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GRADE 12

Life Sciences

SELF STUDY GUIDE 5

EVOLUTION

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1. INTRODUCTION

The declaration of COVID-19 as a global pandemic by the World Health Organisation led to the disruption of effective teaching and learning in many schools in South Africa. The majority of learners in various grades spent less time in class due to the phased-in approach and rotational/ alternate attendance system that was implemented by various provinces. Consequently, most schools were not able to complete all the relevant content designed for specific grades in accordance with the Curriculum and Assessment Policy Statements in most subjects.

As part of mitigating against the impact of COVID-19 on the current Grade 12, the Department of Basic Education (DBE) worked in collaboration with subject specialists from various Provincial Education Departments (PEDs) developed this Self-Study Guide. The Study Guide covers those topics, skills and concepts that are located in Grade 12, that are critical to lay the foundation for Grade 12. The main aim is to close the pre-existing content gaps to strengthen the mastery of subject knowledge in Grade 12. More importantly, the Study Guide will engender the attitudes in the learners to learning independently while mastering the core cross-cutting concepts.

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2. HOW TO USE THIS SELF-STUDY GUIDE

- There are five Self- study Guides covering all Grade 12 topics:
  - Booklet One: DNA: Code of Life and Meiosis
  - Booklet Two: Reproduction in Vertebrates, Human reproduction, Endocrine System and Homeostasis
  - Booklet Three: Genetics and Inheritance
  - Booklet Four: Responding to the Environment: Humans and Plants
  - **Booklet Five: Evolution: Natural Selection and Human evolution**
- You must use this Self-study Guide together with the *Life Sciences Mind the Gap Study Guide*.
- You need to study the content from the *DBE Grade 12 Textbook, DBE Examination Guidelines 2021,* and *Mind the Gap* for all the topics.
- Ensure you understand all the relevant concepts and content.
- This Self-study Guide focuses mainly on the skills you will need to answer the questions in examinations.
- There are exam technique and tips for each topic (*in italics*)
- These tips will guide you on how to approach certain question types in the Life Sciences Examination papers and tests:
  - How to master the relevant terminology
  - Drawing and interpreting of graphs
  - Interpreting tables
  - Interpreting diagrams
  - Genetics crosses and pedigree diagrams
  - Doing calculations
  - Scientific investigation questions
- At the end of each booklet, you will find typical examination questions and answers

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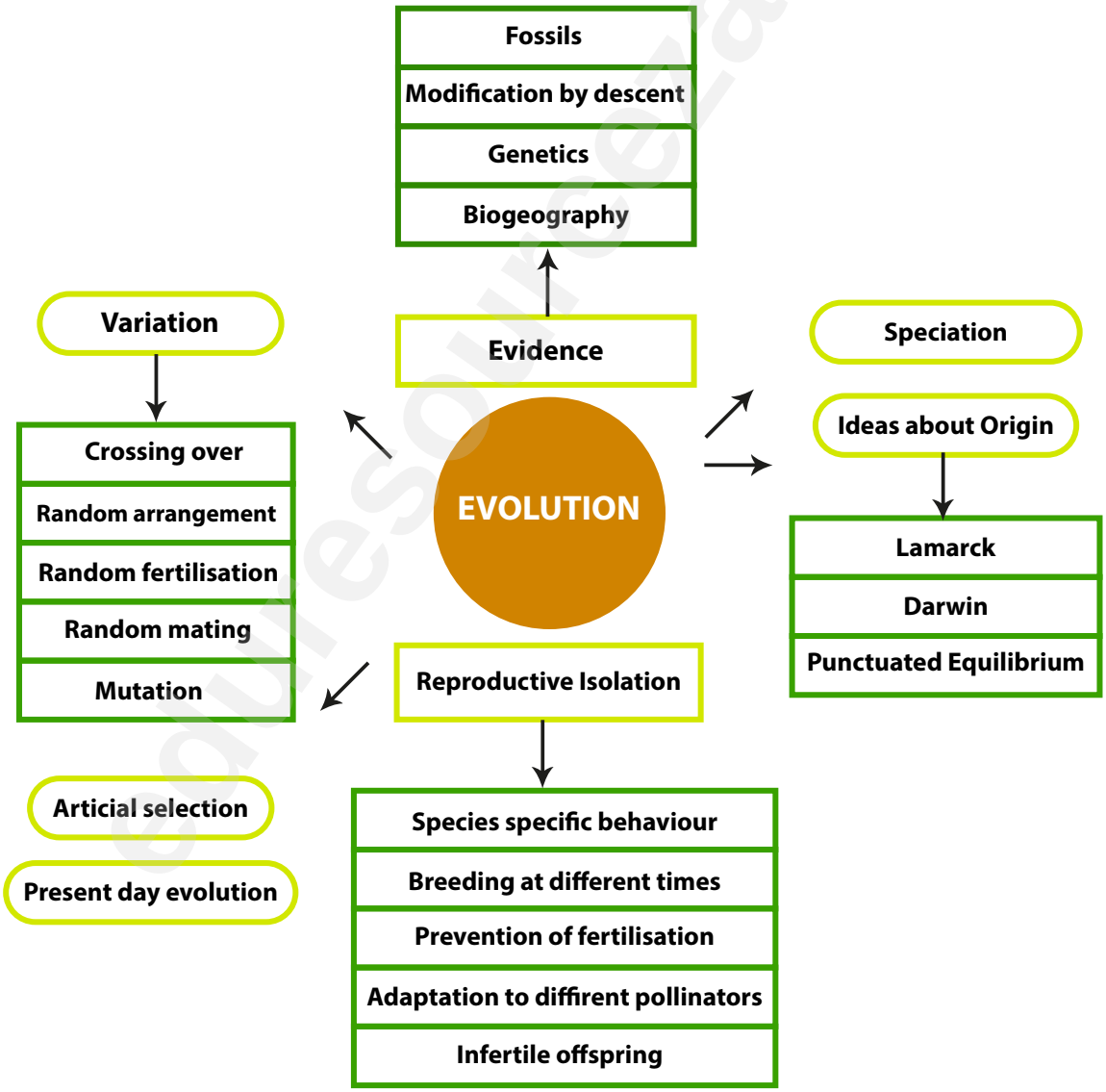
1. TOPIC: EVOLUTION			
TERM	3	PAPER	2
DURATION	8 hours (3 weeks)	WEIGHTING	54 marks
PRIOR-KNOWLEDGE/BACKGROUND KNOWLEDGE			
Gr 10 History of life, classification, Grade 11 biodiversity in animals and plants, Grade 12 DNA, Meiosis			
RESOURCES			
DBE 2020 Textbook, MTG, Past NSC, SC & Provincial Question Papers			

3.1. KEY CONCEPTS/ MIND MAPS



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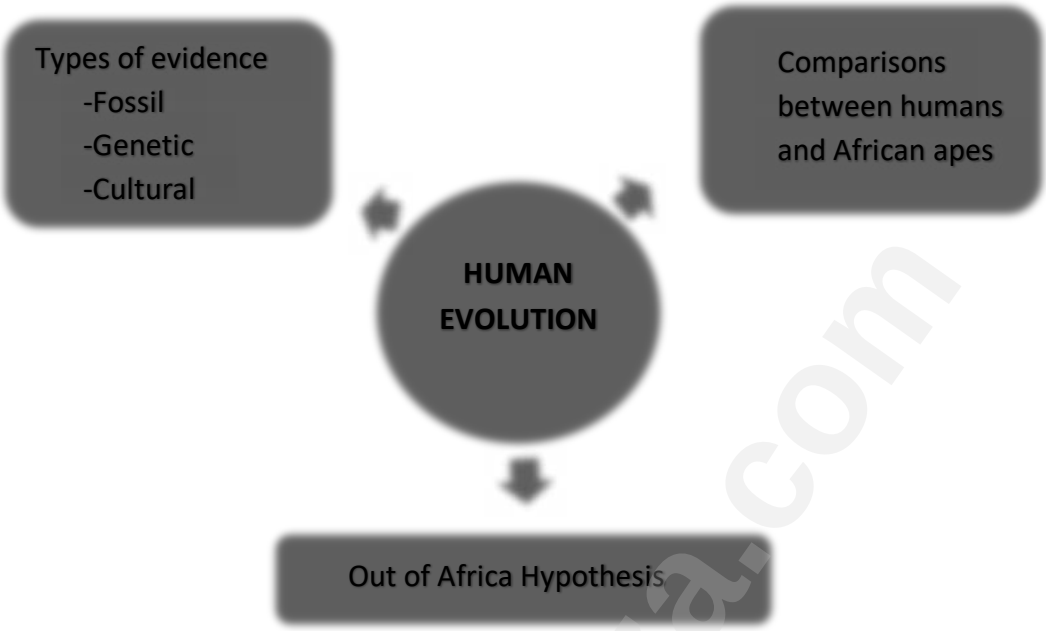

3.2. TERMINOLOGY LIST

TERM	DEFINITION
Acquired characteristic	Is a characteristic that an offspring is not born with but which develops/is acquired through the course of its lifetime; a characteristic not controlled by a gene.
Artificial selection/selective breeding	The breeding of organisms over many generations in order to achieve a desirable phenotype
Biodiversity	The variety of plant and animal species on earth
Biological evolution	Any genetic change in a population that is inherited over several generations
Biotechnology	The use of biological processes, organisms or systems to improve the quality of human life
Common ancestor	An ancestor that two or more descendants have in common
Continuous variation	Type of variation within a population in which there is a range of intermediate phenotypes
Discontinuous variation	The type of variation in a population with no intermediate phenotypes
Extant	Still in existence; surviving
Extinction	The permanent disappearance of a species from earth
Evolution	The processes that have transformed life on earth from its earliest forms to the vast diversity that characterizes life on earth today.

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The Theory of Evolution	The Theory of Evolution is regarded as a scientific theory since various hypotheses relating to evolution have been tested and verified over time
Fossils	The mineralized remains of organisms that have lived in the past
Gene	A segment of DNA/a chromosome that codes for a characteristic
Genetic variation	This includes a variety of different genes that may differ from maternal and paternal genes resulting in new genotypes and phenotypes.
Homologous structures	Pertain to the structures that show similar **morphology** and **anatomy** but have different functions, believed to have developed from a common ancestor
Hypothesis	A tentative explanation of a phenomenon that can be tested and may be accepted or rejected
Inherited characteristic	Is a characteristic that an offspring is born with, having been inherited from one of the parents; a characteristic controlled by a gene.
Mutation	A sudden change in the sequence/order of nitrogenous bases of a nucleic acid
mya	Million years ago,
Natural selection	The process by which organisms best suited to survival in the environment achieve greater reproductive success, thereby passing advantageous characteristics onto future generations
Palaeontology	Study of fossils
Phenotype	This is the external, physical appearance of an organism. The phenotype is determined by the genotype.
Phylogenetic tree/cladogram	A diagrammatic representation showing possible evolutionary relationships among different species
Population	A group of organisms of the same species living in the same habitat at the same time
Speciation	Process whereby new species are formed from the original population
Species	A group of organisms which can interbreed to produce fertile offspring
Theory	Explanation of an observation that is supported by facts, models and laws
Transitional fossil	Shows **intermediate** characteristics between two genera/species. It has **characteristics common** to both the **ancestor species** and the **descendant species** that follows.
Useful mutations	Can be advantageous to the organism and are passed on from parent to offspring

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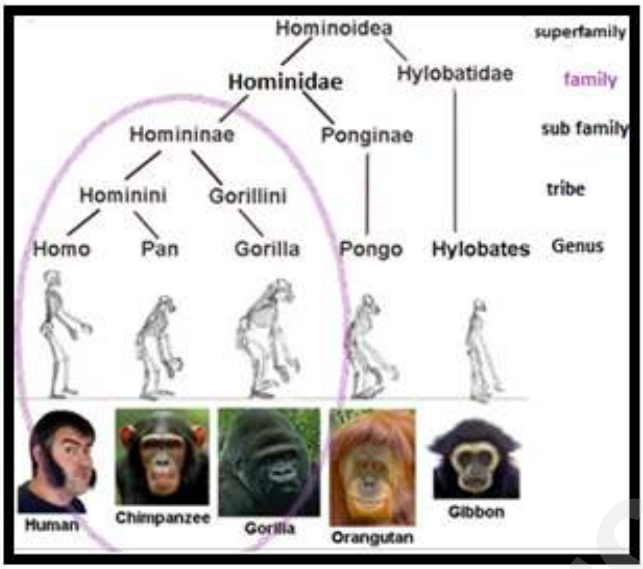
3.3 LINKS TO PRIOR KNOWLEDGE

GRADE 10 LINKS:

- **Classification** in grade 10 taught you how to write scientific names. In human evolution, you must know the difference between a **family name**, a **genus** and a **species**.



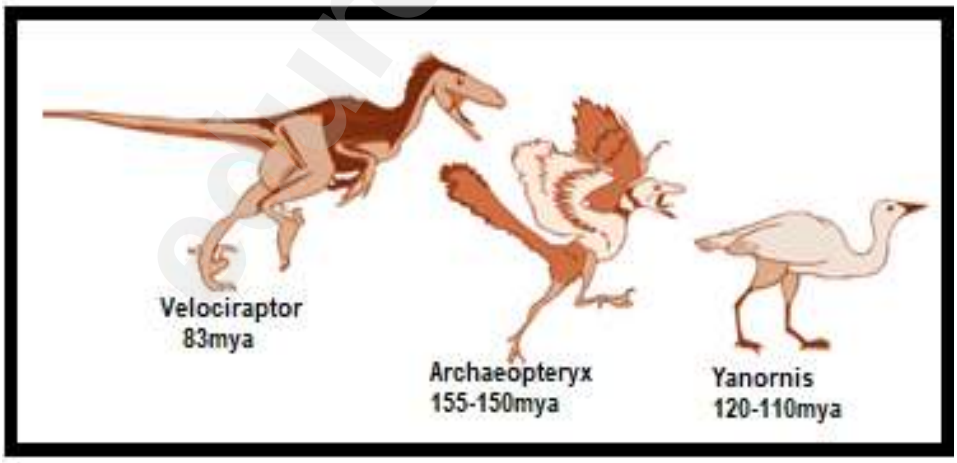
Family name: Hominidae
How scientific names are written:

Genus	**species**
Homo	*neanderthalensis*
Homo	*sapiens*
Australopithecus	*anamensis*
Gorilla	*gorilla*
Pan	*troglodytes*

Genera= the plural of genus
We sometimes shorten genus name with a capital letter and a full stop.
H. sapiens or *P. troglodytes*

Source: https://www.evolutionarymodel.com/apps/photos

- In grade 10 you've learnt about **fossils**, which are the mineralised remains of past living organisms in rock. The fossils are used to see how organism have changed from the past to now. An important concept in grade 12 evolution is **transitional fossils** that shows the changes between older organisms and the newer organism. This concept will be used in human evolution.



The *archaeopteryx* is a transitional fossil between a dinosaur and a bird.

source: Socrates.org

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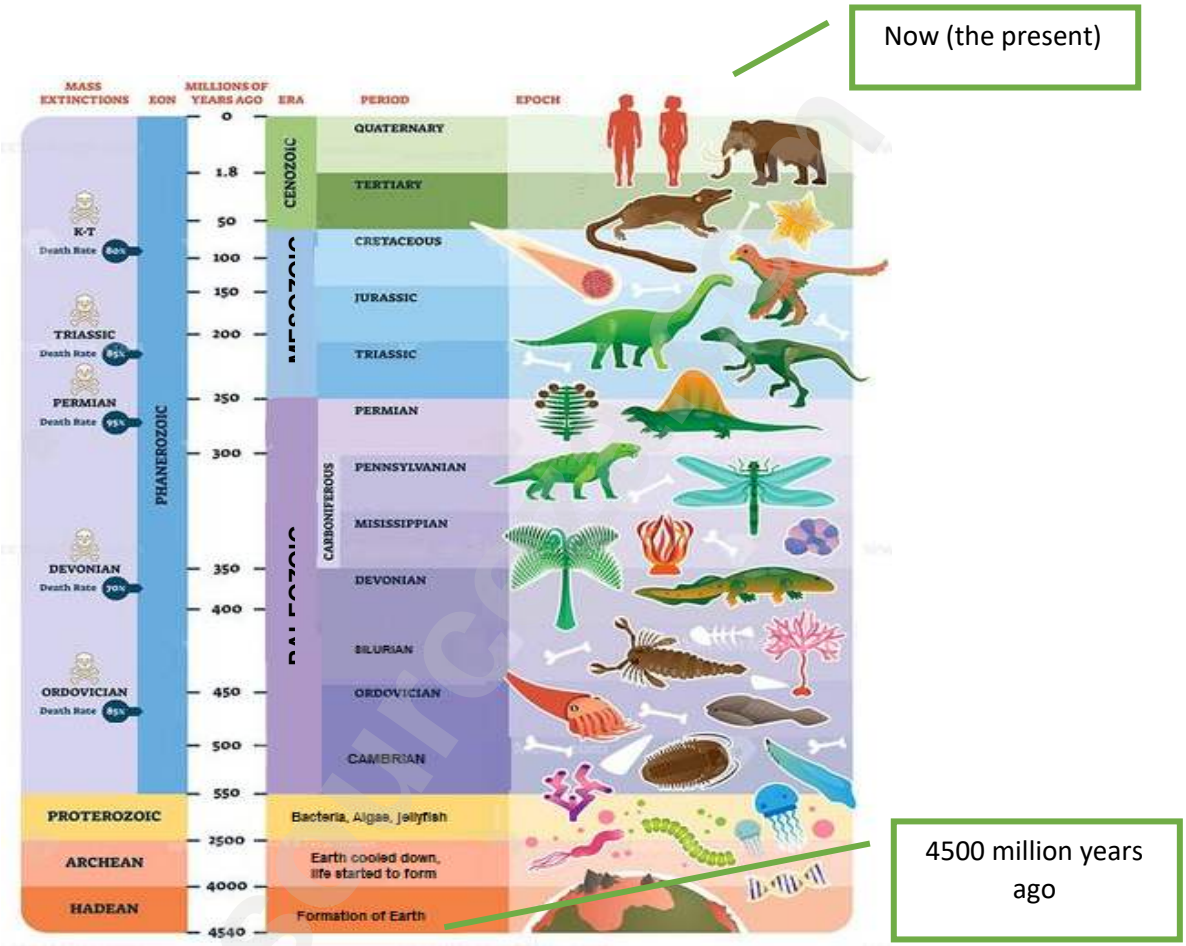
- **The geological timescale** shows the history of life on Earth. There has been life on Earth for the past 4.5 billion years.



Source: https://vectormine.com/item/geologic-timeline-scale-vector-illustration-diagram

- The diagram above is an example of a geological timescale that was done in grade 10.
- You don't have to know the eras or periods or study this timescale.
- Observe how organisms evolved from less complex to more complex throughout the years.

- **Biogeography** is used as evidence for evolution in grade 12.

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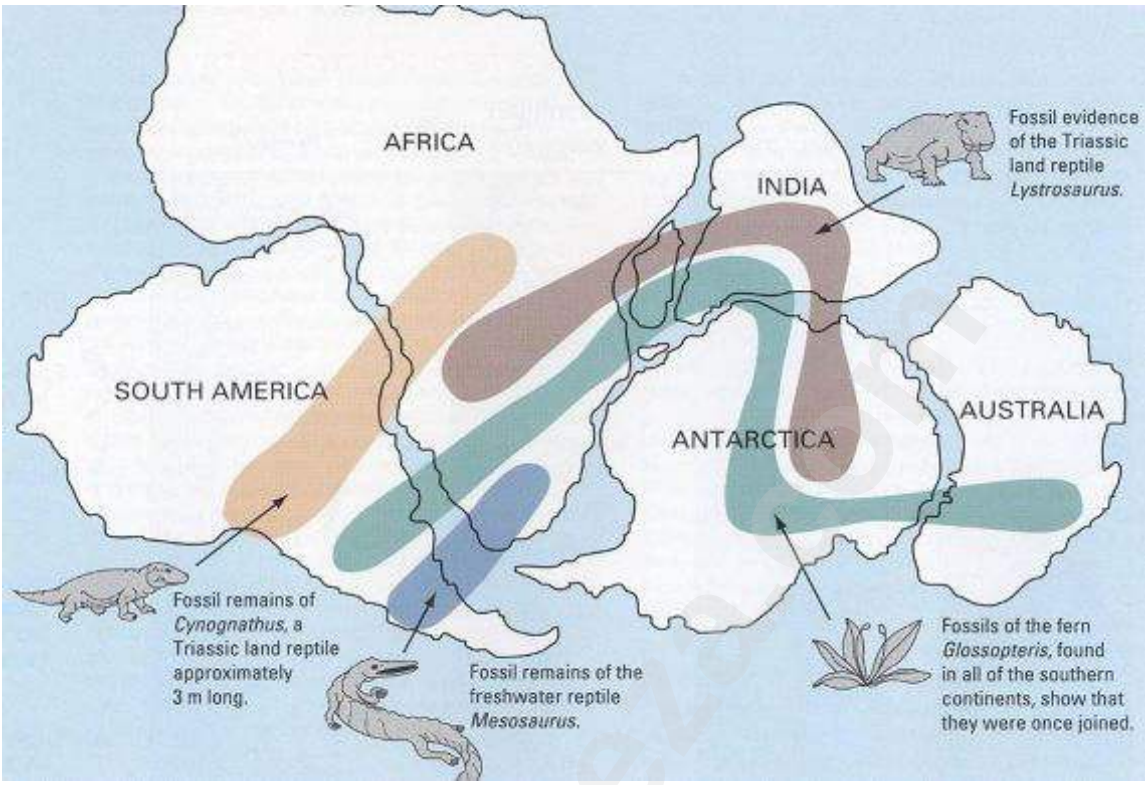

Snider-Pellegrini Wegener fossil map Source: Biologydictionary.net

The diagram shows the *Lystrosaurus* whose fossils are found in Africa, India and Antarctica.
The *Glossopteris*' fossils are found in Australia, Antarctica, Africa and South America.
The *Mesosaurus* and *Cynognathus* fossils are found in South America and Africa.

It is proof that these continents were once joined.

GRADE 11 LINKS:

- Evolution in present times links with micro-organisms and immunity that was done in grade 11.
- **Bacteria and viruses** (think of Covid-19) evolves quickly through genetic mutations into other strains. It causes resistance to medication as the micro-organisms evolve too quickly.

- Malaria mosquitoes became resistant to insecticide.
- Tuberculosis bacteria became resistant to TB drugs because of mutations.
- HIV virus became resistant to ARV

-**Phylogenetic trees** are done with plant and animal biodiversity in grade 11. It shows the evolutionary links between different organisms over a span of time

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GRADE 12 LINKS:

- **Genetic evidence** used for evolution is based on mutations that you've done in grade 12 DNA and protein synthesis as well as in genetics. This evidence is used to indicate how closely organisms are related. Scientists state that organisms are closely related and are likely to have a common ancestor if they have:
- Identical DNA structure
- Similar sequence of genes
- Similar portions of DNA with no functions
- Similar mutations**. Mitochondrial DNA** is used as evidence for human evolution. The mutation within the mitochondrial DNA is used as markers.

Here follows an example of mutations in amino acids in different species:

Species	Number of Amino Acids that differ from a human haemoglobin chain (total length 146 amino acids)
Gorilla	1
Rhesus monkey	8
Mouse	27
Chicken	45
Frog	62

Source: https://open.lib.umn.edu/evolutionbiology

The fewer differences the more closely related they are. Humans and Gorillas have only 1 amino acid that differs, so we are closely related

Species that are closely related have a greater similarity to each other than distant species.

- Evolution also links to **meiosis** in grade 12 especially when you deal with variation. **Crossing over** and **Random arrangement** are two processes in meiosis that deals with genetic variations.

3.4 EXAM TIPS/TECHNIQUES/NOTES

Please note:

Only problematic topics identified by the DBE diagnostic report is discussed in this section. Refer to DBE textbook and exam guidelines to study *all* the required topics.

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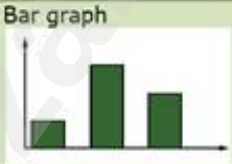
3.4.1. VARIATION

- Remember sources of varation:

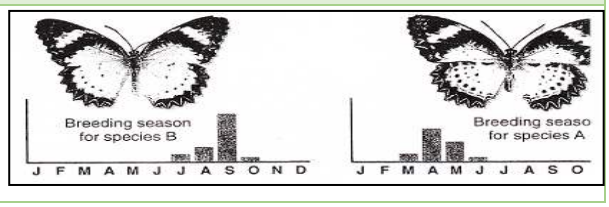
CRRRM → crossing over, random arrangement, random fertilisation, random mating, mutations

- You need to know the difference between the types of variation, namely continuous and discontinuous variation. They will give you examples and then you have to be able to distinguish between them.

	Continuous variation	Discontinuous variation
Properties	- No distinct categories - No limit on the value - Tends to be quantitative	- Distinct categories. - No in-between categories - Tends to be qualitative
Examples	• height • weight • heart rate • finger length • leaf length	• tongue rolling • finger prints • eye colour • blood groups
Representation	Line graph	Bar graph 
Controlled by	A lot of genes and the environment → range of phenotypes between 2 extremes, e.g. height in humans.	A few genes → limited number of phenotypes with no intermediates e.g. A, B, AB and O blood groups in humans

3.4.2. MECHANISMS OF REPRODUCTIVE ISOLATION

Rembember the 5 methods of reproductive isolation:

1.Prevention of fertilisation (example: very small and large dogs cant mate, small female will not be able to give birth normally)	
2.Species-specific courtship behaviour (example: male birds doing specific dances to attract female partner)	
3.Breeding at different times of the year (example: butterflies breeding at different seasons)	

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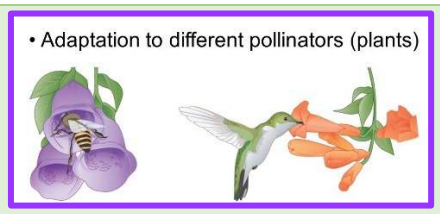
4.Plant adaptation to different pollinators (plants adapted to insects, wind and birds for pollination- link back to grade 11)	
5.Infertile offspring (Example: when donkeys and horses mate they produce mules who are infertile)	

PRACTICE QUESTION 1 (DBE P2 NOVEMBER 2020)

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

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

This is the aim containing both variables

Independent variable (what will be changed)

Dependant variable (what will be measured)

The procedure was as follows:

Sample size

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

How the dependant is measured

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

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The results are shown in the table below.

GROUP	AVERAGE NUMBER OF NESTS PRODUCED
1	0,5
2	2,5
3	1

Not the dependent variable, but how they measured it

1.1 Name the:

(a) Reproductive isolating mechanism that occurs in long-tailed widowbirds. **(1)**

Species-specific courtship behaviour✓

(b)Independent variable in this investigation **(1)**

Independent variable can be found in the aim of the investigation. This is usually where they tell you what they wanted to do.

Length of the (male long-tailed widowbird's) tails✓ **(2)**

1.2 Explain why 27 long-tailed widowbirds were used in the investigation instead of only 3.

They are talking about the size of the sample that has to do with reliability. The bigger it is the more reliable the investigation becomes. **(2)**

A larger sample size✓

Increase the reliability of the investigation✓

Explain why Group 3 was included in the investigation.

1.3 *Nothing was done to group 3, so it's the control, explain what the control is used for. Controlled groups/variables ensure validity.* **(2)**

- To serve as a control✓
- So that it can be compard with the other groups✓
- And show that the tail length is the only factor that affects the results✓/improves the validity of the investigation

State a conclusion for this investigation.

1.4 *Refer back to the aim where the two variables are mentioned. You have to talk about the relationship between the two variables* **(2)**

The longer the (male long-tailed widowbird's tail), the higher the mating success✓✓

OR

The shorter the (male long-tailed widowbird's) tail, the lower the mating success✓✓

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3.4.3. LAMARCK'S THEORY

Guiding questions when Lamarck's theory is applied to a new situation:

- What was the original characteristic?
- What was the challenge?
- What did the organism do/what characteristic was then acquired?
- What was the result?
- What happened to this acquired characteristic**?**
- What was the result of this?

Rejection of Lamarks' theory:

- Organisms do not evolve because they were *determined* to change but changes took place *randomly* due to *mutations*
- Acquired characteristics cannot be inherited i.e., the *phenotype* cannot affect the *genotype* as discovered later by Mendel.

Practice Question 2 (DBE November 2019, P2)

MUTATION IN GENE ALLOWS TIBETANS TO SURVIVE AT HIGH ALTITUDE

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

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

Tip:

Read the questions first and then you read the case study. It helps you to focus when you read the case study.

2.1 A gene mutation caused variation between the Tibetan population and the Han population. (3)

Name THREE other sources of variation in a human population.

*The key word here is **VARIATION** Remember causes of variation is CRRRM:*

Answer:

Crossing over✓

Random arrangement of chromosomes } **meiosis**✓

Random mating✓

Random fertilization✓

Chromosomal **M**utation✓

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If you wrote meiosis, you got a mark, but then you didn't get additional marks if you wrote crossing over or random arrangement of chromosomes because it's part of meiosis. Also, the question talks about gene mutation, and they want other sources of variation, so that is why it should be chromosomal mutation.

2.2

Give evidence from the extract which suggests that the survival of people living at high altitudes could be: **(1)**

(a) Due to a genetically inherited trait **(1)**

(b) Caused by an environmental factor

You need to read the passage and find the evidence for this.

a) Mutant gene/ inherited from their ancestors✓

b) Influenced by altitude/ level of oxygen ✓

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

*This question **links back to grade 11 and 10**. Haemoglobin is a protein found in red blood cells that carry oxygen in our blood to all the tissues etc. At High altitudes, there is less oxygen in the air than at low altitudes (sea level).*

Explain what the question wants you to answer in a cause-and-effect manner.

- More haemoglobin present ✓ *(cause)*
- To allow for maximum absorption of the available oxygen✓ *(effect)*

OR

- More oxygen will be available✓ *(cause)*
- To meet their energy needs✓ *(effect)*

(5)

2.4 **Describe how Lamarck would have explained the survival of Tibetans at high altitudes**

Refer to MTG page 68 to get the following recipe on how to answer

Lamarck:

Guiding questions	**Apply it to this question with the Tibetans (the memo)**
What was the original characteristic at the start?	Originally the number of red cells were similar in all humans✓ /Tibetians didn't produce large numbers of red cells
What did the organism do?	The red cells tried to increase the amount of oxygen absorbed✓
Why did the organism do this?	As a result of the low oxygen content at high altitudes✓

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What was the result?	As a result, the ancestral Tibetians produced more red blood cells/developed ways to use oxygen more efficiently✓ To increase the availability of oxygen to the body✓
What happened to this new characteristic?	This acquired characteristic✓ was then passed on to their offspring✓
What was the result of this	All Tibetans now produce more red blood cells✓ / use oxygen more efficiently to survive at high altitudes
There are 7 possible ticks, but you only need 5 as the question's total is 5.	

3.4.4. NATURAL SELECTION (DARWIN'S THEORY)

Darwin's theory of evolution by natural selection:

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

The difference between natural and artificial selection:

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

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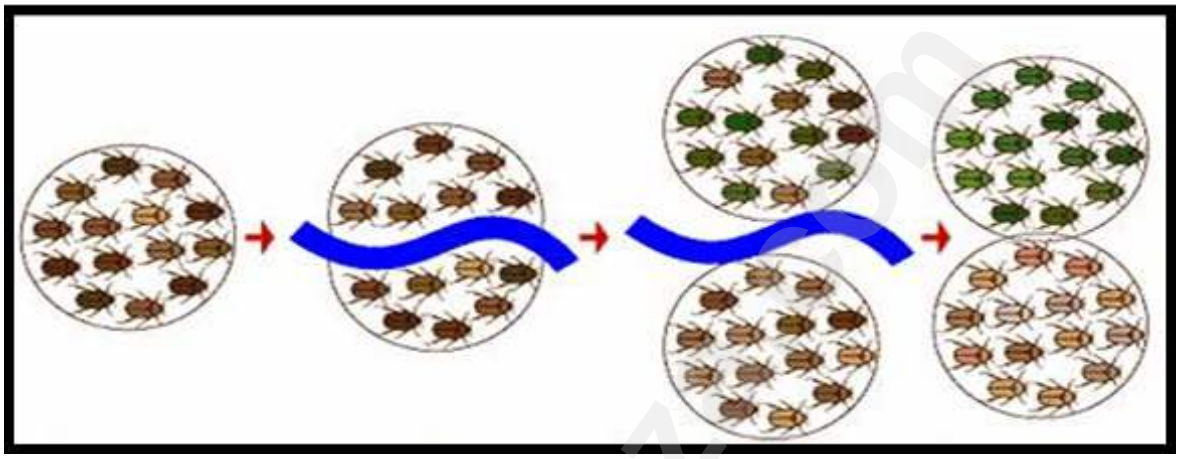
3.4.5. SPECIATION

Geographical isolation and **reproductive isolation** mechanisms, isolate the gene pool of a species resulting with formation of new species



Source: evolution.berkeley.edu

In the diagram above the beetles are separated and after time speciation took place (natural selection took place independently in each environment) and the green beetle species was formed in the top environment and the browner beetle species was formed in the lower environment. They are no longer able to mate and produce offspring.

4.1

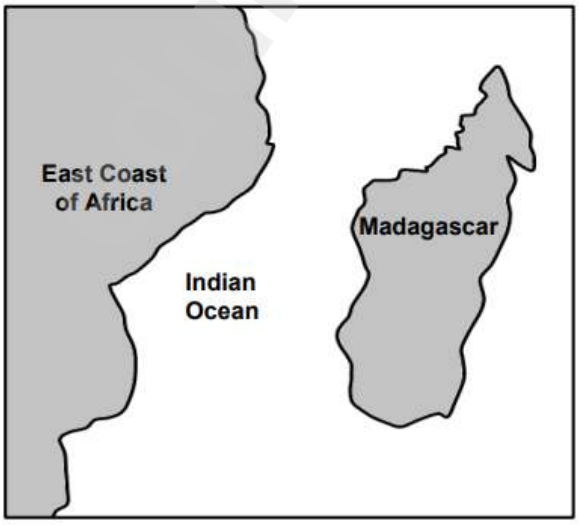
Practice Question 4 (DBE November 2020 P2)

Pottos and lemurs are small mammals.

Scientists believe that pottos and lemurs share a common ancestor that existed in Africa. Presently pottos only occur in Africa while lemurs are only found in Madagascar.

Madagascar is an island off the East coast of Africa as shown in the diagram below.

3.2



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1 **Explain how continental drift could have affected the distribution of the common ancestor. (3)**

Ask yourself what is continental drift – it is the separation of continents.

nmon ancestor – it is a species that gave rise to other descendant species. So how could the continents affect the distribution of the common ancestor of these two mammals? They are not lain how the two mammals originated through speciation. They are asking about the common

- There was once one large continent✓ and
- The common ancestor existed throughout this continent✓
- When Madagascar separated✓
- The common ancestor was found in both✓ regions

2 **Describe the speciation of the pottos and lemurs to become different species. (6)**

Now they asking you to explain the process of speciation starting from the common ancestor and then working towards the pottos and lemurs. (don't start with pottos and lemurs, they are the result of speciation)

Answer:

Generic exam guidelines steps	Application to this question
• **If a population of a single species becomes separated by a geographical barrier (sea, river, mountain, lake)** • **then the population splits into two.**	• The common ancestor became separated into two **groups** by the **ocean***✓ *Firstly, it was not the pottos and lemurs that were separated but the common ancestor. Secondly, the ocean split them up, continental drift is the process not the geographical barrier.* ** is a compulsory mark, if you didn't write this you lose one mark*
• **There is now no gene flow between the two populations.**	• There was no gene flow between the two **groups**✓*(not species, speciation has not taken place yet)*
• **Since each population may be exposed to different environmental conditions/the selection pressure may be different**	• Each **group** experienced different environmental conditions✓

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• **natural selection occurs independently in each of the two populations**	• And underwent natural selection independently✓
• **such that the individuals of the two populations become very different from each other**	• The individuals in each **group** became different✓
• **genotypically and phenotypically.**	• Genotypically and phenotypically✓
• **The two populations are now different species.** • **Even if the two populations were to mix again** • **they will not be able to interbreed.**	• To form the **pottos** and **lemurs** *✓ *(Now you must be specific to the example in the question, these two species originated from the common ancestor due to speciation)* • Eventually if the two groups are mixed again, they cannot interbreed/ produce fertile offspring.

(6)

2* compulsory (had to write them or lose 2 marks, always specify the geographical barrier and in this case you have to mention the exmples) + 4 marks (any other four points)
Write full sentences!!!

4.4.2. HUMAN EVOLUTION

Table taken from DBE Diagnostic report 2020:

Type of evidence	Evidence for human evidence
Fossil record	Anatomical features of fossils are examined, compared and placed in sequence from most simple to more complex. Transitional species are those that display characteristics in-between those that it follows and those that it precedes. Transitional species may also share some characteristics with each of these two groups.
Genetic evidence	Similarities and differences between the genetic composition (DNA) of species shows relatedness between species and their possible evolution from a common ancestor.
Cultural evidence	The increasing complexity of items such as artefacts and tools are an indication of the advances (evolution) of the human intellect.

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- You must know which scientist discovered the fossils of the three genera *Ardipithecus*, *Australopithecus* and *Homo* (especially the South African ones, also where in South Africa they were found.)

  The table below summarizes the different fossils discovered as evidence for human evolutions. The ones with the stars are South African.

Organism	When organism existed	Fossil site	Discovered by	Characteristics
Ardipithecus ramidus Source: wikipedia.	5-4 mya	North-East Ethiopia	**Tim White**	Brain size: 300-350 ml Forward position of foramen magnum. Prognathous (more protruding jaws). Heavy brow ridges. Pelvis structure: bipedal and tree climbing.
Australopithecus afarensis source wikipedia.org	4-2,7 mya	Ethiopia Kenya Tanzania	**Donald Johanson**	Brain size: 375 – 550 ml Forward position of foramen magnum Prognathous Heavy brow ridges Canines large and pointed Long arms No cranial ridge
***Australopithecus africanus* (Ms Ples, Taung child)** wikipedia.org	3-2 mya	Taung Sterkfontein	**Raymond Dart** **Robert Broom** **Ron Clarke**	Brain size: 428-625 ml Forward position of foramen magnum Prognathous Brow ridges Teeth large; canines not long Long arms No cranial ridge
***Australopithecus sediba* (Karabo)**	1,9-1,8 mya	Malapa Cave – in the cradle of humankind	**Lee Burger**	Brain Size: 420 ml Prognathous (less protruding) Brow ridges Large teeth; canines not long Long arms No cranial ridge

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Source:wordpress				
Homo habilis **(Handy man)** Source:Smithsonian	2,2-1,6 mya	Tanzania	**Louis and Mary Leakey**	Brain size: 650 ml Prognathous (less protruding) Less pronounced brow ridges Human-like teeth; smaller canines Long arms
Homo erectus	2-0,4 mya	Java in Indonesia and then Swartkrans	**Eugene Dubois**	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter arms
Homo naledi **(star)** Source: Britannica.	335,000–236,000 Years ago	Cradle of Human kind, Rising Star cave	**Lee Berger** ★	Brain size: 460-610 cm^3 Prognathous Slender body, wide hips Human like feet and hands Long curved fingers
Homo sapiens	200 000 years ago - present	Makapansgat in Limpopo Border Cave in KZN Blombos Cave in the Western Cape	**Tim White** ★	Brain size: 1200-1800 ml No brow ridges Small teeth Short arms Non prognathous

★ **= South African fossils**

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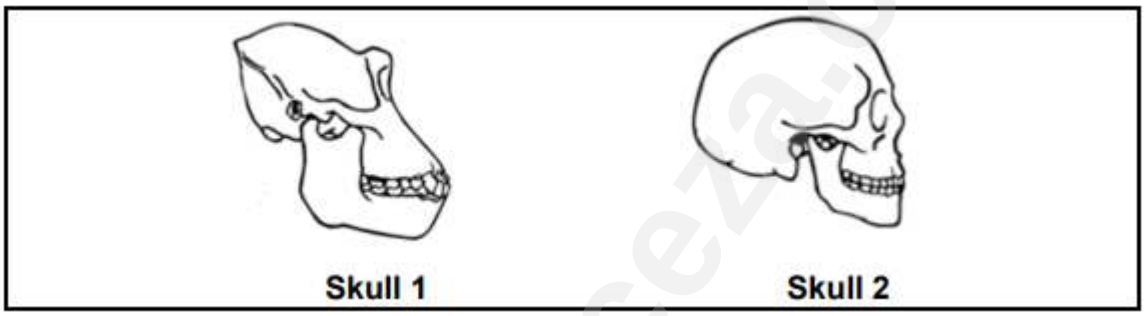
- There is a difference between the **skull** and the **cranium.** The cranium is the part of the skull where the brain is housed in.
- When talking about the differences between jaws of humans and African apes don't refer to more or less prognathous but rather use prognathous and non-prognathous
- Foramen magnum in humans is in a more forward position *not in the center or in the front*
- Bipedalism is the ability to walk on two lower limbs, not only limbs because arms are also limbs so you have to specify lower or hind limbs.

PRACTICE QUESTION 5 (DBE November 2018 P2)

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



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

You can't talk about bipedalism, foramen magnum, pelvic girdle, opposable thumbs etc. here. Only what you can SEE!

SKULL 1	SKULL 2
Brow ridges pronounced✓	Brow ridges less pronounced✓
More protruding jaws✓/prognathous	Less protruding jaws✓/non-prognathous
Larger jaws✓	Smaller jaws✓
Smaller cranium size✓	Larger cranium size✓
Larger teeth/canines✓	Smaller teeth/canines✓
Poorly developed chin✓	Well-developed chin✓
Sloping face✓	Flat face ✓

When you must tabulate your answer, ensure that you have the same trait per row. For example, the first line is about brow ridges that you compare. You can't have brow ridges underneath skull 1 and jaws underneath skull 2 in the same row.

There are 7 possible traits but only the first three are marked

Table ✓ + (3 traits x 2)

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5.2 **Give FOUR characteristics of the upper limbs that humans share with other primates.**

This is from the syllabus, study your work!

- Freely rotating arms✓
- Long upper arms✓
- Rotation around elbow joints✓
- Rotation around the wrist✓
- Opposable thumbs✓
- Bare fingertips✓/ nails instead of claws
- Five fingers✓
- Fingerprints present✓

(Only your first four answers will be marked, make sure they are correct) **(4)**

5.3 **Explain how an increase in cranial volume is related to intelligence.**

The cranium is where the brain is housed so if the volume of the cranium is bigger than the volume of the brain is more

Since the cranium housed the brain✓

A large cranial volume indicates a larger brain/more brain cell✓

Which suggests greater intelligence✓

(3)

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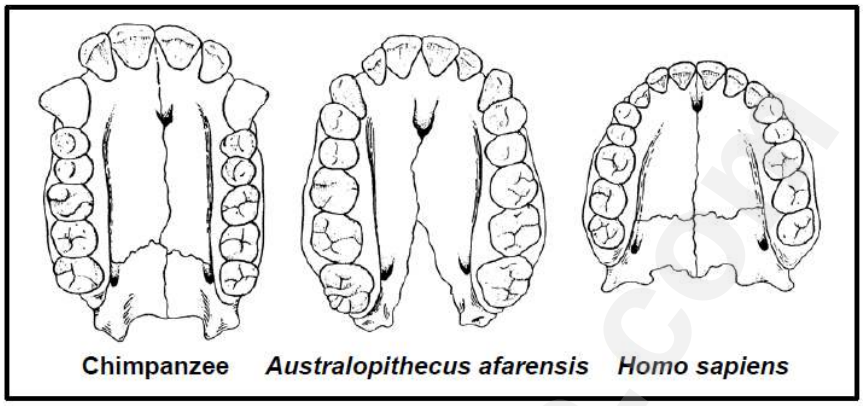
PRACTICE QUESTION 6 (DBE November 2018 P2):

The diagrams below show the upper jaws of some fossils.



6.1. Describe ONE visible difference between the jaw of a chimpanzee and that of *Homo sapiens* which show trends in human evolution. (1)

Underline the key words, one visible difference between a chimpanzee and Homo sapiens. They only ask for one difference, so they will only mark your first answer. You need to look for a visible difference from the diagrams given. You can't talk about foramen magnum, prognathous, brow ridge etc.

- The jaw is large in the chimpanzee✓/smaller in *Homo sapiens*✓
- The jaw is long and rectangular in the chimpanzee✓/small and rounded in *Homo sapiens* ✓
- Large spaces between the teeth in the chimpanzee✓/smalls paces in *Homo sapiens*✓

- Large canines/teeth in the chimpanzee✓/small canines/teeth in *Homo sapiens*✓

6.2. Based on the differences in dentition, what conclusion can be made about the change in diet from *Australopithecus afarensis* to *Homo sapiens?* **(2)**

Underline key words, differences in dentition, diet of A. afarensis and H. sapiens. Look at the teeth of only these two diagrams, how do the teeth differ and what will the size and shape of teeth influence what they eat? The A. afarensis has bigger teeth so they can still eat tubers and raw food. Our teeth are small, we cannot eat raw/tough food.

The diet changed from eating raw food✓ in Australopithecus
to a diet of cooked food✓ in *Homo sapiens*

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6.3. Australopithecus may be described as a transitional species between the chimpanzee and *Homo sapiens.* **(1)**

(a) Define a *transitional species.*

This links back to grade 10.

A transitional species shows intermediate characteristics between two genera /species✓

OR

It has characteristics common to both the ancestor species and the species that follows✓

(2)

6.4. Use ONE visible feature of the jaw to explain why *A. afarensis may be described as a transitional species.*

Remember a visible feature is only what you can see. Now you have to compare the jaw of the A. afarensis with the chimpanzee and human and see if there are intermediate characteristics between them. Look at the size of the teeth and jaw, also the shape of the palate. It is important to note that you have to compare the same feature in your answer, you can't talk about the one species' jaw and the other species' teeth.

The **jaw** is smaller than that of the chimpanzee but larger than that of *Homo sapiens*✓✓

OR

The **canines/ teeth** are smaller than those of the chimpanzee but larger than those of *Homo sapiens*✓

OR

The jaw/ **palate shape** is more rounded than that of the chimpanzee but less rounded than that of *Homo sapiens*✓✓

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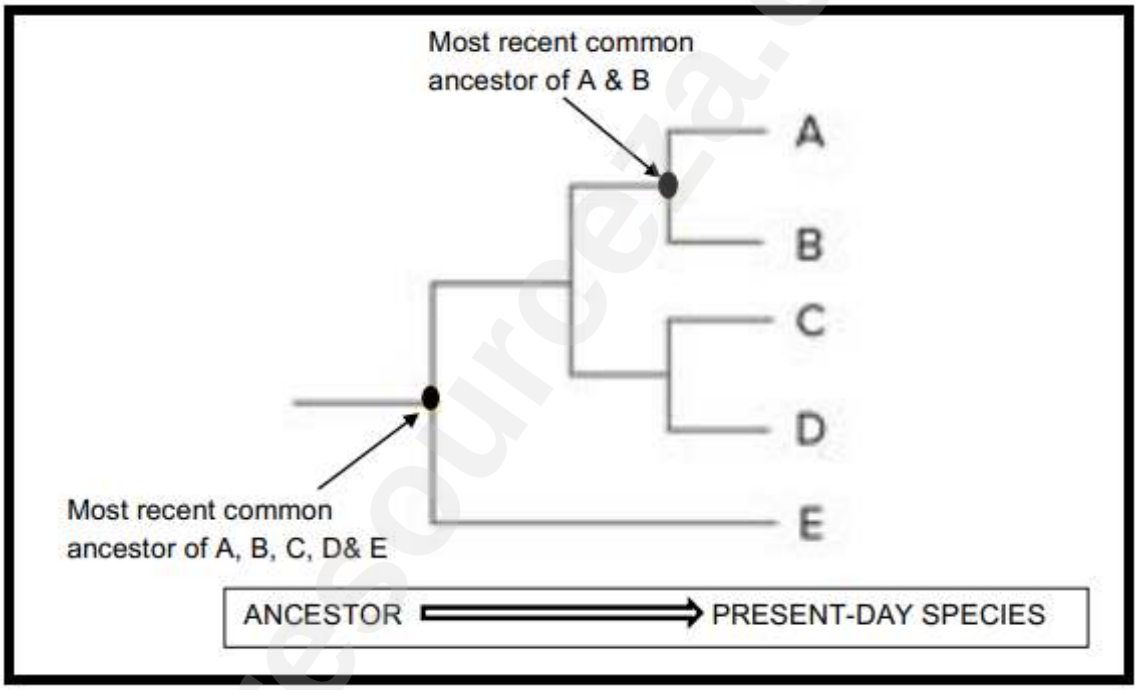
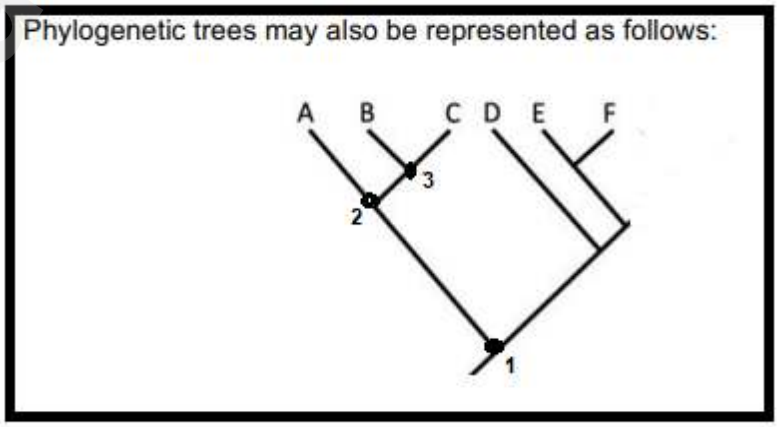
4.4.3. PHYLOGENETIC TREES

- In the diagnostic reports of the past eight years it was stated that learners don't understand phylogenetic trees.
- A phylogenetic tree is a diagrammatic representation of the evolutionary relationships between species.
- A phylogenetic tree is a schematic form that shows the **evolutionary relationships** within a set of organisms or groups of organisms.
- ***Phylo*** = organism's phylum group and ***genetic*** = from the genes/relationship between the genes
- It should not be confused with pedigree diagrams which is the genetic relationships between close family members.





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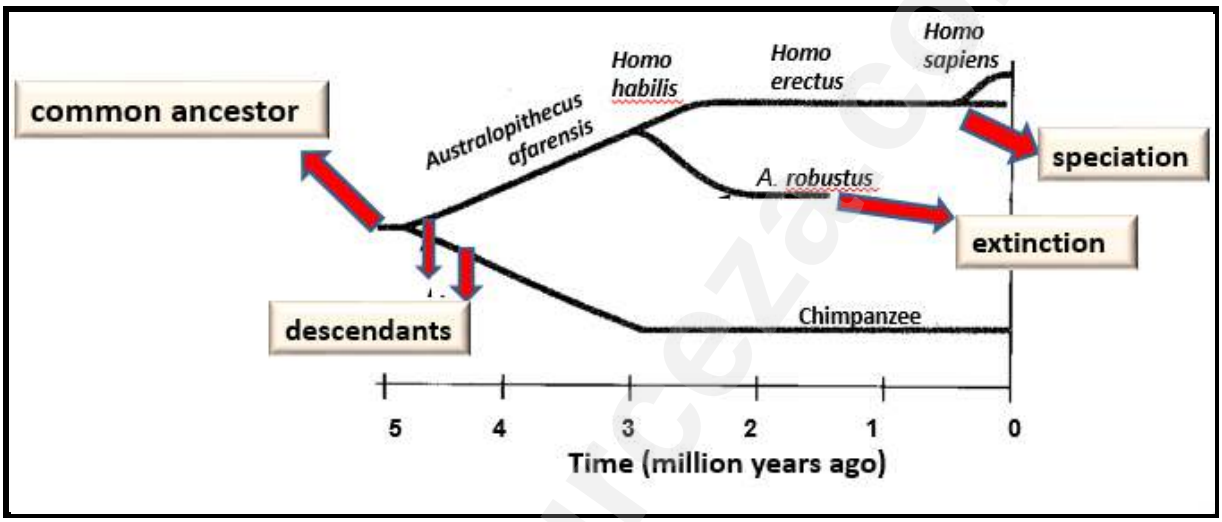
When you look at the phylogentic tree above you will see a lot of branches.

- The first branching (speciation event) is at number 1. That is the common ancestor for all the species in this phylogenetic tree.
- Let us look at the first branch:
  - A, B and C have a common ancestor at number 2 and B and C have a common ancestor at 3.
  - B and C are more closely related to each other than to A.
  - A, B and C are more closely related to each other than to D, E, and F.

Look at the following example of a phylogenetic tree:



In the diagram above the *Austropithecus afarensis* is the common ancestor of *Homo habilis* and *A.robustus*

- When the line forks into branches, speciation takes place and new species originate. The organism that existed when the line forked into branches is the common ancestor of the new species.
- When a line ends, it is the extinction of that specific species.(Refer to DBE textbook page 292)
- Look at the time line (either on x-axis or y-axis) to see how old an organism is. For example *Homo habilis* originated 3mya ago.

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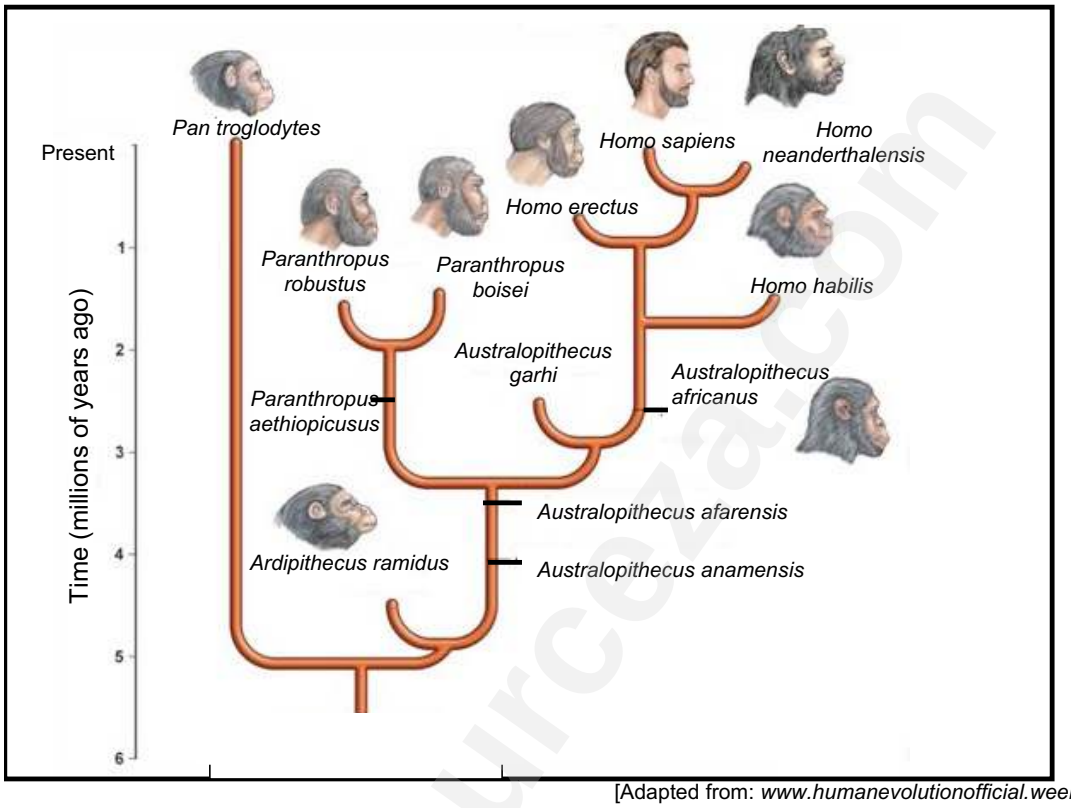
EXAMPLE QUESTION 7 (Gauteng September 2018 P2)

Fossil evidence for humans may be interpreted in different ways. One possible model of human evolution is shown below.



[Adapted from: *www.humanevolutionofficial.weebly.com*]

7.1 **State the number of genera represented in the diagram.** **(1)**

You must look at the first part of their names (the genus) when counting. So, there are Ardipithecus, Australopithecus, Paranthropus, Homo and Pan which is 5.

5✓

Name the most recent common ancestor of the Homo genus.

7.2 *See where the first (lowest) Homo is placed in the tree. In this case its Homo habilis.* **(1)**

Follow the line down and the first organism you find is:

Australopithecus africanus✓

7.3 **Which species went extinct first?** **(1)**

Time is on the y-axis. At the bottom, it is 6 mya. Hence, the organisms at the bottom are the oldest. Start at the bottom and see which organism's line stops first. In this case it is:

Ardipithecus ramidus✓

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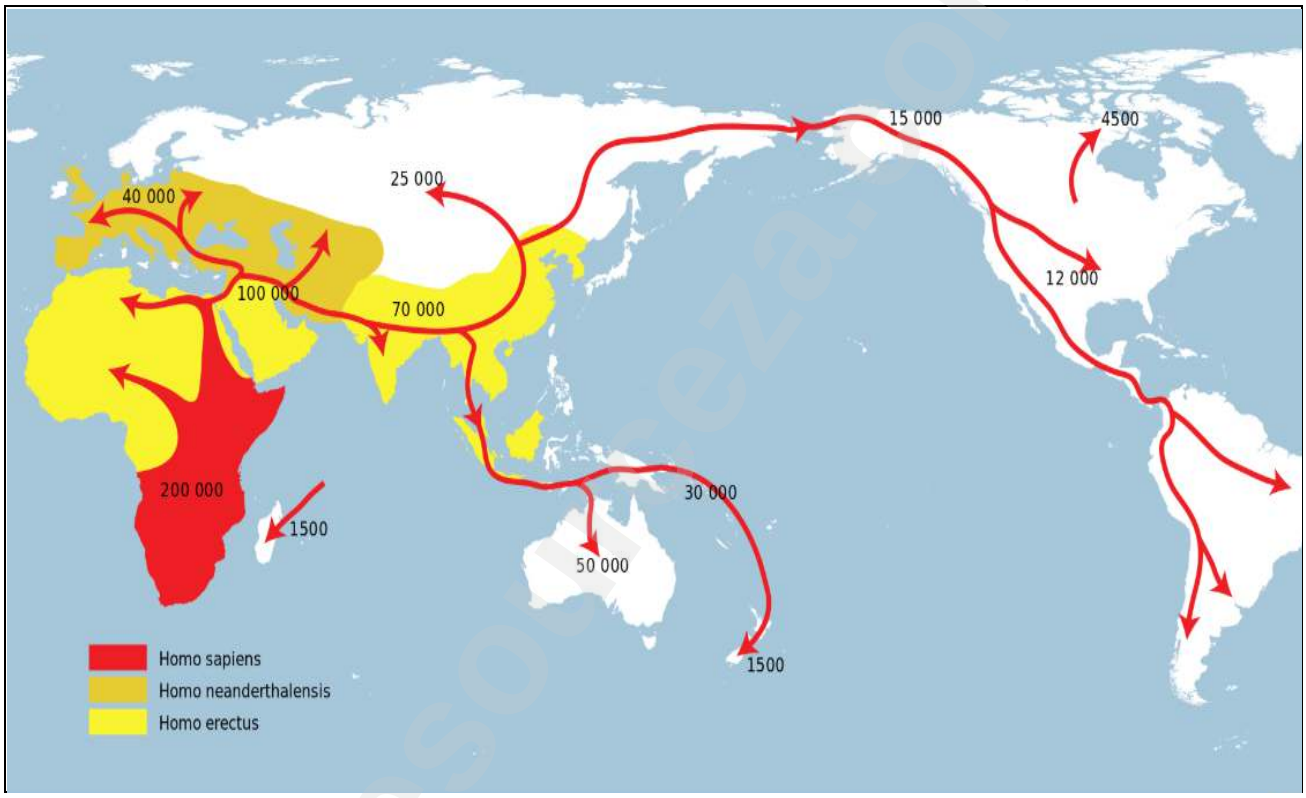
4.4.4. OUT OF AFRICA HYPOTHESIS

This hypothesis states that modern *Homo sapiens* evolved in Africa about 200,000 years ago and migrated outwards to Europe and Asia, according to the Southern Dispersal theory.

Most scientists agree that **modern humans** *(Homo sapiens*) **evolved in Africa and spread outwards across the continents.**



The following lines of evidence have been used to support this hypothesis:

- The oldest fossils of australopithecines/*Homo habilis*/bipedal organisms have been found in Africa
- The oldest fossils of *Homo erectus* have been found in Africa
- Analysis of mitochondrial DNA shows that the oldest female ancestors of humans are from Africa

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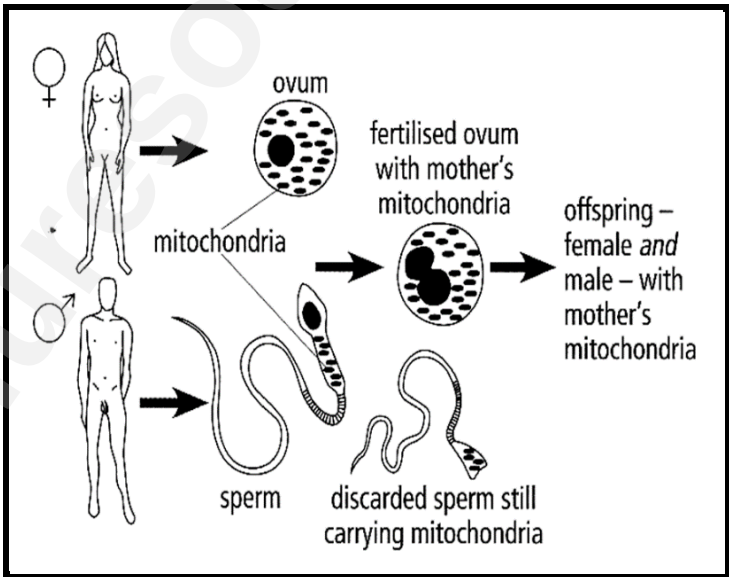
Fossil Evidence:

- *Ardipithecus* fossil were found in Africa **ONLY**, nowhere else in the world. (*so they originated in Africa)*
- *Australopithecus* fossils found in Africa **ONLY** (Karabo, Littlefoot, Taung child and Mrs Ples *all originated in Africa)*
- **Oldest** fossils of australopithecines, *Homo habilis* and other bipedal organisms were found in Africa
- **Oldest** fossils of *Homo erectus* and *Homo sapiens* were found in Africa, followed by Asia and the youngest fossils found in other parts of the world. (*which shows they originated in Africa and then moved out of Africa, the youngest fossils are found where they were living most recent)* **.**

Genetic Evidence:

- Geneticists use mitochondrial DNA (refer to diagrams below) to study human origins and migrations since mtDNA is passed unchanged from mother to offspring. However, during a person's life, mutations (changes) to the mtDNA do occur.
- Scientists can determine the rate at which such mutations (or markers) take place, and can then use them as a type of molecular clock to determine the age of a particular maternal mtDNA lineage.
- The most recent common female ancestor whose genetic marker is found in all living humans, must have lived in eastern Africa approximately 150 000 years ago.



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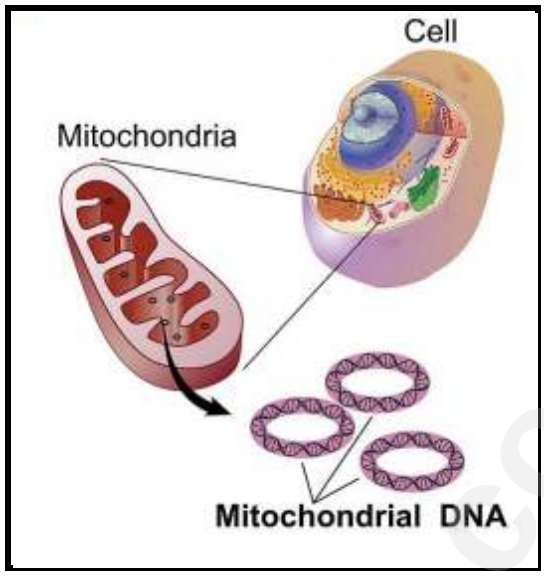
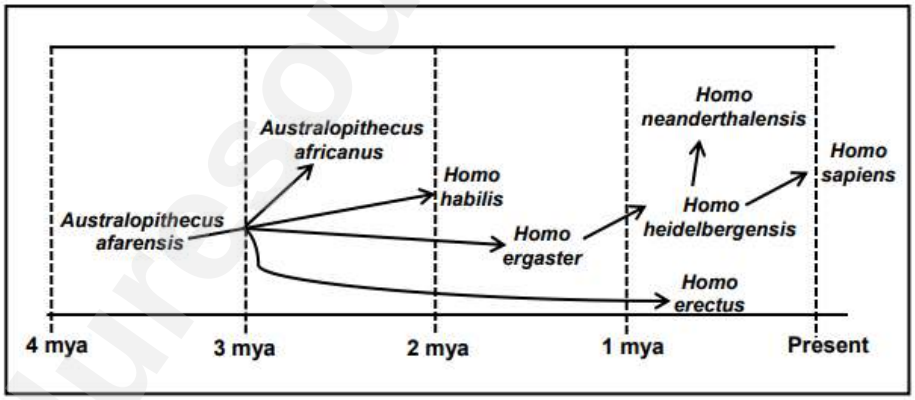


Don't confuse genetic evidence with fossil evidence!

Example Question 8 (DBE November 2020 P2)

Fossil evidence for humans may be interpreted in different ways. One possible model of human evolution is shown below.



8.1 **Name the family to which all of the represented organisms belong.** **(1)**

Remember: you need to know the family name of humans which is

Hominidae ✓

8.2 **Describe how cultural evidence is used to support the theory of human evolution.** **(2)**

There are 3 types of evidence for human evolution namely fossil, genetic and cultural.

Cultural is all about the use of tools and how this indicate the development of thought.

Evidence such as tools/ weapons/language/artefacts✓

Is used to show advances✓ in human development

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8.3 **How long ago did the most recent common ancestor of *H. erectus* and *H. heidelbergensis* exist on earth?** **(1)**

The time is on the X-axis. Follow Homo erectus and Homo heidelbergensis lines back to where they both meet, if you extend down to the x axis it will be

3mya✓

8.4 **Explain a possible reason why *H. ergaster* was placed between *A. afarensis* and *H. heidelbergensis* on the model.** **(2)**

A fossil on a phylogenetic tree, placed in between two other fossils usually indicates a transitional fossil. For 2 marks, you need to say it's a transitional fossil and then explain what that means.

H.ergaster shows characteristics of both *H.heidelbergensis* and *A. afarensis*✓

Therefore, it's a transitional species✓

8.5 **Explain how the fossils of organisms that existed from 4 mya to present time are used to support the 'Out of Africa' hypothesis.** **(3)**

This answer is stated "as is" in the exam guideline.

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

***1 compulsory mark**(the last bullet) because this state what the out of Africa hypothesis is about and **any 2 other bullets**. Emphasis is on **oldest** and **only.** If they are not stated you do not receive the mark.

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5. TYPICAL EXAM QUESTIONS

QUESTION 1 *(Questions taken from various sources)*

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1 to 1.12) in your ANSWER BOOK, for example 1.13 D.

1.1 Study the list below.

1 Fossils
2 Modification by descent (Homologous structures)
3 Biogeography
4 Genetics

Which of the above combinations can be used as evidence for evolution?

A 1, 2 and 3 only
B 1, 2, 3 and 4
C 2, 3 and 4 only
D 1, 3 and 4 only

1.2 The fossil of *Australopithecus sediba* (Karabo) was discovered by …

A Tim White.
B Lee Berger.
C Louis and Mary Leakey.
D Raymond Dart.

1.3 Which ONE of the following characteristics applies to bipedal organisms?

A A more backwards position of the foramen magnum
B A short, narrow pelvis
C A long, wide pelvis
D An S-shaped spine

1.4 Which ONE of the following statements about biodiversity, is CORRECT?

A Speciation increases biodiversity
B Biodiversity is the number of organisms in a population
C Extinction increases biodiversity
D Speciation and extinction have no effect on biodiversity

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1.5 The jaw of African Apes is…

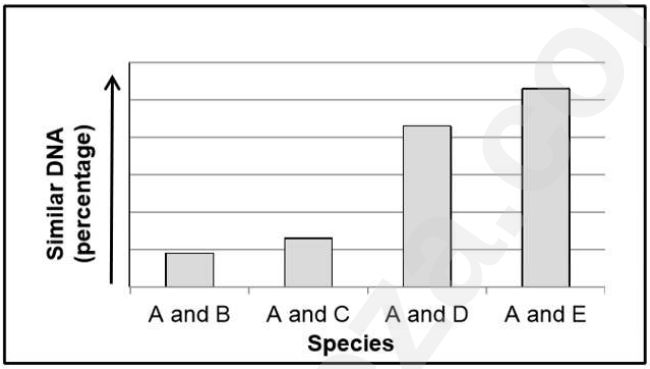
A shorter and wider than humans

B has no spaces between the teeth

C has large sharp canines

D is flat and has a chin

1.6 THE GRAPH BELOW SHOWS THE COMPARISON OF DNA BETWEEN SPECIES A AND SPECIES B, C, D AND E.



Which statement is a valid conclusion that can be drawn from this graph?

Species **A** is mostly related to…

A species **B**.

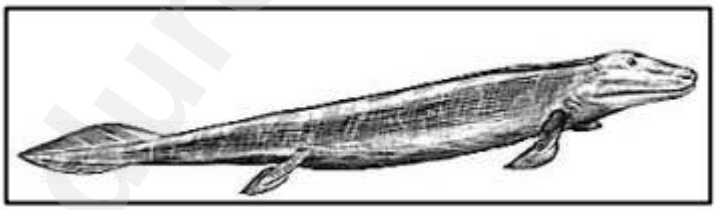
B species **C**.

C species **D**.

D species **E**.

The diagram below shows *Tiktaalik roseae*, a fish that may be the ancestor of the first organisms to live on land.

1.7



According to Lamarck, this species of fish may have evolved the ability to 'walk' on land by …

A undergoing natural genetic mutations which caused the fins to develop into legs.

B the process of natural selection.

C passing on the acquired characteristic of fins to their offspring.

D stretching its fins and using them for 'walking'.

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Variation within a species is introduced through …

A random mating and asexual reproduction.

B mitosis and random fertilisation.

C random mating and random fertilisation

D mitosis and meiosis.

1.8 Which ONE of the following scientists discovered fossils of *Homo sapiens* and *Ardipithecus sp*?

A Raymond Dart

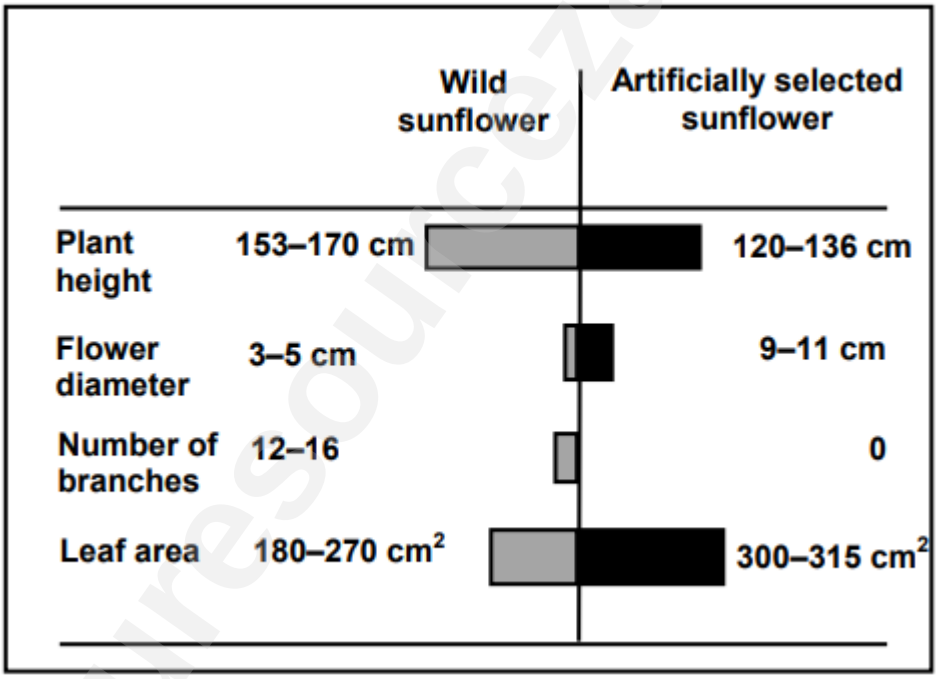
B Lee Berger

C Louis Leakey

D Tim White

1.9 The diagram below compares characteristics of wild sunflowers with sunflowers that have been artificially selected.

1.10



Which ONE of the following characteristics was found undesirable by humans?

A Number of branches and leaf area

B Plant height and leaf area

C Plant height and flower diameter

D Plant height and number of branches

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1.11 Punctuated equilibrium suggests the following:

A Evolution is always a slow and gradual process.

B Natural selection does not explain evolution.

C New species can appear quickly, over a relatively short period time.

D Artificial selection is the only mechanism that causes evolution

1.12 A group of students observed that the long-term use of antibiotics results in the decreased control of bacterial infections.

From this observation the students stated that:

Antibiotic resistance in bacteria is caused by the long-term use of antibiotics.

This statement is a/an …

A theory.

B aim.

C hypothesis

D conclusion. **12x2 =24**

QUESTION 2 *(Questions taken from various sources)*

Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number (2.1 to 2.5) in your ANSWER BOOK.

2.1	Large, pointed teeth in African apes that are used for tearing food	(1)
2.2	Organelle outside the nucleus of animal cells that contain DNA	(1)
2.3	A large opening at the base of the skull through which the spinal cord passes	(1)
2.4	An explanation of evolution that describes the speed at which it takes place	(1)
2.5	The hypothesis which supports migration of human ancestors from the point of origin	(1)
2.6	Similar structures in different organisms indicating descent with modification	(1)
2.7	The part of the skull that houses the brain	(1)
2.8	Having a protruding jaw	(1)
		(8)

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QUESTION 3 *(Questions taken from various sources)*

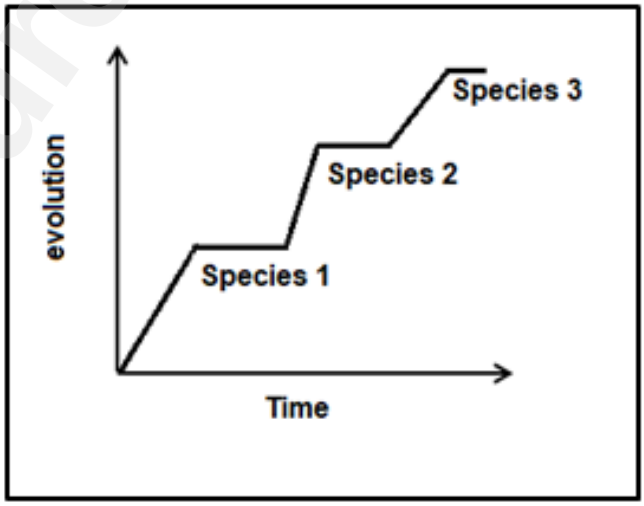
Indicate whether each of the statements in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B or NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B,** or **none** next to the question number (3.1 to 3.4) in the ANSWER BOOK.

	COLUMN I	COLUMN II
3.1	A feature of *Ardipithecus*	A: Opposable thumb B: Stereoscopic vision
3.2	A diagram that is used to represent the evolutionary relationships and characteristics amongst different species	A: Phylogenetic tree B: Cladogram
3.3	Alternating periods of rapid change and slow/no change	A: Punctuated Equilibrium B: Gradualism
3.4	Variation in human height	A: Continuous B: Discontinuous

(4 x 2) (6)

QUESTION 4 *(Free State, Sept. 2019, Paper 2)*

4.1 The following diagram illustrates the theory of evolution by punctuated equilibrium.



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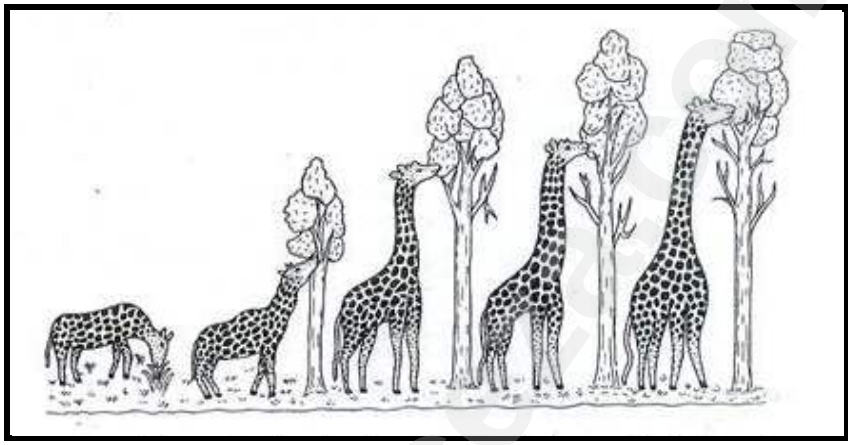
4.1. Give the names of the TWO scientists that formulated this theory. (2)

4.2 Explain the trend observe in this graph. (4)

(6)

QUESTION 5 *(GDE, Sept. 2017, Paper 2)*

The diagram below shows the elongation of the neck of the giraffe according to Lamarck.



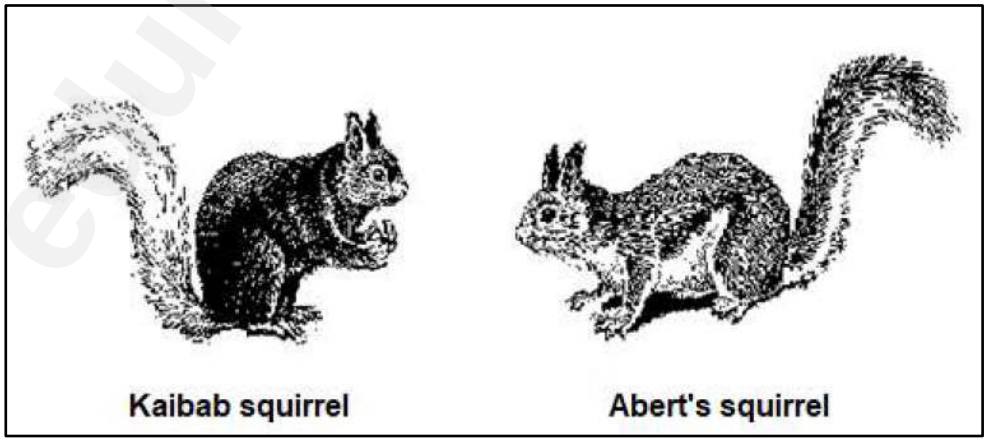
5.1 Use the example in the diagram to describe Lamarck's theory for changes in the giraffe's neck over time. (3)

5.2 Why was Lamarck's theory rejected? (2)

(5)

QUESTION 6 *(Free Stat, Sept. 2018, Paper 2)*

Read the extract about Grand Canyon squirrels



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

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One species is the Kaibab squirrel which has black fur and a fluffy tail. The other is the Albert'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.

6.1 Define *population.* (2)

6.2 State TWO **characteristics** that distinguishes the two squirrel species from each other. (2)

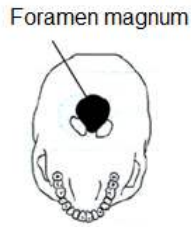
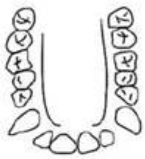
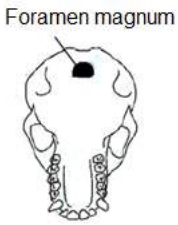
6.3 Describe how speciation of the two Grand Canyon squirrels took place through geographic isolation. (6)

6.4 Name THREE reproductive isolating mechanisms that help to keep species separate (3)

(13)

QUESTION 7 *(Adapted from Free State, Sept. 2019, Paper 2)*

The diagram shows the upper jaw, scull and pelvic girdle of a modern human and an African ape. The diagrams are NOT drawn to scale.

ORGANISM	UPPER JAW	SKULL (BOTTOM VIEW)	PELVIC GIRDLE
A			
B			

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7.1 Which organism is bipedal? (1)

7.2 Use TWO visible features from the table above and explain your answer in QUESTION 7.1.

(4)

7.3 Tabulate THREE visible differences between the upper jaws of organisms **A** and **B**.

(7)

7.4 Which organism is a African ape? (1)

(13)

QUESTION 8 *(Free State, Sept. 2018, Paper 2)*

Study the table below which shows evolutionary trends provided by the anatomical features of fossils of different genera

Different Genera	**Skull**	**Brain volume**	**Period of existence (million years ago)**
African ape		530 cm^3	8 mya
Australopithecus		430 cm^3	4–2,7 mya
Homo erectus		850 cm^3	2–0,4 mya
Homo sapiens		1450 cm^3	0,2 mya–present

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8.1 How many million years ago did *Homo erectus* first appear? (1)

8.2 Calculate the difference in brain volume between *Australopithecus* and *Homo sapiens*. Show ALL calculations. (2)

8.3 State THREE advantages of a larger brain volume. (3)

8.4 Tabulate THREE visible differences between the skulls of *Homo sapiens* and the African ape. (7)
(13)

QUESTION 9 *(DBE June 2018, Paper 2)*

Read the extract below.

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.

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

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

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

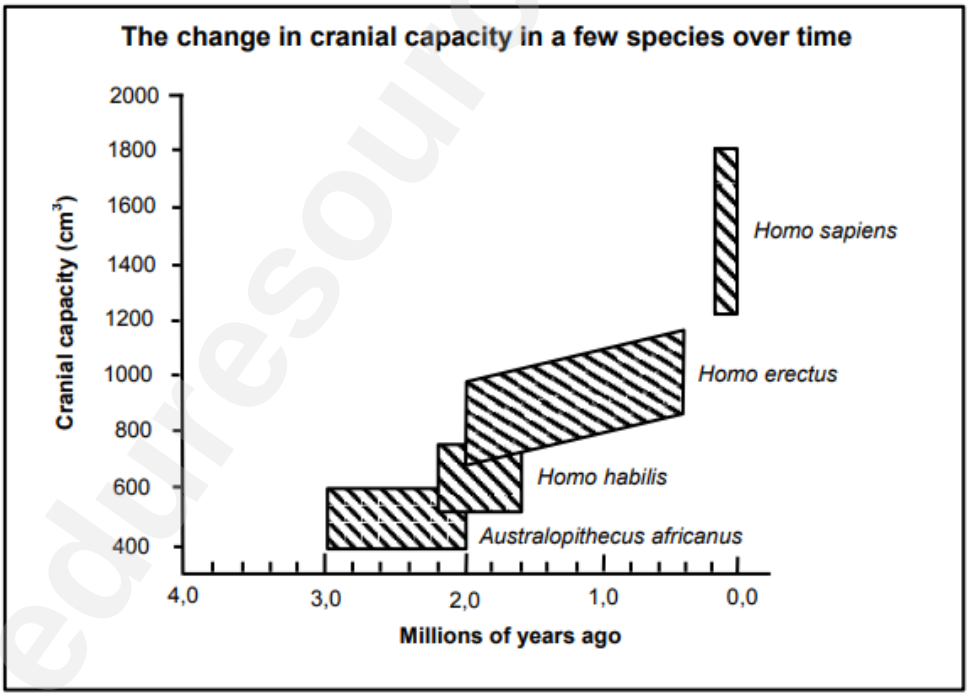
9.3 Calculate the value of X in the table. Show ALL working. (3)

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

9.5 Use the theory of evolution through natural selection to explain (6)
(16)

QUESTION 10 *(DBE, June 2018, Paper 2)*

Study the graph below



10.1 Name the family to which all these species belong. (1)

10.2 What is the largest cranial capacity (in cm^3) of *Australopithecus africanus*? (1)

10.3 When did *Homo habilis* become extinct? (1)

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10.4 Name **TWO** *Australopithecus* fossils found in South Africa. (2)

10.5 Which of the organisms represented above has the greatest range in cranial capacity? (1)

(6)

6. SOLUTIONS

QUESTION 1

1.1 D✓✓
1.2 B✓✓
1.3 D✓✓
1.4 A✓✓
1.5 C✓✓
1.6 D✓✓
1.7 D✓✓
1.8 C✓✓
1.9 D✓✓
1.10 D✓✓
1.11 C✓✓
1.12 C✓✓ **12 X 2** **= (24)**

QUESTION 2

2.1 Caninies✓
2.2 Mitochondrion✓
2.3 Foramen magnum✓
2.4 Punctuated equilibrium✓
2.5 Out of Africa hypothesis✓
2.6 Homologous structures✓
2.7 Cranium✓
2.8 Prognathous✓ **(8)**

QUESTION 3

3.1 Both A and B ✓✓
3.2 A only ✓✓
3.3 A only ✓✓
3.4 A only✓✓ (4x2) **(8)**

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QUESTION 4

4.1.1 Eldredge✓
and Gould✓ (2)

4.1.2 Evolution sometimes involves long periods✓ of time where species do not change/very little change occurs✓ (4)
This alternates with short periods✓ of time where rapid changes occur✓

(6)

QUESTION 5

5.1 All giraffes had short necks. ✓
These giraffes frequently stretched their necks.✓
They did this to reach the leaves that were available only higher up the trees.✓
As a result, their necks became longer. ✓
The characteristic for long necks acquired in this way was then passed on to the next generation. ✓
Eventually all the giraffes had longer necks. ✓ **(Any 3)**

(3)

5.2 There is no evidence ✓to show that acquired characteristics are inherited ✓ / There is no evidence ✓that structures used more frequently became more developed or vice versa✓ / a change in phenotype ✓does not lead to a change in genotype✓

(2)

(5)

QUESTION 6

6.1 A population is a group of organisms of the same species found in the same habitat, that can randomly interbreed✓✓ (2)

6.2
- The colour of the fur coat✓
- Type of tail✓ (2)

6.3
- The population of the Grand Canyon squirrels become split into two populations✓
- by a geographical barrier, a canyon*✓.
- The two populations cannot interbreed✓/there is no gene glow between the two.
- Natural selection occurs independently in each population✓
- due to different environmental conditions on either side of the barrier✓
- The two populations become genotypically and phenotypically✓
- different✓ from each other.
- Even if the geographical barrier is removed, the individuals will not be able to interbreed.✓
- We say the original population has now become two separate species

(*Compulsory 1 + Any 5) (6)

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6.4 Breeding at different times of the year✓
Species-specific courtship behaviour✓
Adaptation to different pollinators ✓
Infertile offspring✓
Prevention of fertilisation✓ (3)

(Mark first THREE only) **(13)**

QUESTION 7

7.1 A ✓ (1)

7.2 Organism A has a short, broad/(wide and short)✓pelvis to support the upper body weight✓
And the foramen magnum is in a forward position✓to allow the spine to enter vertically✓ (4)

7.3 T✓

***Homo sapiens* (A)**	**Primates (B)**
Smaller canines✓	Larger canines✓
Smaller spaces between the teeth✓/No diastema	Larger spaces between the teeth✓/diastema
Jaws with teeth on a gentle/round/C curved✓	Jaws with teeth in a rectangular/U shape✓
Not prognathous✓	Prognathous✓

(7)

(Mark first THREE only) **1 Table and (3 x 2)**

7.4 B✓ (1)

(13)

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QUESTION 8

8.1 2 mya✓ (1)

8.2 1450 cm^3 – 430✓ cm^3 (1450 – 430) ✓ cm^3 (2)

1020✓ cm^3✓ =1020✓ cm^3

8.3 Have better co-ordination of movement✓ (3)

Process large amount of information✓

Processing information faster✓

Development of spoken and written languages to communicate✓

8.4

Homo sapiens	**African ape/Gorilla**
Large cranium✓	Smaller cranium✓
Smaller jaw✓	Bigger jaw✓
Non-prognathous✓	Prognathous✓
Smaller teeth/canines✓	Bigger teeth/canines✓
Eyebrow ridges smaller✓	Eyebrow ridges bigger✓
No cranial ridge✓	Cranial ridge well developed✓
Well-developed chin✓	Less developed chin✓
No diastema✓	Diastema present✓

(7)

QUESTION 9

9.1 - Plan when to do the investigation✓

- Get all the equipment ✓
- Decide where to obtain shrimp cysts✓
- Decide on the different concentrations of solution to use✓
- Decide on how to record the data✓
- Decide on where to do the investigation ✓ **Any 2**

(Mark first TWO only) (2)

9.2 (a) Salt concentration✓

(b) Percentage of cysts hatched ✓

(2)

9.3 % Hatched = $\frac{1}{53}$ ✓ x 100✓

= 1,8 ✓%

(3)

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9.4 - Room temperature✓
- The volume of solution used✓ /30ml solution was used
- The amount of time ✓/ left the beakers for 48 hours
- Cysts from the same type of shrimp✓

Any 3 (3)

(Mark first THREE only)

9.5 - There was variation ✓amongst the brine shrimp
- Some had the ability to produce cysts✓
- and some did not ✓
- When conditions became unfavourable ✓
- the brine shrimp which were unable to produce cysts died ✓
- Those which were able to produce cysts survived ✓
- and reproduced✓
- The allele for producing cysts was passed on to their offspring✓
- The next generation therefore had a higher proportion of brine shrimp with the ability to produce cysts✓

Any 6 (6)

(16)

QUESTION 10

10.1 Hominidae✓ (1)

10.2 600✓ cm^3 (1)

10.3 1,6✓ million years ago/mya (1)

10.4 Taung child✓
Mrs Ples✓
Karabo✓
Little foot✓ Any 2 (2)
(Mark first TWO only) (1)

(6)

10.5 *Homo sapiens*✓

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