JENN

Training and Consultancy

The path to enlightened education

LIFE SCIENCES

EVOLUTION

GRADE 12

2026

TEACHER AND LEARNER CONTENT MANUAL

THEORIES OF EVOLUTION

HUMAN EVOLUTION

JENN MAREMATLOU TRAINING INSTITUTE
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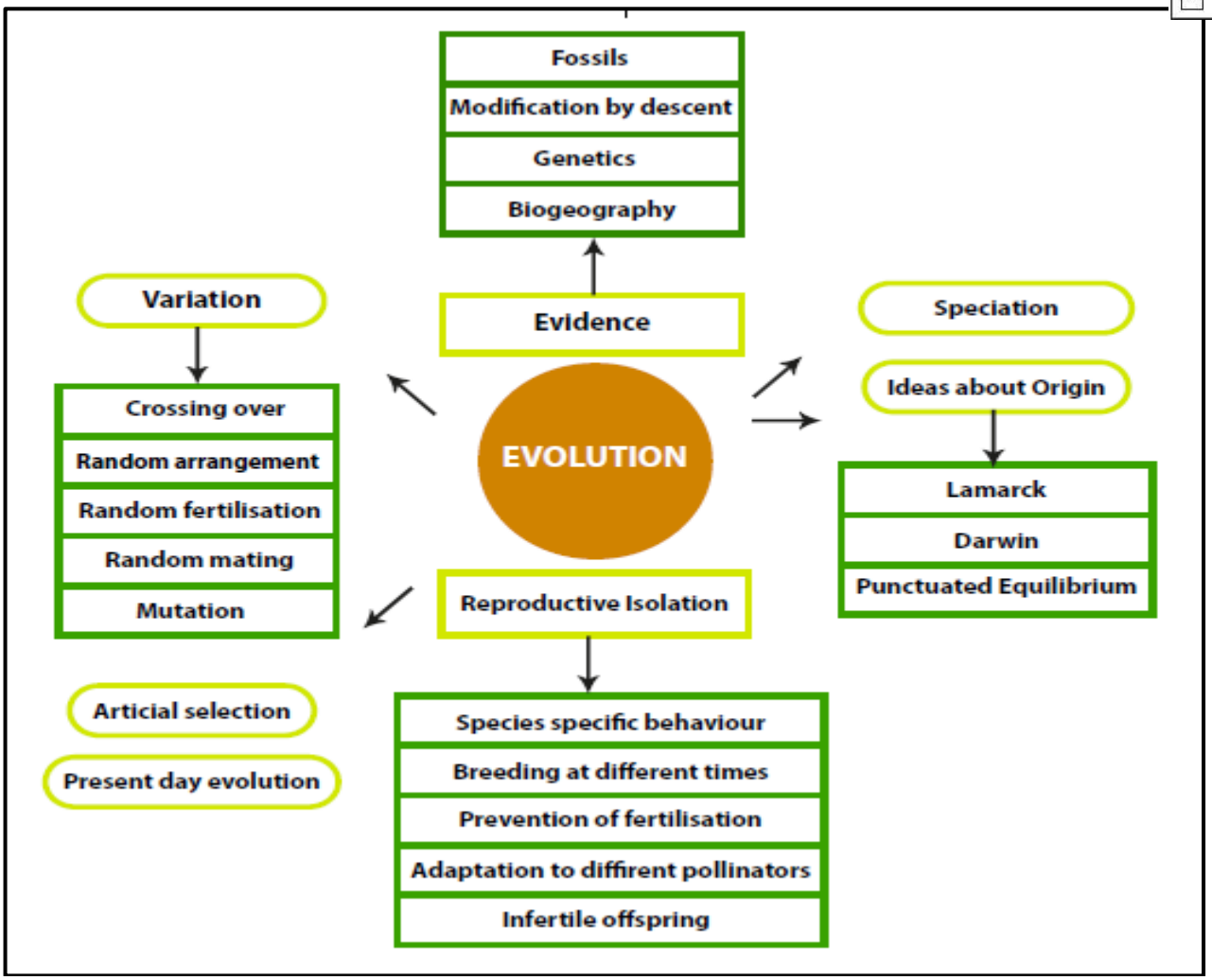
CONTENT **PAGE**

KEY CONCEPTS/ MIND MAPS



Terminology in evolution

TERM	DEFINITION
Evolution	Gradual change that occurs in a population leading to a formation of a new species
Theory	A well-substantiated explanation of some aspect 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, in close proximity to allow interbreeding and producing fertile offspring
Speciation	A process of forming a new specie
Geographic speciation	Forming a new specie because there was a geographic barrier
Mutation	A sudden change in the genetic makeup of an organism
Natural selection	A process whereby the environment chooses a particular organism to survive, due to that organism having favourable characteristics.
Artificial selection	A process whereby the human chooses to selectively breed an organism due to its having a desirable characteristic
Continuous variation	Variation in phenotypic traits 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 with few or no intermediate phenotypes.
Extinction	Total disappearance of a species from Earth
Phylogenetic tree	A diagram that traces the evolution of different species from a common ancestor along a time line
Bipedalism	Walking on two legs
Foramen magnum	An opening in the skull for allowing the entry of the spinal cord,
Prognathism	Having a protruding jaw
Cranial ridge	A longitudinal groove in the skull for attachment of muscles (absent in humans)

Evidence of Evolution

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

Focus on the following definitions.

(a) Definition of biological evolution:

- Biological evolution refers to the change in the characteristics of a species over time.

(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, generalisations, 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.

You must focus more on the role of evidence for evolution
"And make sure you can list the 4 "evidence for evolution"

1. **Fossil record – Link to Grade 10**

   A **fossil** is the preserved remains, impressions, or traces of organisms that lived in the past.

   Example: Bones and teeth
   Shells
   Imprints (footprints, leaf prints)
   Preserved organisms in amber, ice, or tar

2. **Biogeography – Link to Grade 10**

   Biogeography refers to the study of past and present distribution of individual species. Such studies show that closely related species tend to be found in the same geographic regions of the different continents because of very similar habitats.

Example:

Baobab trees in Africa **and** **Madagascar**

- The original common ancestor population of the baobab trees was found in Gondwanaland.
- Continental drift separated Gondwanaland into different continents.
- The common baobab tree ancestor population split into the different continents including Africa and Madagascar.
- There was no gene flow between the baobab tree populations in Africa and Madagascar.
- The Baobab tree populations were in different environments.
- Natural selection occurred independently in the two baobab tree populations.
- They became different genotypically and phenotypically.
- Over many generation the baobab tree population in Africa could not interbreed with the baobab tree population in Africa.
- Two different baobab tree species formed in Africa and Madagascar

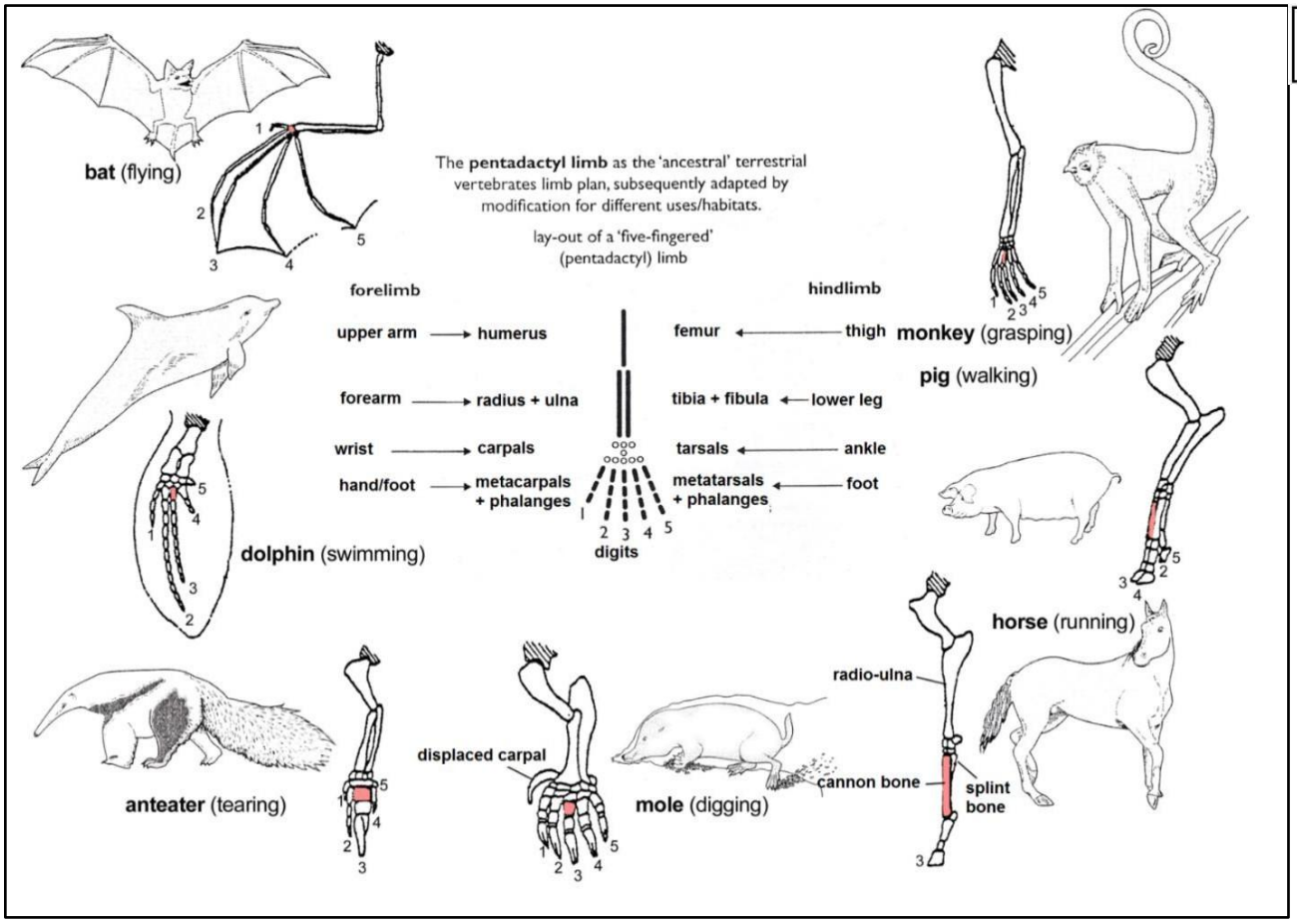
Biogeography can also be used to explain the distribution of the flightless birds of the world ostriches in Africa, Rhea's in southern America, Kiwi's and Emu's in Australia.

3. Modification by descent (homologous structures)

Modifications obtained from the study of the details of the structures of body parts and systems of organisms that belong to a specific phylum.

- Homologous organs: (homo = the same) similarity of the formation of a body part or organ due to a common evolutionary origin, e.g .: the structure of the pentadactyl limb in seals, bats and humans. The bones, muscles and nerves are arranged in a similar manner in a front paw, wing and arm.

(make sure you know why homologous structures are important evidence in evolution)



4. **Genetic evidence**: Scientists state that organisms are closely related and are likely to have a common ancestor if they have:
   - Identical DNA structure
   - Similar sequence of genes and
   - Similar portions of DNA with no functions
   - Species that are closely related have a greater similarity to each other than distant species.

Use of phylogenetic tree

A **phylogenetic tree** is a diagram that shows evolutionary relationships between organisms.
It has several important uses, especially in Biology and Life Sciences:
Example:

1. **Shows evolutionary relationships**
   It helps scientists understand how different organisms are related through evolution and common ancestry.
2. **Traces common ancestors**
   A phylogenetic tree can identify where species share a common ancestor and how they have diverged over time.
3. **Classifies organisms**
   It is used in **taxonomy** to group organisms based on their evolutionary history rather than just physical similarities.
4. **Studies evolution**
   Scientists use it to study patterns of evolution, such as how traits developed or

changed in different species.

5. **Predicts characteristics**
   By looking at related organisms, scientists can predict features or traits that an organism might have.
6. **Helps in research and medicine**
   In fields like **genetics**, phylogenetic trees help track disease evolution (like viruses) and understand genetic relationships.

ACTIVITY 1(EC, SEP,2023)

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)

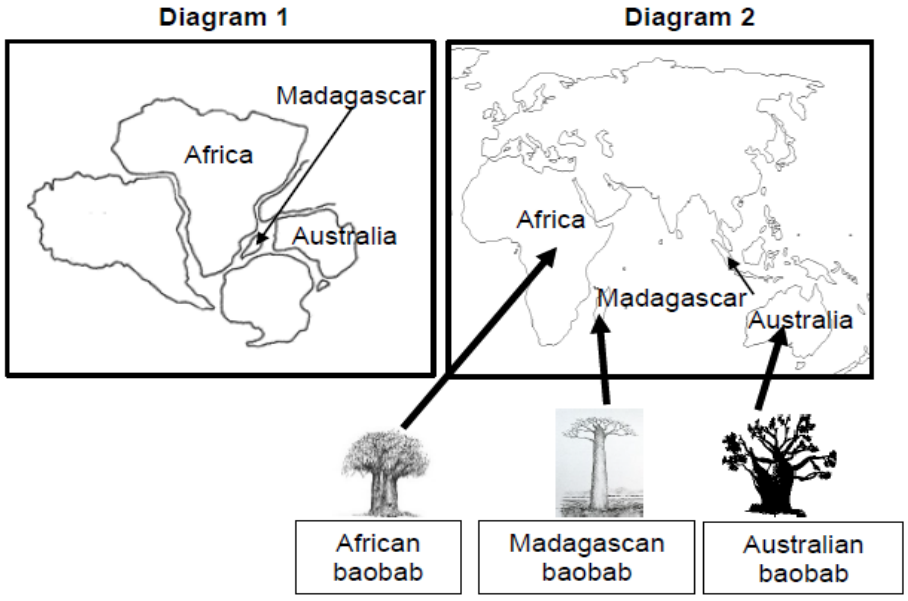
1.1.3 Tabulate ONE difference between a theory and a hypothesis. (3)

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

(9)

ACTIVITY 2 (EC/SEPTEMBER 2019)

2.1 The baobab tree belongs to the genus *Adansonia.* Different species are found in Madagascar, Africa and Australia as shown in the diagram below. Originally these three continents formed part of Gondwanaland as seen in diagram **1**. Today the continents are separated by large oceans as seen in diagram **2**.



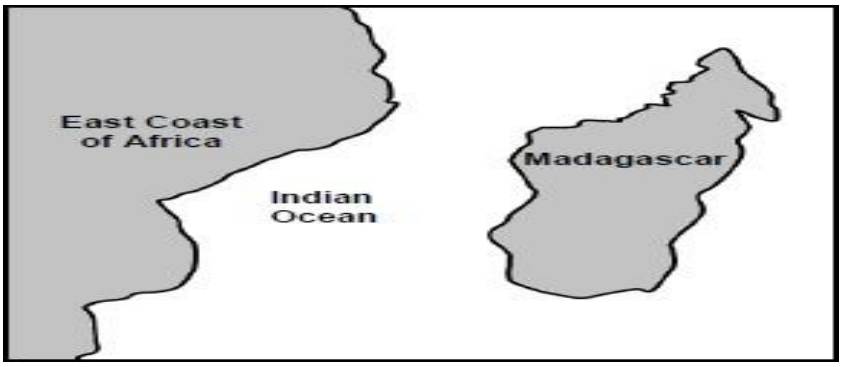
2.1.1 Explain how the different species of baobab could have evolved on the different continents. **(6)**

(6)

ACTIVITY 3 (DBE/November 2020(2))

3.1 Pottos and lemurs are small mammals.

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



3.1.1 Explain how continental drift could have affected the distribution of the common ancestor. **(4)**

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

Variation

- variation causes genetically different individuals, and individuals may have characteristics that make the more suited or less suited to the environment
- how variation can play a role in Natural Selection **(to be studied later)**

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.

You must be able tell if two organisms are the same species or not

- If a **species** can **interbreed** and **produce fertile offspring**, then they are the **same species**.
- But if they **interbreed** but do not **produce fertile offspring**, then they are **not the same species**.

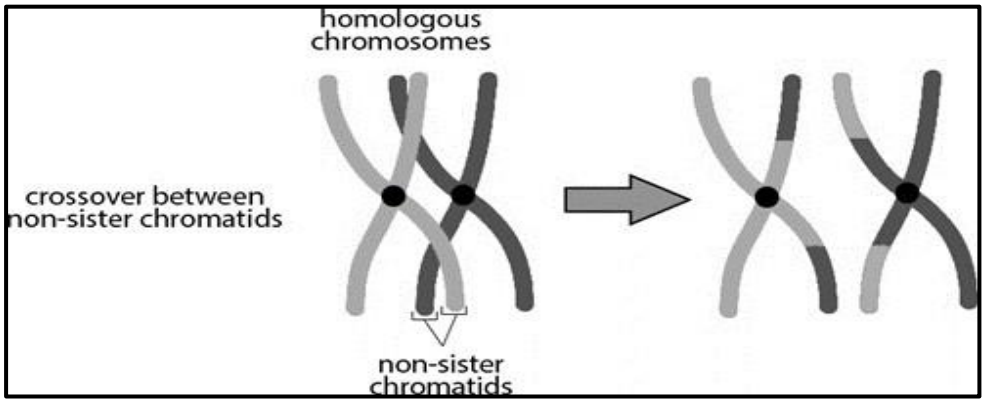
Example: A horse and a donkey = mule

A review of the contribution of each of the following to variation that exists amongst individuals of the same species: ***(here the question can combine genetics and evolution)***

(a) Meiosis

Crossing over

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

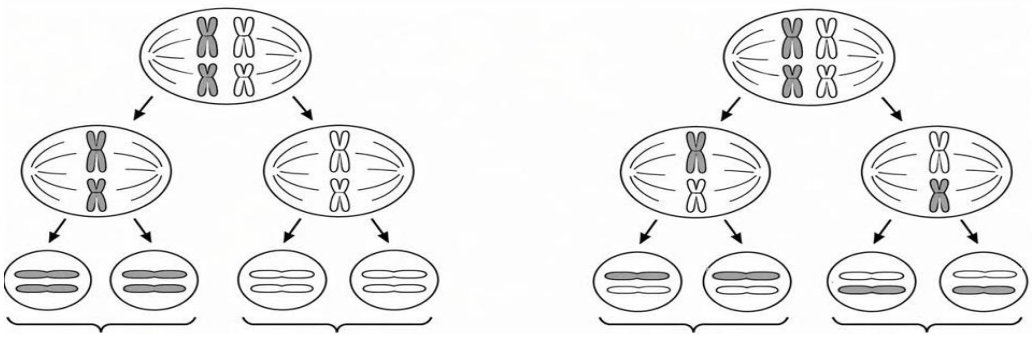


(b) Random arrangement of chromosomes

- Homologous chromosomes are arranged in pairs at the equator during Metaphase I and
- during Metaphase II chromosomes are arranged singly at the equator.

This results in genetically different gametes

Possibility 1 **Possibility 2**

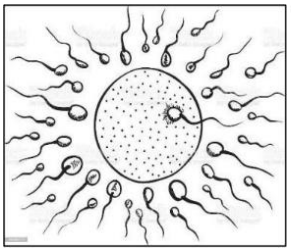


Combination 1	Combination 2	Combination 3	Combination 4

(c) Mutations

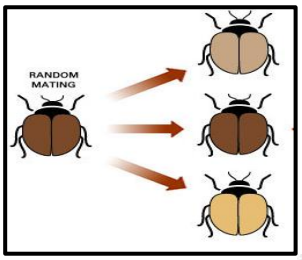
- **Gene Mutation** – a change in the sequence of nitrogenous bases or nucleotides of DNA (learners should know the definition)

Chromosomal mutation – a change in the normal structure or number of chromosomes *(You must use the correct wording as it comes from the Exam Guidelines*



(d) Random fertilisation - between different egg cells and different sperm cells formed by meiosis result in offspring that are different from each other. ***(any sperm cell can fertilise the ovum)***

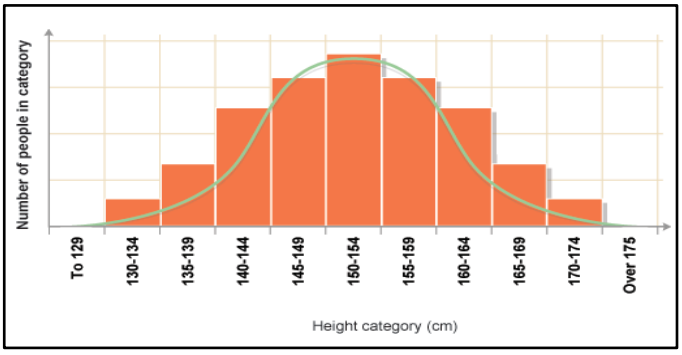
(e) Random mating - between organisms within a species leads to a different set of offspring from each mating pair.



TYPES OF VARIATION

(a) Continuous variation - *(a trait with a range of intermediate phenotype from one extreme to another (intermediate values)*

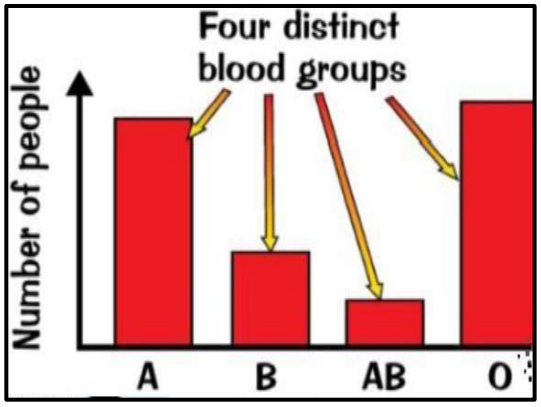
- When traits do not fall into clear cut classes.
- For example, there is every shade of hair colour between black and blond.
- Human height is an example of continuous variation.
- Height ranges from that of the shortest person in the world to that of the tallest person.
- Any height is possible between these values.
- For any species a characteristic that changes gradually over a range of values shows continuous variation.
- Examples of such characteristics are - height, weight, foot length

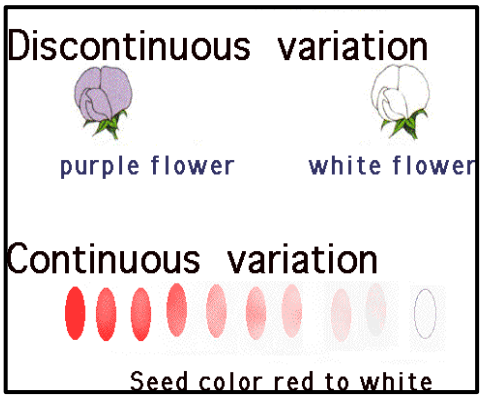


(b) Discontinuous variation- characteristics that fall in definite categories without an intermediate phenotype e.g. Mendel's pea plants were either tall or short and had no intermediate forms between these traits

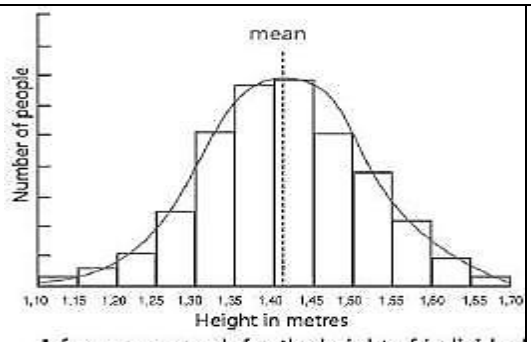
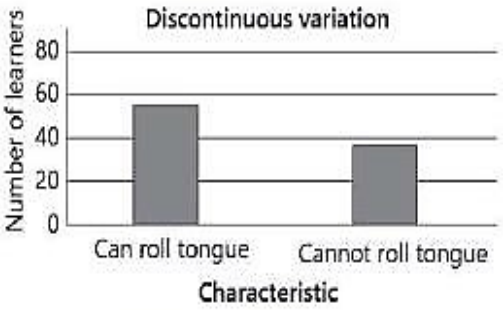
- You are either male or female, there are no intermediates
- Your ABO blood group is either A, B, AB or O

- Easily distinguishable and not affected by environmental conditions
- Brought about by one or two genes
- Genetic defects such as colour blindness, albinism, sickle cell anaemia are all genetically controlled in a discontinuous way
- You either have these conditions, or you do not.
- There are no intermediate states





Feature	Continuous variation	Discontinuous variation
Genes and loci	Controlled by several different genes.	Controlled by one gene
Phenotypes	Range of phenotype	Distinct phenotype.
Examples	Height. Foot size. Hair colour.	Mendel's pea experiments: tall or short; smooth or wrinkled seeds. Tongue roller or non-tongue roller in humans. Rhesus factor in blood, either Rhesus positive or Rhesus negative.
Feature	**Continuous variation**	**Discontinuous variation**
Frequency graphs show the two different types	Histogram graph is drawn as the independent variable is continuous - there are no gaps between the different categories. A normal distribution/bell-shaped curve is the result. The data is evenly spread on either side of the mean (average). See the graph below.	Bar graph is drawn as the independent variable is discontinuous - there are gaps between the different categories. See the graph below.

	 A frequency graph for the height of individual in a population	 A graph showing discontinuous variation

ACTIVITY 4

4.1.1 Define the following terms:

(a) Population (3)

(b) Species (3)

4.2.1 Scientists believe that variation in populations can lead to the formation of new species.

List FOUR sources of variation in populations. (4)

4.3.1 Describe how the following contributes to genotypic variation within a species:

(a) Meiosis (6)

(b) Sexual reproduction (4)

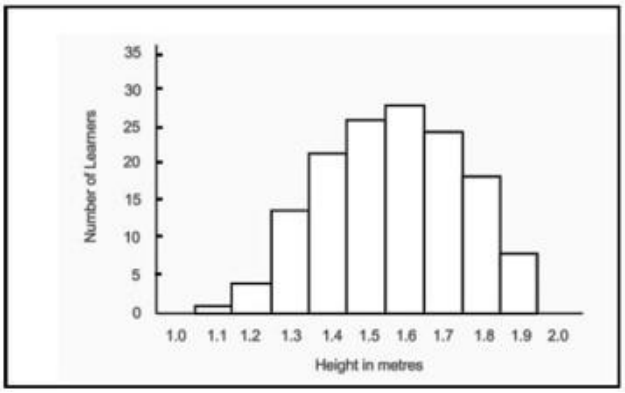
(20)

ACTIVITY 5

5.1 Mutations result in genetic variation.

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

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



5.2.1 Identify the type of graph represented. (1)

5.2.2 Explain why this type of graph mentioned in QUESTION 5.2.1 is most suitable for plotting data on continuous variation. (2)

5.2.3 What is the most common height? (1)

5.2.4 How many people in the group were shorter than 1.3 meters?

(9)

ACTIVITY 6 (DBE/November 2023)

6.1 An investigation was done to determine the relationship between the height of the head land 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

6.1.1 Identify the:

(a) Independent variable (1)

(b) Dependent variable (1)

6.1.2 State TWO factors that were kept constant for this investigation. (2)

6.1.3 Apart from the sample size, state ONE way in which the reliability of the results were ensured for this investigation. (1)

6.1.4 The height of the head was different in each species of lizard.
Name the type of variation displayed by this characteristic. (1)

6.1.5 Describe the relationship between the height of the head of the lizards and the bite force. (2)

6.1.6 Which species (A, B or C) would be expected to be feeding mainly on tough fibrous plants? (1)

6.1.7 Explain your answer to QUESTION 6.1.6 (2)

6.1.8 Which species (A, B or C) would be most suited to live in narrow areas between the rocks? (1)

(12)

Origin of an Idea (Evolution theories)

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

Jean Baptiste de Lamarck – 1744-1829 **(Lamarckism)** ***(You must know how to spell it correctly)***

(a) Law of use and disuse (explain the theory – firstly they must state the law and explain the law)

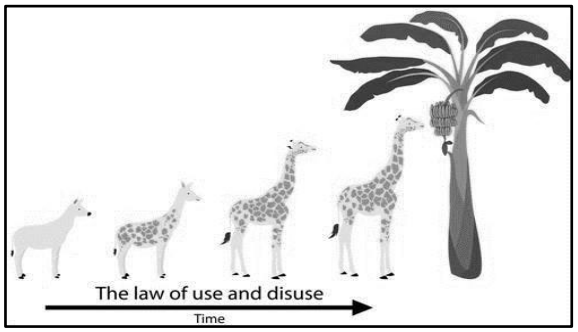
- Changes in the environment create new needs that cause organisms to modify their existing organs to meet the need.
- Repeated use of the organ would cause it to enlarge and become more efficient. Disuse of an organ would cause it to degenerate.

(b) **Law of inheritance** ***(You must be able to explain the theory – but you must firstly state the law and explain the law)***

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

How to describe Lamarckism

Example:



Guiding Questions	Lamarck's explanation
What was the original characteristic at the start?	All giraffes had **short necks** originally
What did the organism do?	Giraffes frequently stretched
Why did the organism do this?	used their necks to reach -for leaves of tall trees/to feed
What was the result?	necks 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**

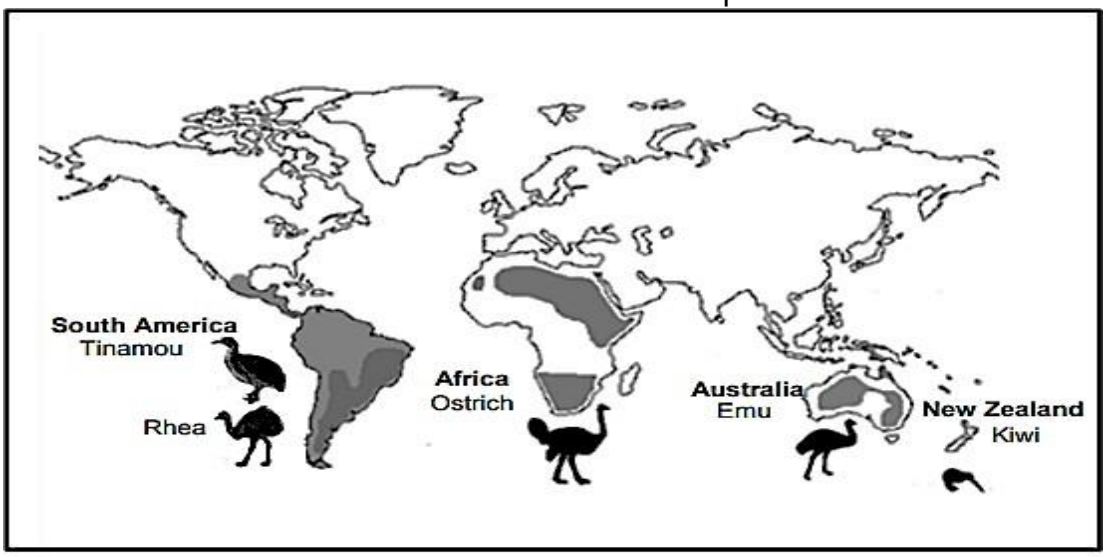
You must no longer give a general statement rather state the favourable characteristics

Example:

Refer to the characteristic (Long necks) – do not only state - "the acquired characteristic was passed on to the next generation"

ACTIVITY 7

7.1 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.



7.1.1 Describe how Lamarck would have explained the evolution of flightless birds. **(4)**

ACTIVITY 8

8.1 The diagram below shows a modern swordfish.

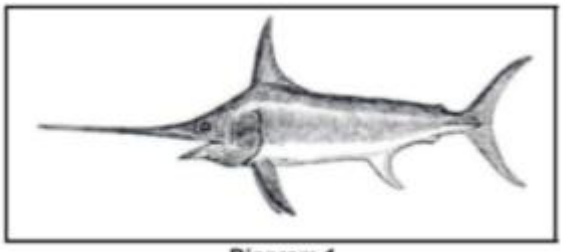


Diagram 1

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.

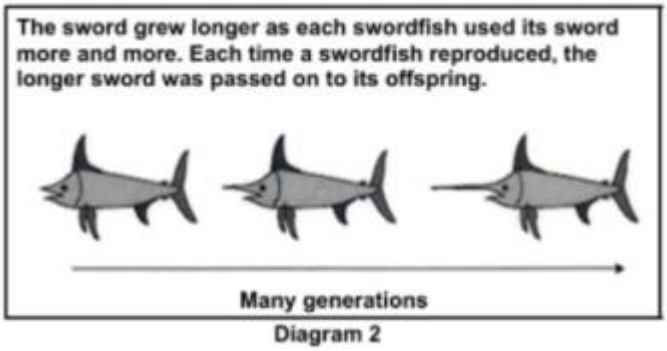


Diagram 2

8.1.1 a) Which scientist suggested the theory shown in Diagram 2? (1)
b) Explain ONE reason why the theory put forward by the scientist in QUESTION 8.1.1 (a) is not accepted. (2)
(3)

ACTIVITY 9 (*DBE/May/June 2025)*

9.1 Read the extract below.

STICKLEBACK FISH

Stickleback fish are small fish found in the ocean and freshwater lakes. The ones in the ocean have spikey fins for protection against predators. Until about 10 000 years ago, most stickleback fish lived in the ocean. But, when the last ice age ended, the melting ice created new lakes and some populations swam into the lakes. The connections between the ocean and the lakes eventually dried up, trapping the stickleback populations in some lakes for thousands of years. Over time, the stickleback fish populations in the lakes lost the spikey fins.

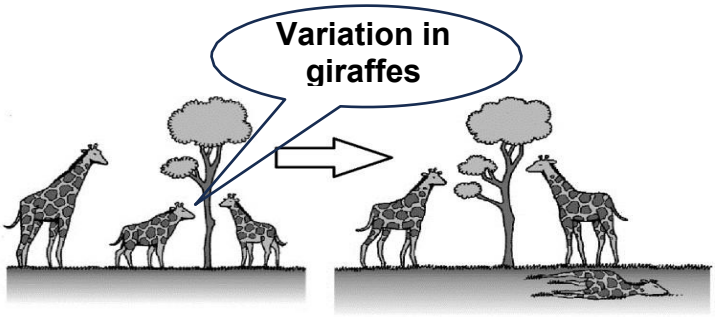
9.1.1 How would Lamarck have explained the absence of spikey fins on stickleback fish in lakes?

(6)

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.

You must adapt generic explanation given in the guidelines to the specific example given in paper.

How to describe Darwinism using example



Natural Selection in action

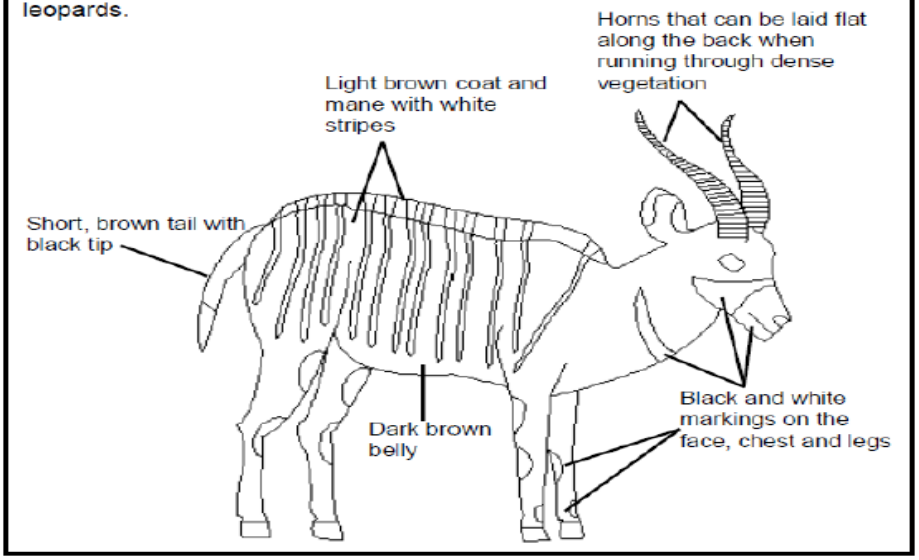
(Natural selection questions keep on changing and you must be able to adapt your answer to specific example given – SEE TABLE BELOW

Guiding Question	Darwin's explanation
1-State the **characteristic** that varies	There is a variation in the 1- **length** of giraffe's necks.
Describe the 2- **variations**	There were giraffes with 2- **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 4- 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	5- 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

ACTIVITY 10

10.1 The extract and the diagram below provide information about a type of antelope called a Bongo.

The Bongo is a large antelope species that is active at night and found in the dense jungles and forests of Africa. The dense forests have very little ground vegetation so the Bongo feeds in forest openings where new herbs and shrubs grow closer to the ground. They are preyed on by lions and leopards.



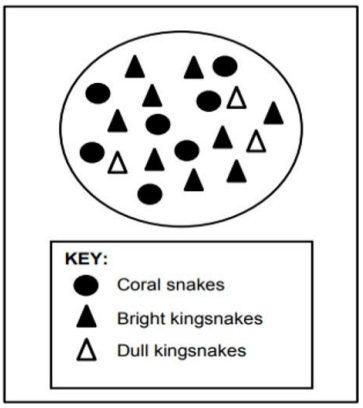
10.1.1 State characteristics that help the Bongo to camouflage themselves in the dense jungle. (5)

10.1.2 Use your knowledge of natural selection and explain how the Bongo's ability to lay its horns along its back could have developed over the years. (5)

(10)

ACTIVITY 11

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

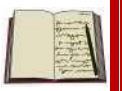


11.1.1 Explain how the bright colour pattern of coral snakes influences their survival. (3)

11.1.2. Use Darwin's theory of evolution through natural selection to explain why there are more brightly coloured kingsnakes in this habitat. (6)

(9)

ACTIVITY 12



12.1 Read the passage below.

ATLANTIC CODFISH EVOLVE TO ESCAPE HUMANS

Large scale over-fishing and slower maturation rates has led to the rapid decline in Atlantic codfish population. Humans often target fish with larger body sizes that can easily be caught by the nets with larger mesh they use when fishing. Over the years the Atlantic codfish has experienced mutations on the GHR genes that has resulted in a 30% reduction of body size and faster maturation rate.

12.1.1 According to the passage which human activity has resulted in a reduced population in the Atlantic codfish? (1)

12.1.2 Explain the effect of the GHR gene mutation on the survival chances of the Atlantic codfish. (2)

12.1.3 Use Darwin's theory of natural selection to explain the evolution of smaller body sizes and faster maturation rates in the Atlantic codfish. (7)

(10)

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 13

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.

13.1.1. Give:

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

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

c) The name of the Scientist that is associated with the theory of punctuated equilibrium. (1)

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

13.1.3 State whose idea evolution is more acceptable today. (2)

(7)

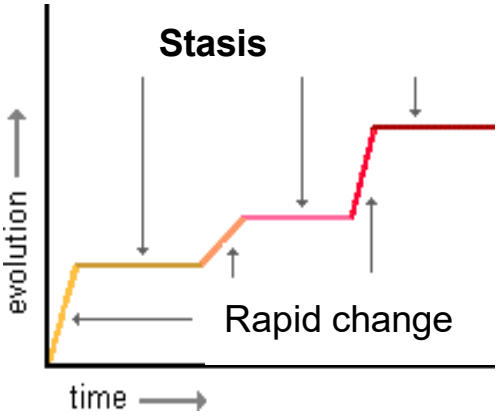
Punctuated Equilibrium

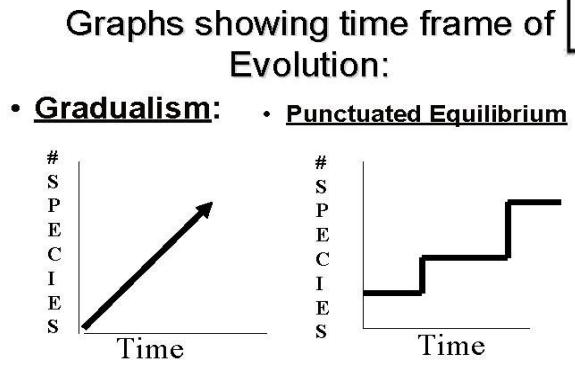
CONTENT	ELABORATION
Punctuated Equilibrium (Eldredge and Gould -1972)	Punctuated Equilibrium explains the speed at which evolution takes place: • Evolution involves long periods of time where species do not change or change gradually through natural selection (known as equilibrium). • This alternates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

Punctuated Equilibrium (Eldredge and Gould – 1972) *(You must know who came up with this theory)*

- 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)





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

How the giraffe got a long neck! – according to punctuated equilibrium

- All giraffes had short necks for a long period of time.
- A mutation occurred and some giraffes were born with long necks.
- These giraffes were able to get more food and survive and therefore reproduced more.
- Therefore, more longneck giraffe survived from generation to generation.
- Over a few generations the whole population had long necks.

Artificial selection

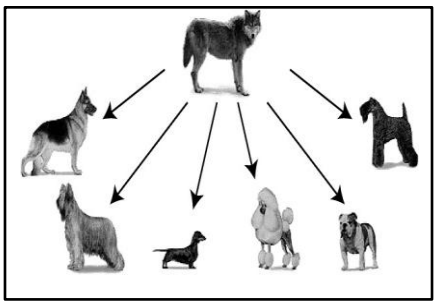
How to d**escribe artificial selection using an example:**

- 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

How is artificial selection done?

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

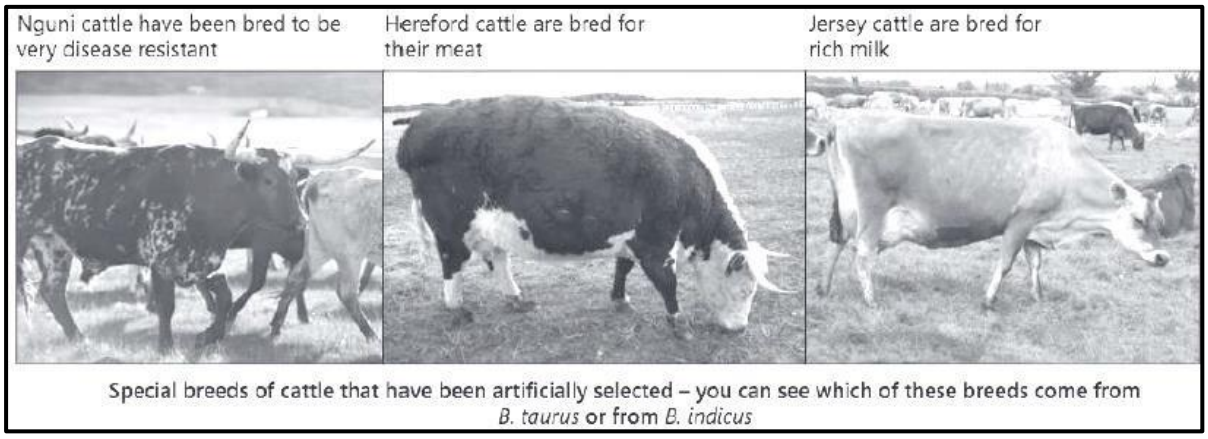
Example: Domestication of dogs



Example: 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*

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).

List similarities between natural selection and artificial selection.

- both create a trend towards organisms better suited for their environment 'purpose'
- both natural selection and artificial selection involve an organism's traits being determined by how much they are favored then, the organisms with favourable traits pass those traits on to future generations both processes eventually form a new species

ACTIVITY 14

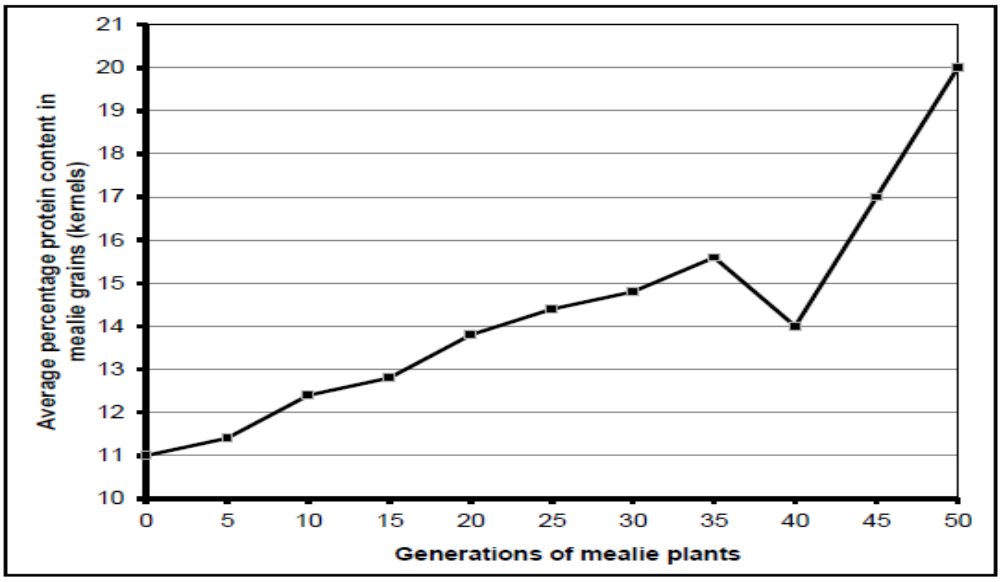
14.1.1 Distinguish between punctuated equilibrium and gradualism. (2)

14.1.2 What is the similarity between punctuated equilibrium and gradualism (2)

(4)

ACTIVITY 15 (DBE/November 2023)

15.1 The graph below shows the results of artificial selection for protein content in mealie plants over 50 generations



15.1.1 Describe how this farmer did artificial selection of the mealie plant. (3)

15.1.2 What was the average percentage of the protein content in the mealie grains (kernels) at the 15h generation? (1)

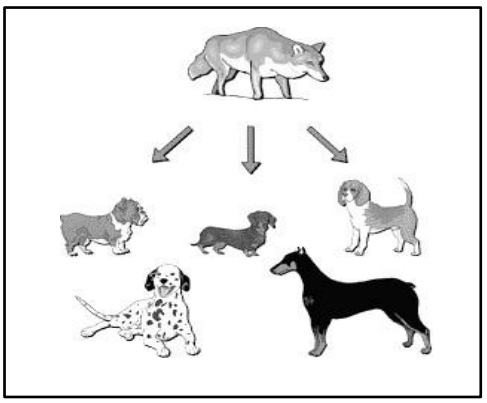
15.1.3 By how many times did the average percentage of the protein content in the mealie grains (kernels) increase between the 40th and 50"h generation? Show ALL working. (2)

15.1.4 Describe ONE way in which the process of artificial selection is different from genetic engineering. (2)

(8)

ACTIVITY 16

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



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

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

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

16.3 What effect does the type of selection mentioned in 16.2 have on the survival change of the dog species? (2)

(7)

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

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.

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 genotypically and phenotypically.**

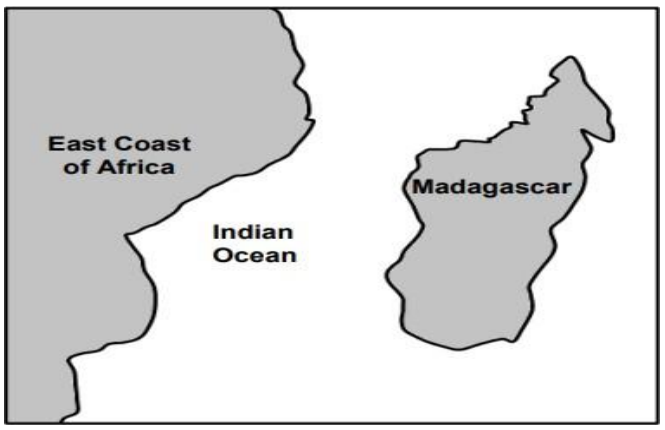
(*Mention the differences if the extract indicates differences)*

5. **Even if the two populations were to mix again they will not be able to interbreed.**
6. **The two populations are now different species, name the new species.**

(mention the new species that form)

Example 1

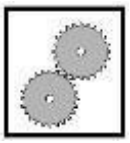
Pottos and lemurs are small mammals. Scientists believe that pottos and lemurs share a common ancestor that existed in Africa. Presently pottos only occur in Africa while lemurs are only found in Madagascar. Madagascar is an island off the East coast of Africa as shown in the diagram below.



Describe the speciation of the pottos and lemurs.

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

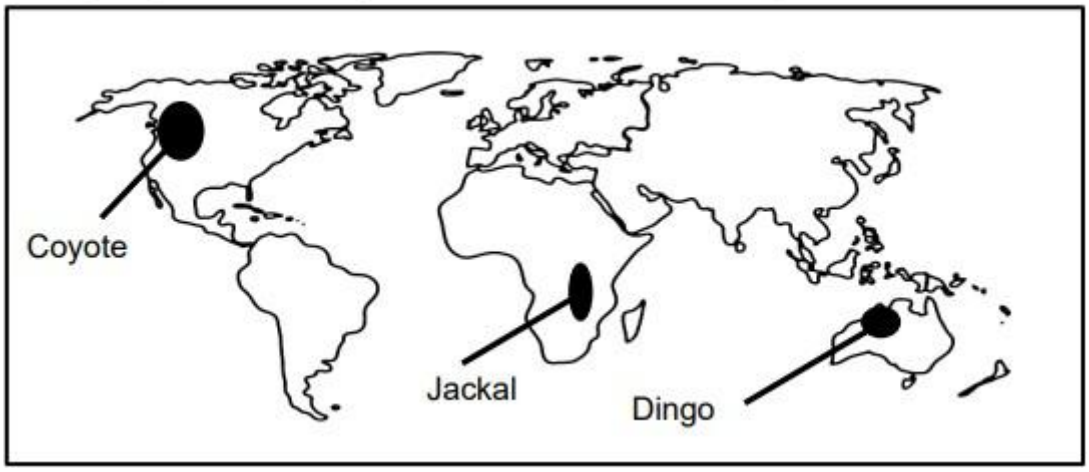
Applying the answer



- **<u>If a population of a single species/original population</u>**
- *Mention the original species in the extract that they give you and refer to where the species lived)*
- ***<u>If the original population of the common ancestor/small mammals of the pottos and lemurs that existed in AFRICA</u>***
- **becomes separated by a geographical barrier**
- *(Mention the specific barriers sea, river, mountain, lake)*
- **<u>becomes separated by a geographical barrier the Indian Ocean</u>**
- **then the population splits into**
- *(Mention in how many population does the original species /original population splits into according to the extract)*
- **<u>then the population splits into 2 - Africa and Madagascar</u>**
- **There is now no gene flow between the**
- *(Mention how many populations are there now)*
- **<u>There is now gene flow between the two populations in Africa and Madagascar</u>**
- **<u>Since each population may be exposed to different environmental conditions/the selection pressure may be different</u>**
- *(Mention the selection pressure if there is one mention in the example)*
- **<u>Each population may be exposed to different environmental conditions on the east coast of Africa and Madagascar</u>**
- **<u>natural selection occurs independently in each of the two/three etc. populations</u>**
- **<u>natural selection occurs independently in each of the islands</u>**
- **<u>such that the individuals of the two populations become very different from each other</u>**
- **<u>genotypically and phenotypically</u>.**
- **<u>Even if the two populations of Africa and Madagascar were to mix again</u>**
- **<u>they will not be able to interbreed</u>.**
- **<u>The two populations are now different species, Pottos and Lemurs</u>**

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 17

17.1 Read the following extract and then answer the questions that follow

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

Kaibab squirrel **Abert's squirrel**

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

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

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

17.1.1 Define a population. (2)

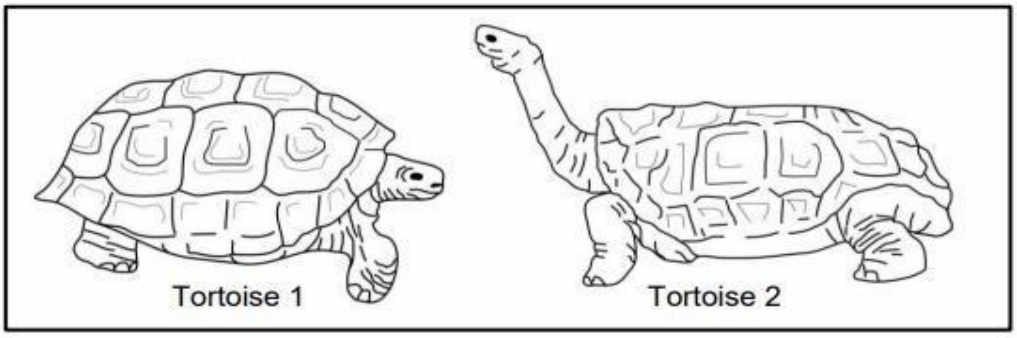
17.1.2 Describe how speciation of the **GRAND CANYON** squirrels took place. (5)

(7)

ACTIVITY 18

18.1 Read the following passage and then answer the questions that follow

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



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

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

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

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

(18)

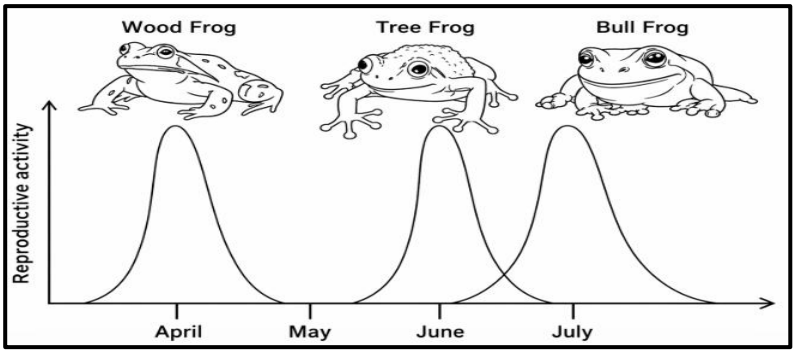
Reproductive isolation mechanisms

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

Reproductive isolation mechanisms that help to keep <u>TWO</u> <u>DIFFERENT</u> species separate:

(a) Breeding at different times of the year

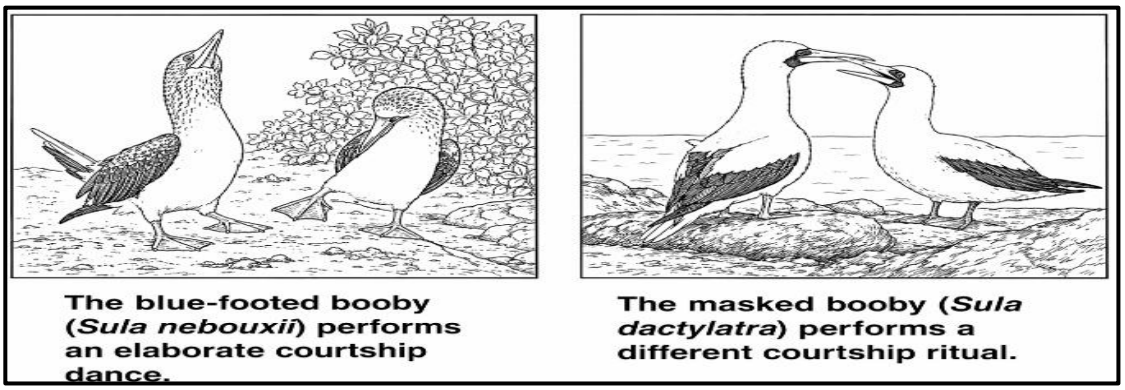
Different species will have different breeding seasons or, in the case of plants, will flower at different times of the year, in order to prevent cross-pollination.



(b) 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.

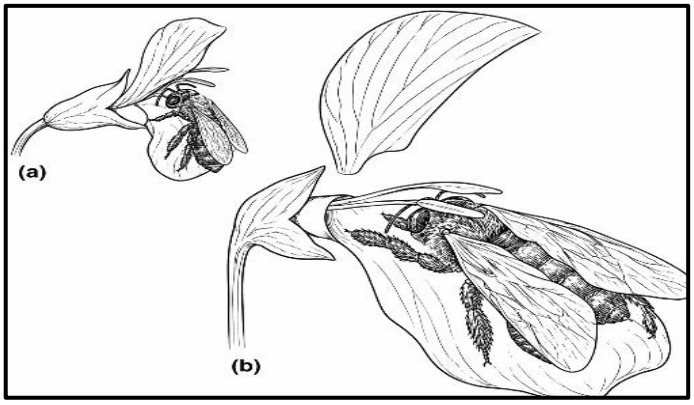


The blue-footed booby (*Sula nebouxii*) performs an elaborate courtship dance.

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

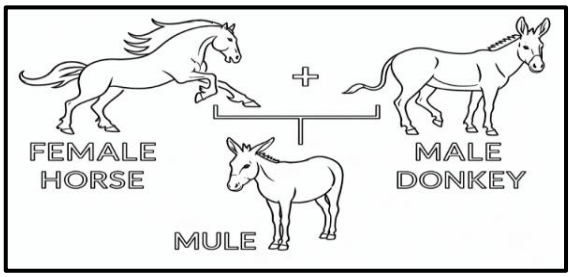
(c) Plant adaptation to different pollinators

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.



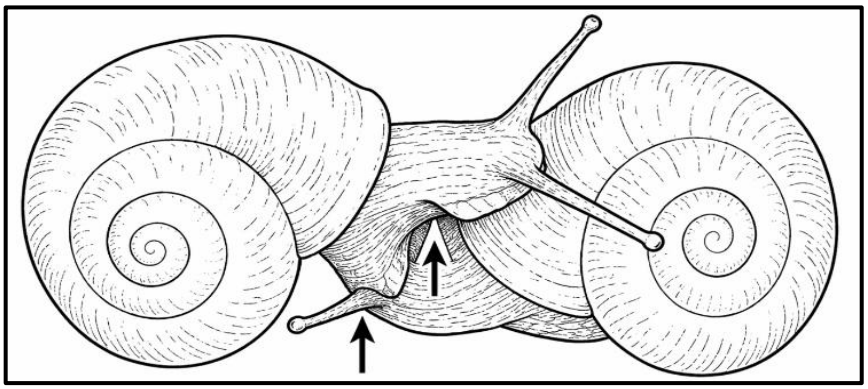
(d) Infertile offspring

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.



(e) Prevention of fertilisation

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



(The genital opening of these snails are not aligned, and mating cannot be completed)

ACTIVITY 19 (Gauteng Province Prep Exam 2025

19.1

> Frogs produce different sounds to attract females of the same species to the breeding site. The calls signal the start of a breeding season. *H. ornate* breeds in summer, and the males make strong chorus sounds. However, *P. adspersus* breeds in spring, and the males make deep, low-pitched whoops.

19.1.1 List THREE requirements that organisms must satisfy before they can be called a species. (3)

19.1.2 Use the text above to identify and describe TWO reproductive isolation mechanisms between these frog species. (4)

19.1.3 Frogs become reproductively isolated because they are different species. This may have happened due to geographic isolation.
Describe speciation through geographic isolation. (10)

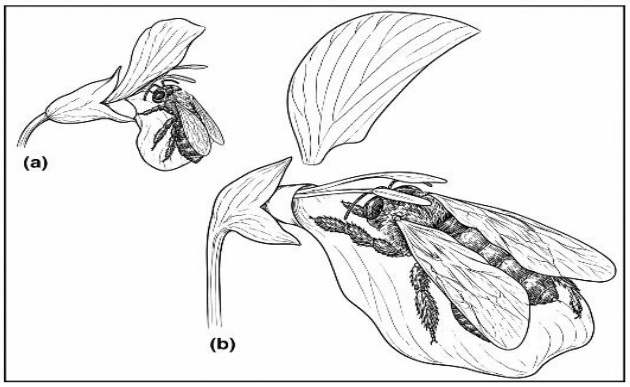
(17)

ACTIVITY 20

20.1.1 What is meant by the term reproductive isolation? (1)

20.1.2 Describe species - specific courtship behaviour. (2)

20.1.3 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.

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

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

20.1.6 Explain the development of infertile offspring between two species. (3)

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

(14)

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

Evolution in present times

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 fittest.*

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.*

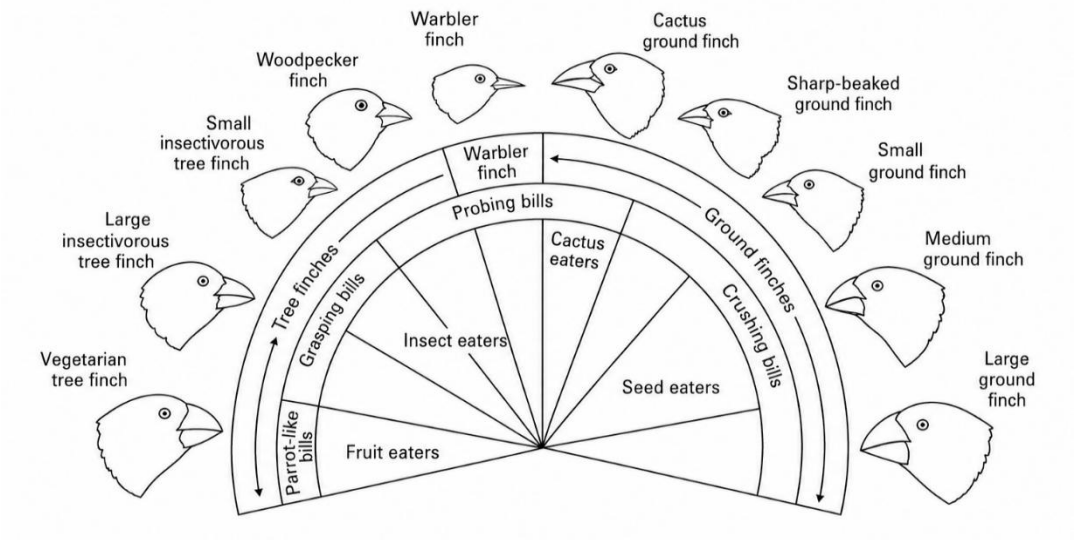
Example 3: HIV resistance to anti-retroviral medication

- 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.



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ACTIVITY 21 (Gauteng Province Pre Exam 2025)

21.1 Tuberculosis (TB) is a bacterial infection caused by the bacterium Mycobacterium tuberculosis. TB can be life-threatening. Resistant strains of Mycobacterium tuberculosis have evolved because some patients do not complete their antibiotic treatment. Isoniazid is one of the antibiotics used as a first-line treatment for TB and to prevent TB from becoming active.

A survey conducted by the National Institute of Communicable Diseases from 2013 - 2014 compared the percentage of patients in whom TB has developed resistance to Isoniazid antibiotics with that of a 2001 - 2002 survey.

The 2013 - 2014 survey was conducted as follows:

- 349 patients with TB receiving treatment with Isoniazid were selected. They were from different South African hospitals or clinics in all nine provinces.
- All the patients were over 18 years of age.
- All the patients' medical records were reviewed.

The table below shows the percentage of patients in which TB has developed resistant to Isoniazid antibiotic in each of the 9 provinces for both surveys.

Province	The percentage of patients in whom TB has developed resistance to Isoniazid antibiotic over the years	
	2001 – 2002	2013 – 2014
Eastern Cape	3,5	5,0
Free State	3,7	5,6
Gauteng	1,3	4,7
KwaZulu-Natal	3,4	4,3
Limpopo	2,9	4,2
Mpumalanga	2,7	6,3
North West	1,4	5,0
Northern Cape	4,2	7,0
Western Cape	2,4	6,1

[Source: *https://www.nicd.ac.za/assets/files/K-12750%20NICD%20National%20Survey%20Report_Dev_V11-LR.pdf*]

21.1.1 Name the theory that Charles Darwin proposed to explain how Mycobacterium tuberculosis evolved to become antibiotic-resistant. (1)

21.1.2 Identify the dependent variable. (1)

21.1.3 Which province had the highest percentage of TB patients with resistance to Isoniazid in the 2013 - 2014 survey? (1)

21.1.4 State ONE way in which the reliability of this survey was ensured. (1)

21.1.5 Give TWO factors that were kept constant during this investigation. (2)

21.1.6 Calculate the average percentage of patients who had drug resistance to Isoniazid in South Africa during the 2013 - 2014 survey. (3)

Show ALL calculations. Round-off your answer to two decimal places.

21.1.7 Use the information in the table to formulate a conclusion for this survey. (2)

Draw a bar graph representing the 2013 - 2014 survey results for the Eastern Cape, Free State, North West and Northern Cape only. (6)

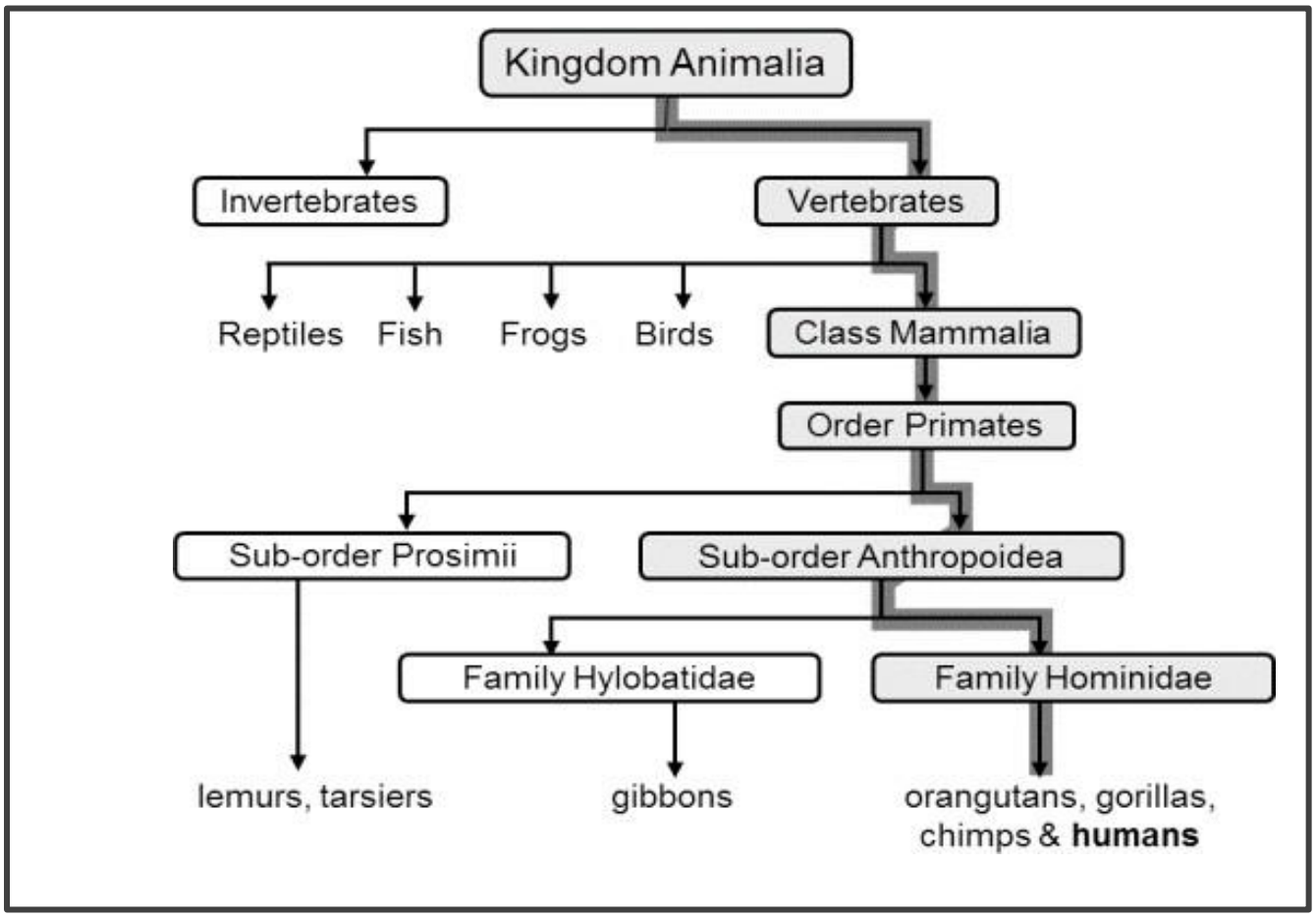
(17)

Evidence of common ancestors

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

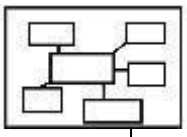
Interpretation of a phylogenetic tree to show the place of the family Hominidae in the animal kingdom

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.

- The Family **HOMINIDAE** includes **HOMINIDS**



Great Apes

Orangutan

Gorilla

Chimpanzee

HOMININS

(refers to bipedalism)

(bipedal)

Ardipithecus

Australopithecus

Homo

HOMINIDS

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

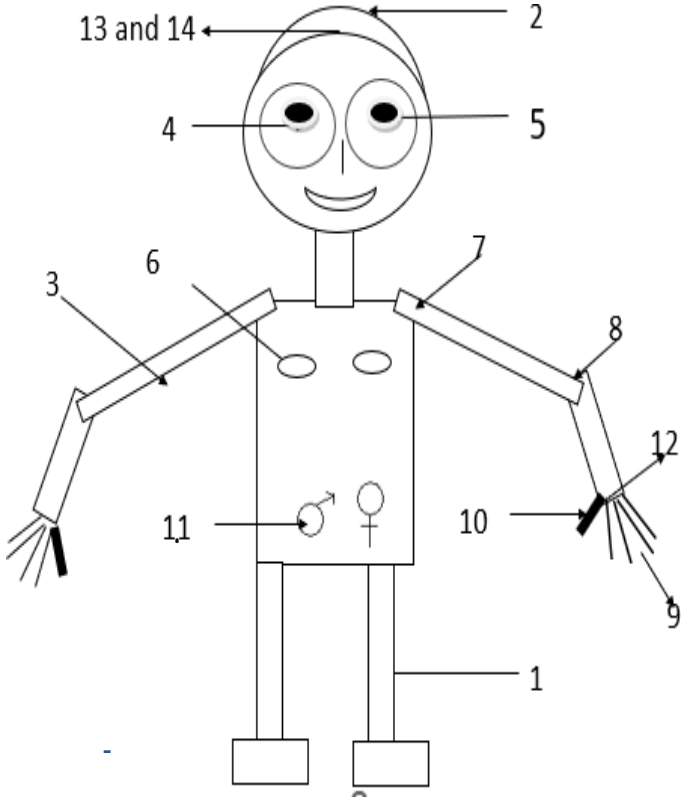
Genus – *Homo*

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"

Characteristics we share with other primates.



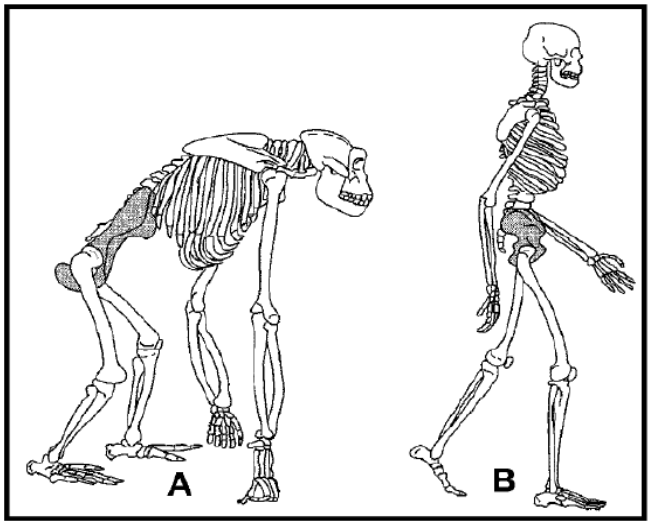
-
- Large brain/skull compared to their body mass
- Olfactory brain centres reduced/ reduced sense so smell
- Parts of the brain that process information from the hands and eyes are enlarged.
- Eyes in front/binocular vision/stereoscopic vision
- Eyes with cones/colour vision
- Freely rotating arms
- Elbow joints allow rotation of the forearm
- Flat nails instead of claws/bare fingertips
- Opposable thumbs which work in opposite direction to their fingers.
- Upright posture

Tabulate anatomical differences between African ape and humans as it applies to the following characteristics:

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*

ACTIVITY 22

22.1 Skeletons of an African ape and a human



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

22.1.2 Give FOUR similarities they share regarding their **upper limbs**. (4)

22.1.3 Which organism:

a) Belongs to the hominin group (1)

b) Is quadrupedal (1)

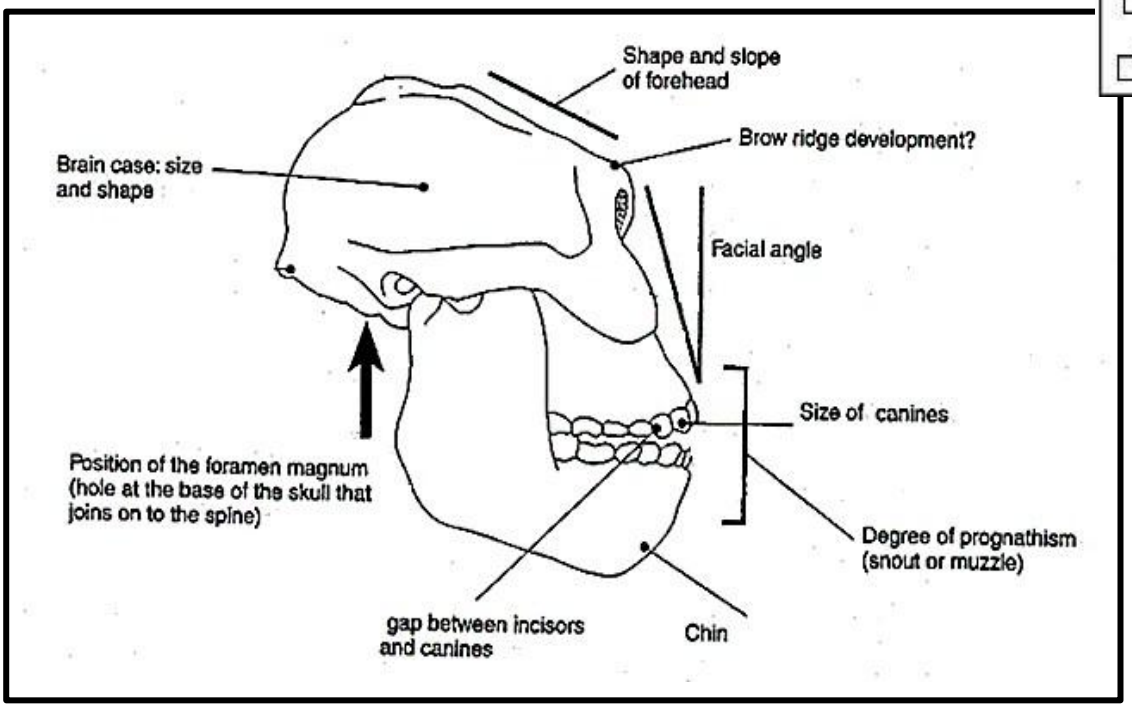
c) Belongs to Mammalia (1)

22.1.4 Give TWO functions of the opposable thumbs of organism **A** and **B**? (2)

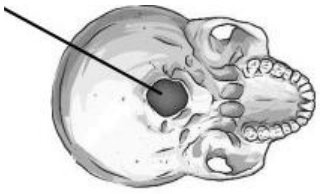
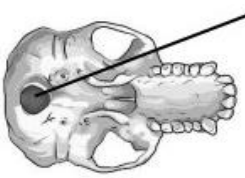
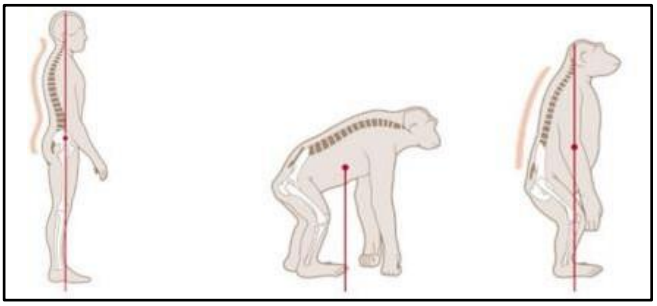
22.1.5 Give TWO similarities in the brain of hominids. (2)

(13)

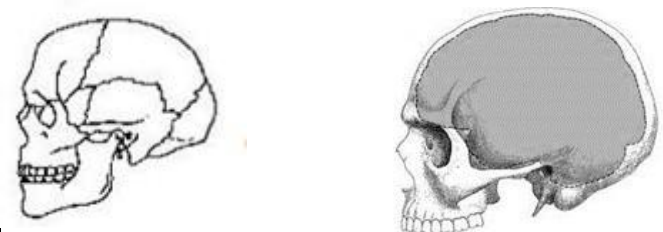
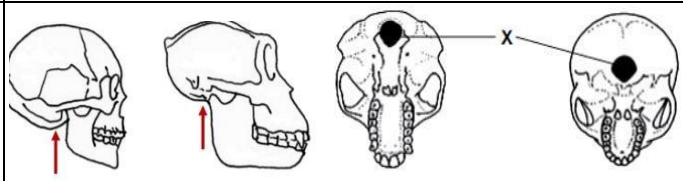
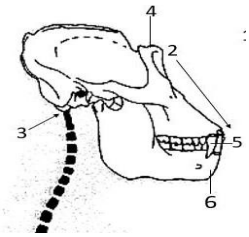
Anatomical differences between Africa apes and humans (also emphasis the significance



Differences between Homo sapiens and other primates

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	3.Foramen magnum in a **more** backwards position
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

(You must be able to identify the visible features)

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	

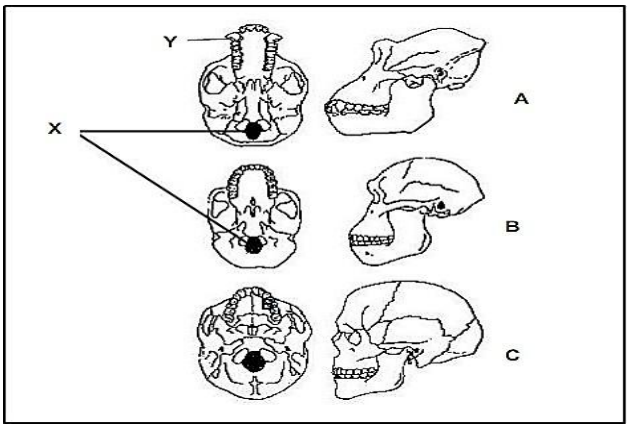
The significance of the structural changes that characterize the evolution of modern humans

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
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-increased intelligence • Processing information faster • Development of spoken and written languages to communicate

Structure	Significance
Jaws Humans have jaws that are non-prognathous compared to the jaws of ape-like beings which are prognathous. A prognathous jaw is large, protruding, with large teeth	• This corresponds with a change in diet from hard, raw food in the ape-like beings • To softer, cooked food in humans • Prognathous jaw serves as attachment for stronger muscles to assist in grinding hard food
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 ape-like beings	• This corresponds with the decreased need for attachment of strong muscles • due to the decreased jaw size in humans
Pelvis Humans have a (Wide and short) pelvis, apes have a (Long and Narrow pelvis)	• Support greater weight due to the upright position
Spine Humans' spine is more S- shape and ape-like beings is less C- Shape	• For flexibility • Shock absorption

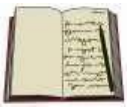
ACTIVITY 23

23.1 Fossilized skulls of three different species of primates.

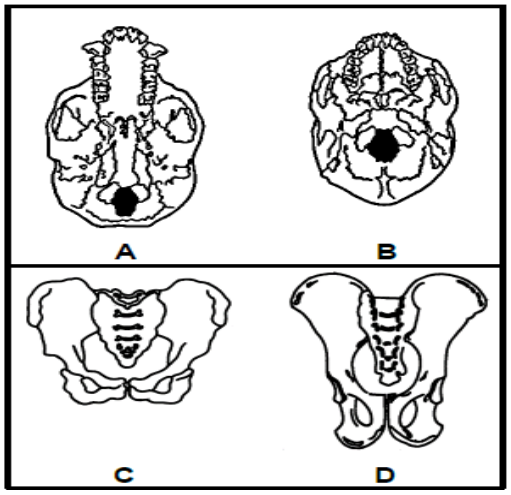


23.1.1 Give the label for **X** and **Y**. (1)
23.1.2 Which skull belongs to:
a) Hominidae
b) Hominin
c) Bipedal (3)
23.1.3 Explain how the change in the skull from **B** to **C** could indicate change in intelligence. (4)
23.1.4 Tabulate FIVE visible differences between the skulls of **A** and **C** (6)
(14)

ACTIVITY 24 (*DBE/May/June 2025)*

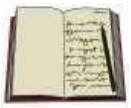


24.1 The diagrams below represent the skulls and pelvises of a human and a chimpanzee in NO particular order. (The diagrams are drawn to scale.)

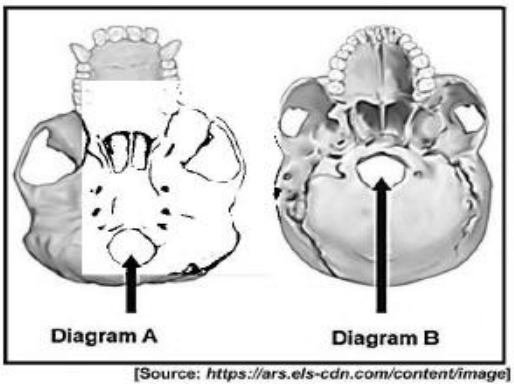


24.1.1 Tabulate THREE observable differences between skull **A** and skull **B**. (7)
24.1.2 State why pelvis **C** belongs to a human (2)
(9)

ACTIVITY 25 (Gauteng Prep Exam 2025)



25.1 Diagrams A and B show the skulls of two hominids.



[Source: *https://ars.els-cdn.com/content/image*]

25.1.1 Which diagram (A or B) shows ... (1)
(a) a larger cranium? (1)
(b) a skull of a chimpanzee?
25.1.2 Name the opening to which the arrows are pointing. (1)
25.1.3 State the shape of the jaw in diagram A. (1)
25.1.4 Give the letter of the diagram (A or B) representing a bipedal hominid. (1)
25.1.5 Which skull in the diagram (A or B) is better adapted to eating raw, uncooked food? (1)
25.1.6 Give the scientific name of the modern human. (1)
(7)

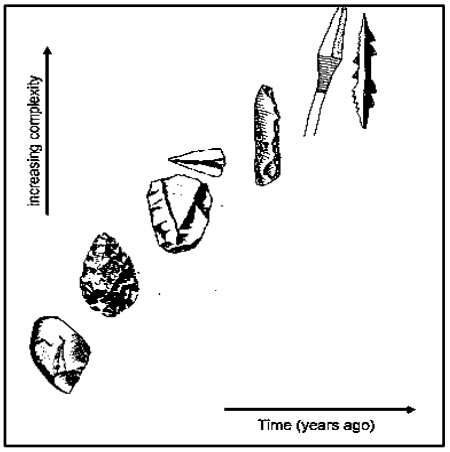
Lines of evidence that support the idea of common ancestors for living hominids including humans:

Genetic evidence: Mitochondrial DNA

- DNA evidence shows that all humans are genetically very closely related.
- Evidence for this comes from gene sequencing and in particular studies of mitochondrial DNA.
- DNA shows that all humans age genetically very closely related
- Through analysis of mitochondrial DNA, all humans have been linked to a common ancestor termed “African” or “Mitochondrial Eve”.
- A mutation in the mitochondrial DNA of a female hominid that lived about 150 000 years ago in Africa is present in all humans
- Scientists state that organisms are closely related and are likely to have a common recent ancestor if they have:
  1. Identical DNA structure
  2. Similar sequence of genes
  3. Similar portions of DNA with no functions
  4. Similar mutations on mitochondrial DNA

Cultural evidence: Tool-making

- Cultural evidence from studies of tools and weapons, as well a language is also used to show similarities and differences between humans and other primates.
- Early hominids used stones that were found on the ground and the branches of trees as weapons and tools.
- The first made tools were made by Homo habilis about 2 million years ago
- Such weapons and tools were used for fishing, farming, hunting and for tearing up food for eating.



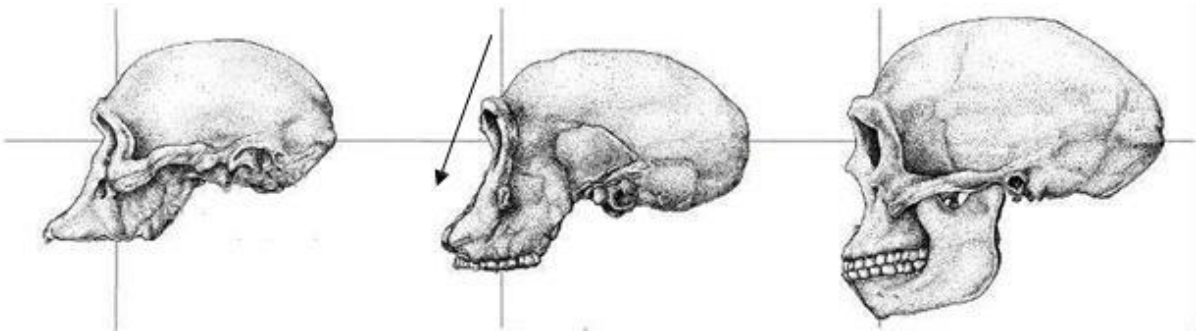
Fossil evidence:

Changes in structure that characterize human evolution (you are expected to list the differences and the significance that these differences are bringing along)

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 / timeline for the existence of the three genera.
  - The fossil sites where they were found, emphasis on the fossil sites that form a part of the Cradle of Humankind

- The scientists who discovered them



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

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 Burger	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 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

Out of Africa Theory

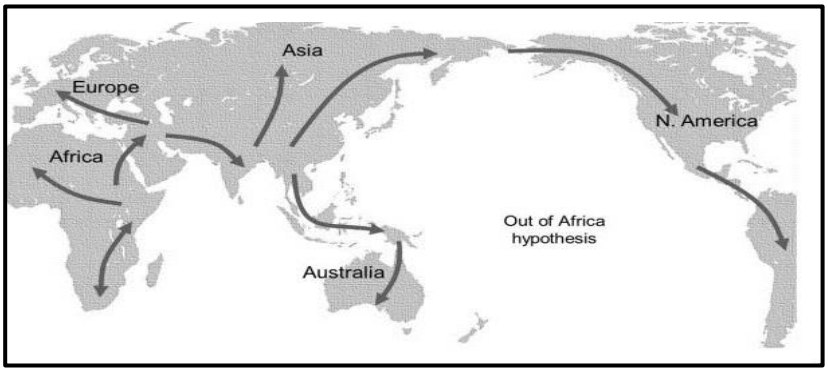
CONTENT	ELABORATION
Out-of-Africa hypothesis	The Out-of-Africa hypothesis: Modern humans originated in Africa and then migrated to other continents Evidence for the 'Out-of-Africa' hypothesis: • Genetic evidence: mitochondrial DNA • Fossil evidence: information on each of the following fossils that serve 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.*

The out of Africa Hypothesis

- 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:

(a) Genetics: Mitochondrial DNA:

Apart from DNA in the nucleus, DNA also occurs in the mitochondria - as mitochondrial DNA

- mtDNA of the sperm cell does not fuse with mtDNA of the egg cell
- mtDNA is therefore handed down from **mother to child**
- By following mutations in mtDNA, we can trace our female line of descent.
- Analysis of mitochondrial DNA leads to ancestral female who lived in East Africa about 150 000 years ago.

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

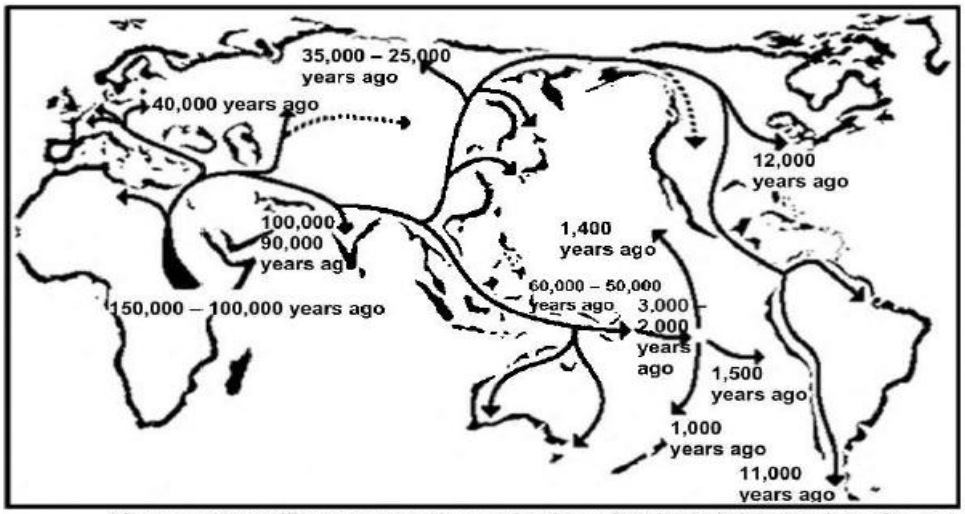
(b) Fossil records:

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

- Ardipithecus (fossils found in Africa only)
- Australopithecus (fossils found in Africa only, including Karabo, Little foot,
- Taung Child, Mrs Ples)
- Homo (fossils of Homo habilis found in Africa only; oldest fossils of Homo erectus and Homo sapiens found in Africa, while the younger fossils were found in other parts of the world)

ACTIVITY 26 (Gauteng Preparatory Exam 2025)

26.1 The map below represents a hypothesis used in evolution to describe the origin of modern humans based on the ages of fossils discovered worldwide.



[Source: *https://factsanddetails.com/archives/003/201810/5bd26afc8eef2.png*]

26.1.1 Identify the hypothesis represented by the map above. (1)

2.6.1.2 Describe how genetic evidence can support the hypothesis identified in QUESTION 26.1.1 (2)

26.1.3 Name ONE type of evidence used to support the hypothesis identified in QUESTION 26.1.2 other than genetic evidence. (1)

(4)

ACTIVITY 27

27.1 The extract below is about human evolution

In 2004 scientists in Indonesia discovered the first fossil of the species *Homo floresiensis* along with stone tools and animal remains. The fossil was made up of a nearly complete skull and skeleton, including hand and foot bones and a pelvis.

Dating of the tools suggests that *H. floresiensis* may have lived from as early as 95 000 years ago until about 12 000 years ago.

Researchers closely analysed three wrist bones and found that they more closely resembled those of apes than modern humans. This finding implied that *H. floresiensis* was indeed a separate species from modern humans.

They had skulls that resembled early *Homo* species. This included a flat forehead and a short, flat face; however, their teeth and jaws more closely resembled *Australopithecus*.

The scans of the skull suggested that the brain volume of *H. floresiensis* was about 426 cm^3; around one-third the size of the modern human brain which has an average volume of about 1 300 cm^3. The findings suggested that *H. erectus* may be the ancestor of *H. floresiensis*, as *H. erectus* had brains about 860 cm^3 in size or, alternatively, it may have evolved from *H. habilis*, whose brains were about 600 cm^3 in size.

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

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

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

27.1.4 Describe ONE feature of the skull that can be used as evidence for bipedalism. (2)

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

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

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

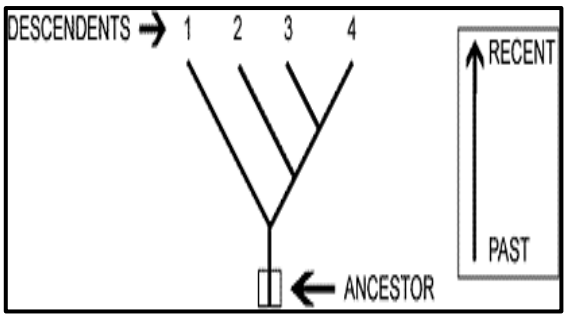
Interpretation of a Phylogenetic tree to show the place of humans in the Animal Kingdom

- 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:

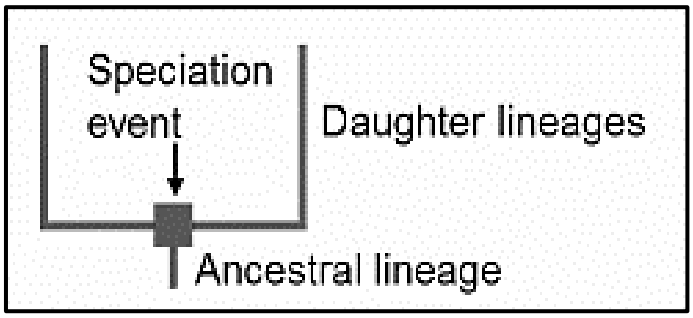
- The root of the phylogenetic diagram represents the ancestor, and the tips of the branches, the descendants of that ancestor. To move upwards is to move forward in time

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

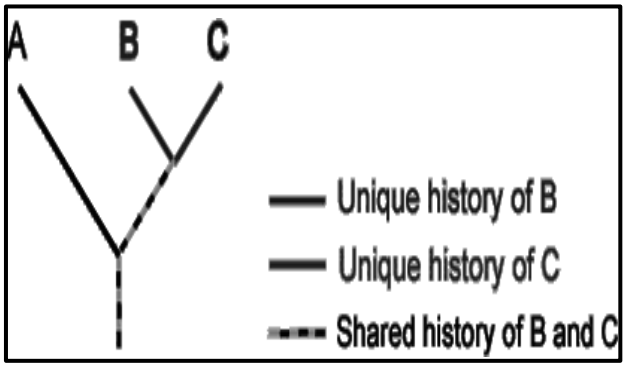


p

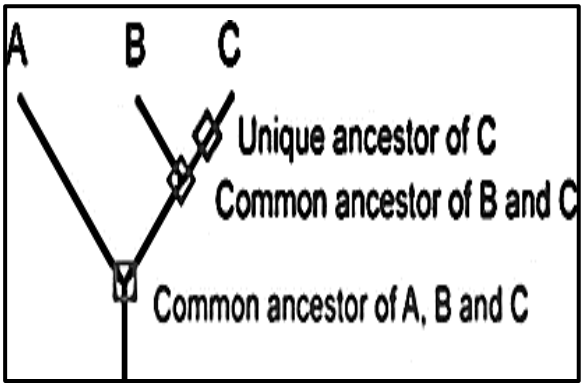
- Speciation is represented as a branching of the tree, as a single ancestral lineage gives rise to two or more daughter lines.



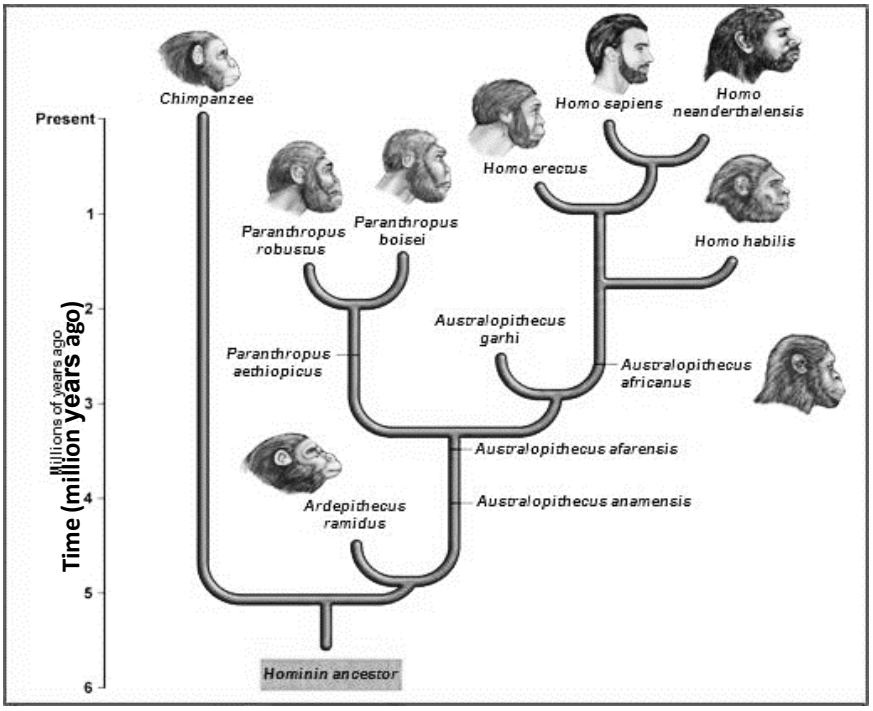
- Each lineage has a part of its history that is unique and parts that are shared with other lineages, as illustrated below …



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

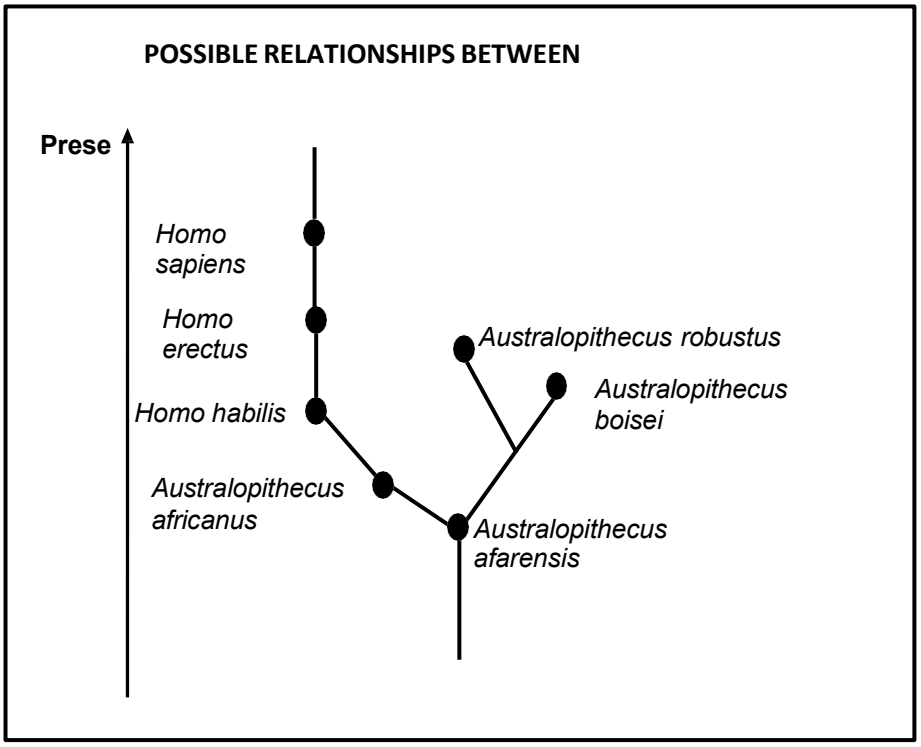


- Evidence from fossils of different ages show that the anatomical characteristics of organisms changed gradually over time.



ACTIVITY 28

28.1 The diagram below shows possible relationships between members of Hominids.



28.1.1 What is the name given to this diagram? (1)

28.1.2 How many of each of the following are represented in the diagram? (2)

a) Genera

b) Species

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

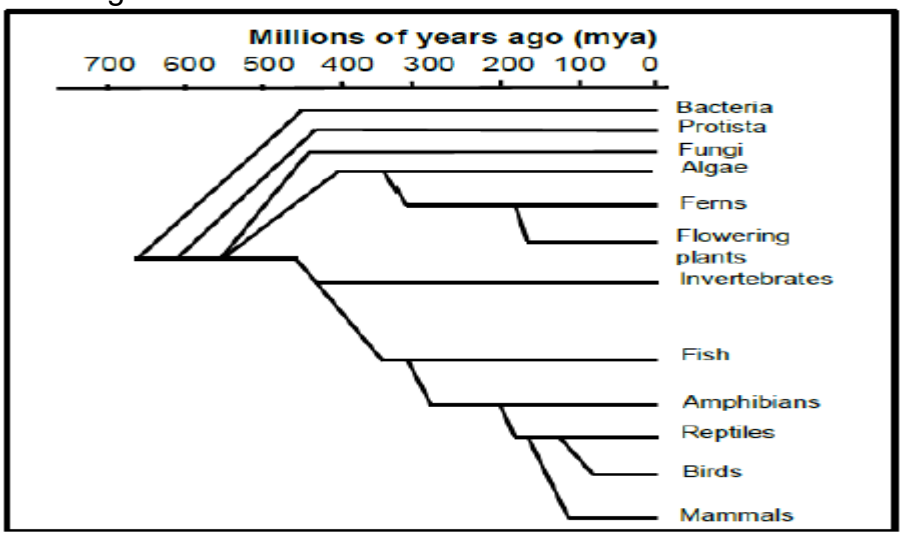
28.1.4 Which hominid is the common ancestor of all the hominids in this diagram? (1)

28.1.5 Give the:

a) Family to which all humans belong to (1)
b) Genera to which all humans belong to (1)
c) Name of the ancestor of *Homo sapiens* (1)

ACTIVITY 29

Study the diagram below.

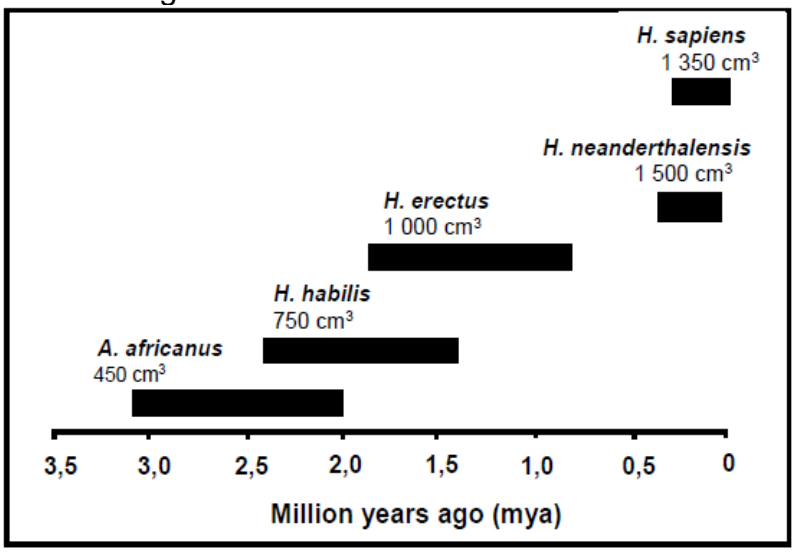


29.1 According to the diagram:

29.1.1 How many million years ago did fungi appear on Earth? (1)
29.1.2 Which were the first organisms to appear on Earth? (1)
29.1.3 Which group is the most recent ancestor to flowering plants? (1)
29.1.4 Which group appeared on Earth most recently? (1)
29.1.5 Which group of organisms is most closely related to the birds? (1)
29.1.6 Give a reason for your answer in QUESTION 29.1.5 (1)
(6)

ACTIVITY 30 (*DBE/May/June 2025)*

30.1 The diagram below shows the evolutionary relationships between different hominids. Their average brain volume is also indicated.



30.1.1 How many genera are shown in the diagram? (1)
30.1.2 When did *A. africanus* become extinct? (1)
30.1.3 Name TWO *A. africanus* fossils found in South Africa. (2)

30.1.4 Using only the species in the diagram, describe the fossil evidence that supports the 'Out-of-Africa' hypothesis. (4)

30.1.5 Explain the influence of brain volume on the complexity of tools made by *H. habilis* and *H. sapiens*. (3)

(11)

ADDITIONAL NOTES SCIENTIFIC INVESTIGATION SKILLS

How to identify variables

Look for a AIM given at the beginning of the investigation

TWO clear "FACTORS" OR "VARIABLES" will stand out

These TWO factors are the **independent and dependent** variables:

- **Independent variable:** The factor/variable that the investigator choose to change or manipulate and that normally influences the other factor/variable
- **Dependent variable:** The factor/variable that is influenced by the independent variable and the one where the investigator measured or observed any change or influence
- **Control/fixed variable(s):** Sometimes mentioned as part of the method OR planning steps. These factors/variables MUST be controlled OR kept constant in order for the investigator to manipulate the independent variable

How to write a hypothesis.

A hypothesis is a **testable statement about a relationship involving two variables**. When a hypothesis is formulated the following is a guideline that should be used:

What is reliability?

The idea behind reliability is that any significant **results of an investigation** must be more than a once-off finding and be **repeatable**. Other researchers must be able to perform exactly the same experiment, under the same conditions and generate the same results. This will reinforce the findings of the experiment and ensure that the wider scientific community accepts the hypothesis. In questions which ask learners to state how the reliability of the investigation could have been improved, the correct answers could generally be the following:

- Repeat the experiment/investigation (use the information given in the question e.g. "Repeat the experiment by recording the temperature 5 times at each site and then calculate the average temperature")
- Increase the sample size e.g. "Measure the pupil diameter of 100 women"
- Take more reading
- Do random sampling

What is validity?

Validity questions **how** the experiment/investigation was carried out. Have all the factors/variables been controlled/fixed except the variable/factor being tested? Have the samples been chosen randomly? Is the design for the investigation appropriate? **Validity therefore speaks to whether the scientific research method was done with the appropriate care and diligence**. In questions which ask learners to suggest some factors that might have decreased the validity of an investigation, the answers should centre on criticism of the scientific process, for example some factors/variables that were not fixed/controlled when carrying out the investigation.

Planning a scientific investigation involves the following:

- **Ethical issues** around the investigation, e.g. by getting permission from the appropriate authorities before the investigation is conducted
- Making all the **logistical arrangements**, e.g. by identifying and getting all the materials to be used in the investigation
- Deciding on the **method/procedure** that is going to be used or followed e.g. how to catch the fish for the investigation
- Dealing with how the **data** will be collected, recorded, analysed and presented.

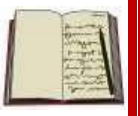
NB: Use hints from the given scenario/investigation to determine PLANNING STEPS applicable to the particular investigation

How to draw a conclusion

The conclusion should:

- Answer the scientific question asked at the start of the investigation
- State the effect that the independent variable had on the dependent variable
- Indicate if the hypothesis can be accepted or be rejected

INVESTIGATIONS



INVESTIGATIONS 1

Study the extract and the Information below.

> A species of the clover plant *(Trifolium repens)* developed a mutation that
> caused the poison, cyanide, to form in the plant's cells. This gives the clover a bitter taste to herbivores that feed on them. However, in a colder climate, some cells burst, releasing the cyanide into the plants' tissues, thereby killing the plants

Scientists observed that there were more clover plants of this species in warmer areas than in colder areas. They formulated a hypothesis that more clover plants survive at higher temperatures,

They conducted the Investigation on the survival of dover plants at different temperatures as follows:

- They placed 200 clover plants in a greenhouse with the temperature controlled at 5 "C and 200 clover plants in a greenhouse with the temperature controlled at 25 "C.
- They controlled all other variables.
- They allowed a period of time for the plants to grow and counted the number of clover plants that survived in each greenhouse.
- Then they calculated the percentage survival of clover plants.

The results of the investigation are shown in the table below:

TEMPERATURE	PERCENTAGE SURVIVAL OF CLOVER PLANTS
5°C	13
25°C	72

1.1 State the: (1)
(a) Independent variable (1)
(b) Dependent variable

1.2 State TWO ways in which the scientists could have improved the reliability of the investigation. (2)

1.3 Describe how the scientists calculated the percentage survival of clover. (2)

1.4 Explain if the hypothesis will be accepted or rejected. (3)

1.5 Based on information in the passage, apart from temperature, explain ONE other way in which the survival rate of clover plants is increased. (2)

1.6 Refer to Darwin's theory of natural selection and explain how the mutation affected the survival of the clover plants at lower temperatures. (6)

(17)

INVESTIGATIONS 2

A species of mice have different fur colours in different habitats. Scientists observed that there were more mice with a lighter fur colour in a beach habitat where the sand was lighter in colour. Also there were more mice with a darker fur colour in the mainland habitat where the sand was darker in colour.
Owls attack and prey on the mice.

Scientists wanted to investigate how the colour of the fur affects the chances of the mice being attacked. They conducted a simulation where they used models to represent the mice.

While conducting the Investigation they:

- Made day models of the mice
- Painted 200 clay models to resemble the lighter fur colour and 200 models to resemble the darker fur colour
- Placed an equal number of mice of each colour randomly in the beach habitat and in the mainland habitat
- Allowed enough time for predators to attack the mice models
- Collected al the models and recorded the number that were damaged after being attacked

The results of the investigation are shown in the diagram below.

HABITAT	FUR COLOUR	NUMBER OF MODELS ATTACKED
Mainland	Lighter	80
	Darker	20
Beach	Lighter	26
	Darker	78

2.1 State TWO independent variables. (2)

2.2 How many mice with a lighter fur colour were placed in the beach habitat? (1)

2.3 State TWO ways in which the scientists ensured the reliability of the results (2)

2.4 Give a conclusion for the investigation conducted in the mainland habitat. (2)

2.5 Explain the results obtained for the beach habitat. (4)

2.6 Explain why the simulation may not be an accurate representation of the survival of the mice. (2)

(13)

BIBLIOGRAPHY

We would like to express our profound gratitude to the following bodies for their contributions to the compilation of this Content Manual for Winter Classes:

- National Senior Certificate, 2022 – 23 National Diagnostic Report.
- Gauteng Department of Education-Secondary School Improvement Programme (SSIP) 2015.
- KwaZulu-Natal Department of Education - 2023 LFSC Composite Revision Document – Final.
- GMMDC – Life Sciences Grade 12 – Teacher's Guide.
- Department of Basic Education - Life Sciences GR 12 Exam Guidelines 2021 Eng
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- Cape Winelands Survival Kit - PAPER 2