evolution.

> In 2004 scientists in Indonesia discovered the first fossil of the species *Homo floresiensis* along with stone tools and animal remains. The fossil was made up of a nearly complete skull and skeleton, including hand and foot bones and a pelvis.
>
> Dating of the tools suggests that *H. floresiensis* may have lived from as early as 95 000 years ago until about 12 000 years ago.
>
> Researchers closely analysed three wrist bones and found that they more closely resembled those of apes than modern humans. This finding implied that *H. floresiensis* was indeed a separate species from modern humans.
>
> They had skulls that resembled early *Homo* species. This included a flat forehead and a short, flat face; however, their teeth and jaws more closely resembled *Australopithecus*.
>
> The scans of the skull suggested that the brain volume of *H. floresiensis* was about 426 cm^3; around one-third the size of the modern human brain which has an average volume of about 1 300 cm^3. The findings suggested that *H. erectus* may be the ancestor of *H. floresiensis*, as *H. erectus* had brains about 860 cm^3 in size or, alternatively, it may have evolved from *H. habilis*, whose brains were about 600 cm^3 in size.

1.1 **Name the TWO lines of evidence for human evolution that is referred to in the extract above.** (2)

1.2 **How long did *Homo floresiensis* exist on Earth?** (1)

1.3 **Name ONE *Homo* ancestor mentioned in the extract.** (1)

1.4 **Describe ONE feature of the skull that can be used as evidence for bipedalism. (Not mentioned in the extract)** (2)

1.5 **State TWO similarities between the hands of African apes and modern humans.** (3)

1.6 **State THREE features of the jaw of *H. floresiensis* that might have led scientists to believe that it resembled that of *Australopithecus*, rather than of a *Homo species*.** (3)

1.7 **Draw a table to show the brain volumes of the different Homo species, using information from the extract.** (4)

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Guideline for assessing the table

Correct table format (separation of columns)	1
Column headings	2
Data entered	1: 1 to 3 data sets correctly entered 2: All 4 data sets correctly entered

2 **Scientists use fossils as evidence for human evolution. The brain volume of some extinct primates has been estimated from their fossils and have been compared to the brain volumes of living primates.**

PRIMATE	PERIOD OF EXISTENCE (million years ago)	AVERAGE BRAIN VOLUME (cm^3)
Ardipithecus ramidus	5,8 to 4,4	400
Australopithecus afarensis	4 to 2,7	450
Australopithecus africanus	3 to 2	450
Homo habilis	2,2 to 1,6	750
Homo erectus	2 to 0,4	1 000
Homo neanderthalensis	0,3 to 0,23	1 500
Homo sapiens	0,2 to present	1 400
Modern apes	0,2 to present	500

2.1 **What type of evidence of human evolution is given in the table?** (1)

2.2 **Give the**

a) **Family to which all these fossils belong to.** (1)
b) **First primate that become extinct.** (1)
c) **Genes of erectus.** (1)

2.3 **Name FOUR fossils of *Australopithecus* that is found in Africa only.** (4)

2.4 **The brain of an organism is not preserved as a fossil. How do scientists determine the brain volume of extinct primates?** (2)

2.5 **Give evidence from the table that suggests that:**

a) **Homo habilis and *Homo erectus* may have existed at the same time.** (1)

b) ***Ardipithecus* was the most primitive of all the primate genera.** (1)

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2.6 **Draw a bar graph to show the average brain volume of EACH of the species of the genus *Homo*.** (6)

Guideline for assessing the graph:

Bar graph drawn	1
Title of graph includes both variables	1
Correct label for X-axis Correct label and unit for Y-axis (cm^3) (L)	1
Equal width and interval of bars Correct scale for Y axis (S)	1
Required bars drawn (B)	1 Only **REQUIRED** bars drawn
Drawing of bars (B)	1 All 4 **REQUIRED** bars drawn correctly

2.7 **Explain how genetic evidence as a line of evidence contribute for human evolution.** (4)

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Evolution: Tabulate the different fossils

Activity 71 **Date: _____**

1 **The image below is that of Mrs. Ples.**

1.1 **Give the:**

a) **Genus and species to which Mrs. Ples belong.** (1)
b) **Site where Mrs. Ples is found.** (1)
c) **Scientist that discovered Mrs. Ples.** (1)

1.2 **Name THREE ape-like features of this skull.** (3)

1.3 **If asked to decide whether a complete skull with jaw bones was that of *Ardipithecus or Australopithecus*, describe which FOUR features would you examine.** (8)

2 2.1 **Complete the table.** (7)

Organism	**Fossil site**	**Discovered by**
Aridipithecus		
		Lee Berger
	Indonesia and Swartkrans	
	Makapansgat in Limpopo; Border Cave in KZN	Tim White
Lucy		Donald Johanson
	Sterkfontein	R Dart

2.2 **Give the name of the *Australopithecus afarensis* that was found in Kenya and Tanzania.** (1)

2.3 **Give the *Australopithecus africanus* that was discovered by …**

a) Robert Broom (1)
b) R Dart (1)
c) Lee Berger (1)
d) Ron Clark (1)

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