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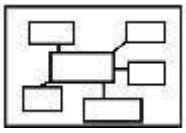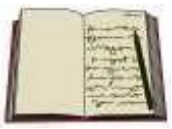
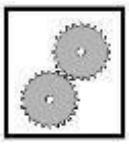
LIFE SCIENCES

GRADE 12

SPRING CLASSES 2026

TEACHER AND LEARNER CONTENT MANUAL

HOW TO USE THIS STUDY GUIDE

 **MIND MAP**	 **EXAMINATION GUIDELINE**	 **CONTENTS**	 **ACTIVITIES**
 **BIBLIOGRAPHY**	 **TERMINOLOGY**	 **WORKED EXAMPLES**	 **STEPS**

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FORWORD

The purpose of this manual is to assist grade 12 learners in preparation for 2026 end of year examination.

The activities in this document are meant to be a guide and not to replace any study material/ textbook.

It aims to assist learners with practice model activities.

The manual focuses on selected challenging content of evolution informed by diagnostic reports of previous years

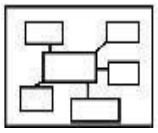
This manual is distributed free of charge, as a learning support material to all Life Sciences teachers and learners in the Free State province and it is fully funded by JENN TRAINING CONSULTANCY

The materials are compiled from different sources.

And we hope that the guide will serve as a valuable and helpful resource for both learners and teachers.

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Phylogenetic tree

EVIDENCE FOR EVOLUTION

- Fossil record and the role of transitional fossils
- Biogeography
- Modification by descent (homologous structures)
- Genetics

THEORIES about Evolution

- Lamarckism
  'Law' of use and disuse
  'Law' of the inheritance of acquired
- Darwinism
  Natural selection
- Punctuated Equilibrium

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

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

EVOLUTION

FORMATION OF A NEW SPECIES

Method of SPECIATION through Geographical barrier

Mechanisms of reproductive isolation

- Breeding at different times of the year
- Species-specific courtship behaviour
- In plants adaptation to different pollinators
- Infertile offspring
- Prevention of fertilization

Evolution in present times

- Use of insecticides
- Development of resistant strains of tuberculosis-causing bacteria
- HIV resistance to ARV's
- Beak and body size of Galapagos finches

TERMINOLOGY IN EVOLUTION

TERM	DEFINITION
Evolution	Over several generations genetic in a population leading to the formation of a new species
Theory	A well-substantiated explanation of some aspects of the natural world that can incorporate facts, laws, inferences, and tested hypotheses.
Hypothesis	An intelligent guess that seeks to explain something observed in nature. It is made up of independent variable, dependent variable and a relationship between them. It is formulated based on the aim of the investigation or based on how the investigation was done. It must be a statement stating the cause (independent variable) and effect (dependent variable)
Fossil record	A record that is based on the discovery of petrified dead, organisms preserved in rocks
Homologous structures	Structures with similar body plans (wing. upper limb) which may perform different functions
Biogeography	A study of the past and present distribution of organisms
Species	Organisms with similar characteristics- interbreeding to produce fertile offspring
Population	A group of individuals belonging to same species, in a particular area, at a given time and can interbreed
Mutation	A sudden change in the genetic makeup of an organism
Continuous variation	Variation a range of intermediate phenotypic such as body weight or height in which a series of types are distributed on a continuum rather than grouped into discrete categories.
Discontinuous variation	Variation in phenotypic traits such as blood groups or gender in which types are grouped into discrete categories

 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 and the role of transitional fossils - Link to Grade 10 • Biogeography - Link to Grade 10 • Modification by descent (homologous structures) • Genetics Use of phylogenetic tree



INTRODUCTION

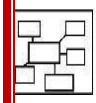
(a) Definition of biological evolution:

- Biological evolution refers to genetic change in a population that inherited and become a characteristic of that population over several generations.

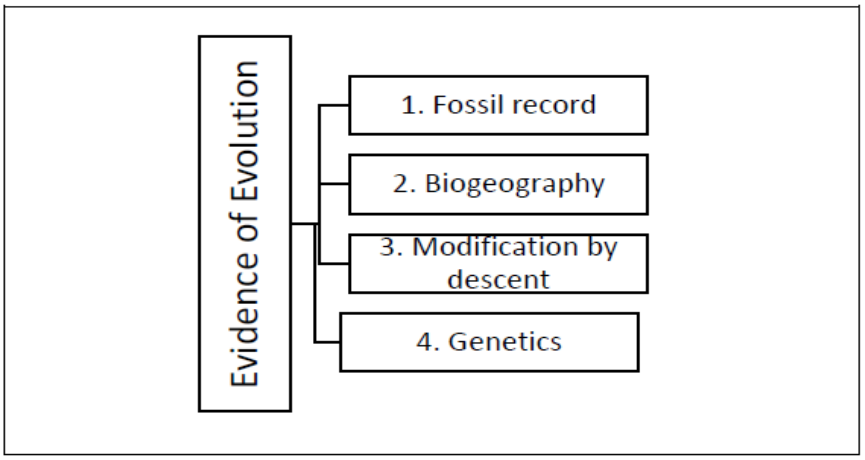
(b) Difference between a hypothesis and a theory

- **A theory** is an explanation of something that has been observed in nature which can be supported by facts, generalizations, tested hypotheses, models, and laws.
- **A hypothesis** is a possible solution to a problem. A possible prediction and/or explanation of the relationship between the two variables.
- It is testable.

(c) The Theory of Evolution is regarded as a scientific theory since various hypotheses relating to evolution have been tested and verified over time.



1.1 EVIDENCES FOR EVOLUTION



NB: You must focus more on the role for evidence for evolution and make sure you can list the 4 "evidence for evolution"

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Describe how each of the following provides evidence for evolution:

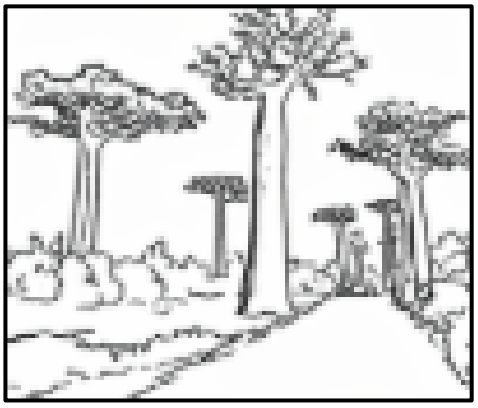
1.1.1. Fossil record – Link to Grade 10

- The remains of millions of extinct organisms are preserved as fossils within ancient sediments that record several billion years of Earth's history.
- Generally, the oldest sedimentary rocks contain the fossils of simpler, more primitive, forms of life (e.g. bacteria, algae, invertebrates), while fossils of more complex organisms (e.g. flowering plants, mammals) are found in much younger sediments.
- The overall trend from simpler ancestral forms to more complex forms as you go through the rock succession clearly shows a pattern of evolutionary change over time.

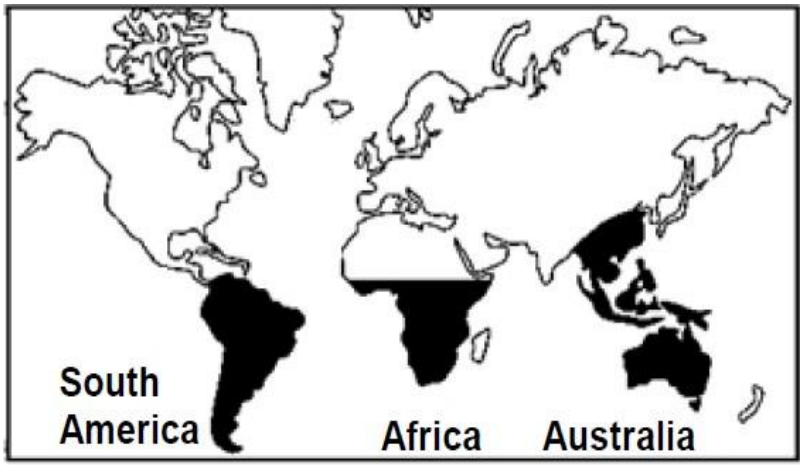
1.1.2. Biogeography – Link to Grade 10

- Biogeography refers to the study of past and present distribution of individual in specific habitat and climatic conditions but separated by geographic barriers.
- For example, **Baobab trees in Africa** and **Madagascar**

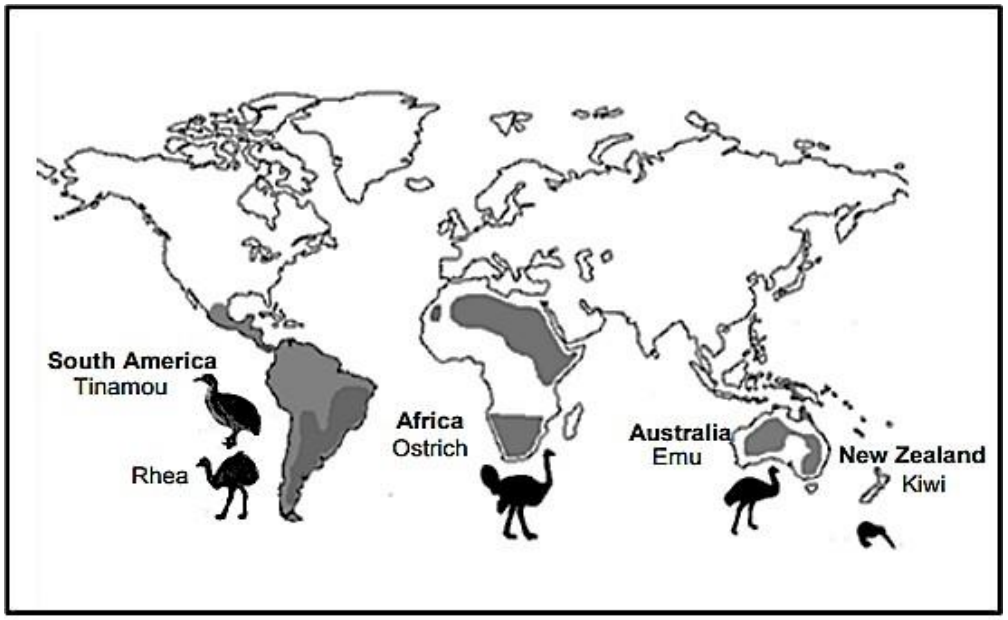




- And the shrubs of the family Proteaceae (e.g. Waratahs and proteas) can be found in Australia, South America, Indo-China and parts of Africa



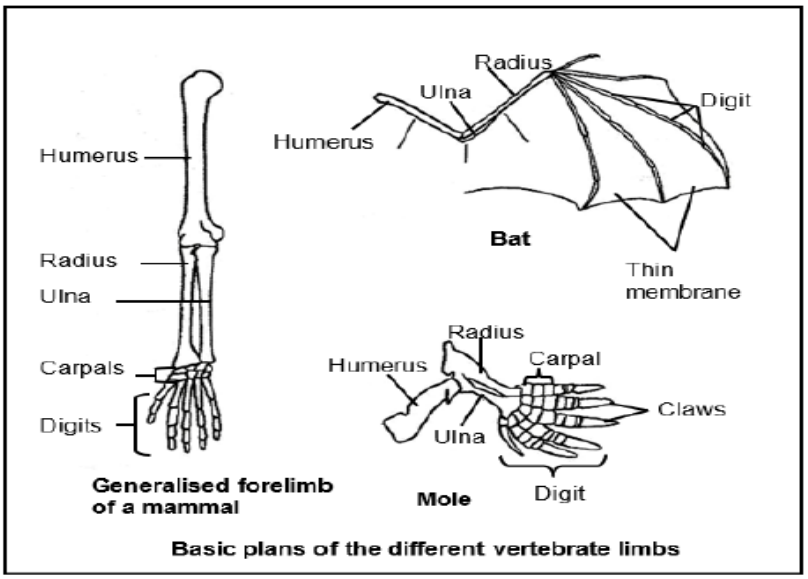
- The distribution of the flightless birds of the world we get ostriches in Africa, Rhea's in southern America, Kiwi's and Emu's in Australia



- There are also ancient fossils of plants and animals distributed across several continents.
- And this provides that these had large populations across the supercontinent before it was separated as a result of continental drift.

1.1.3. Modification by descent (homologous structures)

- The limbs of all classes of vertebrates have a similar arrangement of skeletal bones, although they are modified to perform different functions, generally for different modes of locomotion.
- This arrangement is so similar that all classes of vertebrates must have arisen from a common ancestor



1.1.4. Genetic evidence

- 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
  - similar mutations (mitochondrial DNA)



ACTIVITY 1.1

1.1 The theory of evolution is based on many lines of evidence.

1.1.1 Define biological evolution. (2)

1.1.2 Why is the Theory of Evolution regarded as a scientific theory? (2)

1.1.3 Tabulate ONE difference between a theory and a hypothesis. (3)

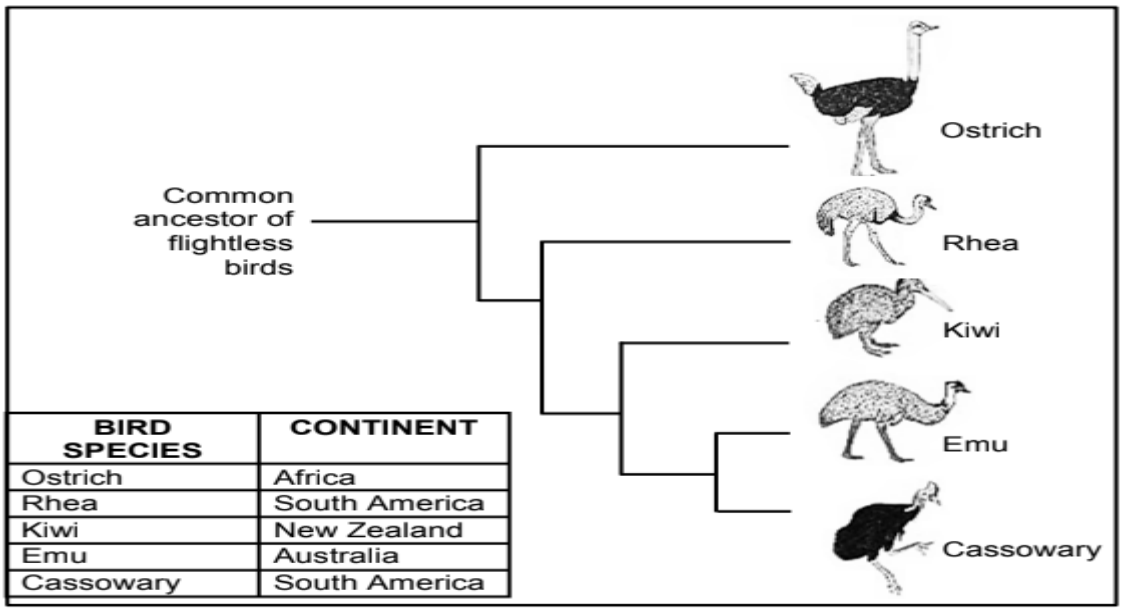
1.14 Name TWO sources where scientists find evidence for evolution. (2)

[7]



ACTIVITY 1.2

1.2 Describe how these three species could have evolved from a common ancestor.



BIRD SPECIES	CONTINENT
Ostrich	Africa
Rhea	South America
Kiwi	New Zealand
Emu	Australia
Cassowary	South America

1.2.1 Identify the type of diagram shown above. (1)

1.2.2 Name the TWO species that share the most recent common ancestor. (2)

1.2.3 Use information in the diagram to describe how biogeography supports the theory of evolution. (4)

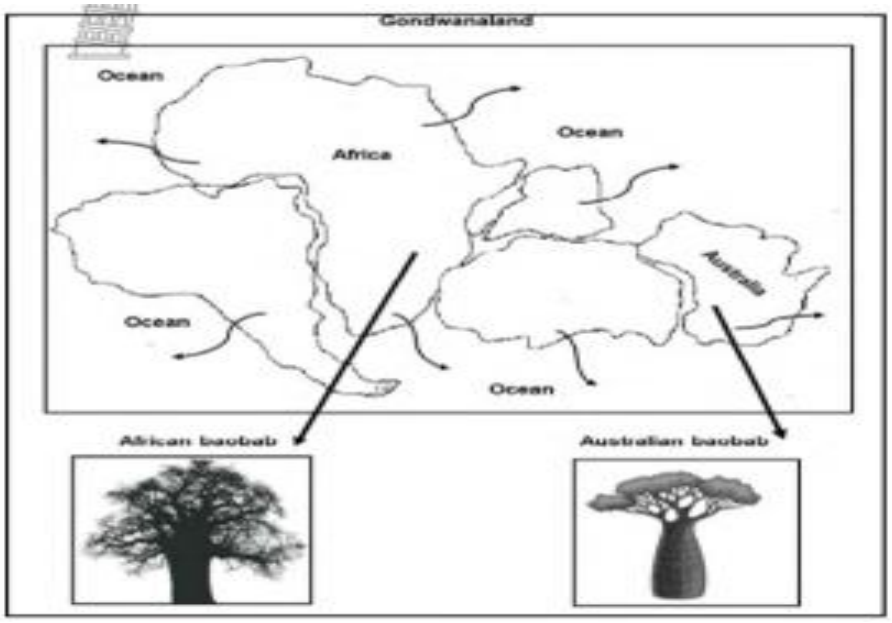
1.2.4 Describe how it can be proven that ostriches and rheas are different species. (2)

(9)

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ACTIVITY 1.3

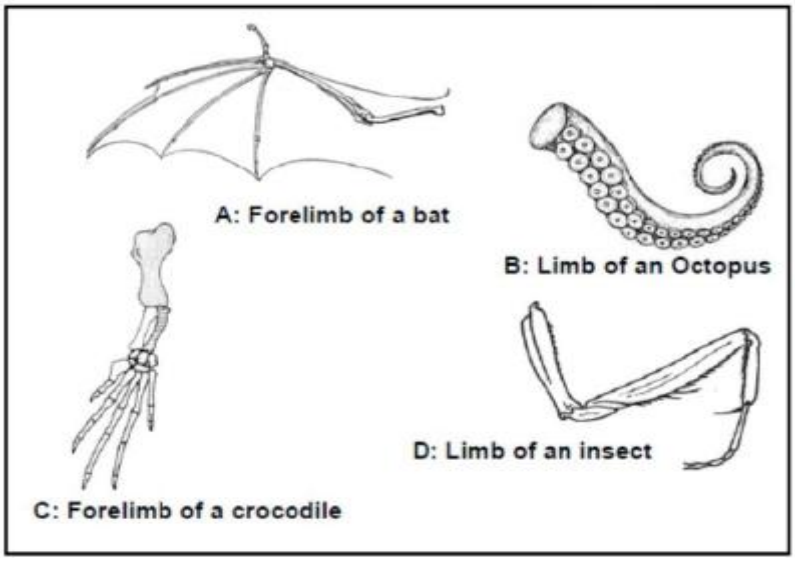
1.3 The baobab tree belongs to the genus Adansonia. Different species are found in Africa and Australia. Originally these two continents formed part of Gondwanaland, as shown in the diagram below.



1.3.1 Explain how the different species of baobab could have evolved on the different continents. (6)

ACTIVITY 1.4

1.4 The diagram below shows the limbs of various animals.



1.4.1 Give only the LETTERS of the diagrams that represent homologous structures. (2)

1.4.2 Describe how homologous structures provide evidence for evolution. (2)

1.4.3 Besides studying homologous structures, name TWO other sources that scientists use as evidence for evolution. (2)

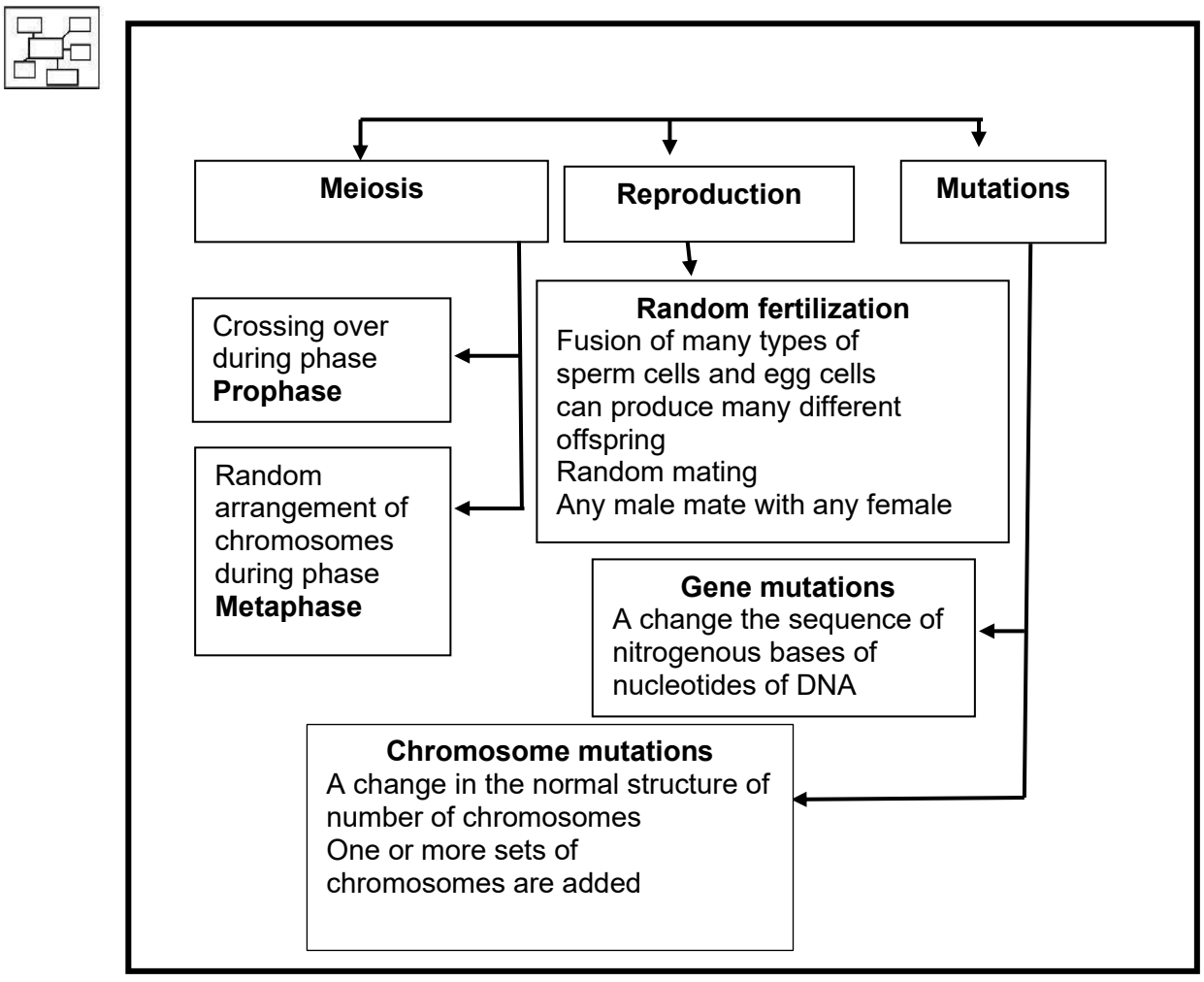
(6)

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2. VARIATION

CONTENT	ELABORATION
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 o Crossing over o 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

2.1. SOURCES OF VARIATION



2.2. DEFINITION OF A BIOLOGICAL SPECIES AND A POPULATION

- **Species**
- A group of organisms that have **similar characteristics** and can **interbreed** to produce **fertile offspring**
- **Population**
- A group of organisms of the same species that lives together in a defined area at a given time and interbreeding can take place.

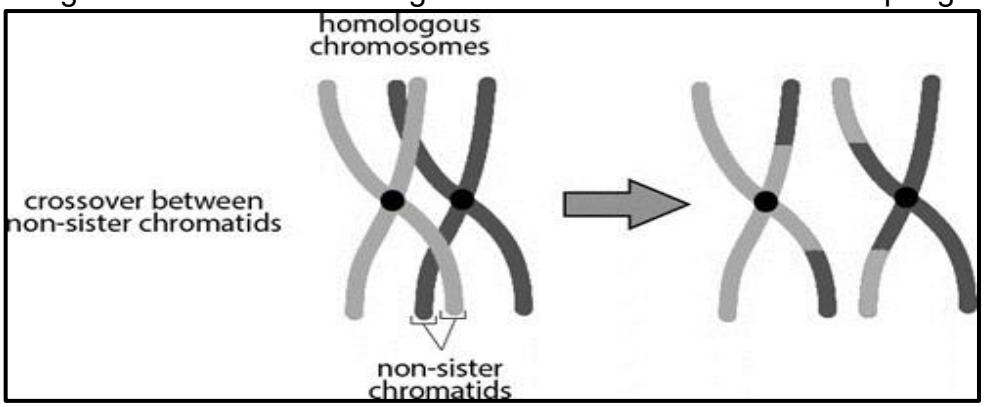
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2.3. DESCRIBE HOW EACH OF THE FOLLOWING CONTRIBUTES TO VARIATION AMONGST INDIVIDUALS OF THE SAME SPECIES:

(i) Meiosis

Crossing over

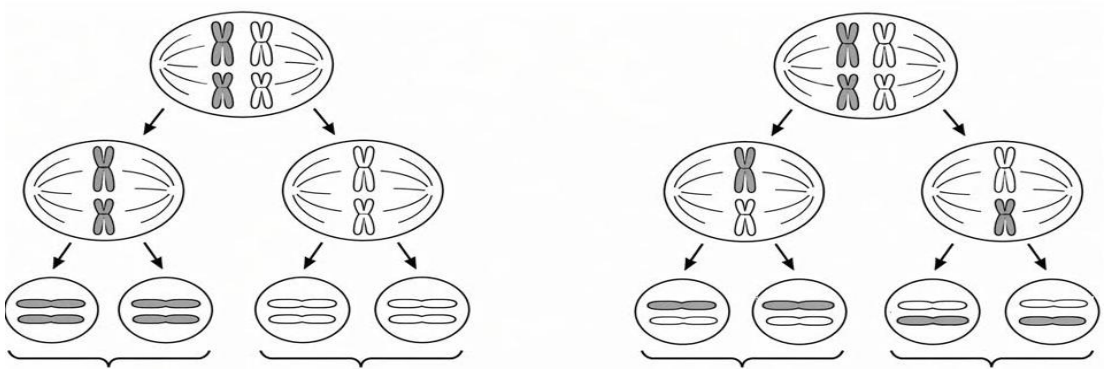
- Homologous chromosomes/bivalents pair up
- Each chromosomes has two chromatids
- Non-sister chromatids overlaps/cross over
- Points at which crossing over takes place are referred to as chiasmata
- Genetic material is exchanged between non-sister chromatids
- After the process of crossing over chromosomes have alleles from its homologous partner
- This means that each gamete formed will have a mix of alleles from both parents
- Brings about variation in the gametes formed and also the offspring



Random arrangement of chromosomes

- Each pair of homologous chromosomes may line up either way on the equator of the spindle
- Independently of what the other pairs are doing
- This means that gametes will have differing number/mix of both parental chromosomes

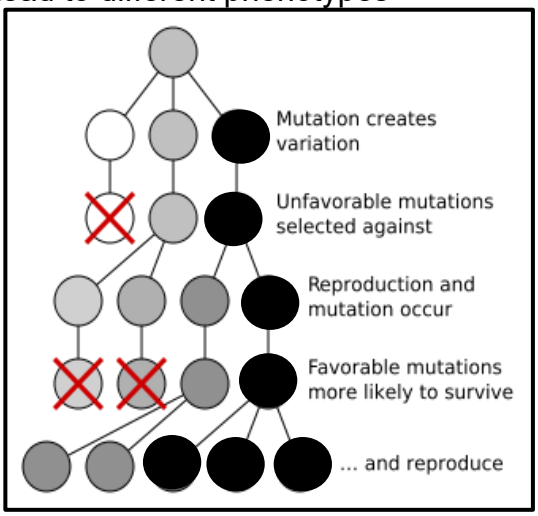
Possibility 1 **Possibility 2**



Combination 1 **Combination 2** **Combination 3** **Combination 4**

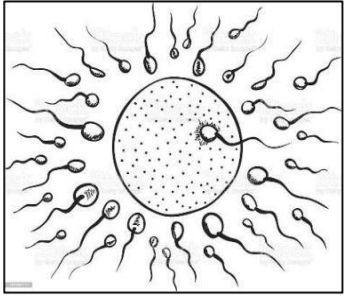
(ii) Mutations

- Mutations are **alterations** in the DNA of chromosomes.
- Many mutations may be **neutral** or '**silent**' (i.e. they have no observable effect on the organism).
- **Harmful** mutations become evident because they may alter the **survival capacity** of the organism.
- Errors/mistakes/changes may occur during transcription/DNA replication
- Resulting in changing the order/sequence of all the bases of the codons
- Resulting in forming a different protein with different functions
- Lead to different phenotypes



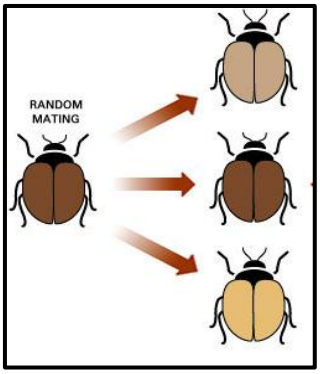
(iii) Random fertilisation

- Firstly, the egg cells and sperm cells produced by meiosis are different from each other. Since there is random fertilization of these different gametes, there will be different combinations of genetic material offspring.



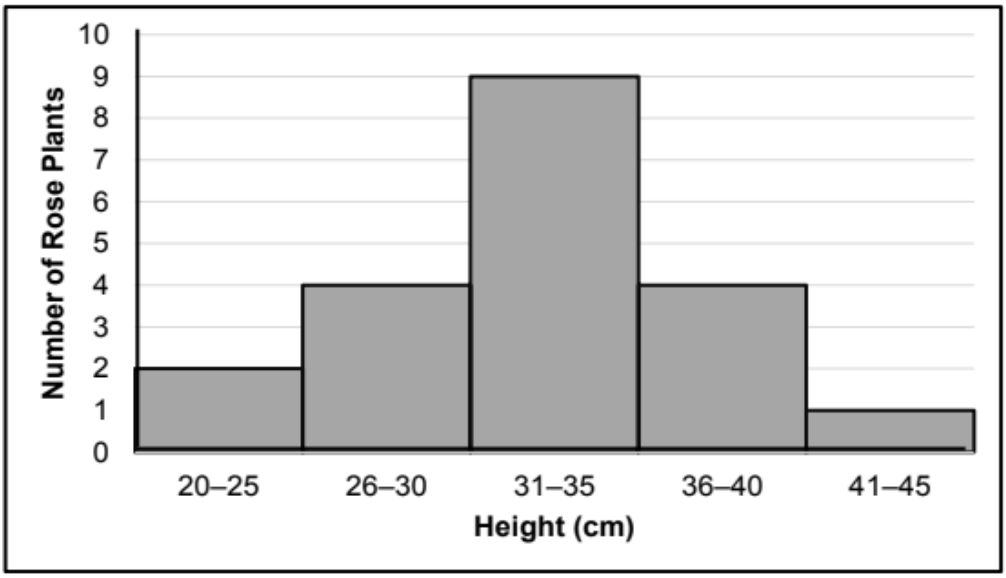
(iv) Random mating

- A population is one where all individuals are potential partners.
- This assumes that there is no mating restrictions, neither genetic or behavioural, upon the population, and that therefore, all recombination is possible.
- The choice of mates coming down to chance, this increases the number of heterozygotes in the offspring



ACTIVITY 1.5

The histogram below shows the range of heights in a sample of rose plants.



1.5.1 What type of variation is shown by the height of rose plants? (1)

1.5.2 Give a reason for your answer in QUESTION 1.5.1 (2)

(3)

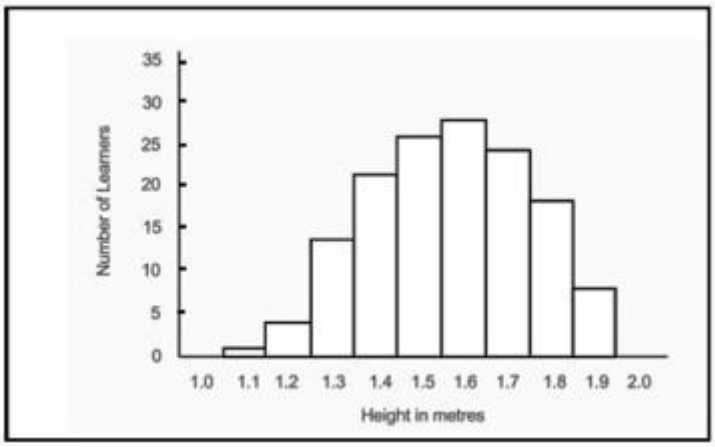
ACTIVITY 1.6

1.6 Mutations result in genetic variation.

1.6.1 (a) Give THREE other sources of genetic variation in a species. (3)

(b) Differentiate between continuous variation and discontinuous variation. (2)

1.6.2 The graph below shows the variation of heights of a group of 18- year-old students.



1.6.2.1 Identify the type of graph represented. (1)

1.6.2.2 Explain why this type of graph mentioned in QUESTION 1.6.2.1 is most suitable for plotting data on continuous variation. (2)

1.6.2.3 What is the most common height? (1)

1.6.2.4 How many people in the group were shorter than 1.3 meters? (1)

(9)

ACTIVITY 1.7

1.7 Read the following extract.

MUTATION IN GENE ALLOWS TIBETANS TO SURVIVE AT HIGH ALTITUDE

It is possible to cope with the low oxygen content at high altitudes.

One way is for the body to produce more red blood cells in response to an increase in altitude.

Another way of coping has developed in Tibetans as a result of a gene mutation that they inherited from their ancestors. The mutant gene helps them to use the low amount of oxygen present more efficiently. The mutant gene was found in 87% of the Tibetan population but only in 9% of the Han population that live at a lower altitude than the Tibetans.

1.7.1 A gene mutation caused variation between the Tibetan population and the Han population.
Name THREE other sources of variation in a human population. (3)

1.7.2 Give evidence in the extract which suggests that the survival of people living at high altitudes could be:
(a) Due to a genetically inherited trait (1)
(b) Caused by an environmental factor (1)

1.7.3 Explain the advantage of producing more red blood cells. (2)

(6)

3. THEORIES ABOUT EVOLUTION

CONTENT	ELABORATION
Origin of an idea about origins (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

3.1. Jean Baptiste de Lamarck – 1744-1829 (**Lamarckism)**

3.1.1. 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.

3.1.2. Law of inheritance

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

3.1.2. How to describe Lamarckism

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 became 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**

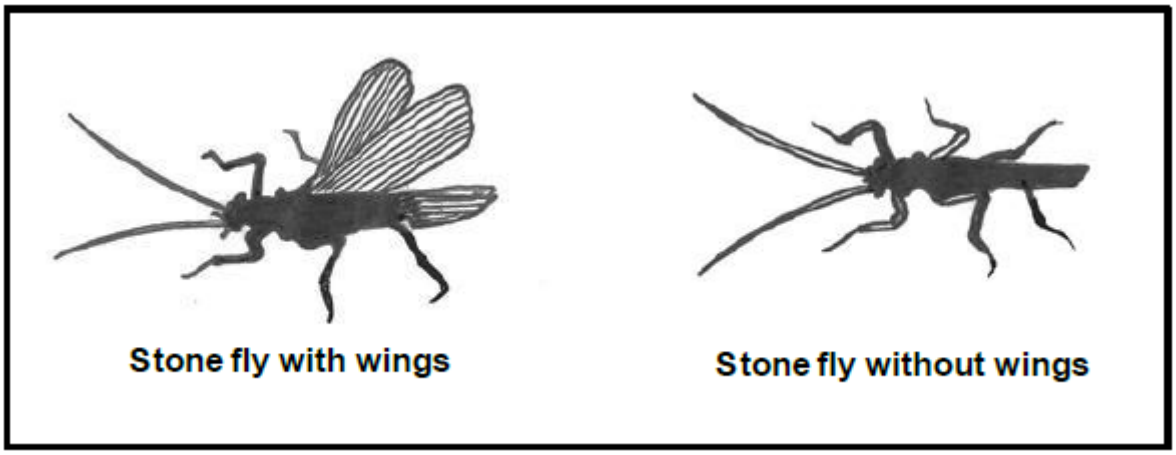
3.1.3. Application of Lamarckism

Insects on islands without trees are likely to be wingless because flying is dangerous for them in an area with strong winds.

A certain island was once covered with tall trees. Over the years, there has been deforestation in some areas of the island. On this island, insects called stoneflies, have undergone natural selection. Some have wings and some do not have wings, depending on the area where they are found.

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The diagram below shows stoneflies with and without wings.



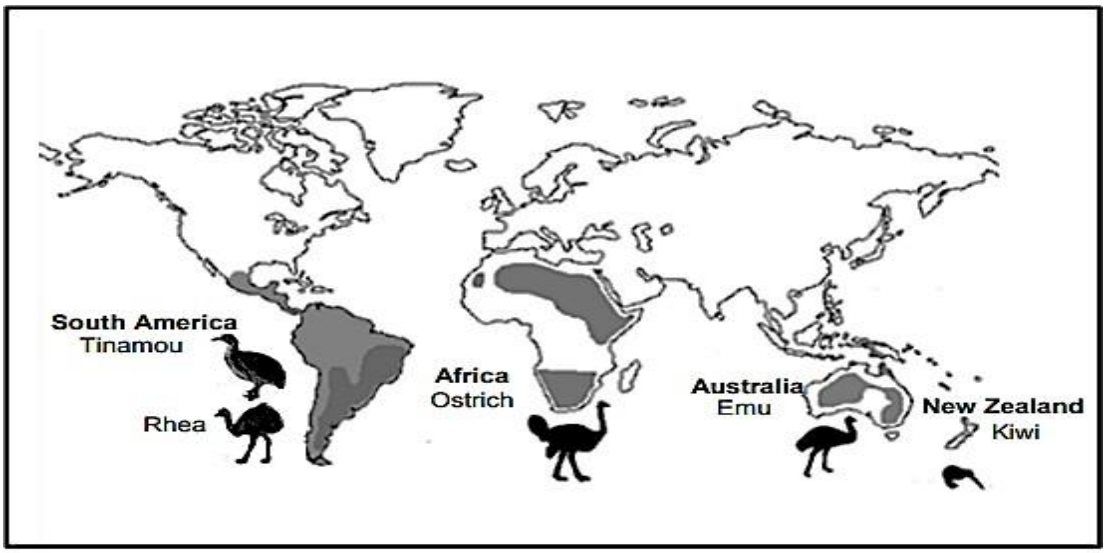
Scientists wanted to determine the relationship between the presence of tall trees and the wings on the stoneflies.

- They selected six locations, of which three had tall trees and three were without trees.
- Using a specialised net, they collected thousands of stoneflies in each location.
- The samples were labelled according to the area of collection.
- These samples were all collected in the morning during summer.
- The number of stoneflies with wings and without wings at each location was counted and recorded

Describe how Lamarck would have explained the evolution of stoneflies without wings in the areas without trees.

ACTIVITY 1.8

1.8 Originally birds were able to fly but today there are flightless bird species that are distributed across different continents are shown in the picture below.



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

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ACTIVITY 1.9

1.9 The diagram below shows a modern swordfish.

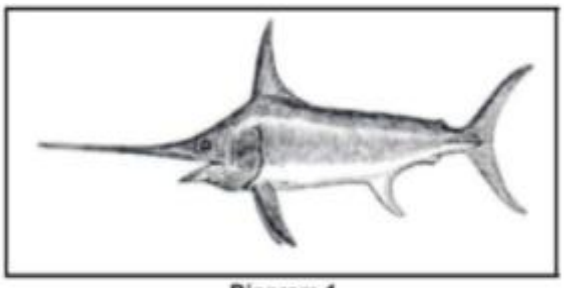


Diagram 1

Ancestors of swordfish had short swords. Modern swordfish have long swords. Swordfish use their swords to injure prey. The injured prey is easier to catch and eat. The diagram below shows one theory of how the length of the sword of swordfish evolved.

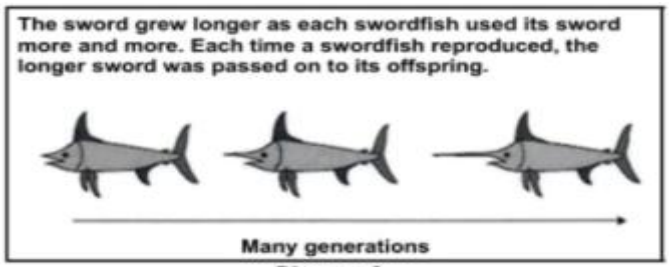


Diagram 2

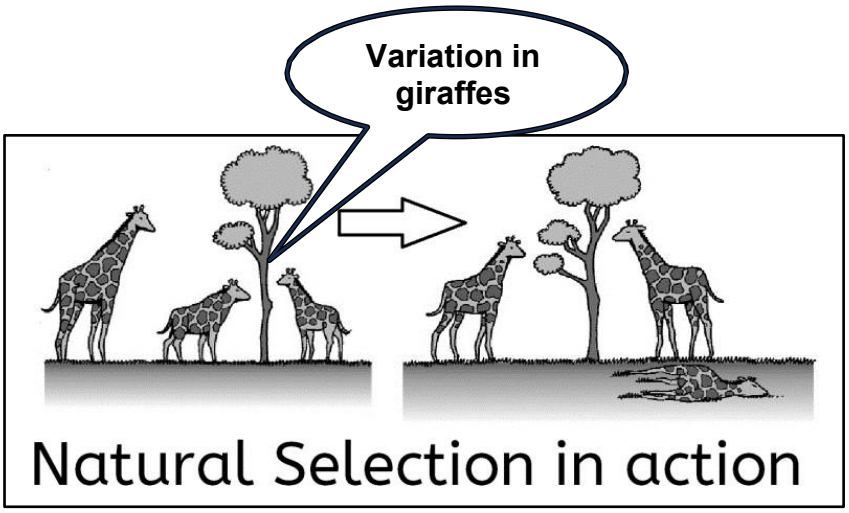
1.9.1 a) Which scientist suggested the theory shown in Diagram 2? (1)
b) Explain ONE reason why the theory put forward by the scientist in is not accepted. (2)

1.9.2 Was Lamarck's work entirely without value because his theory had been rejected? (2)

4. DARWINISM

CONTENT	ELABORATION
Darwinism (Charles Darwin - 1809-1882)	Darwin's theory of evolution by natural selection: • In a population, 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 the favourable 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.

4.1. How to describe Darwinism using example



(Natural selection questions keep on changing and you must be able to adapt your answer to specific example given – SEE TABLE BELOW

Guiding Question	Darwin's explanation
1-State the **characteristic** that varies	There is a variation in the - **length** of giraffe's necks.
Describe the 2- **variations**	There were giraffes with - **long** neck and **short** necks
3- Explain the environmental change/ **selection pressure** for natural selection (what is causing 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
4- State the **unfavorable characteristic** and why it is unfavorable	Giraffes with - short necks (unfavourable characteristic) could not get food from the top of a tree/higher trees, their neck was too short
Explain 5- **What happens** to this individual with **unfavorable** characteristics	They die of hunger
State **the favourable** characteristic and why it is favorable	Giraffes with long necks (favourable characteristic) could get food from the top of a tree/higher trees, their neck was long enough
Explain what happens to this individual with the **favourable characteristics**	They could eat more leaves/food and survive
What happen to the **favourable** characteristic	The giraffes with the long necks reproduce
	The **allele for long necks** will be passed on to the offspring
	The next generation of giraffes will have higher proportion with long necks

4.2. Application of Darwinism by natural selection

In 1986 there was a huge radioactive disaster in Chernobyl and all humans immediately left the area because of the deadly high radiation.

Animals exposed to this high radiation developed cancer or died. Almost 40 years later, scientists have been studying the wolves that live in this highly radioactive environment where they are exposed to high radiation.

They found that these wolves have a mutation that makes them immune to cancer.

Use Darwin's theory of natural selection to explain the development of immunity to cancer in these wolves.

MUTATION IN GENE ALLOWS TIBETANS TO SURVIVE AT HIGH ALTITUDE

It is possible to cope with the low oxygen content at high altitudes. One way is for the body to produce more red blood cells in response to an increase in altitude.

Another way of coping has developed in Tibetans as a result of a gene mutation that they inherited from their ancestors. The mutant gene helps them to use the low amount of oxygen present more efficiently.

The mutant gene was found in 87% of the Tibetan population but only in 9% of the Han population that live at a lower altitude than the Tibetans.

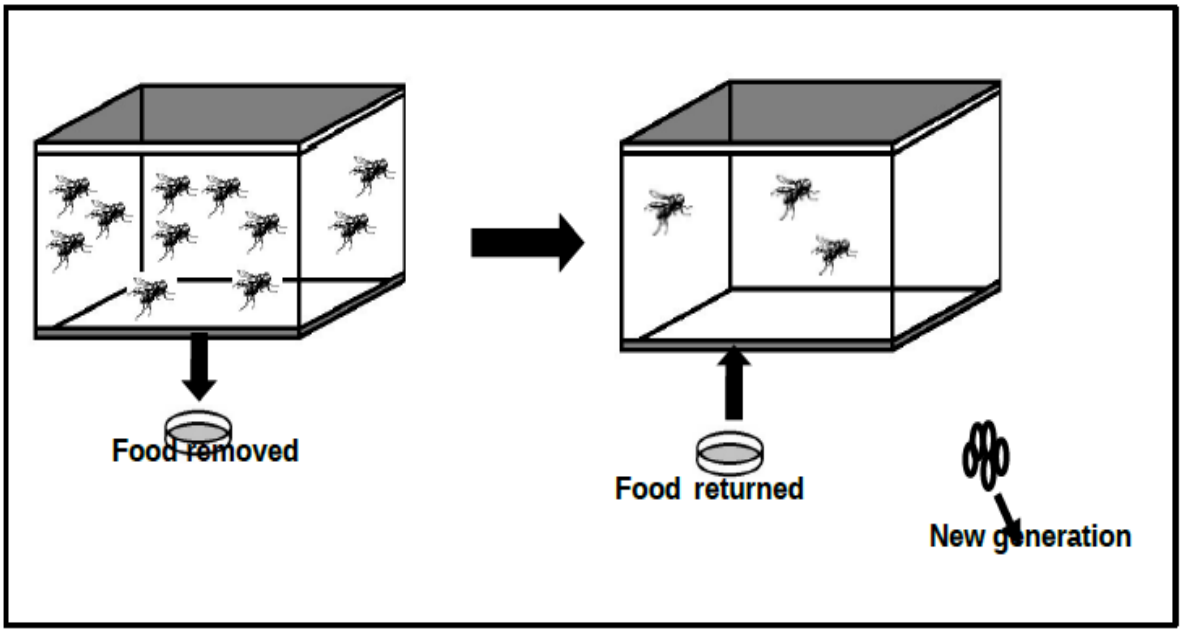
Describe how Darwin would have explained the survival of Tibetans at high altitudes

ACTIVITY 1.10

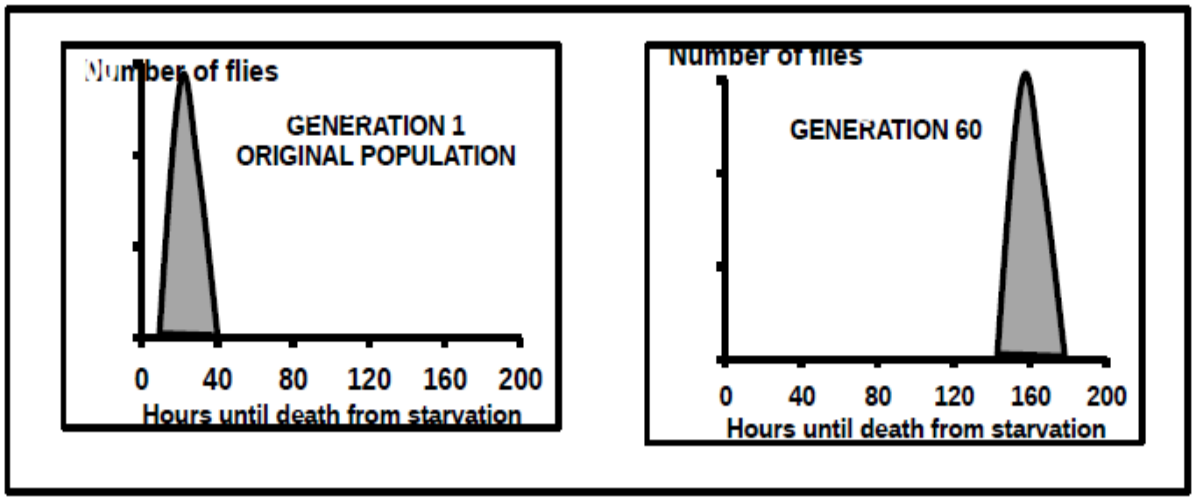
1.10 Starvation resistance refers to the period for which an organism can go without food before it dies.
An investigation was conducted to determine the effect of the availability of food on the starvation resistance in fruit flies.

The procedure was as follows:

- 5 000 fruit flies of the same age were used.
- They were all placed in a container suitable for the growth of fruit flies and were given a maltose-based food source.
- The food source was removed after an hour.
- The time it took for 80% of the fruit flies to die from starvation was recorded.
- The dead flies were removed from the container.
- The food source was then returned to the container.
- The remaining fruit flies were allowed to interbreed.
- Their eggs were collected and transferred to a new container with a food source where they were allowed to hatch.
- These fruit flies were allowed to grow to the same age as the 1st generation.
- The food source was then removed again.
- The time it took for 80% of the fruit flies to die from starvation was recorded again.
- This procedure was repeated until the 60th generation of fruit flies was reached.



The graphs below show the results obtained for the 1st generation and the 60th generation.



1.10.1 Using Darwin's theory of natural selection, explain the increase in starvation resistance in fruit flies **(6)**

4.3. Differences between Lamarck's and Darwin's evolution theories

Lamarck's	*Darwin's*
Variation of offspring brought about by individuals in the population changing	*Offspring inherit variation*
Individuals want to change	*Environmental factors working randomly*
Change because of adaptation to environment	*Natural selection – best suited to the environment to survive*
Individuals in the population change	*The population as a whole changes*
Changes brought about by adaptation to the environment are inherited from parent to offspring	*Characteristics are passed on from generation to generation to enable individuals to survive in the environment*

ACTIVITY 1.11

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.

1.11.1 Give:

a) The term that describes Lamarck's ideas. (1)

b) The term that describes Darwin's idea of Natural selection. (1)

1.11.2 Tabulate the difference between Lamarck's theory of evolutions and Darwin's theory of evolution (2)

1.11.3 Explain whose idea evolution is more acceptable today. (2)

(6)

4.4. PUNCTUATED EQUILIBRIUM

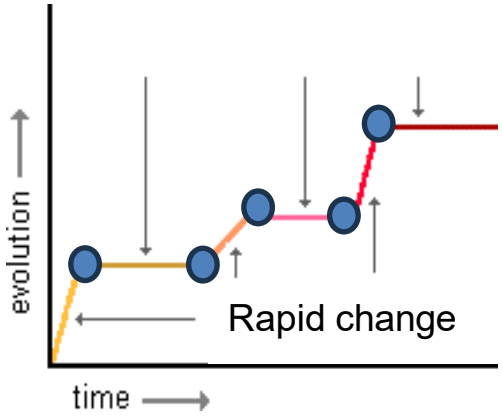
CONTENT	ELABORATION
Punctuated Equilibrium (Eldredge and Gould -1972)	Punctuated Equilibrium explains the speed at which evolution takes place: • Evolution involves long periods of time where species do not change or change gradually through natural selection (known as equilibrium). • This alternates 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

4.5. Punctuated Equilibrium explains the speed at which evolution takes place:

- Stephan J Gould and Niles Eldredge formulated this model (1972).
- They observed that the fossil record gives a different picture of evolution.
- They claim that there were long periods of **stasis** (4-10 million years) involving little evolutionary change.
- Then followed by occasional rapid formation of new species (5,000 - 50,000 years).
- 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.

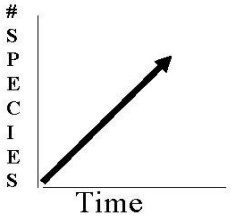
(Punctuated equilibrium is supported by the absences of transitional fossils indicating the period of rapid change

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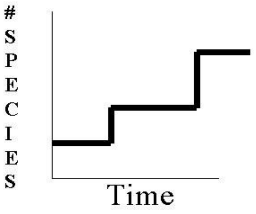


Graphs showing time frame of Evolution:

- **Gradualism:**



- **Punctuated Equilibrium**



4.6. Differences between Gradualism and Punctuated equilibrium

Gradualism		Punctuated equilibrium
Change is continuous and slow for many years	*Time period*	Change occurs during brief period of time
New species evolve through the accumulation of many small changes over a long 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

Similarities between Gradualism and Punctuated equilibrium – natural section occurs in both of them, gradualism it occurs slowly and continually over along period of time. And punctuated equilibrium is there no change for a long time then change through natural selection occurs rapidly in a shot period of time

4.7. Artificial selection

How to describe artificial selection using an example:

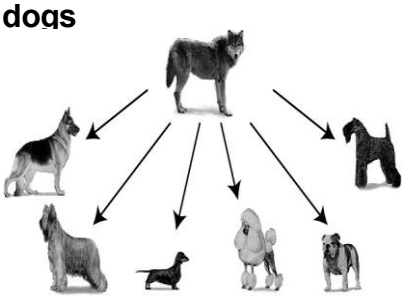
- Artificial selection (is also known as selective breeding) occurs when humans determine which genes will be passed on to future generations.
- They chose characteristics that will desirable/beneficial to human needs and not necessarily beneficial to the organism.
- Farmers, scientists and pet breeders choose their best individuals to interbreed so that they may produce the best characteristics such as:

  - high butterfat milk in jersey cattle
  - high quality meat in Hereford cattle
  - resistance to disease and a hot climate in indigenous Nguni cattle

4.8. How is artificial selection done?

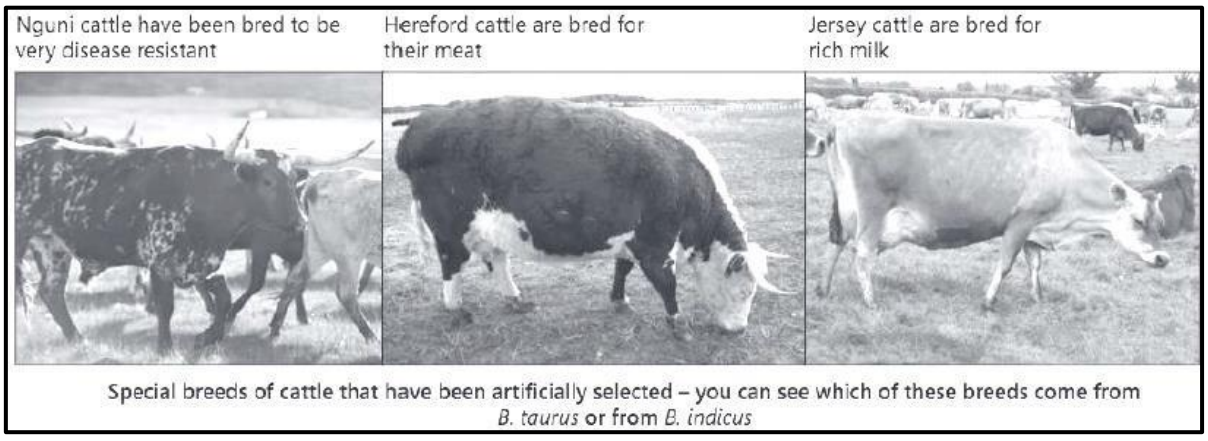
- Organisms with the desirable traits are selected
- and interbred
- over many generations
- to produce offspring with these desirable traits

Example 1: Domestication of dogs



Example 2: Herd of cattle

- For many years farmers have used artificial selection to improve their herds.
- Special characteristics have been bred in certain types of cattle.
- Jersey cows have been selectively bred to produce high butterfat milk.
- Nguni cattle have been bred to be very disease resistant.
- Hereford cattle have been bred for their meat.



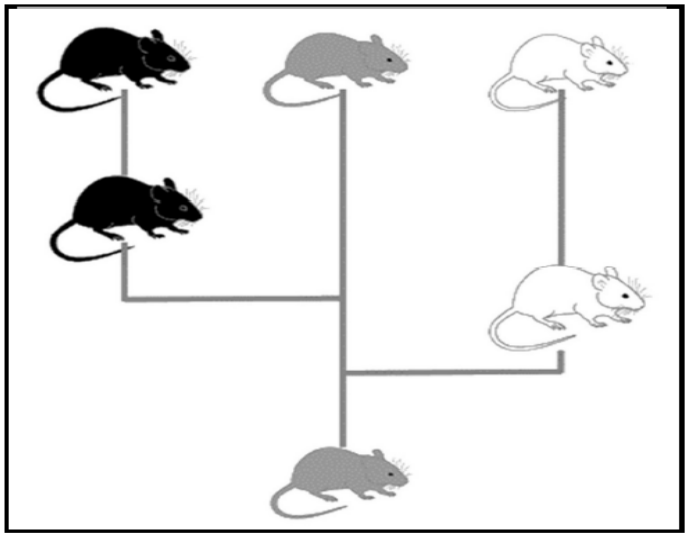
Special breeds of cattle that have been artificially selected – you can see which of these breeds come from *B. taurus* or from *B. indicus*

4.9. Table showing the differences between artificial and natural 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).

ACTIVITY 1.12

1.12 The diagram represents a concept in evolution.



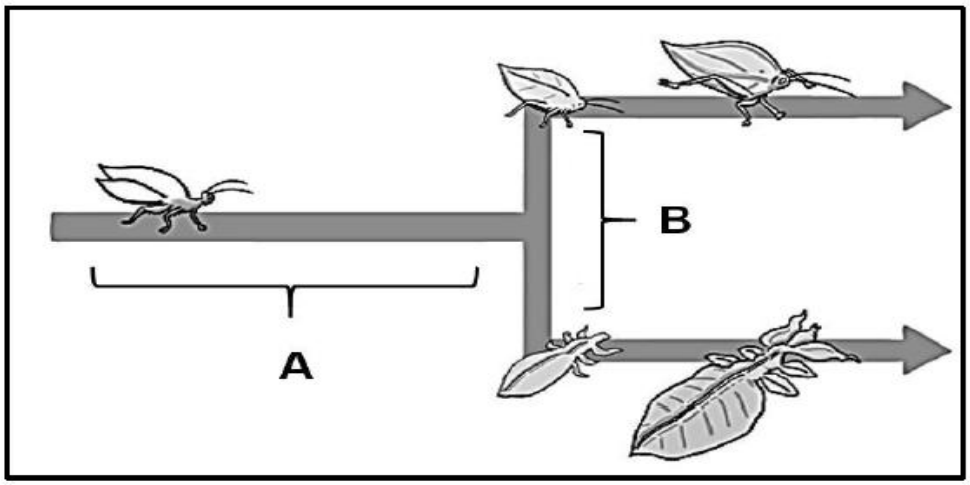
1.12.1 Identify the concept of evolution illustrated by the example in the diagram above. (1)

1.12.2 Give the definition of the concept *evolution* as shown in the diagram above (4)

(5)

ACTIVITY 1.13

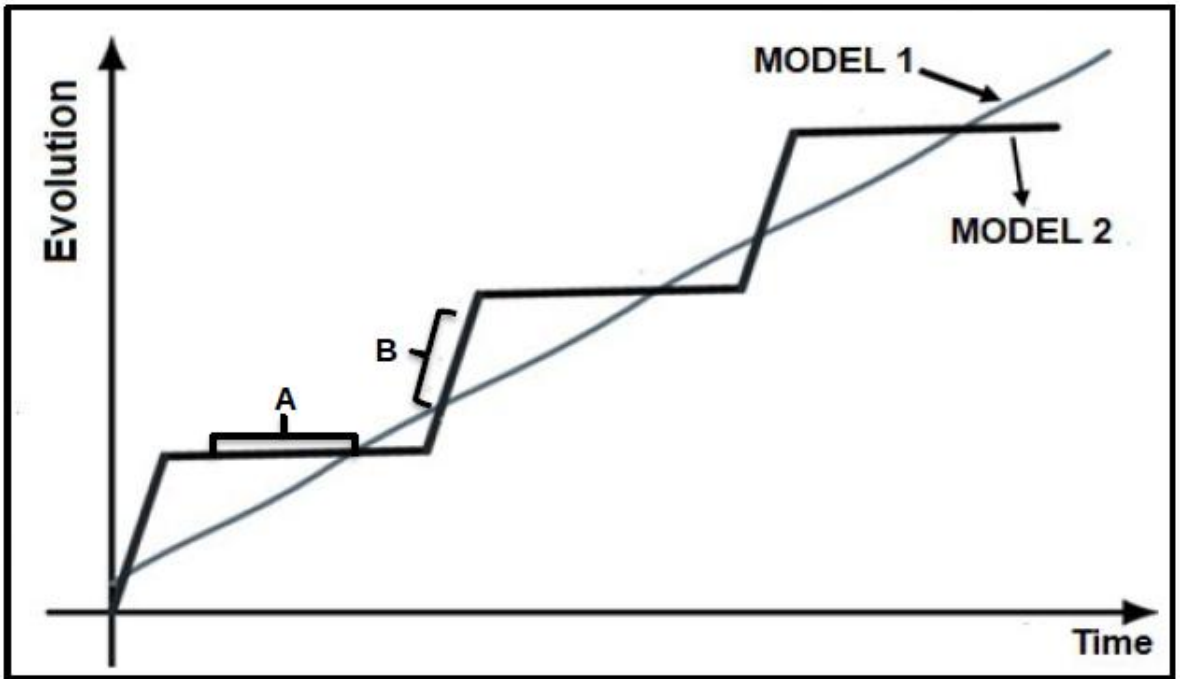
1.13. The phylogenetic tree below shows evolution by punctuated equilibrium in a species of insect.



1.13.1 Use letters **A** and **B** to explain the theory of punctuated equilibrium. **(4)**

ACTIVITY 1.14

1.14 The diagram below shows two models used to explain the theory of evolution.



1.14.1 Identify the evolutionary theory in MODEL **2**.

1.14.2 Name the TWO scientists who proposed the theory of evolution in MODEL **2**.

1.14.3 Which evolutionary MODEL **1** or **2** is:

(a) Showing small gradual changes in organisms from one generation to another? (1)

(b) Supported by the absence of transitional fossils? (1) (1)

(c) Supported by a scientist who proposed the theory of evolution by natural selection? (1)

1.14.4 State what happens respectively to species at points **A** and **B** in MODEL **2**. (2)

1.14.5 Name the type of evolution where there is a change in characteristic of a species over time. (1)

(6)

ACTIVITY 1.15

1.15 Flies lay their eggs in the urine and faeces that stick to the wool of sheep. The eggs hatch and the larvae damage the sheep's skin, leading to infection.

To reduce this problem, farmers in New Zealand have been developing sheep with no wool growth on their legs, backside (bottom) or the underside of their abdomen.

Farmers have crossed different breeds of sheep to produce offspring with the desired characteristics. The characteristics of other breeds of sheep are shown in the table below.
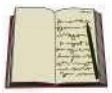
Breed of sheep	Characteristic
Cheviot	Bare heads and legs
East Friesian	Bare backsides
Wiltshire	Bare abdomens

1.15.1 Using evidence from the table above, describe how farmers could use selective breeding to develop sheep with bare legs and bare backsides. (5)

1.15.2 Tabulate the differences between *selective breeding* and *natural selection*. (6)

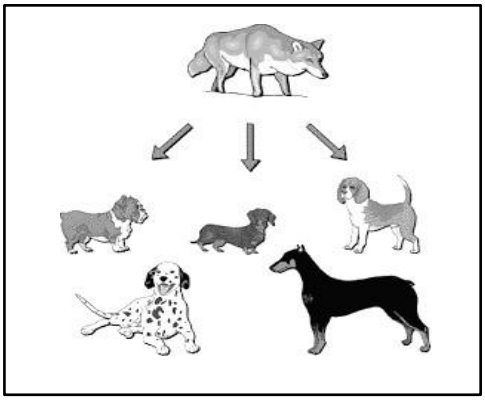
Explain ONE disadvantage of selective breeding of the sheep in QUESTION 1.15.1 (2)

(13)



ACTIVITY 1.16

1.16 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.

1.16.1 Explain why all breeds of domestic dogs belong to the same species (2)

1.16.2 Domestic dogs are bred to show specific characteristics with respect to their health, personality, and appearance. Explain why this is considered artificial selections (3)

1.16.3 Describe how artificial selection led to different breeds of domestic dogs (3)

1.16.4 What effect does the type of selection mentioned in 1.16.3 have on the survival change of the dog species? (2)

(7)

5.SPECIATION

 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) o Baobabs in Africa and Madagascar o Proteas in South Africa and Australia • Any example of mammals on different land masses



5.1. Example: Speciation by Geographic Isolation

Speciation by geographic isolation occurs when part of a population becomes isolated from the parent population due to physical barriers. Such barriers could be continental drift, oceans, rivers, mountains, or other natural disturbances such as volcanos or earthquakes.

Speciation through geographic isolation ***(according to the exam guidelines)***

- 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 or 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.

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5.2. NOTE HOW TO ANSWER THIS QUESTION BY APPLYING EXAMPLE

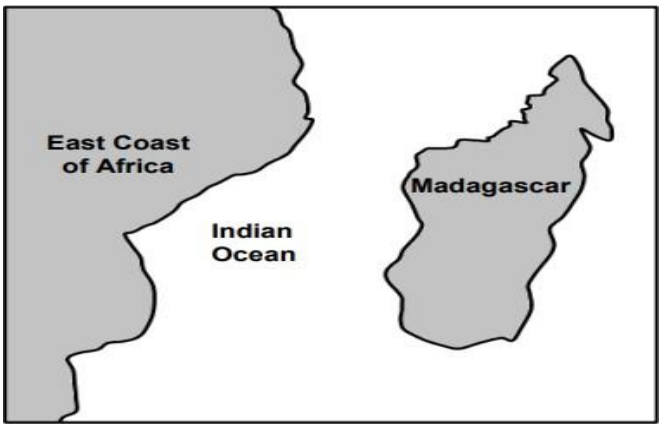
- **The BOLD is the fact that you state** according to the exam guidelines
- ***The italics is what you must get out of the example in the exam paper.***

1. **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)
2. **becomes separated by a geographical barrier**
   (Mention the specific barriers sea, river, mountain, lake)
3. **then the population splits into**
   (Mention in how many populations does the original species /original population splits into according to the extract)
4. **There is now no gene flow between the**
   (*Mention how many populations are there now)*
5. **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)
6. **natural selection occurs independently in each of the two/three etc. populations such that the individuals of the two populations become very different from each other**
7. **genotypically and phenotypically.**
   (*Mention the differences if the extract indicates differences)*
8. **Even if the two populations were to mix again they will not be able to interbreed.**
9. **The two populations are now different species, name the new species.**
   (mention the new species that form)

5.3. Application of Speciation by Geographic Isolation

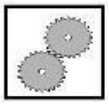
Example 1

Pottos and lemurs are small mammals. Scientists believe that pottos and lemurs share a common ancestor that existed in Africa. Presently pottos only ccur 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.

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8.4. REMEMBER

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

APPLICATION IN THE ANSWER

(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***

  (Mention the specific barriers sea, river, mountain, lake)
- **becomes separated by a geographical barrier, the INDIAN OCEAN then**
- **the population splits into**

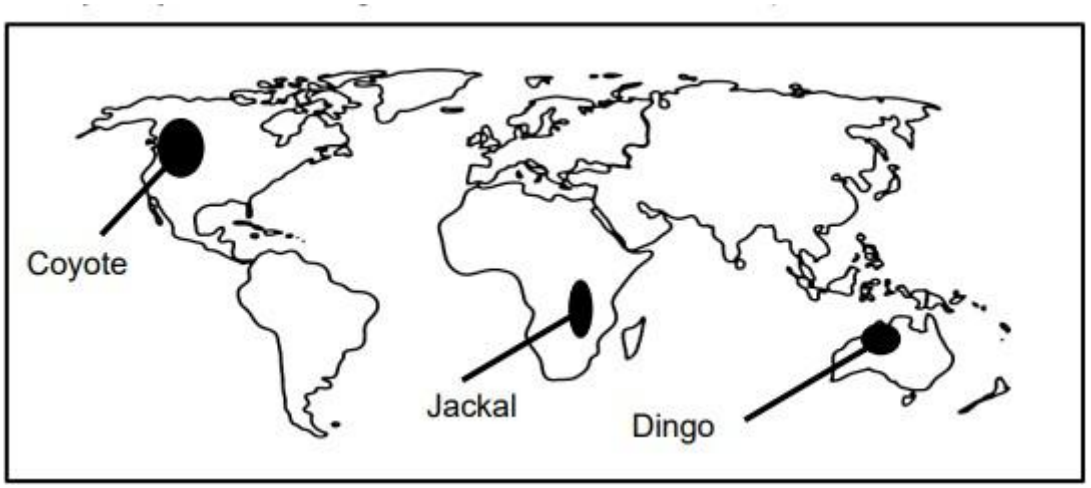
  (Mention in how many populations does the original species /original population splits into according to the extract)
- **then the population splits into (2 - Africa and Madagascar)**
- **There is now no gene flow between the**

  (Mention how many populations are there now)
- **There is now gene flow between the two populations 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**
- **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**

8.5. 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

ACTIVITY 1.17

1.17.1

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.

1.17.2 Define a population. (2)

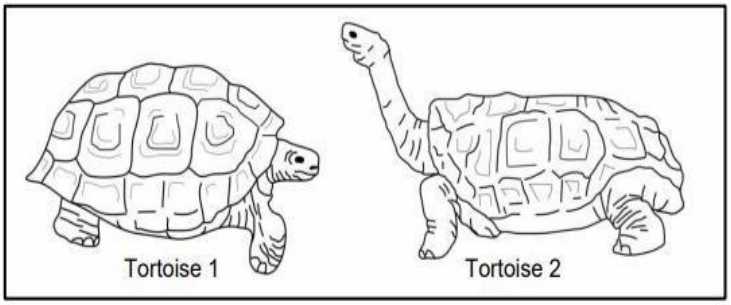
1.17.3 Describe how speciation of the **GRAND CANYON** squirrels took place. (5)

(7)

ACTIVITY 1.18

1.18

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 mains?



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

1.18.2 Describe how the two tortoise species become different (6)

1.18.3 List FOUR sources of variation that could have led to the variation in the tortoise population (4)

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

(8)

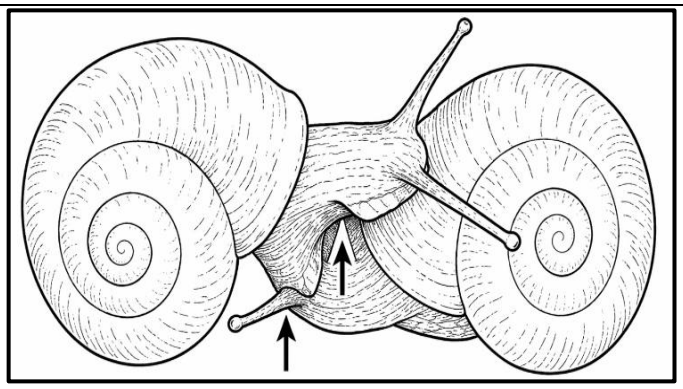
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9. Mechanisms of reproductive isolation

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 behaviour • Plant adaptation to different pollinators • Infertile offspring • Prevention of fertilisation

1.Prevention of fertilisation

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

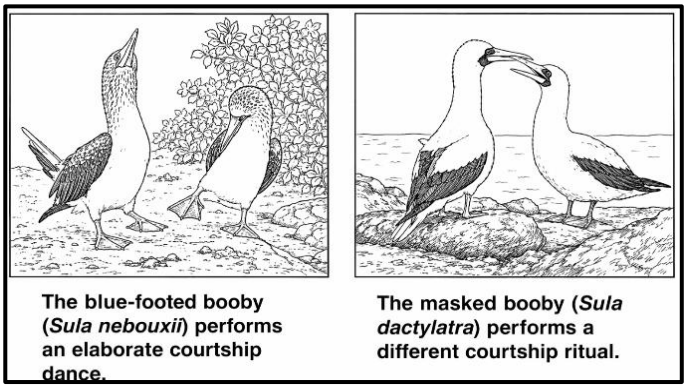


2.Species-specific courtship behaviour

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 in order to attract a mate.

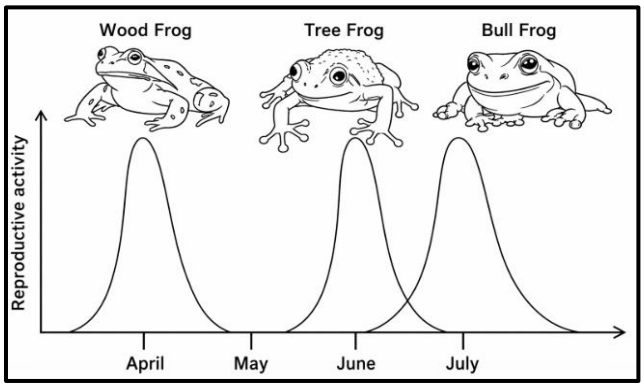


The blue-footed booby (*Sula nebouxii*) performs an elaborate courtship dance.

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

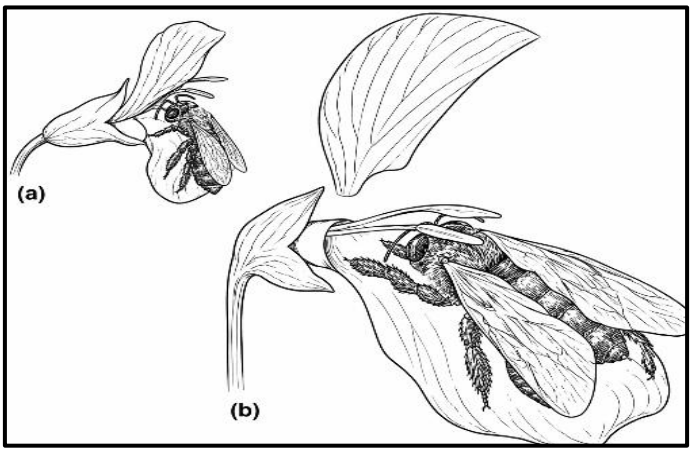
3.Breeding at different times of the year

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



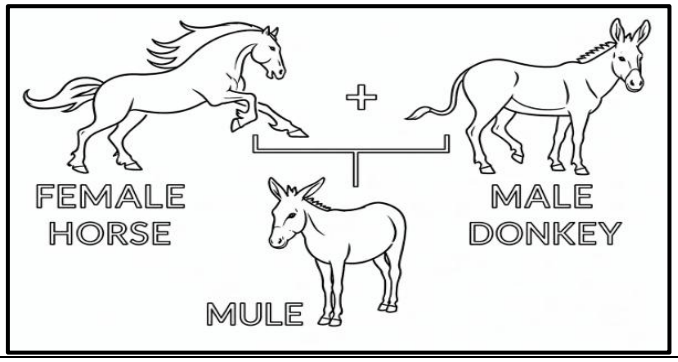
4.Plant adaptation to different pollinators

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 attracted certain pollinators to them.
Also, cross-pollination between the different species is prevented.



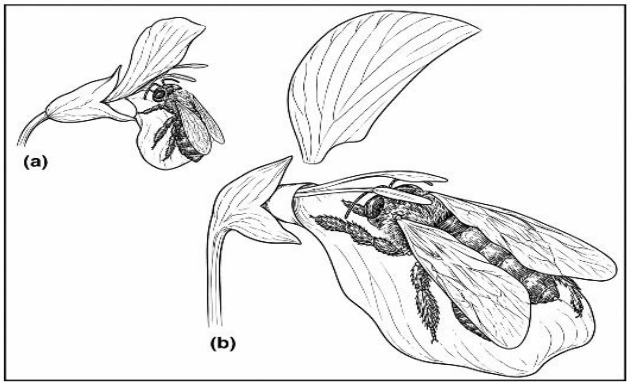
5.Infertile offspring

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



ACTIVITY 1.19

1.19.1 What is meant by the term reproductive isolation? (1)
1.19.2 Describe species - specific courtship behaviour. (2)
1.19.3 Give THREE examples of species- specific courtship behaviour. (3)



Differences in flowers structure in black and white sage select for different pollinating bees. Big bees do not fit on black sage petals.

1.19.4 Identify the reproductive isolation mechanism that is illustrated in the diagram above. (1)
1.19.5 Explain what the significance of this isolation mechanism is. (2)
1.19.6 Explain the development of infertile offspring between two species. (3)
1.19.7 Give an example of infertile offspring between two species. (2)

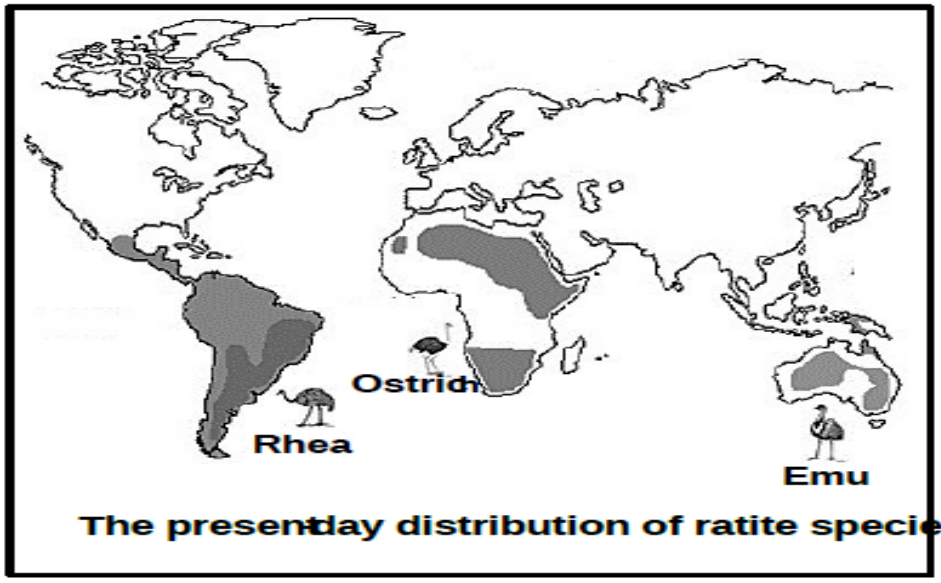
(14)

ACTIVITY 1.20

1.20

BREEDING MONTHS IN RATITES

Ratites are egg-laying flightless birds. The egg-laying months are influenced by many factors such as the temperature, length of the day and availability of food. Ostriches normally lay their eggs in September, rheas between October and March, while emus lay their eggs from November to April.



The present-day distribution of ratite species

1.20.1. The ratites shown in the map are classified as different biological species

(a) State what is meant by a *biological species*. (2)

(b) Using the information in the extract, explain why the ostrich and emu are considered different species. (2)

(c) Name TWO other reproductive isolation mechanisms that would have prevented the rhea and ostrich from interbreeding if they were in the same habitat. (2)

1.20.2. Identify the evidence for evolution represented in the diagram. (1)

1.20.3 Describe how the evidence identified in QUESTION 1.20.2 supports the theory of evolution. (5)

(12)

10. Evolution in present times

CONTENT	ELABORATION
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

The use of **insecticides** and the consequent **resistance to insecticides** in insects can be explained in terms of **natural selection**

Example 1: *Mosquitoes*

- ***Initially mosquitoes were*** *not resistant to* ***DDT*** *when it was first introduced to them.*
- *However, as time went on, a* ***gene mutation*** *occurred in one of the mosquitoes.*
- *It lived and reproduced to have baby mosquitoes that* **are immune** *to* ***DDT****.*
- *The mosquitoes that were not resistant to* ***DDT*** *died off, while the gene mutation mosquitoes that were* ***DDT*** *– resistant lived on.*
- *It is the survival of the* ***natural selection***

Example 2: Tuberculosis-causing bacteria (MDR and XDR)

- The 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.
- *The question is, why will the antibiotic that was previously useful in 'fighting' a bacterial infection not work the next time if it was not completed the first time?*
- *And the answer can be, that a mutation has occurred in the bacteria, which makes them resistant against the drug because the medication was not completed and the bacteria that survived actually mutated and became drug – resistant.*
- ***MDR-TB*** *is when the bacterium mutates and fights against the first two drugs given for TB because it was not initially completed by the patient.*
- *When patients is then given a second chance dose of three of more different drugs to help cure TB.*
- *This is known as* ***XDR-TB****. It is very expensive and may not be as effective as the first line drugs given, had the patient completed the course.*

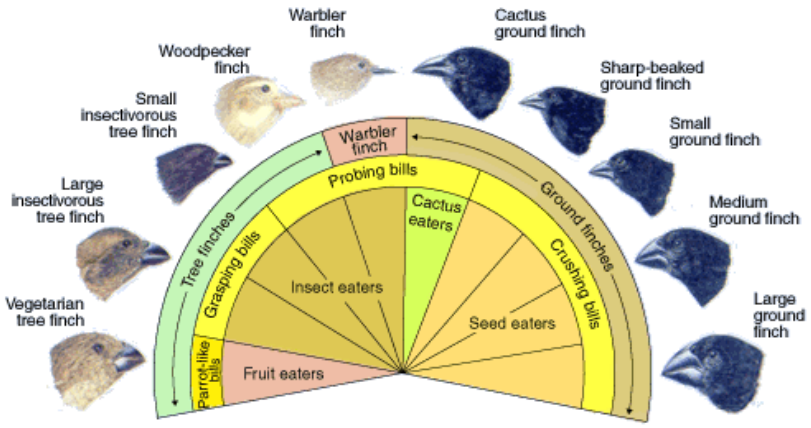
Example 3: HIV resistance to anti-retroviral medication

- HIV is a virus and AIDS is a disease caused by the virus.
- Scientists have developed several drugs to combat the HI- virus.
- At the beginning the treatment with ARV, the environment of the virus has changed.
- A few of the viruses may have the gene to be ARV resistance.
- Due to changing environmental conditions/ selection pressures most viruses will die.
- Resistant viruses will survive, live on and reproduce and the resistant gene is passed onto the next generation.
- Because viruses reproduce so rapidly and mutations may occur due to changes in environment/ selection pressure after a while, population of viruses become resistant to new antiretroviral in a short space of time. This is natural selection.
- the HIV which causes AIDS can also mutate against the first line of ARV's (antiretroviral tablets).
- This will lead to the need to formulate stronger and more expensive ARV's which may not be very effective if the HIV is in its last stages.

Example 4: Bill (Beak) and body size of Galapagos finches

Natural selection is still occurring on Daphne Major, which is a Galapagos Island where small, medium and large beaked finches were present. There was variation in the size of beaks.

- Between1976 – 1978 there was a serious drought.
- Many of the small to medium beak finch species could not survive the drought and died.
- Environmental selection pressure eliminated finches with small beaks due to a lack of food.
- During normal wet seasons plants used to produce small and large seeds.
- The small seeds could be eaten by the finches with small and medium beaks.
- During the drought the small seeds were depleted and larger seeds were plentiful.
- Therefore, the finches with larger beaks had a competitive advantage during the drought period where larger seeds were available.
- The deeper bigger beaked finches were able to break open the coats of large seeds in order to get to the seeds.
- Presently only large beaked finches have been able to survive and were naturally selected due to their advantageous gene of having larger beaks.



ACTIVITY 1.21

Scientists investigated the resistance of mosquitoes to DDT.
The following steps were followed:

- They captured a sample of mosquitoes from the environment.
- The mosquitoes were then exposed to a standard dose of DDT (4% DDT for 1 hour) in the laboratory.
- The number of mosquitoes that died was counted.
- Those that survived were left to reproduce.
- A sample was taken from this population every two months and the same procedure was followed for a period of 16 months.

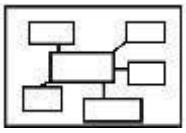
The results are shown in the table below.

TIME (IN MONTHS)	MORTALITY OF MOSQUITOES (%)
0	95
2	87
4	80
6	69
8	60
10	54
12	35
14	27
16	22

1.21.1. Identify the:
1.21.2. Formulate a hypothesis for this investigation. (3)
1.21.3. Draw a line graph to show how the mortality of mosquitoes changed over the period of the investigation due to the application of DDT. (6)
1.21.4. State TWO factors, other than those mentioned, that should be controlled in this investigation. (2)
1.21.5. State TWO ways in which the scientists could improve the reliability of their results. (2)
1.21.6. Explain, in terms of natural selection, how mosquitoes may develop resistance to DDT. (8)
(21)

11. EVIDENCE OF COMMON ANCESTORS FOR LIVING HOMINIDS - INCLUDING HUMANS

 CONTENT	ELABORATION
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: • Genetic evidence: Mitochondrial DNA • Cultural evidence: Tool-making • Fossil evidence: Evidence from fossils of different ages show that the anatomical characteristics of organisms changed gradually over time. o Emphasis on evolutionary trends provided by the anatomical features of fossils of the following three genera: ▪ Ardipithecus ▪ Australopithecus ▪ Homo as well as: o The age of each fossil found/time-line for the existence of the three Genera o The fossil sites where they were found: emphasis on the fossil sites that form a part of the Cradle of Humankind o The scientists who discovered them



HUMAN EVOLUTION

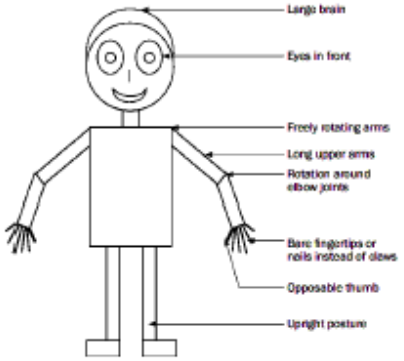
EVIDENCE OF COMMON ANCESTORS FOR LIVING HOMINIDS - INCLUDING HUMANS

- Evidence that support the idea of common ancestors for living hominids including humans:
  - Fossil evidence (including evolutionary trends provided by the anatomical features of:
    * Ardipethicus
    * Australopithecus
    * Homo
  - Genetic evidence: mitochondrial DNA
  - Cultural evidence: tool making

- Interpretation of a phylogenetic tree to show the place of the family Hominidae in the animal kingdom



LIST characteristics that we share with African apes



THE OUT OF AFRICA HYPOTHESIS STATES THAT ALL MODERN HUMANS ORIGINATED IN AFRICA

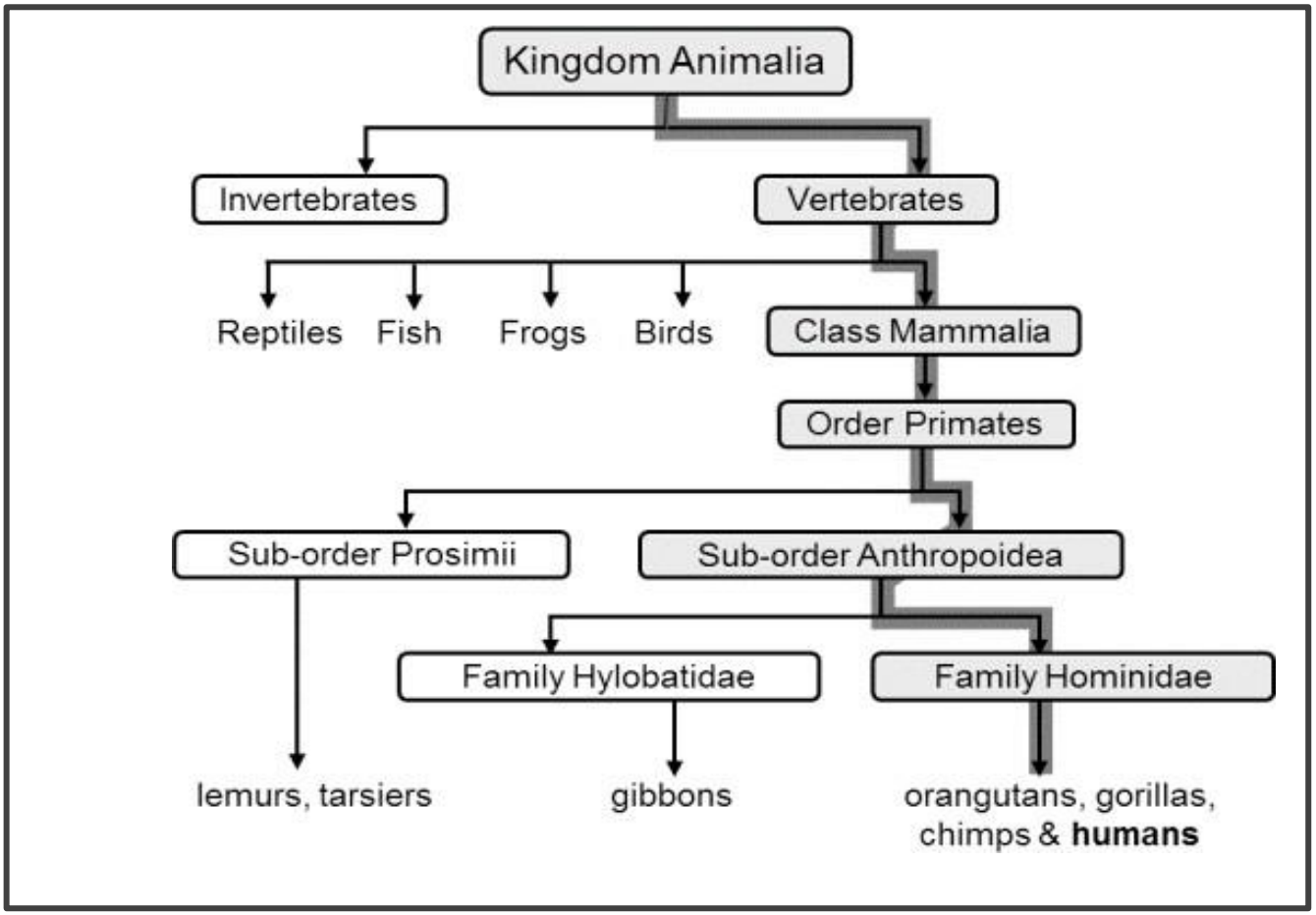
- How the following evidence support the Out of Africa hypothesis:
  - Fossil evidence
  - Genetic evidence - Mitochondrial DNA
- Give information on each of the following fossils that serve as evidence for the Out of Africa hypothesis:
  - *Ardipithecus*
  - *Australopithecus*
  - *Homo*

  With regard to:
  - The fossil sites where they were found with examples
  - The scientists who discovered them
- Timeline for the existence of different species of the genus *Homo* and the significant features of each type of fossil to illustrate the differences amongst them

- Compare anatomical differences between African apes and Humans
  - Bipedalism (Foramen magnum, spine & pelvic girdle)
  - Brain size
  - Teeth (dentition)
  - Prognathism
  - Palate shape
  - Cranial ridges
  - Brow ridges

11.1 Interpretation of a phylogenetic tree to show the place of the family Hominidae in the animal kingdom

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 include humans, apes, orangutangs, gorillas and chimpanzees

.

Hominids refer to the modern and extinct **Great apes** (i.e. modern humans, chimpanzees, orangutans and all their immediate ancestors)

Great Apes is also referring to as **African Apes**

Hominin – the group consisting of **modern humans**, **extinct human species** and all our **immediate ancestors** (including members of the genera *Homo, Australopithecus* and *Ardipithecus)*.

Are all **bipedal organisms**.

Ardipithecus, Australopithecus and early ***Homo*****-** species are considered fossil ancestors of modern humans **(learners must know this line of development)**

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

Homo – sapiens

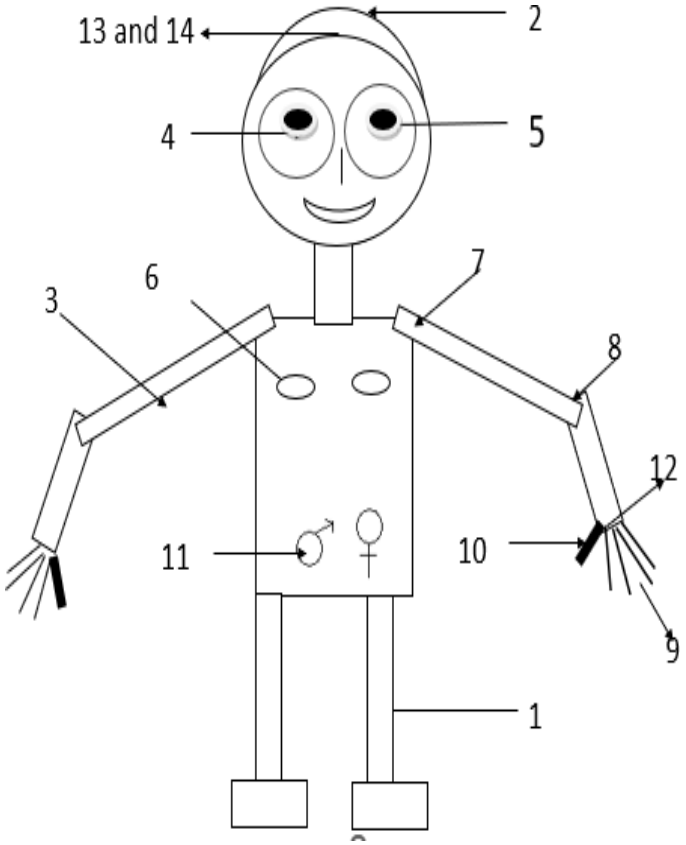
Genus – ***Homo***

Specie- ***sapiens***

The genus name and species name must be underlined / cursive

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

11.2. Characteristics we share with other primates.



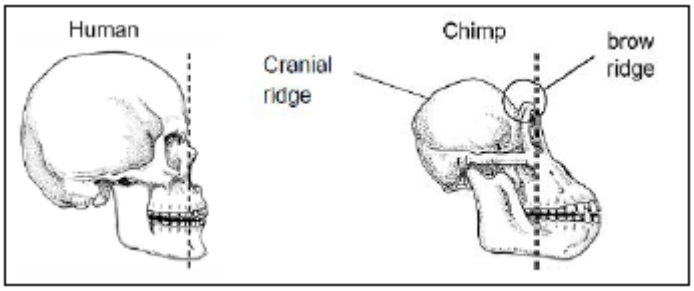


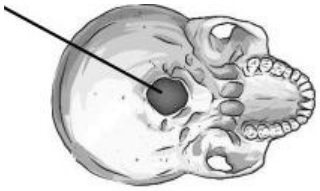
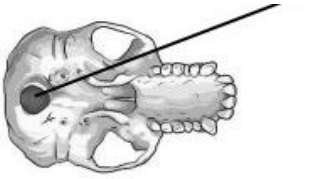
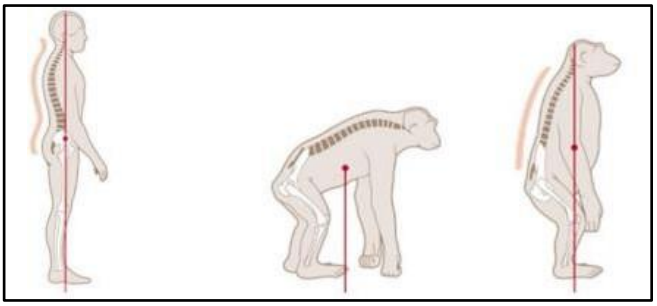
1. **Upright posture**: the back limbs of hominids are generally stronger than their front limbs, enabling them to stand erect (upright) and use their hands for grasping; standing erect also gives a better view of surroundings and exposure of genitals to attract the opposite sex.
2. **Large brains:**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

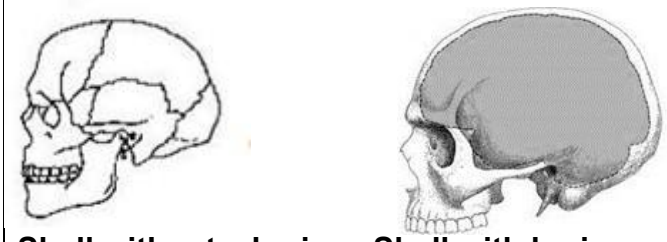
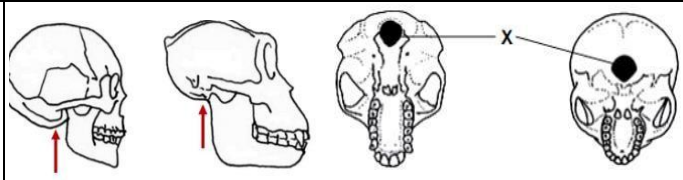
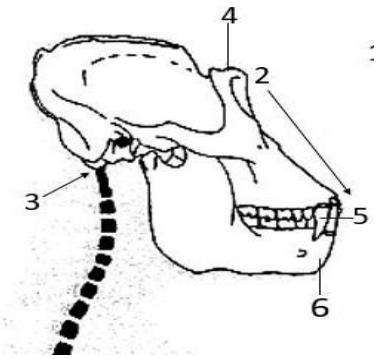
How to answer it in the Examination

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	*Not just two eyes*
Long upper arms	*Long arms/ upper limbs*
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*

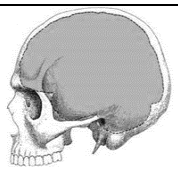
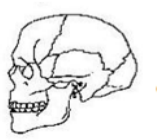
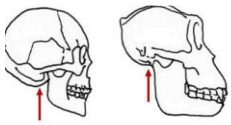
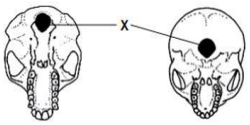
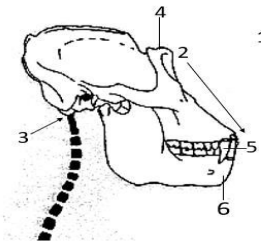
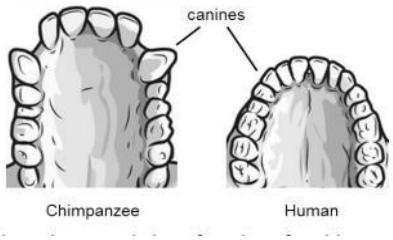
11.3. Anatomical DIFFERENCES between Humans and African apes



Homo sapiens	*Other primates*
1.Larger cranium	1.Smaller cranium
2.Flat face/ Forehead slope less backwards	2.Face sloping/Foreheads slope more backwards
3. Foramen magnum in a **more** forward position under the skull	3.Foramen magnum in a **more** backwards Position under the skull
Foramen magnum  Human skull	**Foramen magnum**  Chimpanzee skull
4. Brow ridges are **less prominent**	4. Brow ridges are **more prominent**
5.**Smaller** canines	5. **Larger** canines
6.**Smaller spaces**/diastema between the teeth	6. **Larger spaces**/diastema between the teeth
7.Jaws with teeth on a gentle/round curve/**C** - shape	7. Jaws with teeth in a rectangular/**U** shape
8.Jaws - Non–prognathous/ Less protruding jaw	8. Jaws - prognathous/ More protruding jaw
9. Lower jaw has a well-developed chin	9. Lower jaw has poorly developed chin
10. No cranial ridge	10. Cranial ridges at the top of the cranium
11. Spine more S- shape	11. Less C- Shape
	
12. Pelvic gridle short and wide	12. Pelvic gridle long and narrow
13. Palate small and round	13. Palate long and rectangular

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. *We can only say that the cranium is larger and therefore it will accommodate larger brain*	 **Skull without a brain** **Skull with brain**
Foramen magnum **Human-** *more forward position* **African apes**-*more backwards position* *In both cases you must refer to more forward/backwards position*	
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**	**Jaws 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	

MISTAKES made when answering anatomical differences/visible differences.

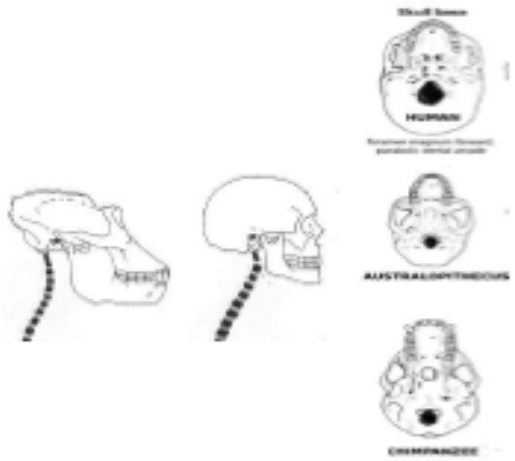
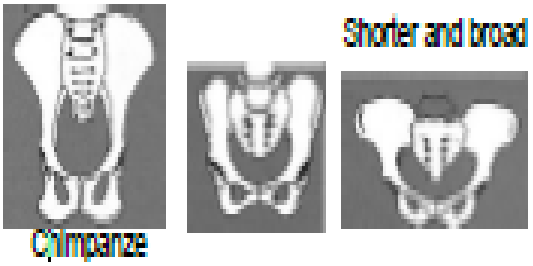
<table>
<tr><td>BRAIN SIZE - if the brain is not indicated in a diagram, you cannot state large brain and small brain when the question refers to visible differences</td><td>
Skull with brain

Skull without a brain</td></tr>
<tr><td>FORAMEN MAGNUM
Human - more forward position
African apes - more backwards position
In both cases you must refer to more forward/backwards position at the bottom of the skull</td><td>
</td></tr>
<tr><td>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</td><td rowspan="2"></td></tr>
<tr><td>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</td></tr>
<tr><td>JAWS
In Humans
None – prognathous
OR
Less protruding</td><td>In African apes
Prognathous
OR
More protruding</td></tr>
<tr><td>TEETH
Canines are larger or smaller
It is canines and not teeth
Not:
Big and small
Larger and shorter
Larger and smaller teeth</td><td></td></tr>
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The significance of the structural changes that characterize the evolution of modern humans

Bipedalism

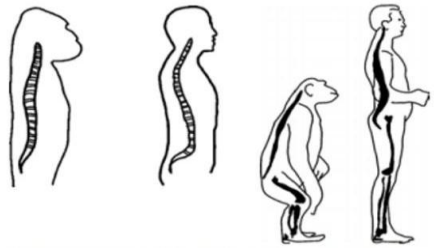
The first main difference is that humans are bipedal and walk on two legs. African apes are quadrupedal, chimpanzee and gorilla 'knuckle walk'.

There are **THREE changes** that can be seen in the human that serve as EVIDENCE for bipedalism

Structure	Significance
Foramen magnum The foramen magnum was in a backward position in the ape- like beings but in a forward position in modern humans 	This represents a change from quadrupedal in ape-like beings To bipedalism in modern humans, to allow vertical entry of the spinal cord through the skull leading to the following in modern humans: • Increased awareness of the environment in sensing danger/food • Freeing of the hands to use implements/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) 	• Support greater weight due to the upright position

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

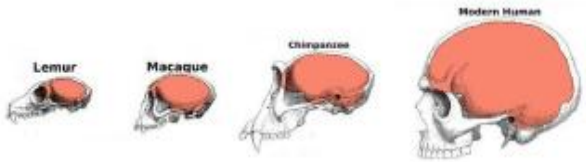
Other structural changes that characterise the evolution of modern humans

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

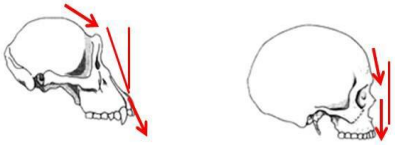
This allowed space for a larger brain in humans than in ape-like beings, making the following possible:

• Better co-ordination of movement
• Processing of a large amount of information
• Processing information faster
• Development of spoken and written languages to communicate



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

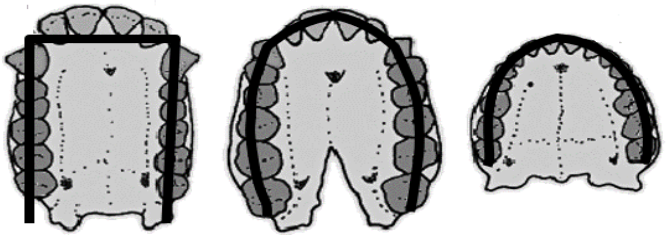


- This corresponds with a change in diet from hard, raw food in the ape-like beings
- To softer, cooked food in humans

Dentition/Teeth

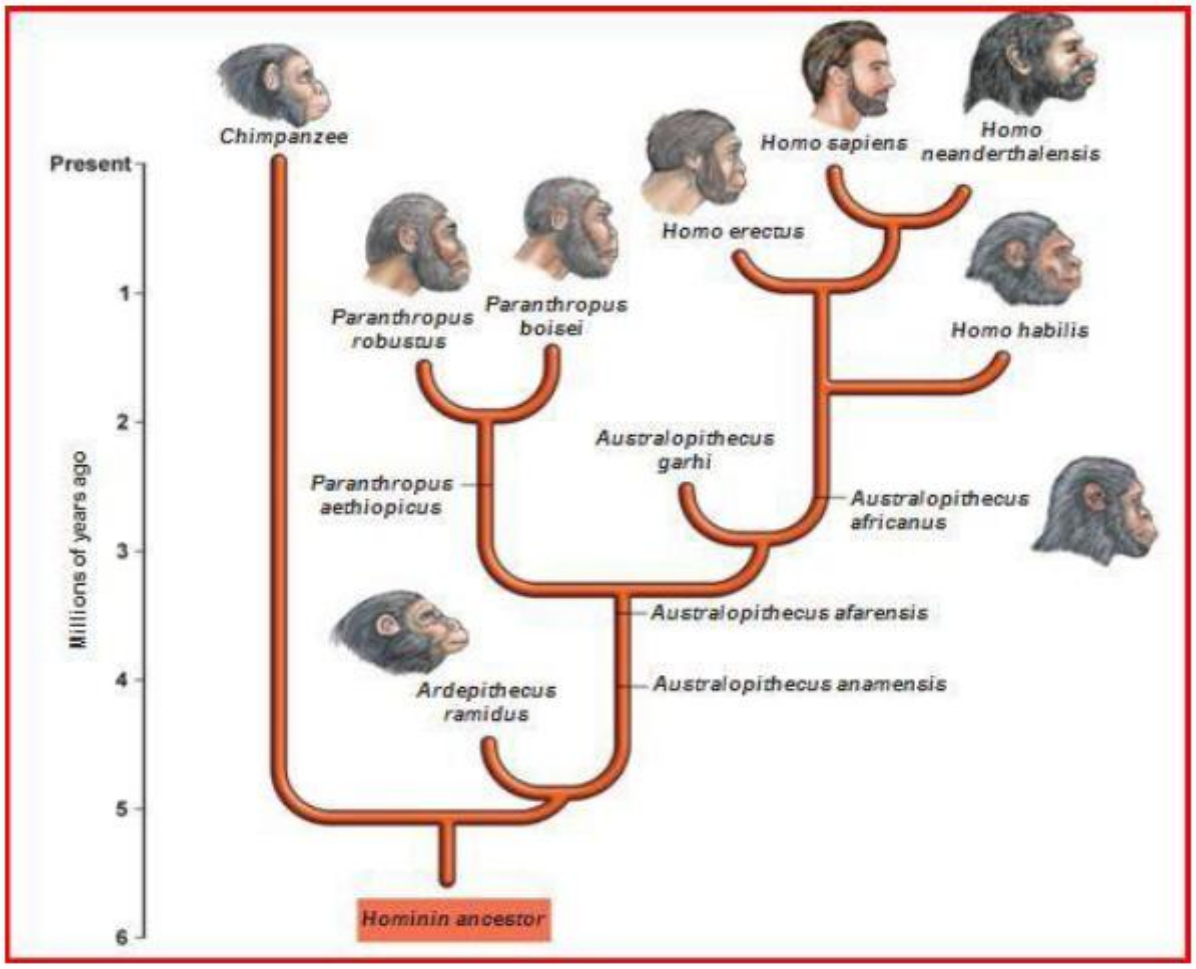
In ape-like beings there are gaps/diastema between incisors and canines
but no gaps between the teeth in humans
Humans have smaller canines than the ape-like beings
Humans have flatter molars and pre-molars than the ape-like beings

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



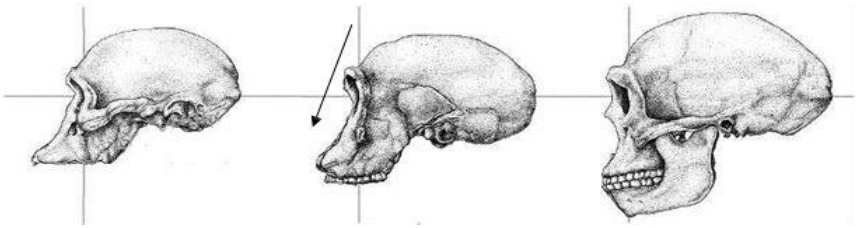
Chin In humans the chin is more developed compared to the ape-like beings	• Developed chin assists with speech in humans
Zygomatic arch In humans the zygomatic arch is less developed than in the ape-like beings	• This corresponds with the decreased need for attachment of strong muscles • due to the decreased jaw size in humans

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.)

Australopithecus **Homo habilis** **Homo sapience's**



11.4. 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*

11.5 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

• 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

Fossil	Fossil site	Scientist who discovered it	Characteristics
Ardipithecus: **Ardipithecus ramidus**			
Australopithecus:			
Australopithecus afarensis	Ethiopia, Kenya, Tanzania	Donald Johanson	Brain size: 37-550 ml Forward position of the foramen magnum. Very prognathous. Heavy brow ridges Pelvis structure: bipedal and tree climbing.
Australopithecus africanus 	Taung, Sterkfontein	Raymond Dart	Brain size: 428-625 ml Forward position of foramen magnum. Prognathous Brow ridges Large teeth, canines not long. Long arms No cranial ridge
Australopithecus sediba 	Malapa Cave in the cradle of humankind	Lee Berger	Brain size: 420 ml Less prognathous Brow ridges Large teeth, canines not long. Long arms No cranial ridge
Homo			
Homo habilis	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges. Human-like teeth, smaller canines. Long arms.
Homo erectus	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter arms
Homo naledi 	Cradle of Humankind, Rising Star cave		Brain size: 460-610 cm3 Prognathous Slender body, wide hips Humanlike feet and hands Long curved fingers
Homo sapiens 	Ethiopia, Border Cave in KZN, Blombos Cave in Western Cape	Tim White	Brain size: 1200 -1800 ml. No brow ridges Small teeth Short arms

 **= South Africa**

ACTIVITY 1.22

1.22 Scientists find evidence for human evolution by comparing humans to other hominids. The upper limbs of humans and African apes show similar characteristics, whereas there are differences between the dentition (teeth) of the two.

1.22.1 Why do scientists look for similarities between humans and African apes? (1)

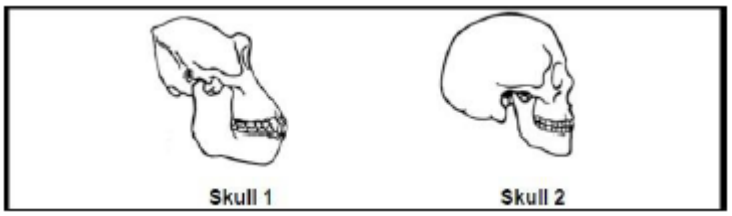
1.22.2 Explain the importance of the positioning of the thumbs for humans and African apes. (2)

1.22.3 State ONE difference between the teeth of humans and African apes. (2)

(5)

ACTIVITY 1.23

1.23 The diagrams below show the skulls of two species of primates.



1.23.1 Tabulate THREE observable differences between skull **1** and skull **2** that show trends in human evolution. (7)

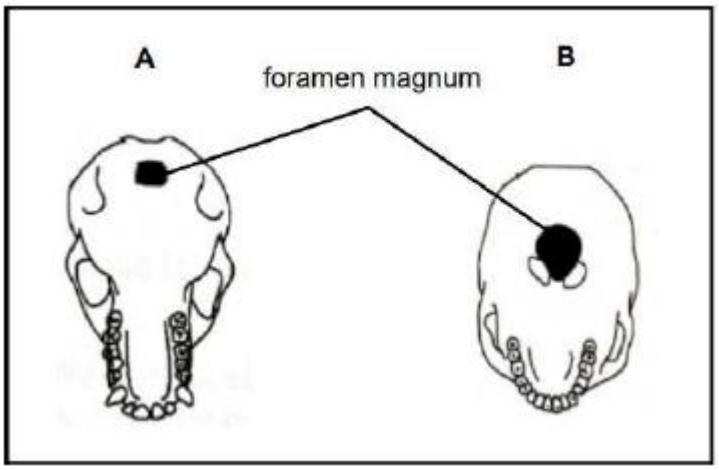
1.23.2 Give FOUR characteristics of the upper limbs that humans share with other primates. (4)

1.23.3 Explain how an increase in cranial volume is related to intelligence. (3)

(14)

ACTIVITY 1.24

Diagram **A** and **B** show the ventral (bottom) view of the skulls of two organisms. The diagrams are NOT drawn to scale



1.24.1 Which diagram represents the skull of a bipedal organism? (1)

1.24.2 Give ONE visible reason for your answer to QUESTION 1.24.1 (2)

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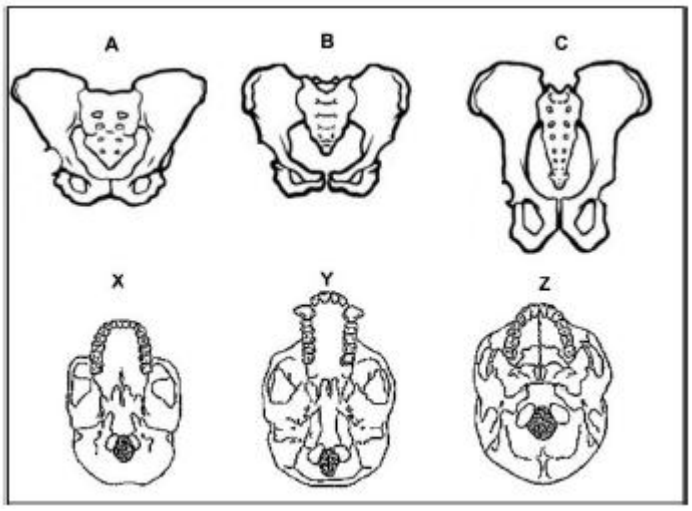
1.24.3 Tabulate TWO visible differences between the upper jaws in the diagrams **A** and **B** that represents trends in human evolution. (5)
(Mark first TWO only) Table 1 + Any (2 x 2)

1.24.4 Explain the significance of the shape of the spine that is associated with the skull in diagram **B.** (2)

(10)

ACTIVITY 1.25

1.25 The diagram below represents the pelvic structure and the ventral view of the skulls of three organisms. The diagrams are drawn to scale



1.25.1 Write down the LETTER(S) if the diagram(s) that represent the: (2)
(a) Skulls of bipedal organisms (1)
(b) Pelvic structure of a quadrupedal organism

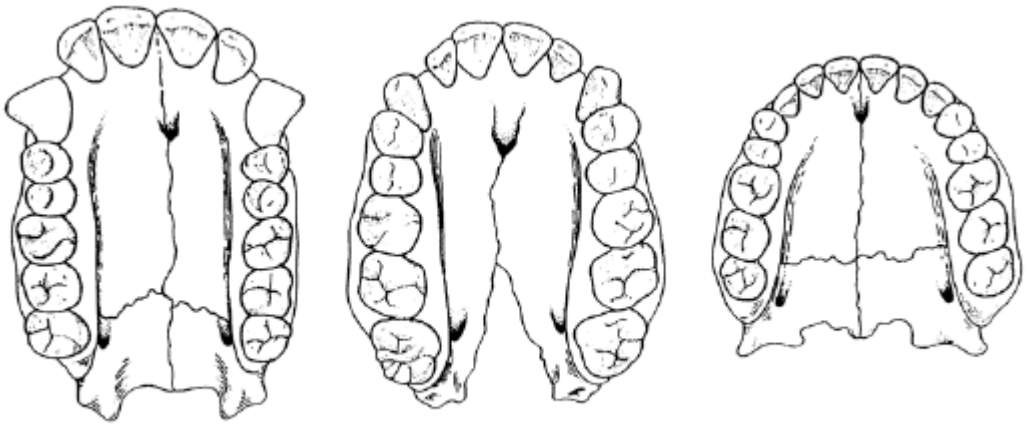
1.25.2 Give a reason for your answer to QUESTION 1.25.1(b). (2)

1.25.3 Describe ONE other structural difference between a bipedal and a quadrupedal organism. (3)

(8)

ACTIVITY 1.26

1.26



Chimpanzee ***Australopithecus afarensis*** ***Homo sapiens***

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1.26.1 Describe ONE visible difference between the jaw of a chimpanzee and that of Homo sapiens which show trends in human evolution

1.26.2 Based on the differences in dentition, what conclusion can be made about the change in diet from Australopithecus afarensis to Homo sapiens?

1.26.3 Australopithecus may be described as a transitional species between the chimpanzee and Homo sapiens.

1.26.4 Define a transitional species.

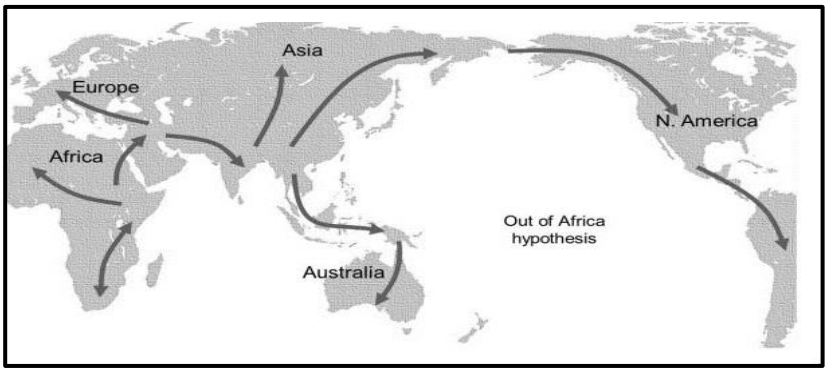
11.6. OUT-OF-AFRICA HYPOTHESIS

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: Genetic evidence: mitochondrial DNA • 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, including Karabo, Little Foot, Taung Child, Mrs Ples) o 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

Terminology

- **Theory** - *based on a number of different hypothesis, explanations, principles and laws.*
- **Hominidae** – *order to which humans, chimps, apes, gorillas, lemurs and gibbons belong*.
- **Transitional fossil** – *fossil having characteristics of species that arose before it as well as species that arose after it.*

- Out of Africa hypothesis explains the possible reason\ for the distribution of hominins across the earth.



- And it states that modern humans originated in Africa and then migrated to other continents.

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

(i) GENETIC EVIDENCE

Describe how genetic evidence is used to support the theory of human evolution.

Geneticists use mitochondrial DNA to study human origins and migrations since mtDNA is passed unchanged from mother to offspring.
However, during a person's life, mutations (changes) to the mtDNA do occur.

- Mitochondrial DNA
- Is inherited only from the maternal line
- Analysis of mutations on this mitochondrial DNA shows that the oldest female ancestor were located in Africa
- and that all humans descended from herv/mitochondrial

(ii) FOSSIL RECORD

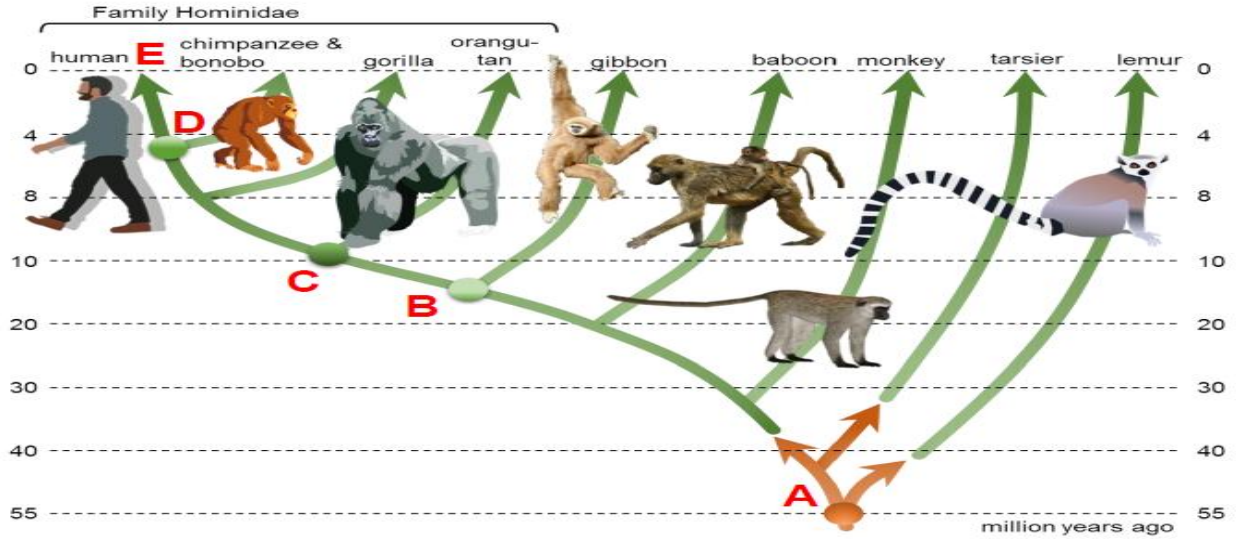
Explain how the fossils of organisms that existed from 4 mya to present time is used to support the 'Out of Africa' hypothesis.

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

- The fossils of *Australopithecus* were ONLY found in Africa
- 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
- This suggests that the Homo sapiens originated in Africa

Interpretation of a Phylogenetic tree to show the place of humans in the Animal Kingdom

Study the illustration in the phylogenetic diagram below and note the place of the Family Hominidae in the tree, and the relationships between the various primates, humans included.



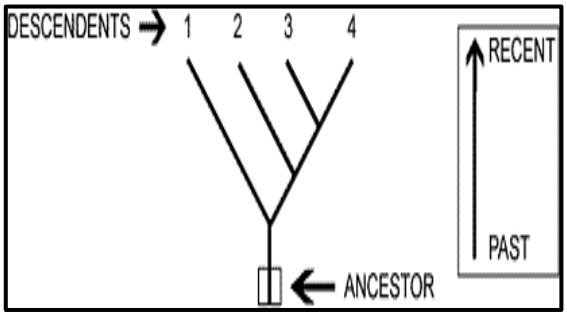
- On the left, and right, we have a timeline, in millions of years, beginning at 55 million years ago (in the past), and ending with the present (0 years).
- It illustrates the evolution of various primates from a common ancestor (marked A), who lived 55 million years ago. Markers B, C and D point to speciation events that lead eventually, at marker E, to the emergence of the modern human.
- Marker **B** indicates a speciation event that led to the evolution of gibbons as a separate species from the other primates.
- Marker **C** represents the common ancestor for the Family Hominidae that includes humans, chimpanzees and bonobos, gorillas and orangutans.
- This common ancestor lived approximately 10 million years ago.
- Marker **D** represents the common ancestor of humans and chimpanzees.
- This ancestor lived approximately 5 – 6 million years ago. This indicates that of all primates, humans and chimpanzees are the most closely related.
- The line from **D** to **E** represents the unique history of humans, and we will explore that in some detail later in this chapter.
- The line from **C** backwards to **A** represents the shared history of the Family
- Hominidae, and from **D** backwards to shared history of humans and chimpanzees.

The evolutionary relationships 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:

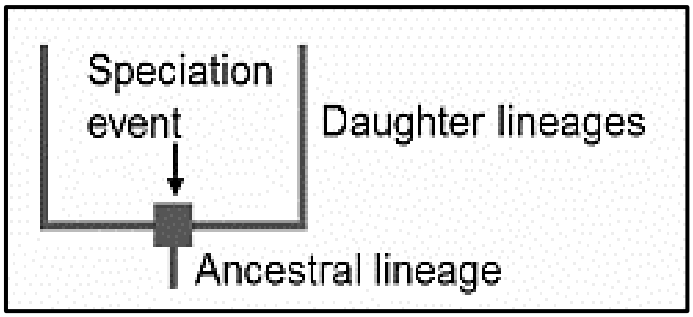
- The root of the phylogenetic diagram represents the ancestor, and the tips of the branches, the descendants of that ancestor. To move upwards is to move forward in time

(3 and 4 are more related to each other because there we have a more recent common ancestor)

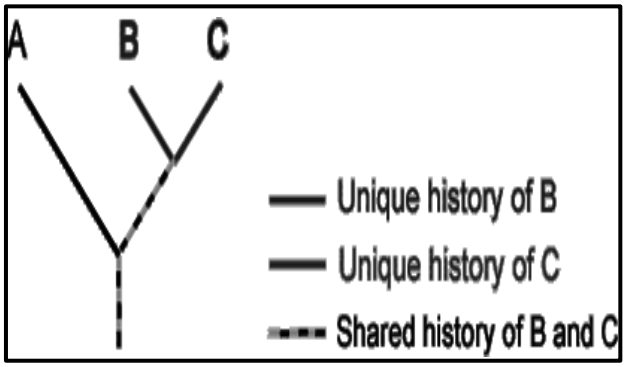


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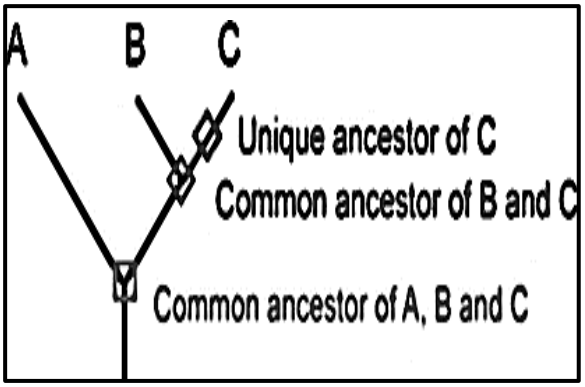
- Speciation is represented as a branching of the tree, as a single ancestral lineage gives rise to two or more daughter lines.



- 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.



- Evidence from fossils of different ages show that the anatomical characteristics of organisms changed gradually over time.

ACTIVITY 1. 27

Fossil evidence is used to support the 'Out-of-Africa' hypothesis.

1.27.1 State the 'Out-of-Africa' hypothesis. (2)

1.27.2 What genetic evidence is used to support the 'Out of Africa' hypothesis? (1)

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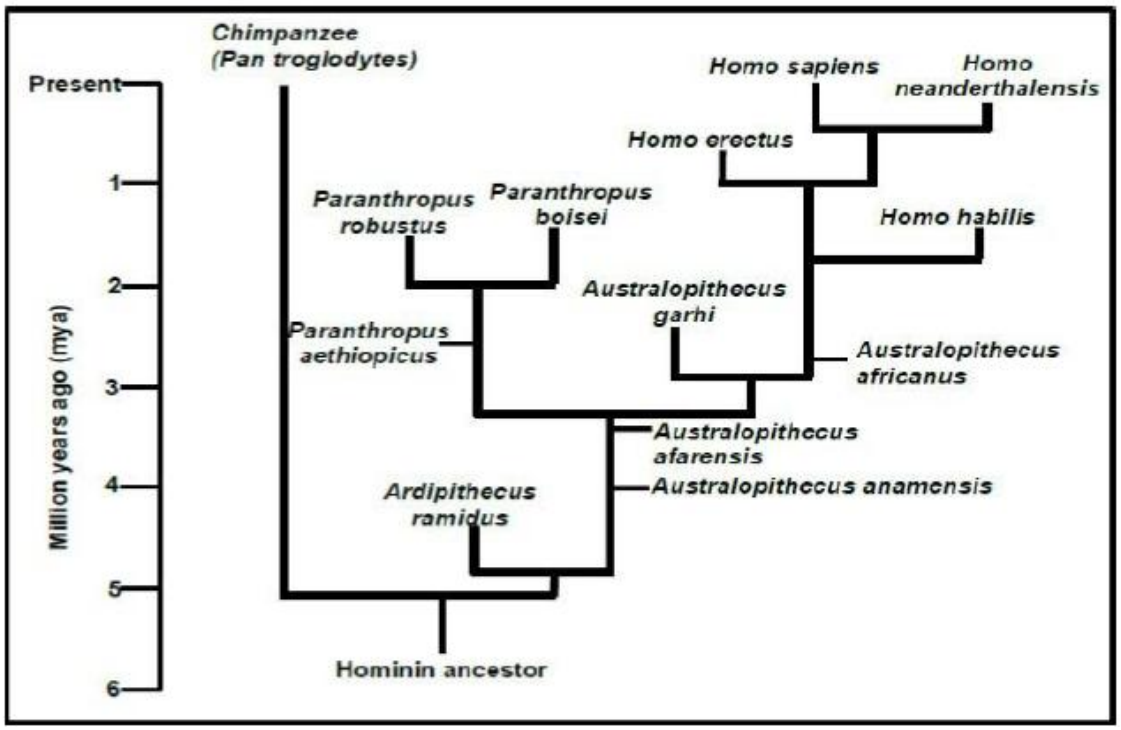
1.27.3 Describe how fossil evidence is used to support 'Out-of-Africa' hypothesis. (6)

1.27.4 Describe how genetic evidence is used to support 'Out-of-Africa' hypothesis (4)

(13)

ACTIVITY 1.28

1.28 The diagram below shows possible evolutionary relationships among some hominids



1.28.1 What is this type of diagram called? (1)

1.28.2 How many of EACH of the following are represented in the diagram:

(a) Genera (1)

(b) Homo species (1)

1.28.3 Name the species that have *Paranthropus aethiopicus* as a common ancestor. (2)

1.28.4 When did:

(a) *Ardipithecus ramidus* become extinct (1)

(b) *Homo erectus* first appear (1)

1.28.5 Name the:

(a) Hominid species that existed at the same time as Homo sapiens. (1)

(b) First Homo species to use tools (1)

(9)

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11.6. HOW TO APPROACH AN INVESTIGATION TYPE QUESTIONS

Male long-tailed widowbirds have extremely long tail feathers that they use in mating displays to attract females. → *This is the background information*

Scientists conducted an investigation to determine the relationship between the length of the male long-tailed widowbird's tail and its mating success.

Independent variable (what will be changed)

Dependant variable (what will be measured)

This is the aim containing both variables

The procedure was as follows:

Sample size

- A total of 27 male long-tailed widowbirds was sampled and divided into 3 equal groups.
- The tail feathers of the birds in each group were treated in the following **way:**
  - Group 1 – Cut short
  - Group 2 – Made longer by adding artificial feathers } *this is what the investigators changed*
  - Group 3 – Left unchanged → *this is the control, nothing was changed*
- The 3 groups of male long-tailed widowbirds, along with female long-tailed widowbirds, were released into an environment suitable for mating.
- Each time a pair mated successfully they produced a nest and all the nests were counted.

How the dependant is measured

The average number of nests produced by each group was calculated and used as an indication of mating success. → *A way to ensure reliability, calculating average*

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ACTIVITY 1.29

An investigation was done to determine the relationship between the height of the head and bite force in lizards.

The procedure was as follows:

- The scientists collected 120 lizards with similar characteristics that were around the same reproductive age in different habitats.
- Their body characteristics and DNA were analysed to determine if they belonged to the same species.
- 40 lizards belonged to species A, 36 to species B and 44 to species C.
- Each species was kept in its cage with environmental conditions similar to their habitats.
- The height of the head was measured for each lizard and averages calculated for each species.
- Using a Kistler force, the bite force of each lizard in each species was measured five times and the average calculated for each lizard and each species.

The results are shown in the table below.

Species	Height of the head (mm)	Bite force (N)
A	**10.3**	**12,4**
B	**10.7**	**14,3**
C	**13.2**	**20,4**

1.29.1. Identify the:
(a) Independent variable (1)
(b) Dependent variable (1)
1.29.2 State TWO factors that were kept constant for this investigation. (2)
1.29.3 Apart from the sample size, state ONE way in which the reliability of the results was ensured for this investigation. (1)
1.29.4 The height of the head was different in each species of lizard. Name the type of variation displayed by this characteristic. (1)
1.29.5 Describe the relationship between the height of the head of the lizards and the bite force. (2)
(8)

ACTIVITY 1.30

Male long-tailed widowbirds have extremely long tail feathers that they use in mating displays to attract females.

Scientists conducted an investigation to determine the relationship between the length of the male long-tailed widowbird's tail and its mating success.

The procedure was as follows:

- A total of 27 male long-tailed widowbirds was sampled and divided into 3 equal groups.
- The tail feathers of the birds in each group were treated in the following way:
- Group 1 - Cut short
- Group 2- Made longer by adding artificial feathers
- Group 3- Left unchanged
- The 3 groups of male long-tailed widowbirds, along with female long-tailed widowbirds, were released into an environment suitable for mating

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- Each time a pair mated successfully they produced a nest and all the nests were counted.
- The average number of nests produced by each group was calculated and used as an indication of mating success.

The results are shown in the table below.

GROUP	AVERAGE NUMBER OF NESTS PRODUCED
1	0.5
2	2,5
3	1

1.30.1 Name the:
(a) Reproductive isolating mechanism that occurs in long-tailed widowbirds (1)
(b) Independent variable in this investigation (1)

1.30.2 Explain why 27 long-tailed widowbirds were used in the investigation instead of only 3. (2)

1.30.3 Explain why Group 3 was included in the investigation. (2)

1.30.4 Draw a bar graph to represent the results of this investigation. (6)

1.30.5 State a conclusion for this investigation. (2)

References



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