

LIFE SCIENCES

WINTER CLASSES

GRADE 12

TERM 2

TEACHER AND LEARNER CONTENT MANUAL





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WINTER SCHOOL PACESETTER PROGRAMME 2025



DURATION: 20 Hrs

TOPIC: EVOLUTION

MOTIVATION ON selected topic

- Evolution topic – Weighting in paper 2 is 54 marks out of 150 (36%)
- Easy to score marks in topic if well taught
- Topic taught in term 3 coinciding with SBA moderation and preparation for trial examinations (Contact time in term 3 minimised)
- Learners struggle with questions of high cognitive level from this topic
- Teaching this topic during the winter school translates to all paper two topics being completed-sufficient time for learners to be exposed to past papers as revision

RESOURCES: JENN GENETICS CONTENT MANUAL
2021 EXAMINATION GUIDELINES
PAST NSC EXAMINATION PAPERS
DBE VIRTUAL WORKSHOP VIDEO
CHIEF MARKERS & DIAGNOSTIC REPORT



DAY	TEACHER ACTIVITY	LEARNER ACTIVITY	TIME
1	Invigilator	Pre-test	50 min
	Define biological evolution State the difference between a hypothesis and a theory. Use an example to show the difference Explain the evidence to support evolution- <ul style="list-style-type: none">• Fossil record• Biogeography• Modification by descent-homologous structures• Genetic evidence	Class work (10 min) Activity 1.1 Homework Activity 1.2 & 1.3	1 hr. 10 min



2	Feedback on Homework	Mark homework	10 min
	<ul style="list-style-type: none"> Define a species and a population Brief mention of factors that cause genetic variation Difference between continuous and discontinuous variation (35 min) 	Classwork (15 min) Activity 2: 2.1- 2.4	50 min
	<ul style="list-style-type: none"> History of evolutionary theory – focus on Lamarck and Darwin Lamarck's theory- Law of use and disuse, inheritance of acquired characteristics and its rejection 	Homework Activity 3 :3.1.1	1hr
3	Feedback on Homework	Mark homework	10 min
	<ul style="list-style-type: none"> Darwin's Theory of natural selection Darwin's observation (40 min) Feedback on classwork (10 min)	Classwork (10 min) Activity 4: 4.1.1-4.1.2	1 hour
	Tabulated differences between Lamarck's and Darwin's Theory (20min) Feedback on classwork (15min)	Homework – Activity 5: 5.1-5.3	



4	Feedback on Homework	Mark homework	10 min
	<ul style="list-style-type: none"> - Punctuated Equilibrium theory (Brief History and definition of Punctuated equilibrium) - Comparison of punctuated equilibrium and gradualism (natural selection) - Artificial Selection Feedback on classwork 10 min	Classwork (10 min) Activity 6: 6.1-6.3	1 hour, 30 min
	Tabulated differences and similarities between Natural Selection and Artificial Selection)		
5	Feedback on Homework	Recap on Larmackism, Darwinism and Punctuated Equilibrium	10 min
	Explain differences between the concept species, speciation and Population Process of geographic speciation- Use Galapagos finches and example 1 & 2 on Content Manual	Classwork (10 min) Activity 7: 7.1.1-7.1.2 Homework Activity 8: 8.1.1 -8.1.4	1 hour, 30 min
	(Examination guidelines pg. 17) Define and explain reproductive isolating mechanisms (four mechanisms)	Classwork Activity 9 Homework Activity 10: 10.1 -10.2	



DAY	TEACHER ACTIVITY	LEARNER ACTIVITY	TIME
6	Feedback on Homework	Mark homework	10 min
	Evolution in present times (Evolution of Drug resistance in bacteria)	Classwork (15 min) Activity 11: 11.1.1-11.1.5	30 min
	Human Evolution looking at our place in animal kingdom (Schematic diagram) Human evolution from, Ardipithecus, <i>Australopithecus</i> species (Phylogenetic tree)	Classwork Activity 12: 12.1.1 - 12.1.5	1hr, 20min
7	Feedback on Homework	Recap Phylogenetic Trees	10 min
	Similarities between Humans and other primates; Use teaching tool 9	Classwork (10 min) Activity 13: 13.1.1-13.1.6	50 min
	Tabulated Differences between Humans and other Primates. Focus on skull, pelvis and spine-link structure to function	Classwork Activity 14: 14.1.1 – 14.1.4	1hr

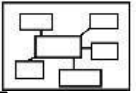


DAY	TEACHER ACTIVITY	LEARNER ACTIVITY	TIME
8	Recap		10 min
	Out of Africa Hypothesis definition. Fossil Evidence for the OUT of Africa Hypothesis (Use table on fossil discovered, responsible person, species characteristics)	Classwork (15 min) Activity 15: 15.1.1 – 15.1.7 Homework Activity 15: 15.2.1 – 15.2.7	50 min
	Analysis of Mitochondrial DNA as Evidence for the Out of Africa Hypothesis	Classwork Activity 16: 16.1.1 - 16.1.3 Homework Activity 16: 16.2.1 -16.2.3	50 min
9	Feedback on Homework	Mark homework	10 min
	Post Test - Invigilator	Write Post test	50 min
	SCIENTIFIC INVESTIGATION/hypothesis, investigative question, description of method to collect data, identifying dependent and independent variables, controlled variables- validity, reliability	Classwork Activity 17: 17.1.1 - 12.1.5	1hr,
10	Recap		10 min
	Activities on Scientific Investigation based on Evolution from past exam papers		50 min

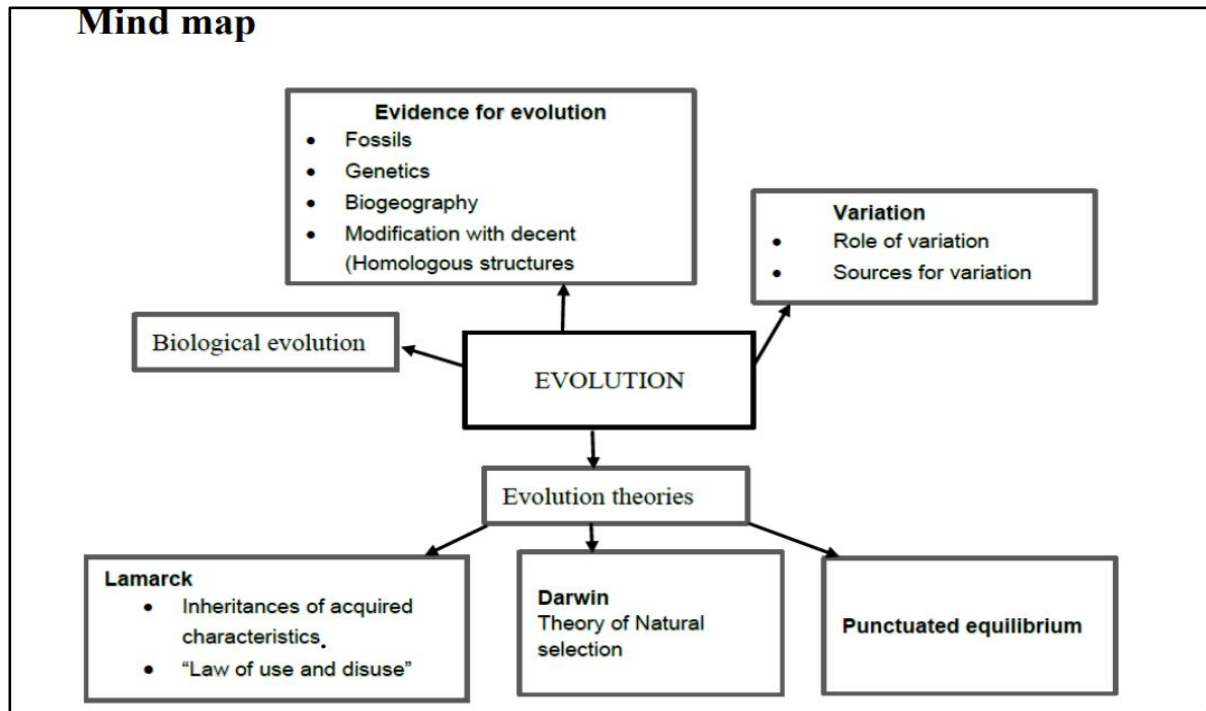


TERM 3 (53 days)	Week 4 11/8 – 15/8 (4 days)	Week 5 18/8 – 22/8 (5 days)	Week 6 25/8 – 29/8 (5 days)
CURRICULUM COVERAGE	83,9%	87,1%	91,3%
CAPS TOPIC	EVOLUTION (NATIONAL EXAMINATION GUIDELINE PG. 13)		
CORE CONCEPTS, SKILLS AND VALUES	<p>Introduction to evolution, e.g., biological evolution, hypothesis, theory Evidence for evolution and variation</p> <p>Lamarckism, Darwinism and punctuated equilibrium, artificial selection and speciation</p>	<p>Reproductive isolation mechanisms evolution in present times</p>	<p>Evidence of common ancestors for living hominids, including humans</p> <p>Out of Africa hypothesis</p>
REQUISITE PRE- KNOWLEDGE	<p>Revise fossil record and biogeography (Grade 10), Genetics (Grade 12) Revise genetics and variation (Grade 12) Human skeleton (Grade 10)</p>		<p>Revise genetics and variation (Grade 12) Human skeleton (Grade 10)</p>
RESOURCES (OTHER THAN TEXTBOOK) TO ENHANCE LEARNING	<p>Past examination papers, videos and PowerPoints on an introduction to evolution</p> <p>Watch Telematics video on natural selection, punctuated equilibrium and speciation at: https://bit.ly/2lq6LzI</p>		<p>Mind the Gap study guide, past examination papers, videos and PowerPoints</p>

EVOLUTION



Mind map



TERMINOLOGY IN EVOLUTION

T

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	<ul style="list-style-type: none"> <input type="checkbox"/> Definition of biological evolution change in the characteristics of species over time <input type="checkbox"/> Difference between a hypothesis and a theory <input type="checkbox"/> 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	<ul style="list-style-type: none"> <input type="checkbox"/> Role of the following as evidence for evolution: <ul style="list-style-type: none"> • Fossil record - Link to Grade 10 • Biogeography - Link to Grade 10 • Modification by descent (homologous structures) • Genetics

1. Focus on the following definitions.



1.1 Definition of biological evolution:

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

1.2 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.

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

2. Emphasize the Role of the following as evidence for evolution:



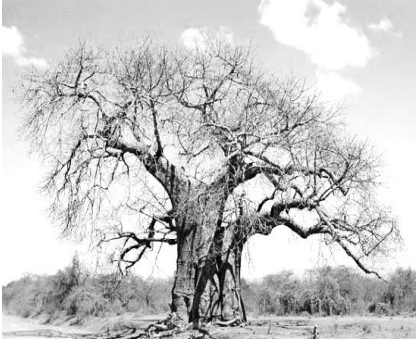
2.1 Fossil record – Link to Grade 10

Palaeontology refers to the study of fossils. Fossils are the remains of ancient life forms preserved usually in rock. Radiometric dating is used to determine the age of the rock in which the fossil is preserved. Scientists used the age of fossils to establish when organisms excised and to determine the characteristics of the organism by studying the fossil. Knowledge of these characteristics allows us to see relationship amongst different organisms, this is represented in a phylogenetic tree, Fossils provide evidence of the history of extinct organism on earth and give an indication of the climate and environment millions of years ago. ***(Fossils record is not good evidence of evolution – not all organisms can be fossilised and there are lots of gabs in fossil record)***

2.2 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. For example:

Baobab trees in Africa

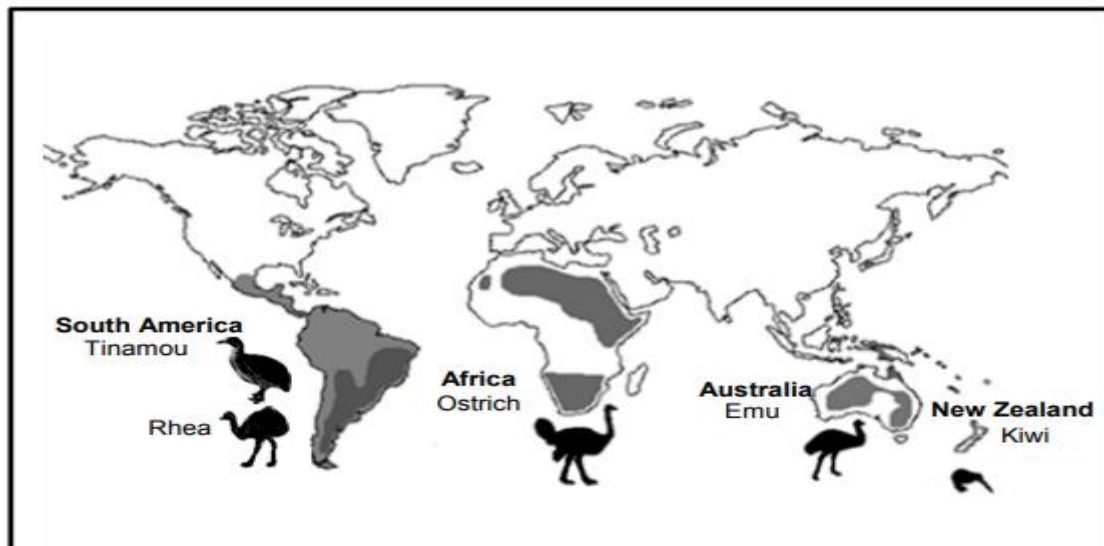


and

Madagascar



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



2.3 Modification by descent (homologous structures)

Modification by descent

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

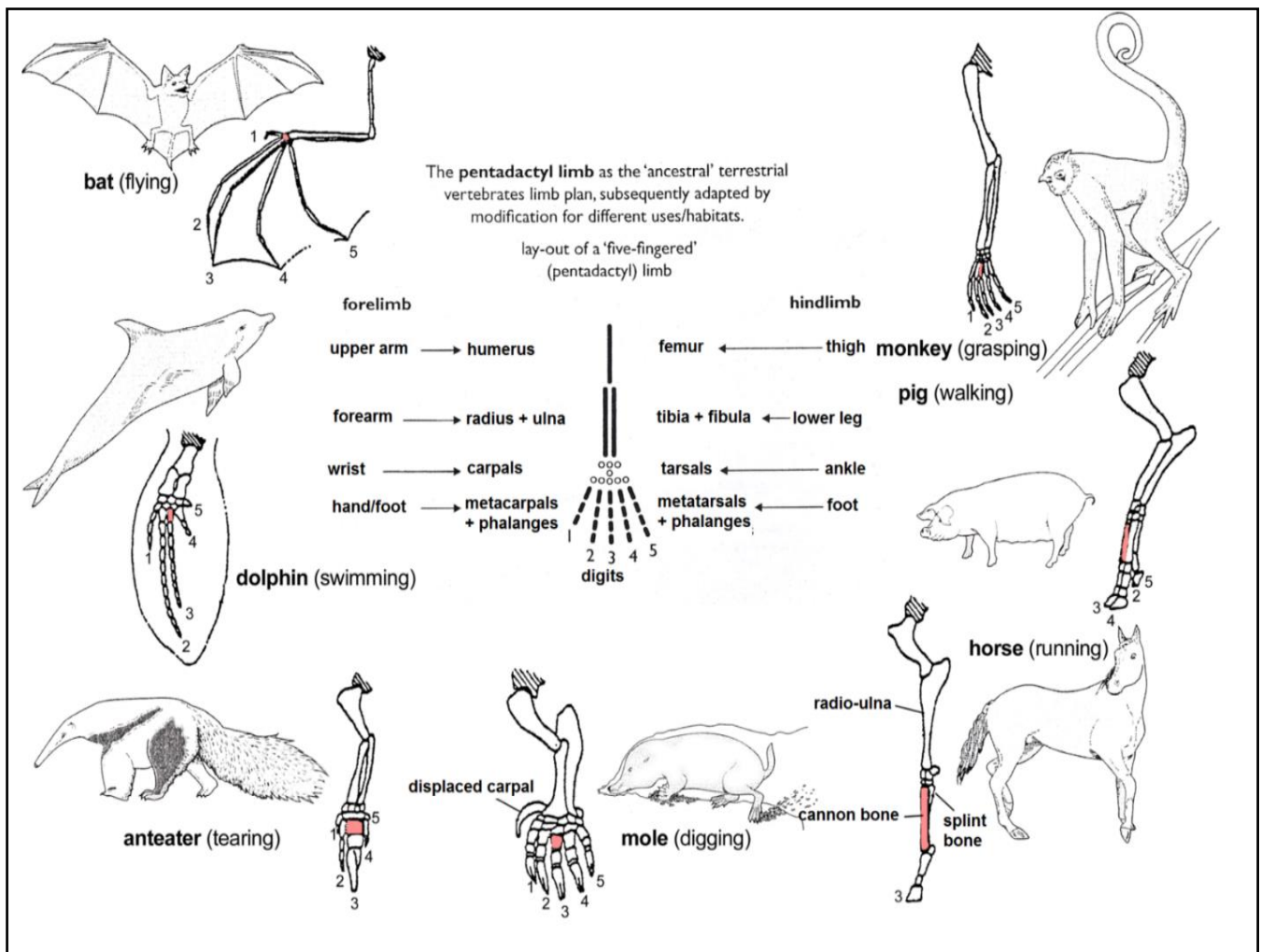
Because the similarities may be traced back to a common ancestor

Important to note

Homologous structures (*act as evidence for modification by descent*)

Homologous structures have the same basic plan even though they may look different or perform different functions. Comparison of homologous structures among organisms to show similarities and differences e.g. Homologous bone structures in the front limbs of different vertebrates, Scientist interpret homologous

structures in the way that it indicates common ancestor. **(why is homologous structure important evidence in evolution – because they indicated common ancestors)**



2.4. Genetics (used as evidence for human evolution and evidence for “OUT OF AFRICA HYPOTHESIS”)

All living organisms share a universal code of three DNA bases (codons) that are used to specify each amino acid.

Comparison of the human genetic code with that of other organisms shows that chimpanzees are nearly genetically identical (differ by less than 1.2%) whereas the mouse differs by ≈15%.

The following features show possible common origin of different organisms:

- Identical DNA compounds
- Similar sequence of genes
- Similar portions of DNA with no function
- Identical protein synthesis
- Similar metabolic pathways such as glycolysis, Krebs's cycle and
- Electron transport system

ACTIVITY 1.1 (EC, SEP,2023)

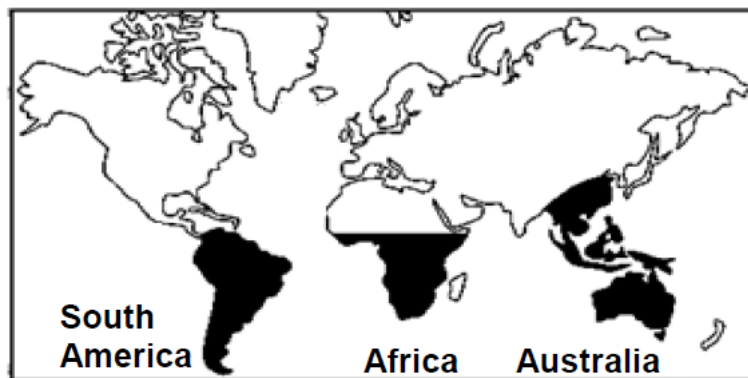


- 1.1 The theory of evolution is based on many lines of evidence.
- 1.1.1 Define biological evolution. (2)
 - 1.1.2 Why is the Theory of Evolution regarded as a scientific theory? (2)
 - 1.1.3 Tabulate ONE difference between a theory and a hypothesis. (3)
 - 1.14 Name TWO sources where scientists find evidence for evolution. (2)
- [7]**

ACTIVITY 1.2 (May-June, DBE,2023)



- 1.2 Shrubs of the family Proteaceae (e.g. Waratahs and proteas) can be found in Australia, South America, Indo-China and parts of Africa as shown on the map below.



It is hypothesised that all continents were once one large continent called Pangaea and that they separated due to continental drift.

This is evidence that the family Proteaceae ...

- (a) all belong to the same species.
- (b) are equally distributed on all continents.
- (c) became extinct when Pangaea separated.
- (d) arose from a common ancestor when Pangaea separated. (2)

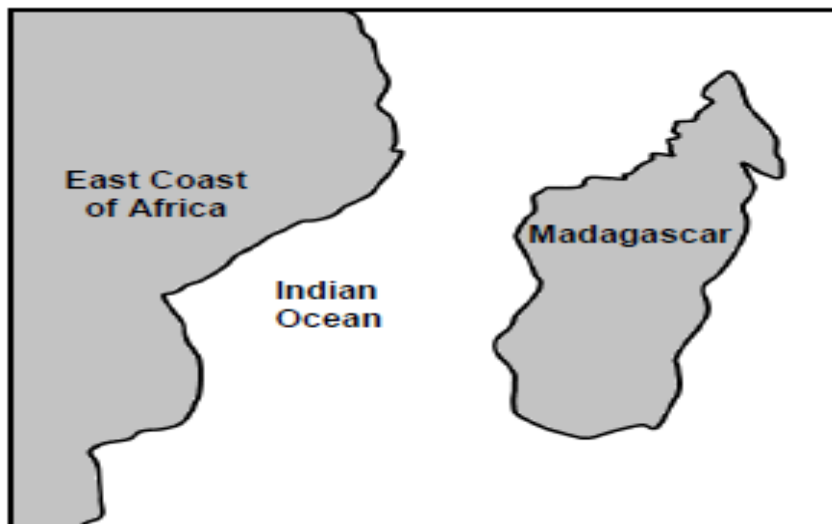
ACTIVITY 1.3 (DBE/November 2020(2))



1.3 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.



- 1.3.1 Explain how continental drift could have affected the distribution of the common ancestor.

(4)



VARIATION

CONTENT	ELABORATION
Variation	<ul style="list-style-type: none"><input type="checkbox"/> Definition of a biological species and a population<input type="checkbox"/> A review of the contribution of each of the following to variation that exists amongst individuals of the same species:<ul style="list-style-type: none">• Meiosis<ul style="list-style-type: none">○ Crossing over○ Random arrangement of chromosomes• Mutations• Random fertilisation• Random mating<input type="checkbox"/> Types of variation:<ul style="list-style-type: none">• Continuous variation - those characteristics where there is a range of inter-mediate phenotypes, e.g. height• Discontinuous variation - those characteristics that fall into distinct categories e.g., blood groups

3. Sources of Variation

- *variation causes genetically different individuals and*
- *the 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)*

3.1 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.

How do you tell if two organisms are the same species:

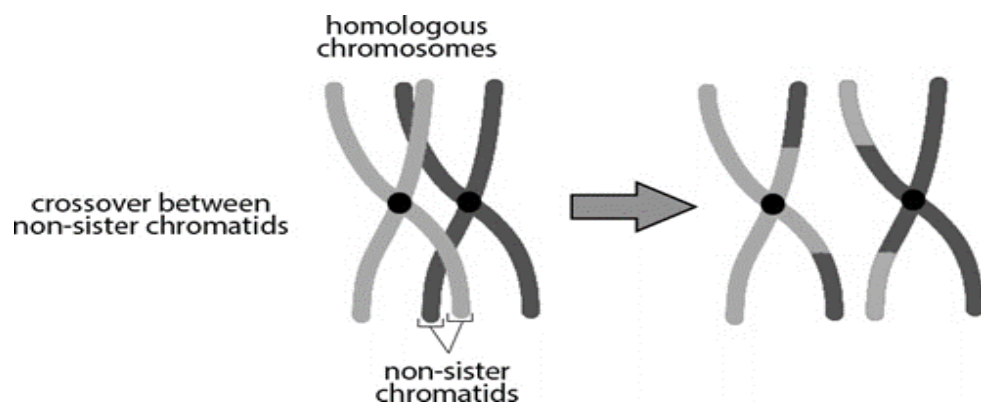
If a species can interbreed and produce fertile offspring, then they are the same species. If they interbreed but do not produce fertile offspring, then they are not the same species.

3.2 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)*

3.2.1 Meiosis *(what is the role of meiosis in variation)*

3.2.1.1 Crossing over *(what is the difference in variation on crossing over and random arrangement - genetic different chromosomes)*

- occurs during prophase I ✓
- parts of homologous chromosomes /non-sister – chromatids/adjacent chromatids overlap ✓
- at points called chiasma ✓/chiasmata
- Genetic material is exchanged ✓

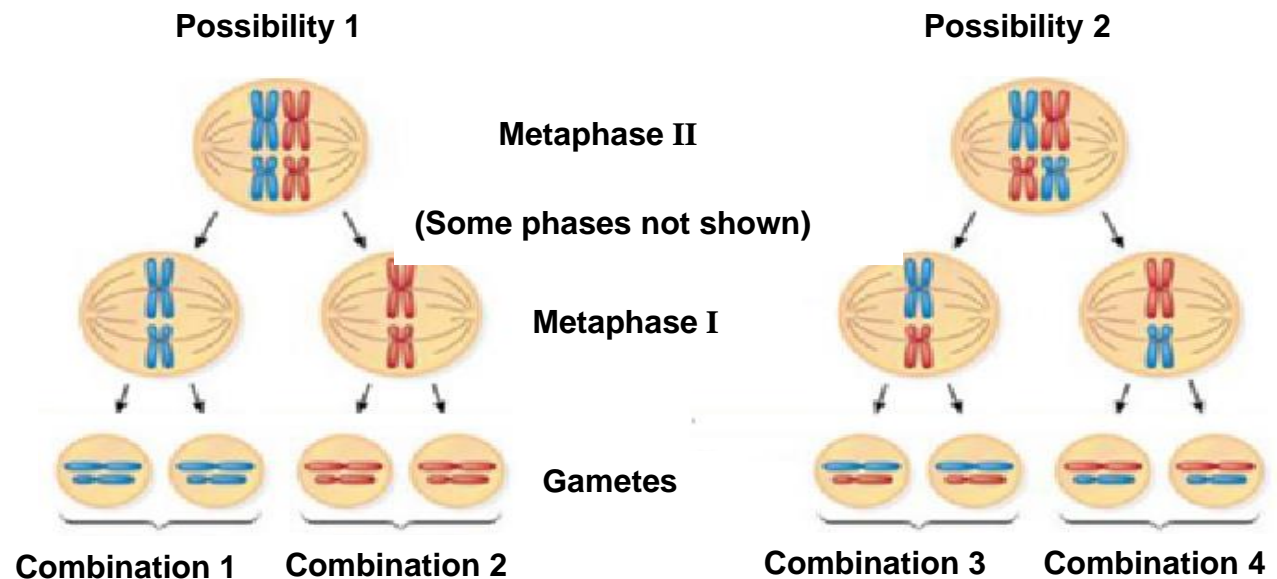


- resulting in new combinations of genetic material from both parents ✓

3.2.1.2 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



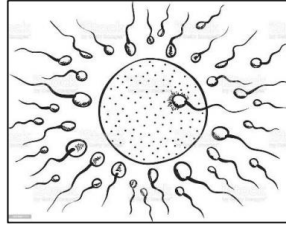
3.2.2 Mutations



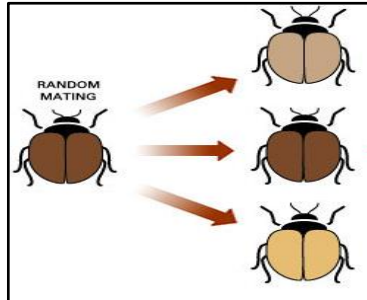
- **Gene Mutation** – a change in the sequence of nitrogenous bases or nucleotides of DNA (learners should know the definition)
- **Chromosomal mutation** – a change in the normal structure or number of chromosomes (*use the correct wording as it comes from the Exam Guidelines*)



3.2.3 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*)



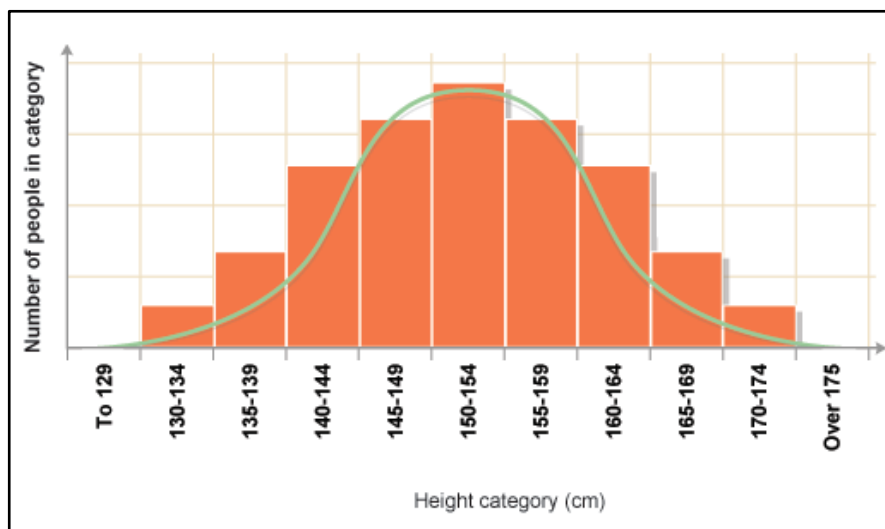
3.2.4 Random mating - between organisms within a species leads to a different set of offspring from each mating pair. (*any male can mate with any female*)



3.3 TYPES OF VARIATION

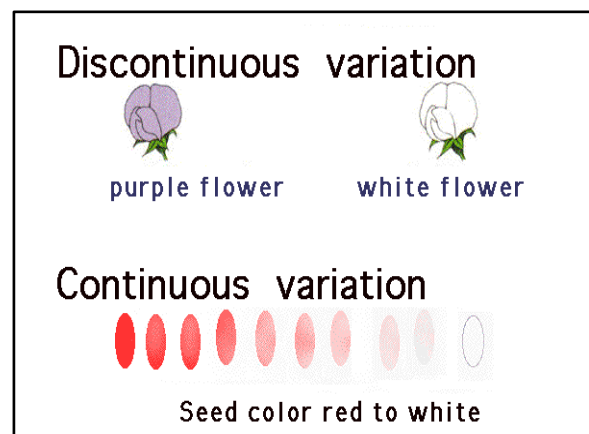
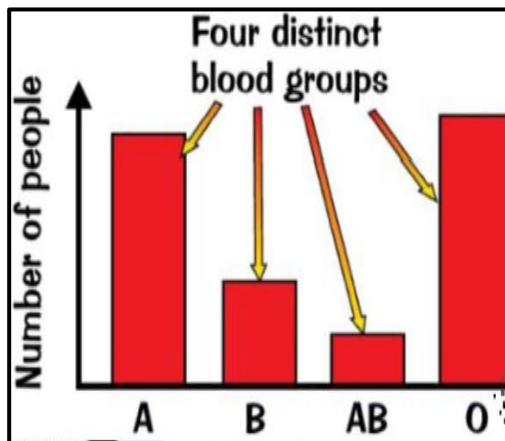
3.3.1 Continuous variation - (*the word range must be emphasized and taught*)

- When traits do not fall into clear cut classes.
- For example, there is every shade of hair colour between black and blond. People do not belong to one or other of a small number of distinct categories i.e. there is continuous variation from one extreme to the other.
- Variations such as these are under genetic control but there are several pairs of genes involved.
- The genome **AA BB CC DD** might give black hair while the genome **aa bb cc dd** might give blond hair. *
- Genomes **Aa Bb Cc Dd** or **AA Bb CC dd** or **aa BB cc Dd** and all the other possible combinations would give intermediate colours
- The condition of having more than one gene controlling a characteristic is called polygenic inheritance (*polygenic inheritance is not for exams*)



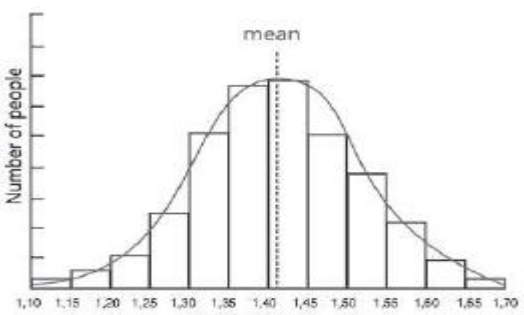
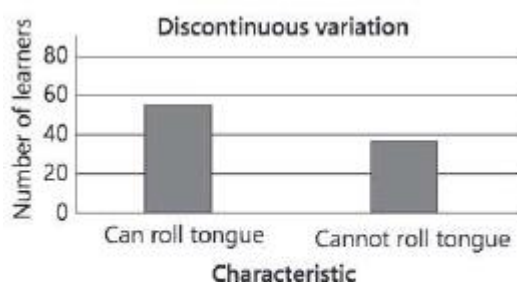
Discontinuous variation e.g. Mendel's pea plants either tall or short and had no intermediate forms between these traits

- 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



Discontinuous variation in blood group. The figures cannot be made to fit a smooth curve because there are no intermediates.

Feature	Continuous variation	Discontinuous variation
Genes and loci	Controlled by several different genes found at different loci on the homologous chromosomes.	Controlled by a gene at a certain locus on the homologous chromosomes.
Phenotypes	Dependent on genes and environment. Many variants.	Dependent on genes only. Only two variants.
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.

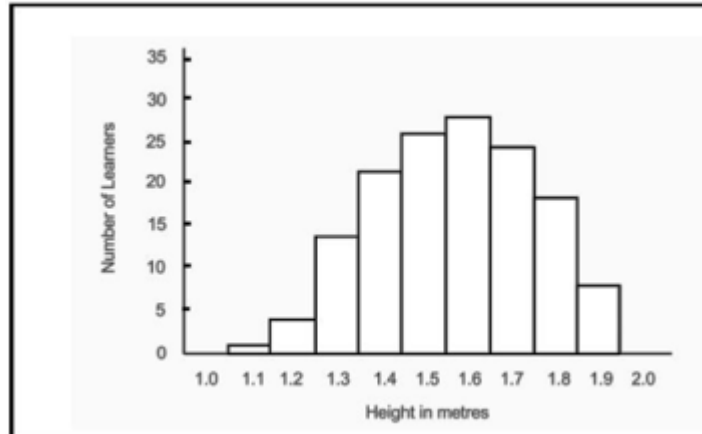
Feature	Continuous variation	Discontinuous variation
Frequency graphs to show the two different types	<p>Histogram graph is drawn as the independent variable is continuous - there are no gaps between the different categories.</p> <p>A normal distribution/bell-shaped curve is the result. The data is evenly spread on either side of the mean (average). See the graph below.</p>  <p>A frequency graph for the height of individuals in a population</p>	<p>Bar graph is drawn as the independent variable is discontinuous - there are gaps between the different categories. See the graph below.</p>  <p>A graph showing discontinuous variation</p>

ACTIVITY 2

- 2.1 Define the following terms: (3)
- 2.1.1 Population (3)
- Species
- 2.2 Scientists believe that variation in populations can lead to the formation of new species. (4)
- 2.2.1 List FOUR sources of variation in populations. (4)
- 2.3 Describe how the following contributes to genotypic variation within a species: (6)
- 2.3.1 Meiosis (6)
- 2.3.2 Sexual reproduction (4)

ACTIVITY 3

- 3.1 Mutations result in genetic variation.
- 3.1.1 Give THREE other sources of genetic variation in a species. (3)
- 3.1.2 Differentiate between continuous variation and discontinuous variation. (2)
- 3.2 The graph below shows the variation of heights of a group of 18-year-old students.



- 3.2.1 Identify the type of graph represented. (1)
- 3.2.2 Explain why this type of graph mentioned in QUESTION 3.2.1 is most suitable for plotting data on continuous variation. (2)
- 3.2.3 What is the most common height? (1)
- 3.2.3 How many people in the group were shorter than 1.3 metres?

ORIGIN OF AN IDEA (Evolution theories)

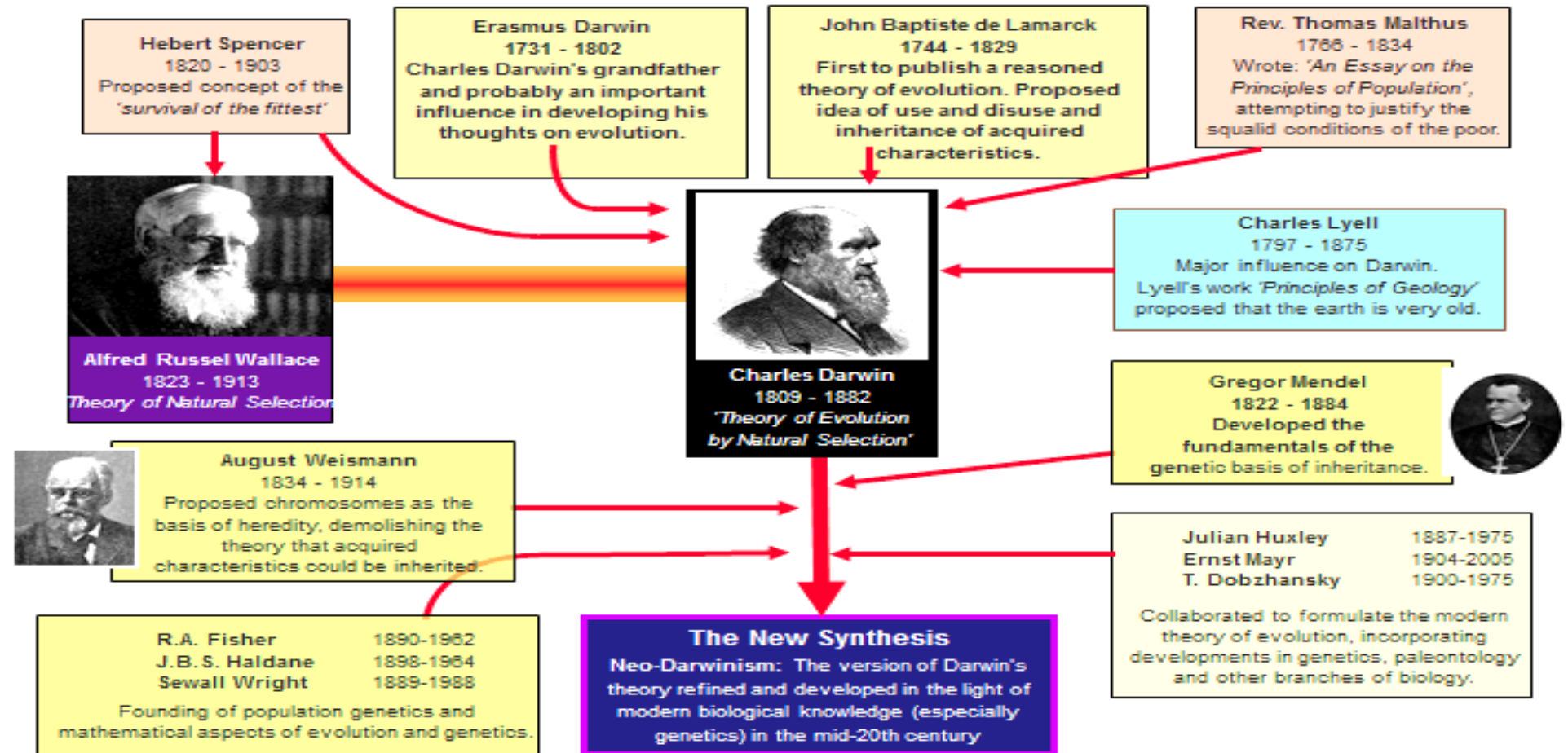


CONTENT	ELABORATION
Origin of an idea about origins (Historical development)	<input type="checkbox"/> Ideas on evolution in the order of their origin are as follows: <ul style="list-style-type: none"> • Lamarckism • Darwinism • Punctuated Equilibrium
Lamarckism (Jean Baptiste de Lamarck - 1744-1829)	<input type="checkbox"/> Lamarck used two 'laws' to explain evolution: <ul style="list-style-type: none"> • 'Law' of use and disuse • 'Law' of the inheritance of acquired characteristics <input type="checkbox"/> Reasons for Lamarck's theory being rejected
Darwinism (Charles Darwin - 1809-1882)	<input type="checkbox"/> Darwin's theory of evolution by natural selection: <ul style="list-style-type: none"> • There is a great deal of variation amongst the offspring. • Some have favourable characteristics and some do not. • When there is a change in the environmental conditions or if there is competition, then organisms with characteristics, which make them more suited, survive whilst organisms with unfavourable characteristics, which make them less suited, die. • The organisms that survive, reproduce • and thus, pass on the allele for the favourable characteristic to their offspring.

- | | |
|--|--|
| | <ul style="list-style-type: none">• The next generation will therefore have a higher proportion of individuals with the favourable characteristic. |
|--|--|

4.1 Ideas on Evolution

History of Evolutionary Thought



5.1. Jean Baptiste de Lamarck – 1744-1829 (Lamarckism) (*learners have to know how to spell it*)

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

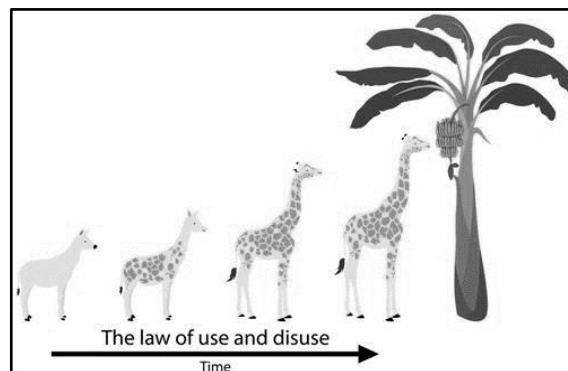
- Changes in the environment create new needs that cause organisms to modify their existing organs to meet the need.
- Repeated use of the organ would cause it to enlarge and become more efficient. Disuse of an organ would cause it to degenerate.

2. Law of inheritance (explain the theory – firstly they must state the law and explain the law)

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

How to describe Lamarckism

Example:



Guiding Questions	Lamarck's explanation
<i>What was the original characteristic at the start?</i>	All giraffes had short necks originally
What did the organism do?	Giraffes frequently stretched
<i>Why did the organism do this?</i>	used their necks to reach -for leaves of tall trees/to feed
<i>What was the result?</i>	necks became longer
<i>What happened to this new characteristic?</i>	The long necks acquired in this way could be passed on to the next generation /were inherited
<i>What was the result of this?</i>	All the giraffes have long necks

(no longer a general statement - learners must state the favourable characteristics)

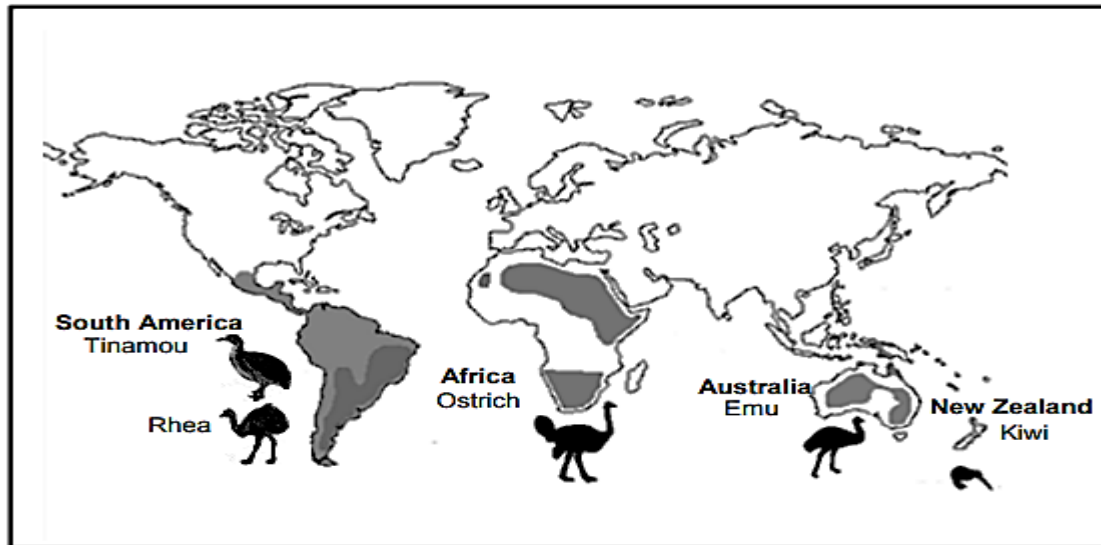
Example:

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



ACTIVITY 3

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



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

3.1.1 Describe how Lamarck would have explained the evolution of flightless birds.

(6)

6.1 Darwinism (Charles Darwin – 1809–1882)

6.1.1 Darwin's theory of evolution by natural selection:

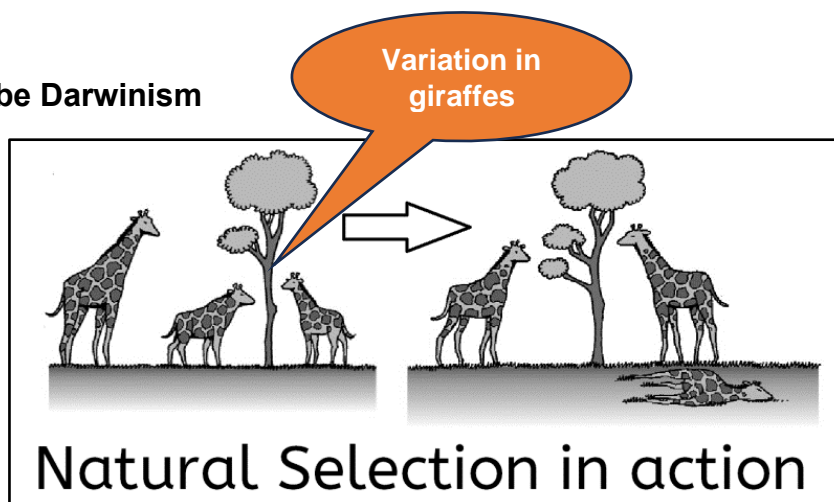
- There is a great deal of variation amongst the offspring
- Some have favourable characteristics, and some do not.
- When there is a change in the environmental conditions or if there is competition,
- then organisms with favourable characteristics, which make them more suited, survive.
- whilst organisms 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.

(If learners are asked to describe Darwinism – the answer is straight forward – no example – just as it come from examination guidelines)

Note the difference on how to answer questions relating to Darwinism/ natural selection this from previous years

How to describe Darwinism

Example:



(Natural selection questions keep on changing and learners must be able to answer it – it is not a straightforward question – refer to 2018 question paper – new way to answer natural selection) follow guidelines 2021 – it shows exactly how to answer

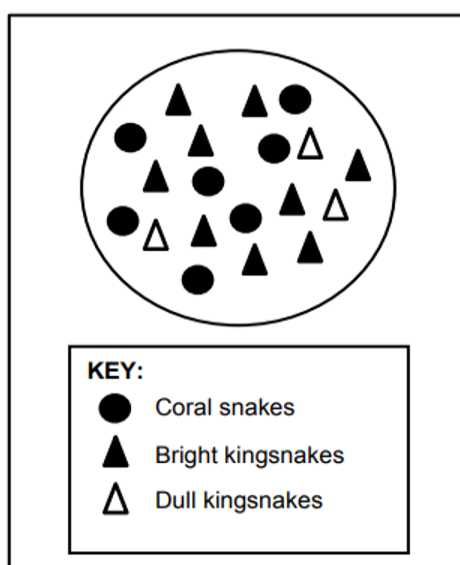
Guiding Question	Darwin's explanation
1-State the characteristic that varies	There is a variation in the 1- length of giraffe's necks.
Describe the 2- variations	There were giraffes with 2- long neck and short necks
3- Explain the environmental change/ selection pressure for natural selection (what is 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 unfavourable 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 4

4.1.

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.



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

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

6.1.2 Differences between Lamarck's and Darwin's evolution theories

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



ACTIVITY 5

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.

5.1. 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)

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

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



PUNCTUATED EQUILIBRIUM

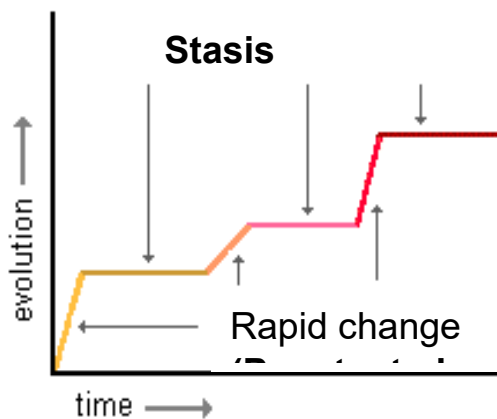
CONTENT	ELABORATION
Punctuated Equilibrium (Eldredge and Gould -1972)	<input type="checkbox"/> Punctuated Equilibrium explains the speed at which evolution takes place: <ul style="list-style-type: none"> • Evolution involves long periods of time where species do not change or change gradually through 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	<input type="checkbox"/> Artificial selection involving: <ul style="list-style-type: none"> • A domesticated animal species • A crop species



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

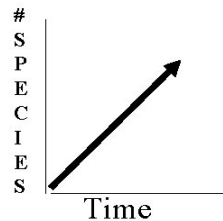
- Stephan J Gould and Niles Eldredge formulated this model (1972).
- They observed that the fossil record gives a different picture of evolution.
- They claim that there were long periods of **stasis** (4-10 million years) involving little evolutionary change.
- Then occasional rapid formation of new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

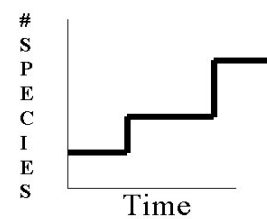


Graphs showing time frame of Evolution:

• **Gradualism:**



• **Punctuated Equilibrium**



7.1.1. Differences between Gradualism and Punctuated equilibrium

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

(Similarities between Gradualism and Punctuated equilibrium – natural selection occurs in both of them the other one takes long and the other one the change is slow)

7.1.2. 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.

8.1. Artificial selection

- This is selection carried out by people.
- People select a certain characteristic that is required and will deliberately breed this characteristic into the offspring.

Artificial selection	Natural selection
The selective force is humans.	The selective force is the environment or nature.
Selection takes place in response to satisfy the needs of humans.	Selection takes place in response to the suitability to the environment.
May involve one or more species (as in cross breeding).	Occurs within a single species.

Table showing the differences between artificial and natural selection.

Examples

Domesticated animals

- Different varieties of dogs were bred by people long before Darwin and Wallace explained natural selection.
- Cattle were domesticated (humans used them for their benefit) about 10 000 years ago in the Middle East. They were used as a source of food (for their meat, milk); to carry heavy loads and to pull a plough; and their skins/hides could be used to make shoes and clothes.
- For many years farmers have used artificial selection to improve their herds. Special characteristics have been bred in certain types of cattle. Some examples:
 - 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.

Nguni cattle have been bred to be very disease resistant



Hereford cattle are bred for their meat



Jersey cattle are bred for rich milk



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

E _____

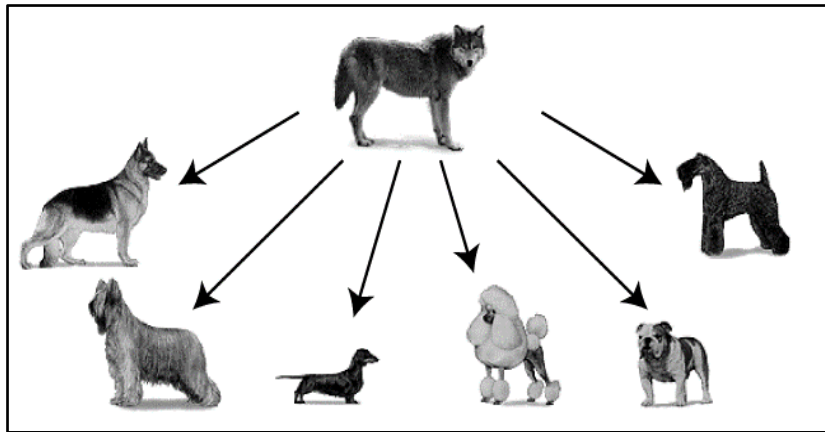
E _____

Wheat is the most widely grown cereal crop in the world. A cool climate is the ideal condition for wheat to grow.

In 1953 a scientist, Dr Norman Borlaug, started a breeding programme to produce wheat that would survive and produce well in Mexico. The results were plants that were rust (a disease) resistant; had short, thick stems that did not break easily; needed less water and that gave a high yield of grain.

Natural selection VS Artificial selection

Natural selection	Artificial selection
Environment is the selective force	Human is the selective force
Response is adaptation to nature	Response to satisfy human need
Happens in a species	Can include more than one species



4.1. Describe artificial selection using an example of each of the following:

- A domesticated animal species e.g. different breeds of dogs
- A crop species e.g. maize with full kernels is selected by farmers

4.2. 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.

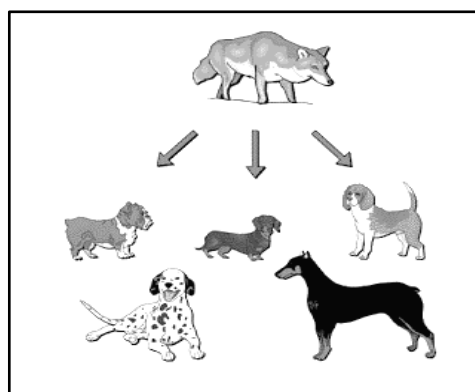
ACTIVITY 6



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

6.2. What is the similarity between punctuated equilibrium and gradualism (4)

6.3. 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.

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

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

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

6.3.4. What effect does the type of selection mentioned in 6.3.3 have on the survival change of the dog species? (2)



SPECIATION

CONTENT	ELABORATION
Formation of new species	<ul style="list-style-type: none"> <input type="checkbox"/> Biological species concept: similar organisms that are capable of interbreeding to produce fertile offspring <input type="checkbox"/> Speciation and extinction and the effect of each on biodiversity <input type="checkbox"/> Speciation through geographic isolation: <ul style="list-style-type: none"> • 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. <input type="checkbox"/> Speciation through geographic isolation in ONE of the following: <ul style="list-style-type: none"> • Galapagos finches • Galapagos tortoises • Plants on different land masses (linked to continental drift) <ul style="list-style-type: none"> o Baobabs in Africa and Madagascar o Proteas in South Africa and Australia • Any example of mammals on different land masses

9. Formation of new species (Speciation)

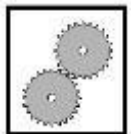


Speciation by geographic isolation occurs when part of a **population becomes isolated** from the **parent population** due to **physical barriers**. Such barriers could be continental drift, oceans, rivers, mountains, or other natural disturbances such as volcanos or earthquakes.

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/the selection pressure may be different
- natural selection occurs independently in each of the two populations
- such that the individuals of the two populations become very different from each other
- genotypically and phenotypically.
- Even if the two populations were to mix again
- they will not be able to interbreed.
- The two populations are now different species.

NOTE HOW WE ANSWER IT BY APPLYING AN EXAMPLE



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

If a population of a single species/original population

(Mention the original species in the extract that they give you and refer to where the species lived)

becomes separated by a geographical barrier

(Mention the specific barriers sea, river, mountain, lake)

then the population splits into

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

There is now no gene flow between the

(Mention how many populations are there now)

Since each population may be exposed to different environmental conditions/the selection pressure may be different

(Mention the selection pressure if there is one mention in the example)

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.

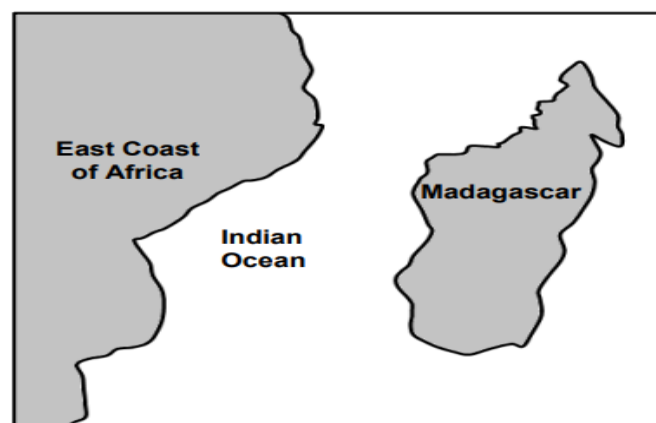
(Mention the differences if the extract indicates differences)

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

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

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.

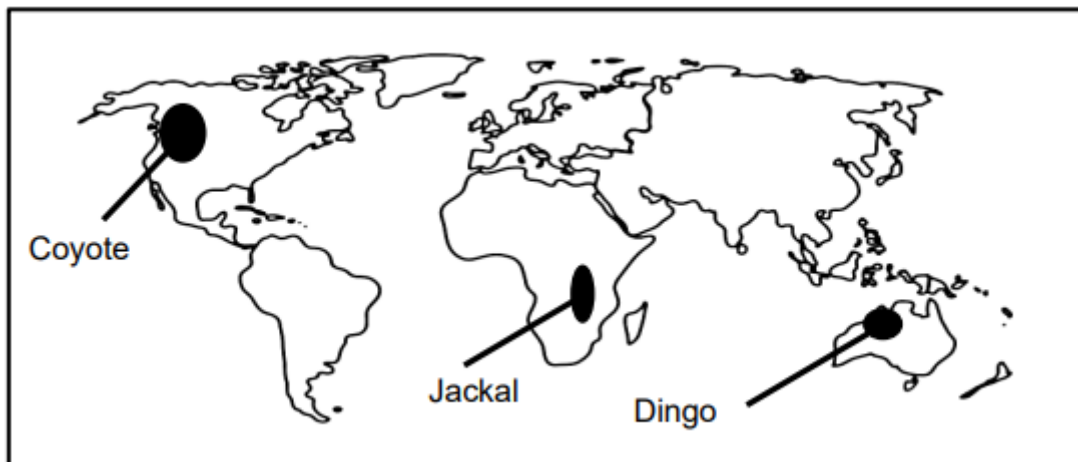
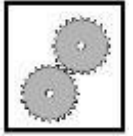
- **The BOLD is the fact that you state** according to the exam guidelines.
- **The highlight is what you must get out of the example.**
- **Applying the answer**
- **If a population of a single species/original population**

- (Mention the original species in the extract that they give you and refer to where the species lived)
- **If the original population of the common ancestor/small mammals of the pottos and lemurs that existed in AFRICA**
- becomes separated by a geographical barrier
- (Mention the specific barriers sea, river, mountain, lake)
- **becomes separated by a geographical barrier the Indian Ocean**
- then the population splits into
- (Mention in how many **population** does the original species /original population splits into according to the extract)
- **then the population splits into 2 - Africa and Madagascar**
- There is now no gene flow between the
- (Mention how many populations are there now)
- **There is now gene flow between the two populations in Africa and Madagascar**
- **Since each population may be exposed to different environmental conditions/the selection pressure may be different**
- (Mention the selection pressure if there is one mention in the example)
- **Each population may be exposed to different environmental conditions on the east coast of Africa and Madagascar**
- **natural selection occurs independently in each of the two/three etc. populations**
- **natural selection occurs independently in each of the islands**
- **such that the individuals of the two populations become very different from each other**
- **genotypically and phenotypically.**

- Even if the two populations of Africa and Madagascar were to mix again
- they will not be able to interbreed.
- The two populations are now different species, Pottos and Lemurs

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 7

7.1

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



Kaibab squirrel

Abert's squirrel

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

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

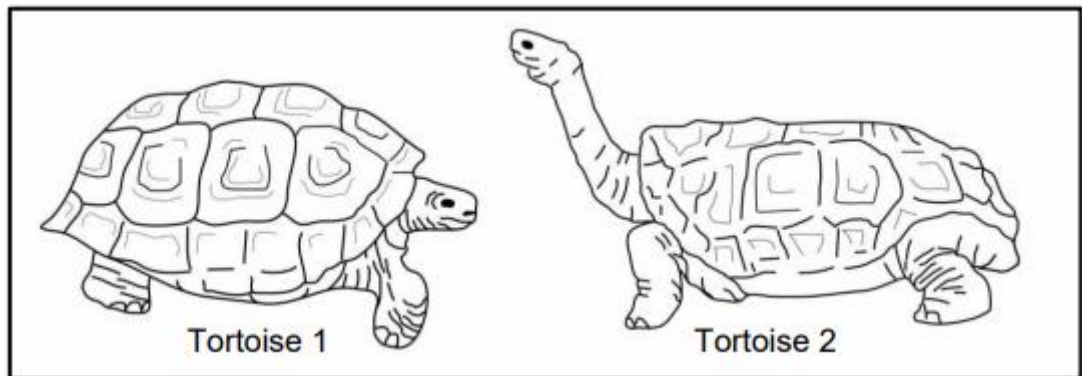
[Adapted for <http://biologydictionary.net/allopatric-speciation>]

- 7.1.1. Define a population. (2)
- 7.1.2. Describe how speciation of the **GRAND CANYON** squirrels took place. (5)



ACTIVITY 8

- 8.1. 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???



- 8.1.1. Which tortoise would be found on island **Y** (2)
- 8.1.2. Describe how the two tortoise species become different (6)
- 8.1.3. List FOUR sources of variation that could have led to the variation in the tortoise population (4)
- 8.1.4. Explain the role of natural selection on **island X** where more of tortoise 2 are found. (6)



REPRODUCTIVE ISOLATION MECHANISMS

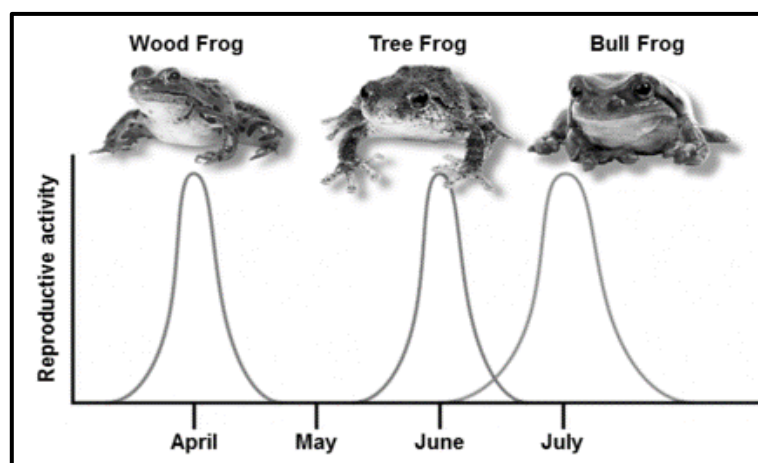
CONTENT	ELABORATION
Mechanisms of reproductive isolation (Keeping species separate)	<ul style="list-style-type: none"> □ A brief outline of reproductive isolation mechanisms that help to keep species separate: <ul style="list-style-type: none"> • Breeding at different times of the year • Species-specific courtship behaviour • Plant adaptation to different pollinators • Infertile offspring • Prevention of fertilisation

10. Reproductive isolation mechanisms that help to keep TWO DIFFERENT species separate:



10.1 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.



10.2 Species-specific courtship behaviour

Some animals have very specific courtship behaviours that do not attract individuals of other species, even if they are closely related species.

Courtship behaviour is a physical or chemical signal that an organism is ready to mate.

This can include anything from being brightly coloured, to singing elaborate mating songs or mating dances, to the secretion of pheromones in order to attract a mate.



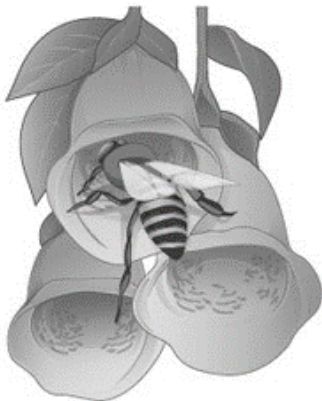
The blue-footed booby (*Sula nebouxi*) performs an elaborate courtship dance.



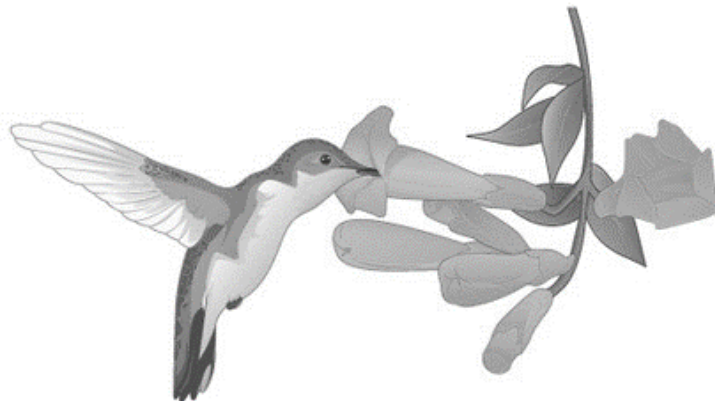
The masked booby (*Sula dactylatra*) performs a different courtship ritual.

10.3 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.



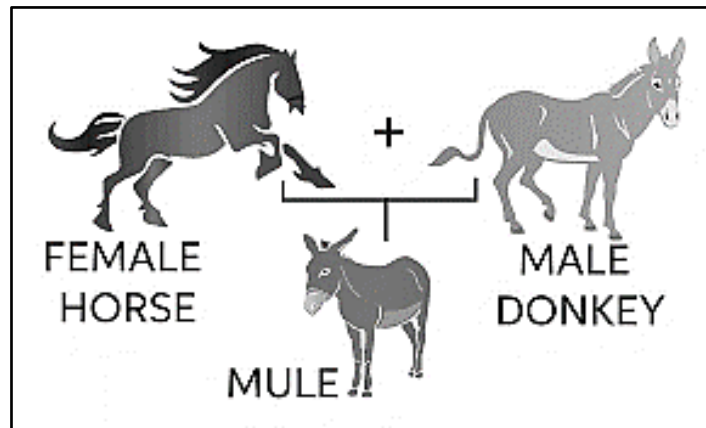
(a) Honeybee drinking nectar from a foxglove flower



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

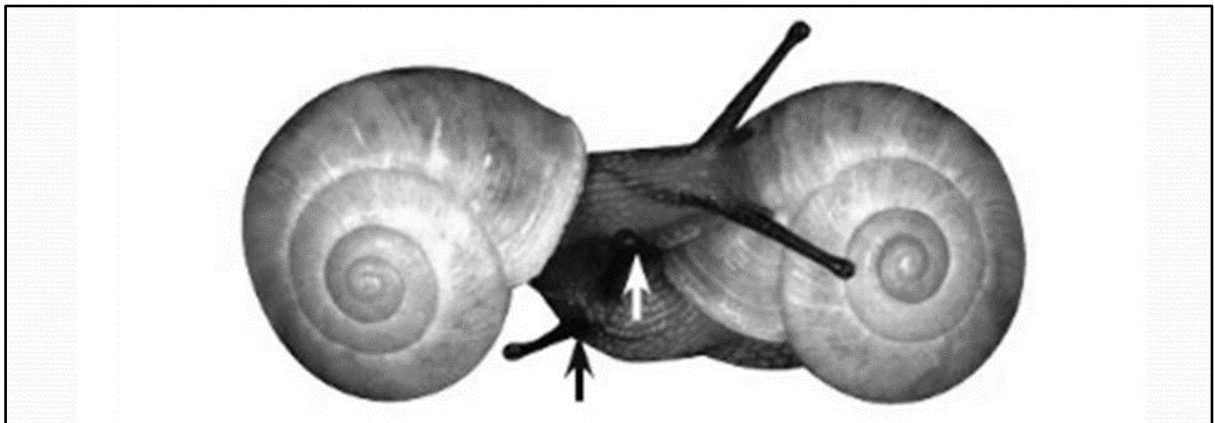
10.4 Infertile offspring

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.



10.5 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 9

9.1. Identify the reproductive isolation mechanisms that is illustrated in the diagrams below. (5)



Insects have very specific copulatory organs.

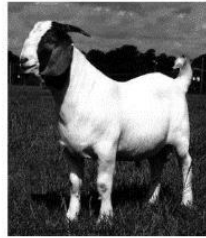
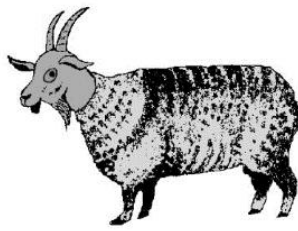


May



Species 1

Species 2



Sheep and goat hybrid dies before birth

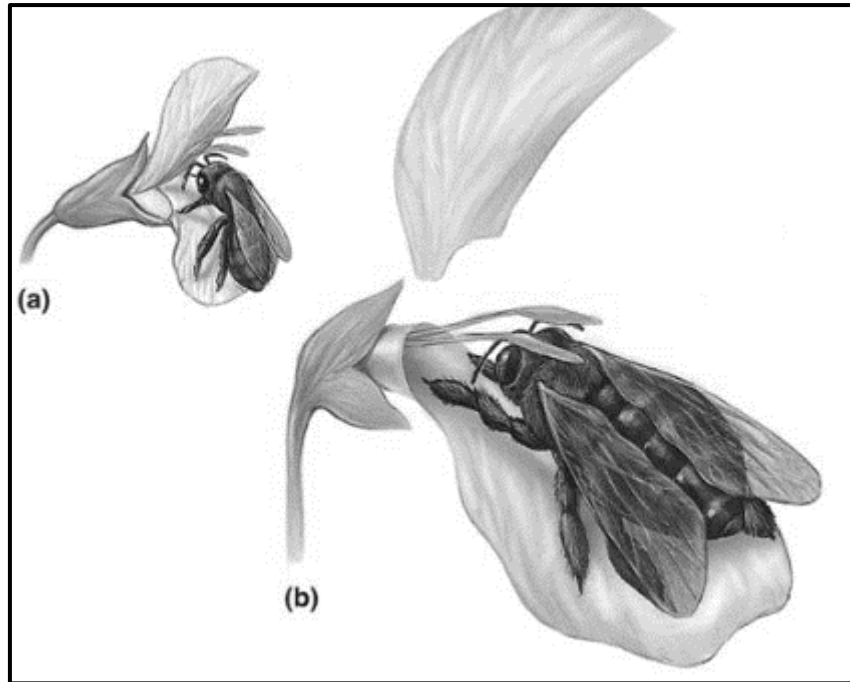


ACTIVITY 10



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

(1)



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

- 10.2.1 Identify the reproductive isolation mechanism that is illustrated in the diagram above. (1)
- 10.2.2. Explain what the significance of this isolation mechanism is. (2)
- 10.2.3. Explain the development of infertile offspring between two species. (3)
- 10.2.4 Give an example of infertile offspring between two species. (2)



EVOLUTION IN PRESENT TIMES

CONTENT	ELABORATION
Evolution in present times	<ul style="list-style-type: none"> Any ONE example of natural selection and evolution in present times: <ul style="list-style-type: none"> 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

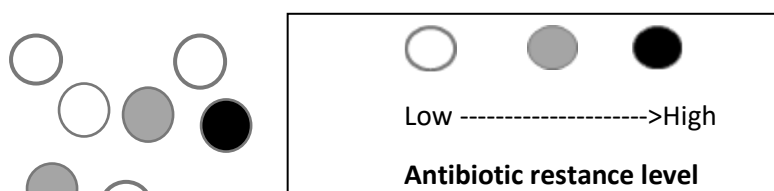
11. Evolution in present times



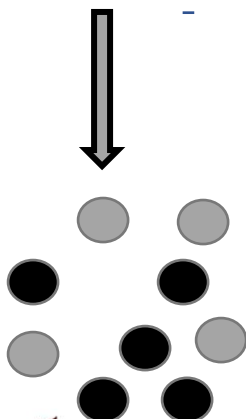
Evolution in present times (*based on the theory of natural selection – teach it based on COVID 19 which mutated many times EXAMPLE PFIZER and JOHNSON & JOHNSON*)

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

The evolution of drug resistance in bacteria



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



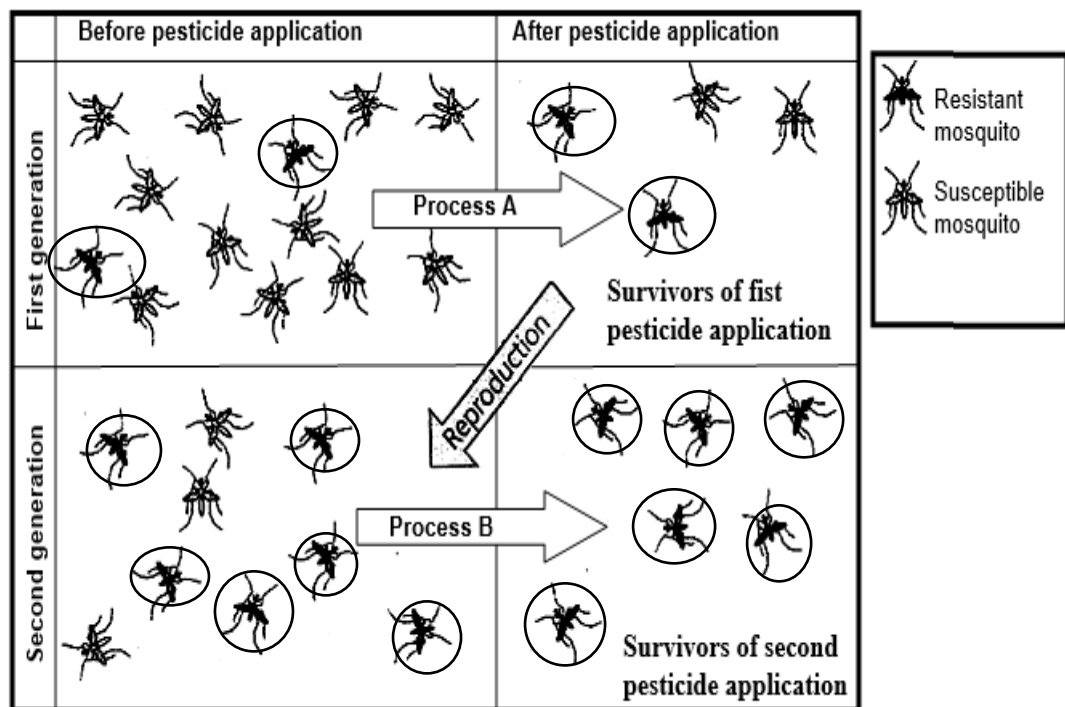
- The population of resistant bacteria increase
- Continued use of antibiotics had little effect on the resistant bacteria
- The resistant bacteria reproduce and pass the resistant gene on to the next generation and increased
- Non- resistant bacteria decrease
- The antibiotics will now be ineffective

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

ACTIVITY 11



- 11 The introduction of DDT represents a change in the environment of the mosquito. Study the diagram and answer the questions (1)



- 11.1.1. Give a suitable heading for the diagram above. (2)

- 11.1.2. What process is represented by:

- a) A (1)
b) B (1)

11.1.3 Describe the composition of the first generation. (2)

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

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

Evidence for common ancestors



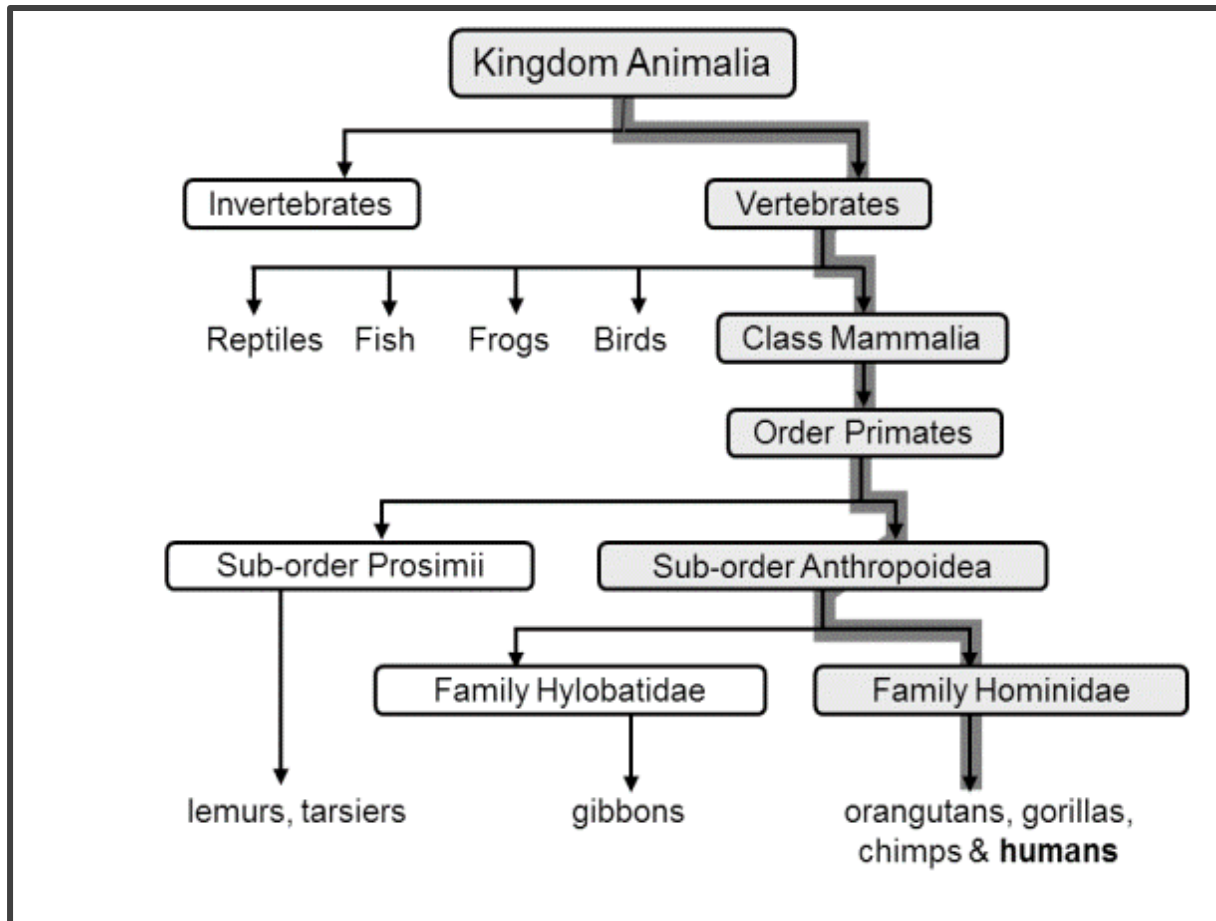
CONTENT	ELABORATION
Evidence of common ancestors for living hominids, including humans	<ul style="list-style-type: none"><input type="checkbox"/> Interpretation of a phylogenetic tree to show the place of the family Hominidae in the animal kingdom<input type="checkbox"/> Characteristics that humans share with African apes<input type="checkbox"/> Anatomical differences between African apes and humans, with the aid of diagrams, as it applies to the following characteristics:<ul style="list-style-type: none">• Bipedalism (foramen magnum, spine and pelvic girdle)• Brain size• Teeth (dentition)• Prognathism• Palate shape• Cranial ridges• Brow ridges<input type="checkbox"/> Lines of evidence that support the idea of common ancestors for living hominids including humans:<ul style="list-style-type: none">• Fossil evidence: Evidence from fossils of different ages show that the anatomical characteristics of organisms changed gradually over time.• Emphasis on evolutionary trends provided by the anatomical features of fossils of the following three genera:<ul style="list-style-type: none">○ Ardipithecus○ Australopithecus○ Homoas well as:<ul style="list-style-type: none">○ 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• Genetic evidence: mitochondrial DNA• Cultural evidence: tool-making

The place of humans in the phylogenetic tree

Human Evolution

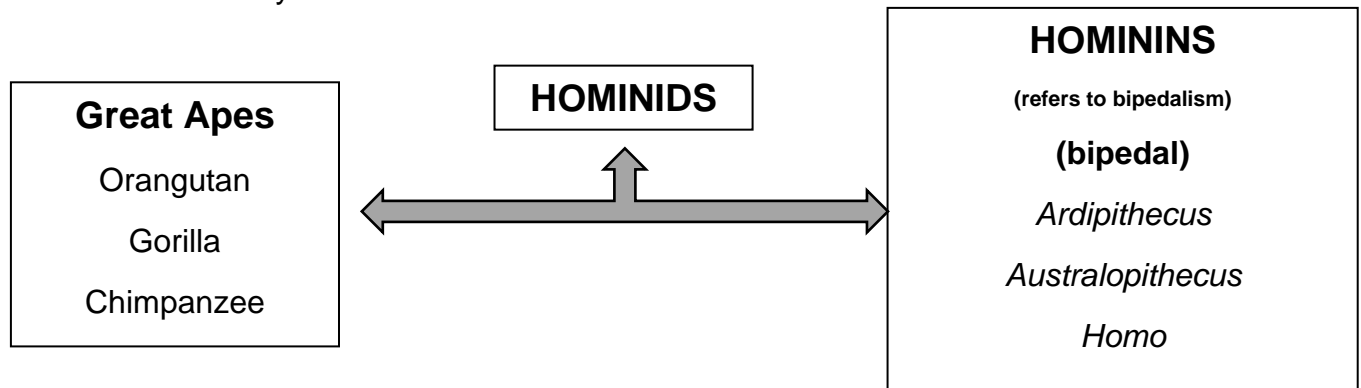
The place of the family Hominidae in the animal kingdom

Hominidae is the family name for all primates including all African Apes



- Humans are mammals and belong to the class **MAMMALIA**, because their bodies are covered with hair and they suckle their young
- The order they belong to is **PRIMATES**. - Primates includes human, apes, orangutans, gorillas and chimpanzees

- The Family **HOMINIDAE** includes **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

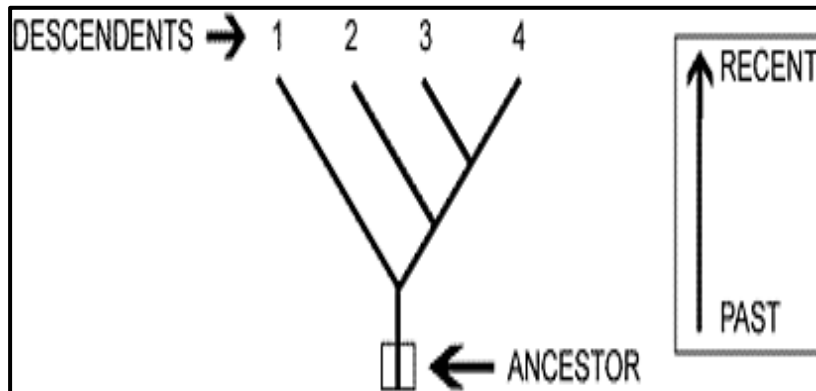
Read what the question asks – Give the Genus, species, family, class or order name

12.1 Interpretation of a Phylogenetic tree to show the place of humans in the Animal Kingdom (in grade 12 it is not necessary to emphasis the clinogram) (is it not cladogram?)

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.

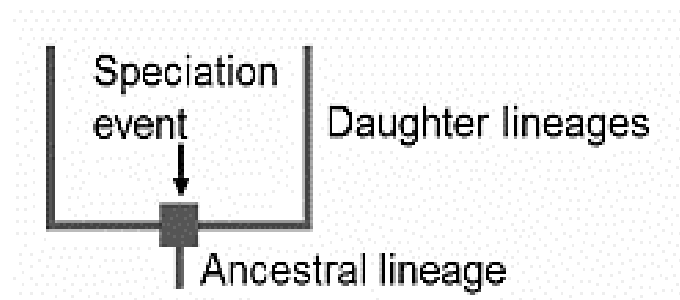
How to interpretate a Phylogenetic tree:

- 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.

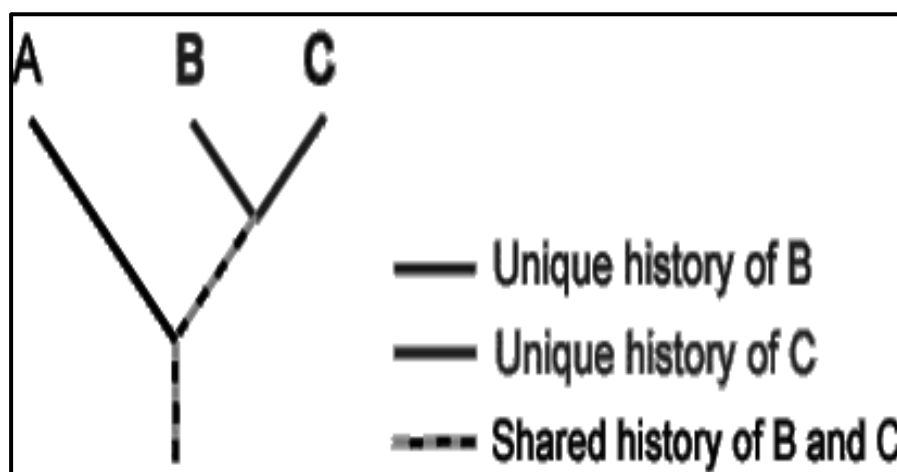


(3 and 4 are more related to each other because there we have a more recent common ancestor)

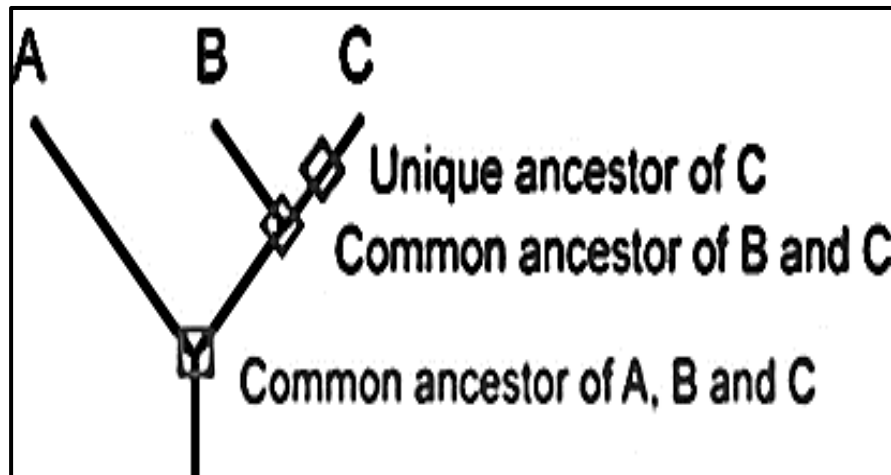
- Speciation is represented as a branching of the tree, as a single ancestral lineage gives rise to two or more daughter lines.



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



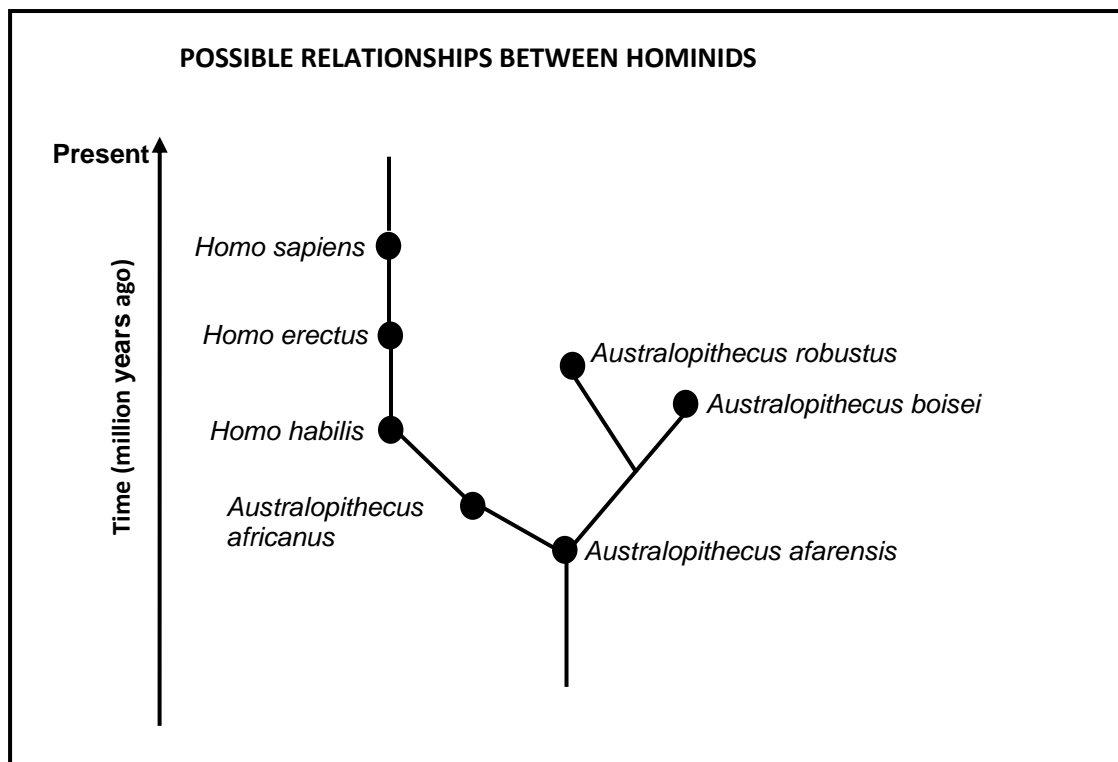
- And each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.



ACTIVITY 12



- 12 The diagram below shows possible relationships between members of Hominids.



- 12.1.1 What is the name given to this diagram? (1)
- 12.1.2 How many of each of the following are represented in the diagram?

a) Genera

b) Species (2)

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

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

12.1.5 Give the:

a) Family to which all humans belong to (1)

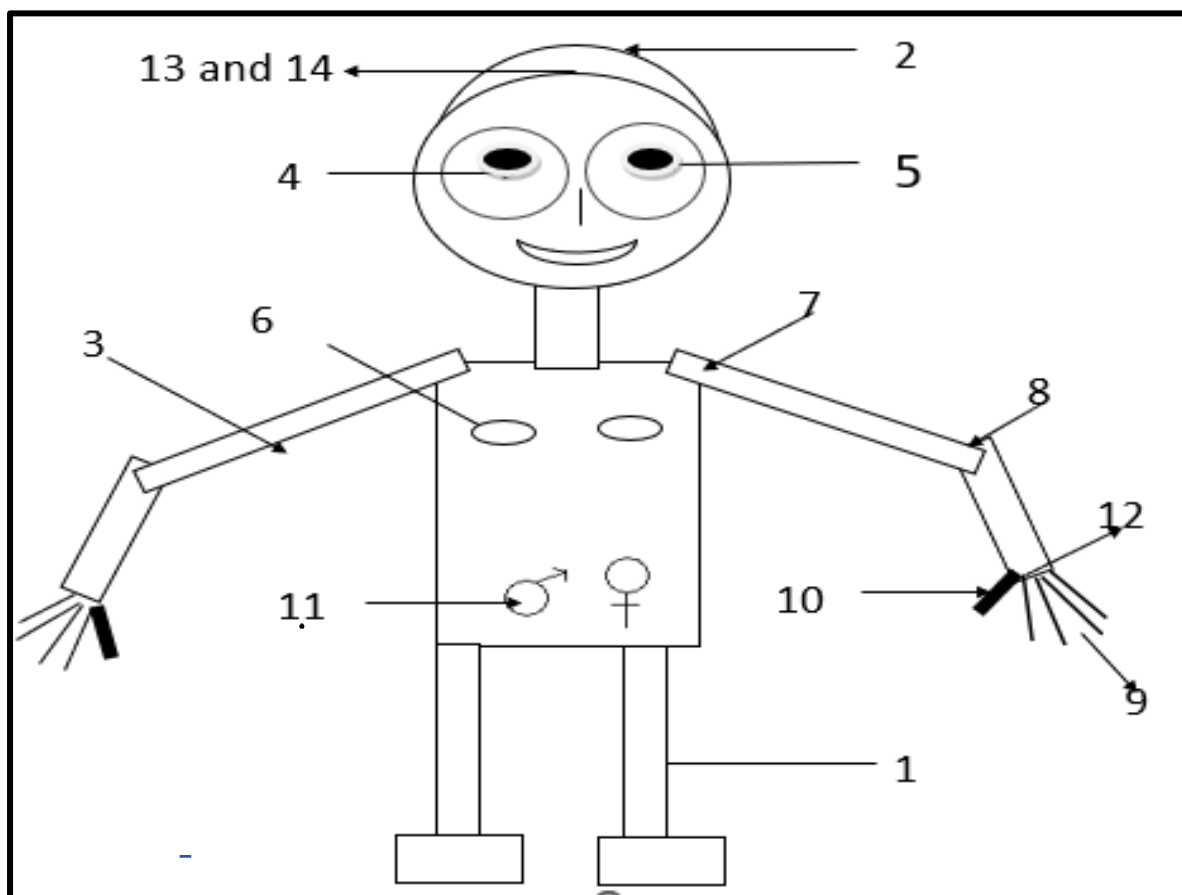
b) Genera to which all humans belong to (1)

c) Name of the ancestor of *Homo sapiens* (1)

(5)

Humans vs African apes

1.2 Characteristics we share with other primates.



1. **Upright posture:** the back limbs of hominids are generally stronger than their front limbs, enabling them to stand erect (upright) and use their hands for grasping; standing erect also gives a better view of surroundings and exposure of genitals to attract the opposite sex
2. **Large brains:** relative to their body size, hominids have larger brains than other species in the Animal Kingdom. This allows them to process and store information.
3. **Long upper arms / front limbs:** apes are normally **quadrupeds**, and this requires longer front limbs. Longer front limbs also make it easier to grasp and swing from branches.
4. **Two eyes in the front** of the head, this provides good binocular vision as both eyes work together.
5. The **eyes have cones** for colour vision that gives greater clarity.
6. **Two teats/nipples** only
7. **Freely rotating arms:** arms can be lifted above the head to swing from branch to branch, or to pick fruit hanging relatively high above the ground. **(learners must also know the significance of this characteristic)**
8. **Elbow joints allowing rotation of forearm** this allows the limb to extend or flex to grasp and reach for objects. It also enables the flexing and rotation of the wrists
9. **Bare fingertips or nails instead of claws:** Digits (finger and toes) have soft, broad, and very sensitive pads. The flat fingernails or toenails protect these pads.
10. **Opposable thumb:** the thumbs of hominids are positioned so that it can oppose other digits, enabling the hand to grip an object
11. **Sexual dimorphism** – this refers to differences between males and females of the same species. Humans and apes are sexually dimorphic. This is linked to competition.
12. **Rotate hands at least 180°**
13. **Olfactory brain centres** reduced/reduced sense of smell
14. **Parts of the brain that process information from the hands and eyes are enlarged**



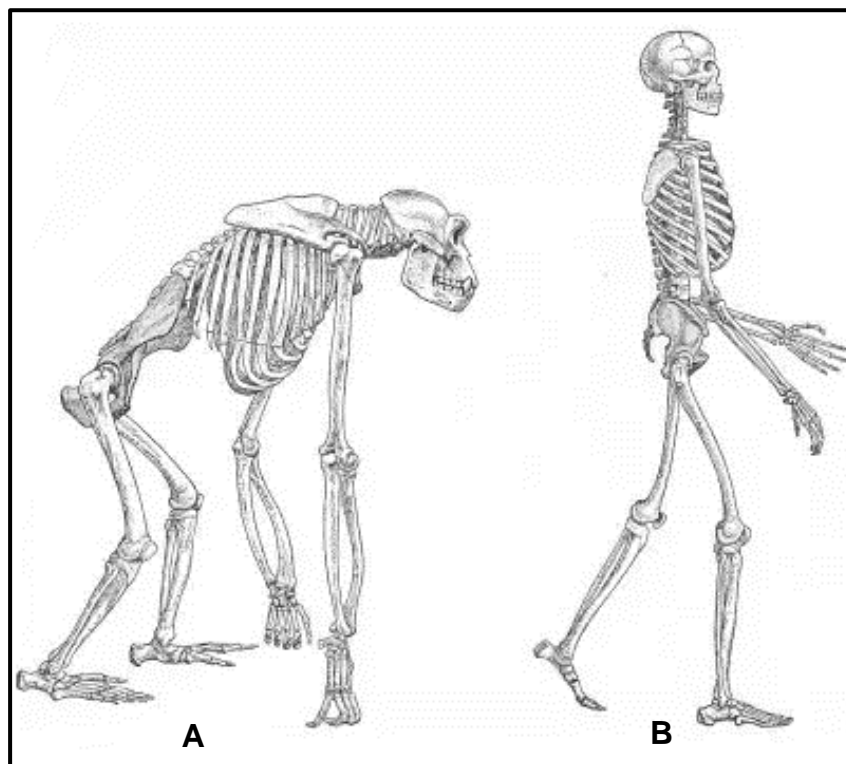
#Note (correct way of stating them)

Correct way to state	Incorrect way
Large brain relative to body size	Not just large brain- elephants have large brain too
Two eyes in front of the head	Two eyes
Long upper arms	Long arms
Upright posture	Can stand up straight
Two teats/nipples	Two mammal glands
Freely rotating arms	Rotating arms
Elbow joints allowing rotation of forearm	Elbow rotate

ACTIVITY 13



13 Skeletons of an African ape and a human



13.1.1. Organism **A** and **B** belong to the same order and family.

Give the name of the order and family (1)

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

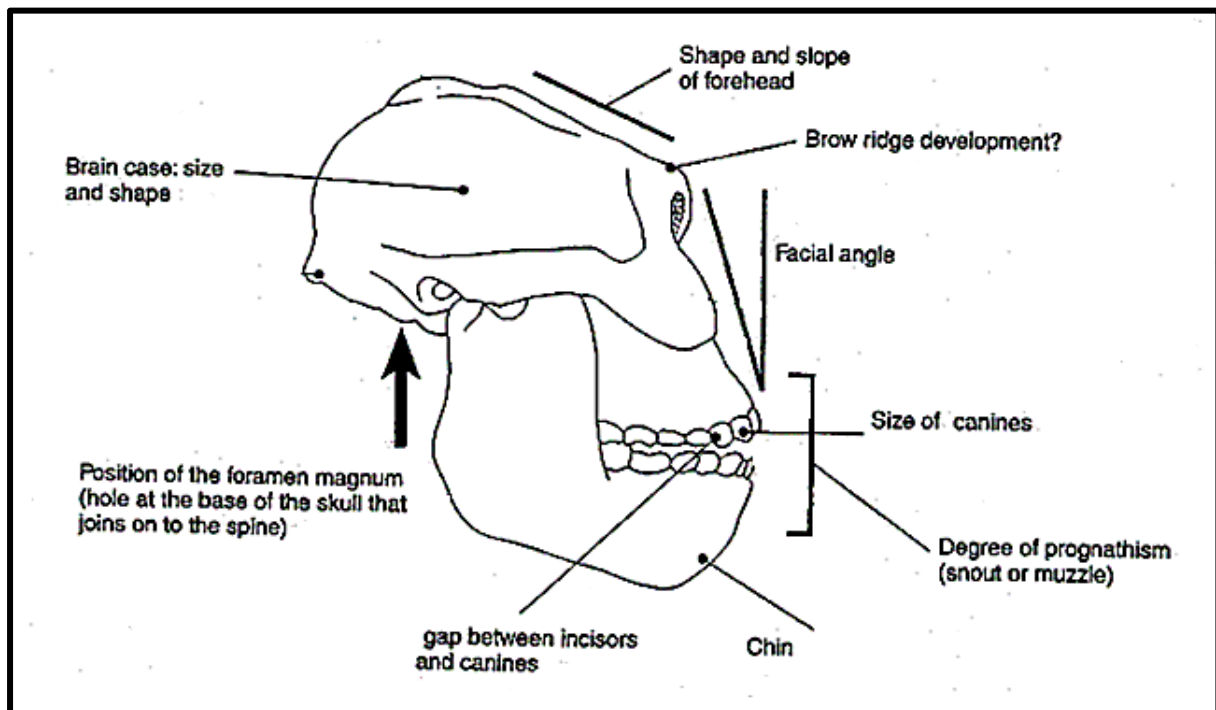
13.1.4. Which organism: (1)

- a) Belongs to the hominin group
- b) Is quadrupedal
- c) Belongs to Mammalia

13.1.5. What is the different function of the opposable thumbs of organism **A** and **B**? (2)

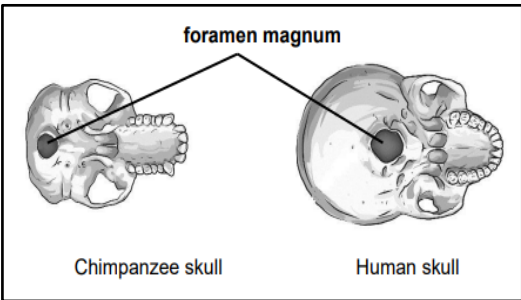
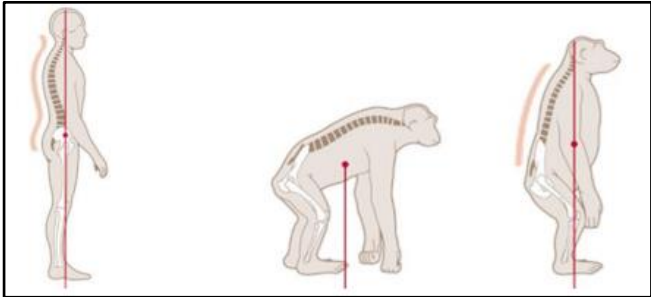
13.1.6. Give any other similarities that you did not mention in 13.1.2

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



Differences between Homo sapiens and other primates



<i>Homo sapiens</i>	<i>Other primates</i>
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 at the bottom of the skull	3. Foramen magnum in a more backwards position at the bottom of the 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 curve/ S- shape	11. Less curve/ C- Shape
	
12. Pelvic girdle short and wide	12. Pelvic girdle long and narrow
13. Palate small and round	13. Palate long and rectangular

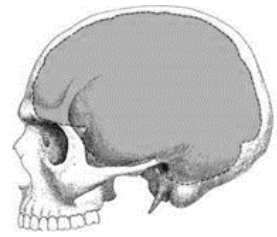
(visible features)

Mistakes made when answering anatomical differences/ visible differences



Brain size- if the brain is not indicated in a diagram, you cannot state large brain and small brain when the question refers to visible differences.

Skull with brain



Skull without a brain

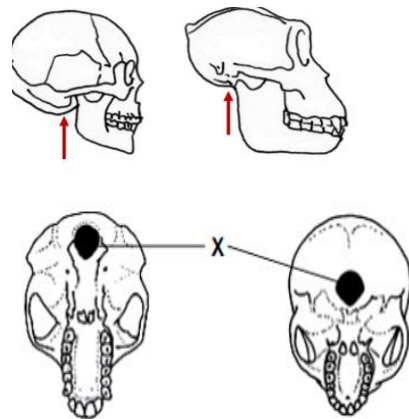


Foramen magnum

Human- *more forward position*

African apes- *more backwards position*

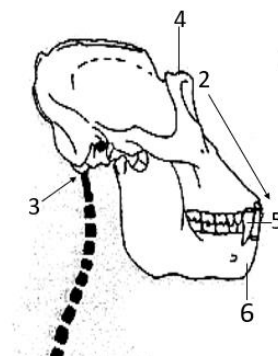
In both cases you must refer to more forward/backwards position at the bottom of the skull



Brow ridges are well or not well develop. (number 4)

No marks will be allocated for:

- Big and small brow ridges
- Visible and not visible
- Prominent and not prominent



Lower jaw has a well-developed chin or poorly develop chin (number 6)

No marks will be allocated for:

- Prominent and not prominent
- Big and small chin

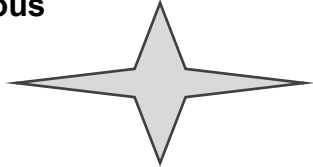
JAWS

In Humans

None – prognathous

OR

Less protruding



In African Apes

Prognathous

OR

More protruding

Teeth

Canines is larger or smaller

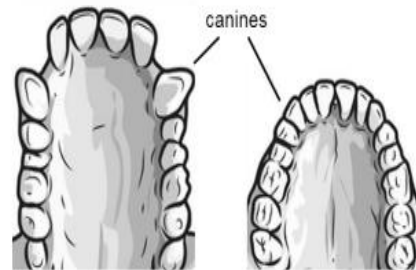
It is canines and not teeth

Not:

Big and small

Larger and shorter

Larger and smaller teeth



Chimpanzee

Human

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



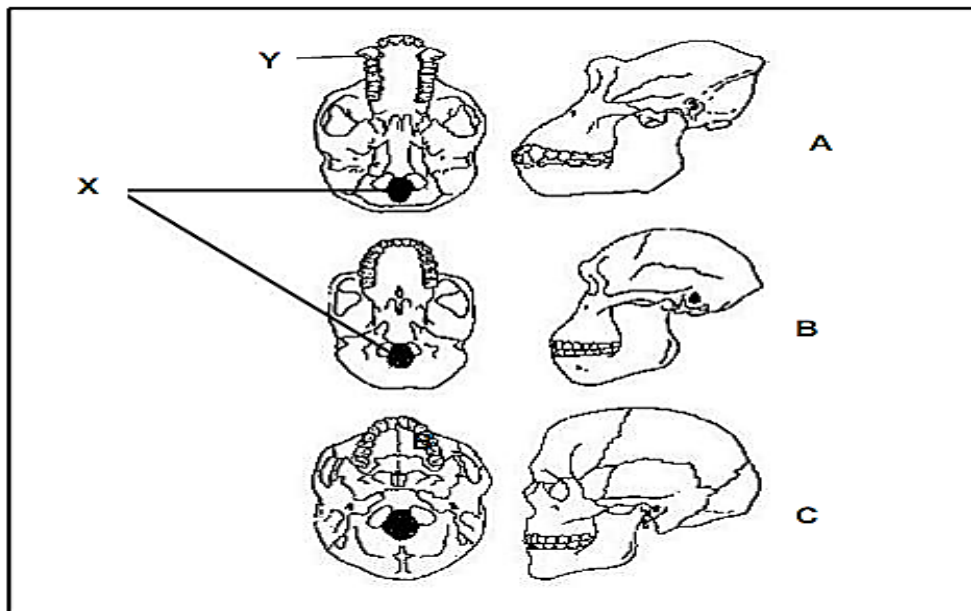
Structure	Significance
<p>Foramen magnum</p> <p>The foramen magnum was in a backward position at the bottom of the skull in the ape-like beings✓ but in a forward position at the bottom of the skull in modern humans✓</p>	<p>This represents a change from quadrupedal in ape-like beings</p> <p>To bipedalism in modern humans, leading to the following in modern humans:</p> <ul style="list-style-type: none"> • 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 S /lose body heat to surroundings in hot conditions/reduce overheating • Display of sex organs /breasts as part of courtship behaviour
<p>Cranium</p> <p>Modern humans have a larger cranium than the ape-like beings</p> <p>Modern humans have a less sloping forehead than the ape-like beings</p> <p>Modern humans have a cranium that is more rounded than the ape-like beings</p>	<p>This allowed space for a larger brain in humans than in ape-like beings, making the following possible:</p> <ul style="list-style-type: none"> • Better co-ordination of movement • Processing of a large amount of information • 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	<ul style="list-style-type: none"> • This corresponds with a change in diet from hard, raw food✓ in the ape-like beings • To softer, cooked food✓ in humans
Dentition/Teeth In ape-like beings there are gaps/diastema between incisors and canines but no gaps between the teeth in humans Humans have smaller canines than the ape-like beings Humans have flatter molars and pre-molars than the ape-like beings	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Developed chin assists with speech in humans
Zygomatic arch In humans the zygomatic arch is less developed than in the ape-like beings	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • Support greater weight due to the upright position
Spine Humans' spine is more curve/ S- shape and ape-like beings is less curve/ C- Shape	<ul style="list-style-type: none"> • For flexibility • Shock absorption



ACTIVITY 14

14.1 Fossilised skulls of three different species of primates.



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

14.1.2. Which skull belongs to:

- a) Hominidae
 - b) Hominin
 - c) Bipedal
- (3)

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

14.1.4 Tabulate FIVE visible differences between the skulls of **A** and **C** (6)
(14)

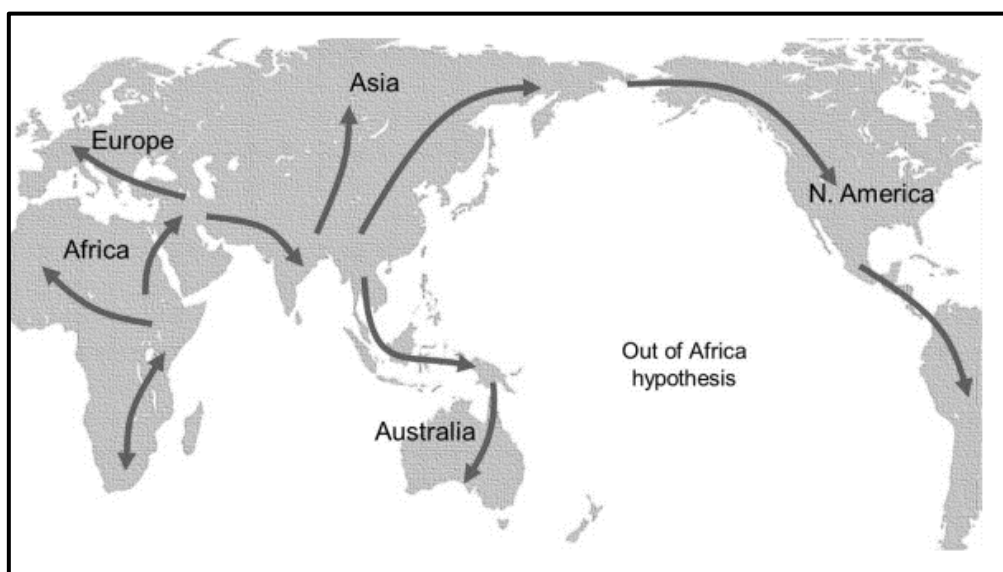


Out of Africa Theory

CONTENT	ELABORATION
Out-of-Africa hypothesis	<ul style="list-style-type: none"> □ The Out-of-Africa hypothesis: Modern humans originated in Africa and then migrated to other continents □ Evidence for the 'Out-of-Africa' hypothesis: <ul style="list-style-type: none"> • Fossil evidence: information on each of the following fossils that serve as evidence for the 'Out-of-Africa' hypothesis: <ul style="list-style-type: none"> ○ Ardipithecus (fossils found in Africa only) ○ Australopithecus (fossils found in Africa only, including Karabo, Little ○ Foot, Taung Child, Mrs Ples) ○ Homo (fossils of Homo habilis found in Africa only; oldest fossils of Homo erectus and Homo sapiens found in Africa, while the younger fossils were found in other parts of the world) • . Genetic evidence: mitochondrial DNA □ Timeline for the existence of different species of the genus Homo and significant features of each of fossil type to show the differences amongst them □ Interpretation of phylogenetic trees proposed by different scientists showing possible evolutionary relationships as it applies to hominid evolution

The out of Africa Hypothesis

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



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

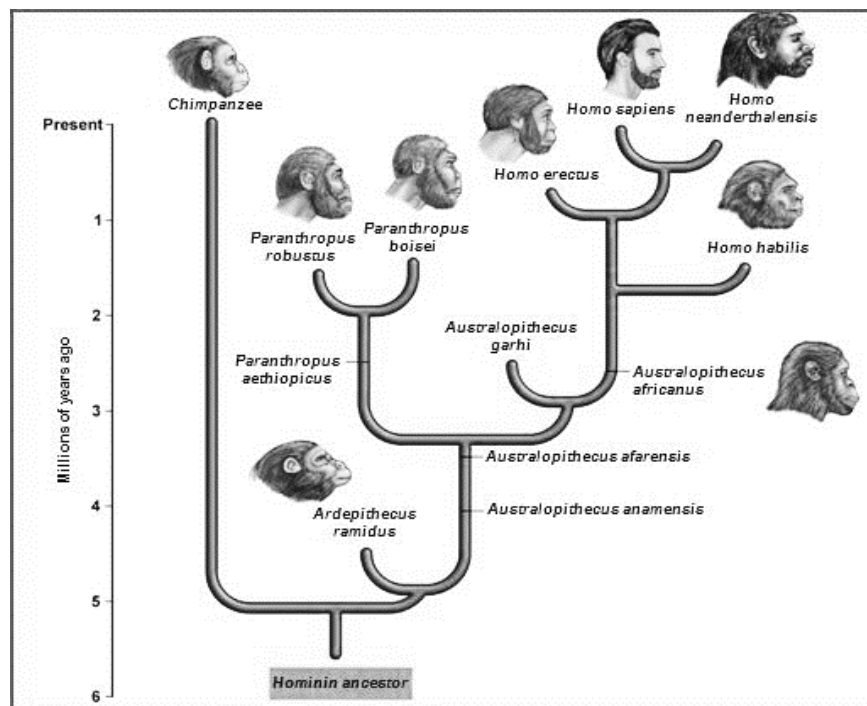
13.1.1 Fossil evidence:

It must be explained as stated here

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

- o Ardipithecus fossils found in **Africa only**
- o Australopithecus fossils found in **Africa only** (Karabo, Little Foot, Taung Child, Mrs Ples)
- o Homo -fossils -
 - **Homo habilis** found in **Africa only**
 - **Oldest fossils of Homo erectus and Homo sapiens** found in Africa,
 - **Younger fossils** were found in other parts of the world)

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



Tree phyla are used in the fossil evidence

Ardipithecus → *Australopithecus* → *Homo* (what learners must know in fossil evidence – lines of evidence)

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

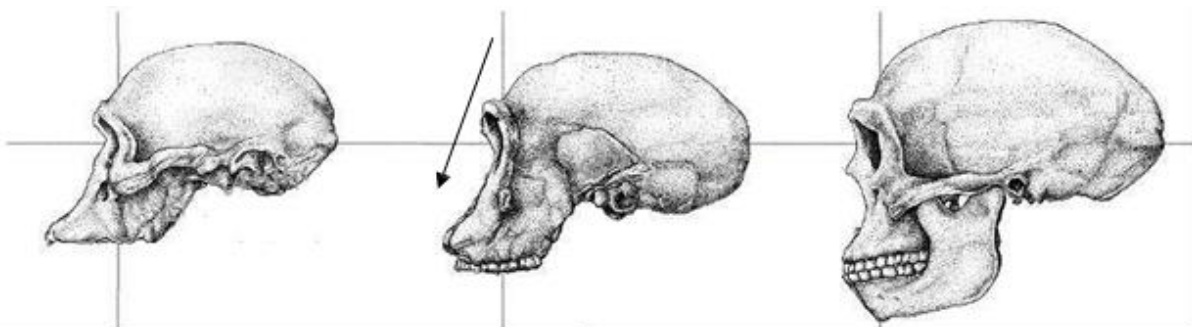
Fossils that are used as reference

<i>Ardipithecus</i>	<i>Ardipithecus ramidus</i>
<i>Australopithecus</i>	<i>Australopithecus afarensis</i> – Lucy
	<i>Australopithecus africanus</i> Mrs. Ples Taung child Little foot
	<i>Australopithecus sediba</i> Karabo
<i>Homo</i>	<i>Homo habilis</i> (the one that used tools) <i>Homo erectus</i> (the first to stand up straight) <i>Homo sapiens</i> (modern humans of today)

Changes in structure that characterise human evolution (learners 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: o *Ardipithecus* o *Australopithecus* o *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
sapience's

Homo habilis

Homo

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

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

The fossils are dealt with in the order in which they appeared on earth.
(the characteristics will be given to learners, but learner must know who discovered the fossil)



Organism	When organism existed	Fossil site	Discovered by	Characteristics
<i>Ardipithecus ramidus</i> (Ardi)	5 – 4 mya	North-East Ethiopia	Tim White	Brain size: 300–350ml Forward position of foramen magnum Very prognathous (more protruding jaws) Heavy brow ridges Pelvis structure: bipedal and tree climbing

<i>Australopithecus afarensis</i> (Lucy)	4 – 2,7 mya	Ethiopia, Kenya, Tanzania	Donald Johanson	Brain size: 375–550ml Forward position of foramen magnum Very prognathous Heavy brow ridges Canines large and pointed Long arms. No cranial ridge
<i>Australopithecus africanus</i> (Mrs. Ples, Taung child, Littlefoot)	3 – 2 mya	Mrs. Ples Sterfontein Taung; Sterkfontein Little foot Sterkfontein	Robert Broom Raymond Dart Ron Clark	Brain size: 428–625 ml Forward position of foramen magnum Prognathous Brow ridges Teeth large, canines not long Long arms No cranial ridge
<i>Australopithecus sediba</i> (Karabo)	1,9 – 1,8 mya	Malapa Cave – in the cradle of humankind	Lee Berger	Brain size: 420 ml Less prognathous Brow ridges Large teeth, canines not long, Long arms No cranial ridge
<i>Homo habilis</i>	2,2 – 1,6 mya	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges Human-like teeth – smaller canines. Long arms
<i>Homo erectus</i>	2 – 0,4 mya	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter arms

<i>Homo sapiens</i>	200 000 years ago – present	Makapansgat in Limpopo; Border Cave in KZN; Blombos Cave in the Western Cape	Tim White	Brain size: 1200–1800 ml No brow ridges Small teeth Short arms
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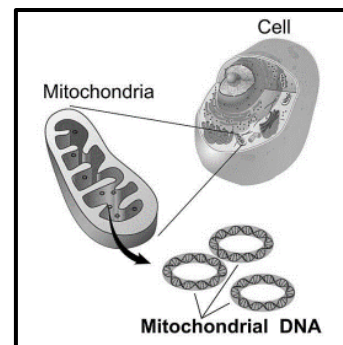
Australopithecus Fossils found in the Cradle of humankind

- Hominid species found in South Africa
- Mrs. Ples(*Australopithecus africanus*),
- Little foot (*Australopithecus africanus*),
- Taung child(*Australopithecus africanus*),
- Karabo(*Australopithecus sediba*) is also regarded as Is the missing link between *Australopithecus africanus* and *Homo erectus*.

13.1.2 Genetic evidence: mitochondrial DNA

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

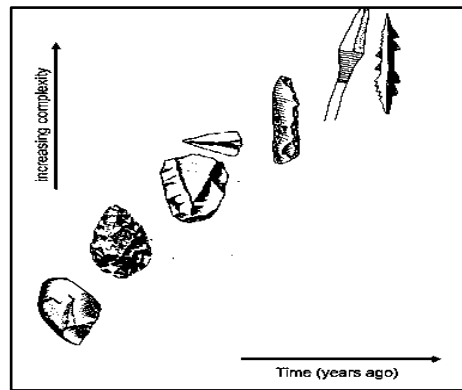
- mtDNA of the sperm cell does not fuse with mtDNA of the egg cell
- mtDNA is therefore handed down from **mother to child**
- By following mutations in mtDNA, we can trace our female line of descent.
- Analysis of mitochondrial DNA leads to ancestral female who lived in East Africa about 150 000 years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

13.1.3 Cultural evidence: toolmaking

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



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



- Behaviour like burial sites



ACTIVITY 15

15 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 cm³; around one-third the size of the modern human brain which has an average volume of about 1 300 cm³. The findings suggested that *H. erectus* may be the ancestor of *H. floresiensis*, as *H. erectus* had brains about 860 cm³ in size or, alternatively, it may have evolved from *H. habilis*, whose brains were about 600 cm³ in size.

- 15.1.1 Name the TWO lines of evidence for human evolution that is referred to in the extract above (2)
- 15.1.2 How long did *Homo floresiensis* exist on Earth? (1)
- 15.1.3 Name ONE *Homo* ancestor mentioned in the extract. (1)
- 15.1.4 Describe ONE feature of the skull that can be used as evidence for bipedalism. (2)
- 15.1.5 State TWO similarities between the hands of African apes and modern humans. (3)
- 15.1.6 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
- 15.1.7 Draw a table to show the brain volumes of the different *Homo* species, using information from the extract. (4)

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

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

15.2.1. What type of evidence of human evolution is given in the table (1)

15.2.2 Give the

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

15.2.3 Name FOUR fossils of *Australopithecus* that are found in Africa only. (4)

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

15.2.5 Give evidence in the table that suggests that:

- a) *Homo habilis* and *Homo erectus* may have existed at the same time (1)
- b) *Ardipithecus* was the most primitive of all the primate genera (1)

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

15.2.7 Explain how genetic evidence as a line of evidence contributes to human evolution. (4)



ACTIVITY 16

16 The image below is of Mrs. Ples



16.1.1 Give the

- a) Genus and species to which Mrs. Ples belong to (1)
- b) Site where Mrs. Ples was found (1)
- c) The scientist that found Mrs. Ples (1)

16.1.2 Name THREE ape-like features of this skull (3)

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

2 16.2.1. Complete the table

Organism	Fossil site	Discovered by
<i>Ardipithecus</i>		
		Lee Berger
	Indonesia and Swartkrans	
	Makapansgat in Limpopo; Border Cave in KZN	Tim White
Lucy		Donald Johanson
	Sterkfontein	R Dart

16.2.2. Give the name of the *Australopithecus afarensis* that was found in Kenya and Tanzania .

16.2.3. Give the *Australopithecus africanus* that was discovered by

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



ACTIVITY 17 – Scientific Investigation Question

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

Scientists wanted to investigate which salt concentration resulted in the highest percentage of hatched cysts

They did the following:

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

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

- 17.1. State TWO planning steps to consider before collecting the samples. (2)
- 17.2 State the: (1)
a) Independent variable (1)
b) Dependent variable. (1)
- 17.3 Calculate the value of X in the table. Show ALL working. (3)
- 17.4 State THREE factors that were kept constant in order to ensure the validity of this investigation. (3)
- 17.5 Which salt concentration resulted in the highest percentage of hatched cysts? (1)

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- GMMDC – Life Sciences Grade 12 – Teacher’s Guide.
- Department of Basic Education - Life Sciences GR 12 Exam Guidelines 2021 Eng
- Department of Basic Education – Sources from Various Previous Question Papers.