SSIP – July 2020

SUBJECT: LIFE SCIENCES

Participant's Guide

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Table of contents

A. FOREWORD

This Just in Time teacher training workshop is organized at the start of term 3. Problematic topics to be covered in term 3 by the gr.12 teacher will be mediated to enable teachers to unlock the content for the learners. The dates for the workshops were announced in 2019 at a joint meeting with Matthew Goniwe School of Leadership and Governance (MGSLG) and Teacher Development (TD). The topics chosen for the workshop were implicated in the diagnostic reports on the NSC 2019 November examinations as well as the analytical report compiled by the province, as problematic topics. Teachers have also expressed the need for content and pedagogical training in these topics.

Therefore, not only content, but also hands-on activities on how to teach Evolution in general and more specifically Human evolution as well as Plant responses to the environment will be part of the workshop content. Typical exam questions on these topics will also be unpacked. ICT integration will be demonstrated by the facilitators.

B. PURPOSE

Training Course Goals: Professional development for teachers from schools at risk to improve the quality of teaching and learning in the targeted schools.

C. OVERALL SSIP AIMS/GOALS

The SSIP programme aims at professional development for Grade 10-12 teachers in the application of effective teaching and reflective practice to improve learner performance on the identified Grade 12 examinable topics. The overall goal for SSIP is to provide teachers with professional expertise, tools and skills to spot student learning difficulties and decide on the course of action.

SSIP came about as a result of the diagnostic needs that are identified through the end of the year NSC examination student learning data. In response to this, design and development of teaching resources will lead to the training of teachers on learners' needs identified.

The four interconnected outcomes that drive the professional development activities for SSIP are:

1. Enhancing Teachers' knowledge: deep understanding of subject matter knowledge and student's ideas on the content.
2. Enhancing quality teaching and assessment for learning: effective instructional approaches that teachers may use to ensure improved understanding by most learners.
3. Developing ICT integration skills: Use of ICT to improve teaching and learning.
4. Building professional learning communities: allow teachers to start collaborating and form professional networks in non-formal settings in the context of their schools.

D. PROGRAMME OUTCOMES

Professional development to improve learner outcomes in the identified term 3 Life Sciences topics.

E. LEARNING ASSUMED TO BE IN PLACE

Teachers who are qualified to teach Life Sciences in grade 10 – 12 (FET Phase)

F. TARGET AUDIENCE

Grade 12 teachers who have obtained below 70% in the 2018 NSC results and grade 12 novice teachers.

G. NOTIONAL HOURS

The time required to successful completion has been allocated as follows:

Contact face to face session	16 hours
Pre Test	½ hour
Day 2 : Content Practice and Demonstration	9¼ hours
Day 3: Content Practice and Demonstration	5½ hours
Post Test	½ hour

H. COURSE DESIGN AND ASSESSMENT STRATEGY

The course will focus on content, teaching and learning approaches and assessment and it will use both pre-pot tests and activities to monitor participants' progress and understanding of the term 3 topics for Life Sciences

COURSE OUTLINE/ MAP

Module 1: Evolution	**Module 2: Human evolution**
Objectives/Outcomes	**Objectives/Outcomes**

When you complete this module, you will be able to:
• Teach the terminology associated with evolution
• Create a cross word puzzle on the computer
• Explain the following as evidence for evolution:
  ○ Fossil records
  ○ Biogeography
  ○ Modification by descent
  ○ Genetics
• Give a review of the contribution of each of the following to variation that exists amongst individuals of the same species:
  ○ Meiosis
  - Crossing over
  - Random arrangement of chromosomes
  ○ Mutations
  ○ Random fertilisation
  ○ Random mating
• Distinguish between continuous and discontinuous variation
• Describe and apply the evolutionary
	When you complete this module, you will be able to:
	• Interpret a phylogenetic tree to show the place of the family Hominidae in the animal kingdom
	• List the characteristics that humans share with African apes
	• Explain the anatomical differences between African Apes and humans with the aid of diagrams
	• Describe the lines of evidence that support the idea of common ancestors for living hominids including humans
	• Explain the out of Africa hypothesis with evidence
	• Set questions on the different levels of Bloom's taxonomy.

theories of Darwin and Lamarck • Administer the gr.12 SBA task and assess the task correctly • Explain what Punctuated Equilibrium is • Explain what artificial selection is • Able to classify questions according Bloom's taxonomy • Explain how speciation takes place through geographic isolation • Give a brief outline of reproductive isolation mechanisms that help to keep species separate • Describe and explain an example of natural selection and evolution in present times	

Module 3: Responding to the environment: Plants

Objectives/Outcomes

When you complete this module, you will be able to:

- Describe the general functions of auxins, gibberellins and abscisic acid.
- Briefly describe the use of plant hormones in controlling weeds.
- Briefly describe the role of auxins in geotropism and phototropism.
- Interpret and conduct investigations based on the role of plant hormones.
- Describe the role of chemicals and thorns in plant defence mechanisms.

ICONS USED IN THIS MODULE

1. Discussion	
2. Group Activity	
3. Individual Activity	
4. Study/Teaching Tips	
5. Notes	
6. Ice Breaker	

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

Matthew Goniwe
SCHOOL OF LEADERSHIP & GOVERNANCE

ANNUAL TEACHING PLAN (ATP)

2020 Post – Covid: National Revised ATP: Grade 12 – Term 3: LIFE SCIENCES

TERM 3 (21days)	Week 1 (5 days)	Week 2 (5 days)	Week 3 (5 days)	Week 4 (5 days)	Week 5 (1 days)	Trial Examination (50%) (20 days)
CAPS Topics	**(National Examination Guideline pg.12) Homeostasis in humans [71%]**	**(National Examination Guideline pg.13) Responding to the environment (plants) [75%]**	**(National Examination Guideline pg. 13) Evolution [79%]**	**(National Examination Guideline pg. 13) Evolution [84%]**		
Topics /Concepts, Skills and Values	Negative feedback mechanisms – glucose, carbon dioxide, water, salts, thermoregulation	Plant hormones, plant defence mechanisms	Introduction to evolution e.g. biological evolution, hypothesis, theory. evidence for evolution and variation	Lamarckism, Darwinism and Punctuated equilibrium, Artificial selection and speciation	Reproductive isolation mechanisms, evolution in present times	
Requisite pre-knowledge	Homeostatic control in nutrition, gaseous exchange and excretion (Grade 11)	Hormones (Grade 12)	Revise fossil record and biogeography (Grade 10), Genetics (Grade 12)	Revise genetics and variation (Grade 12). Human skeleton (Grade 10)		
Resources (other than textbook) **to enhance learning**	Watch Telematics video on homeostasis at: https://bit.ly/2lkTLv2	Mind the Gap Study Guide, past examination papers, videos and power points	Past examination papers, videos and power points on an introduction to evolution	Watch Telematics video on natural selection, punctuated equilibrium and speciation at: https://bit.ly/2lq6LzI		

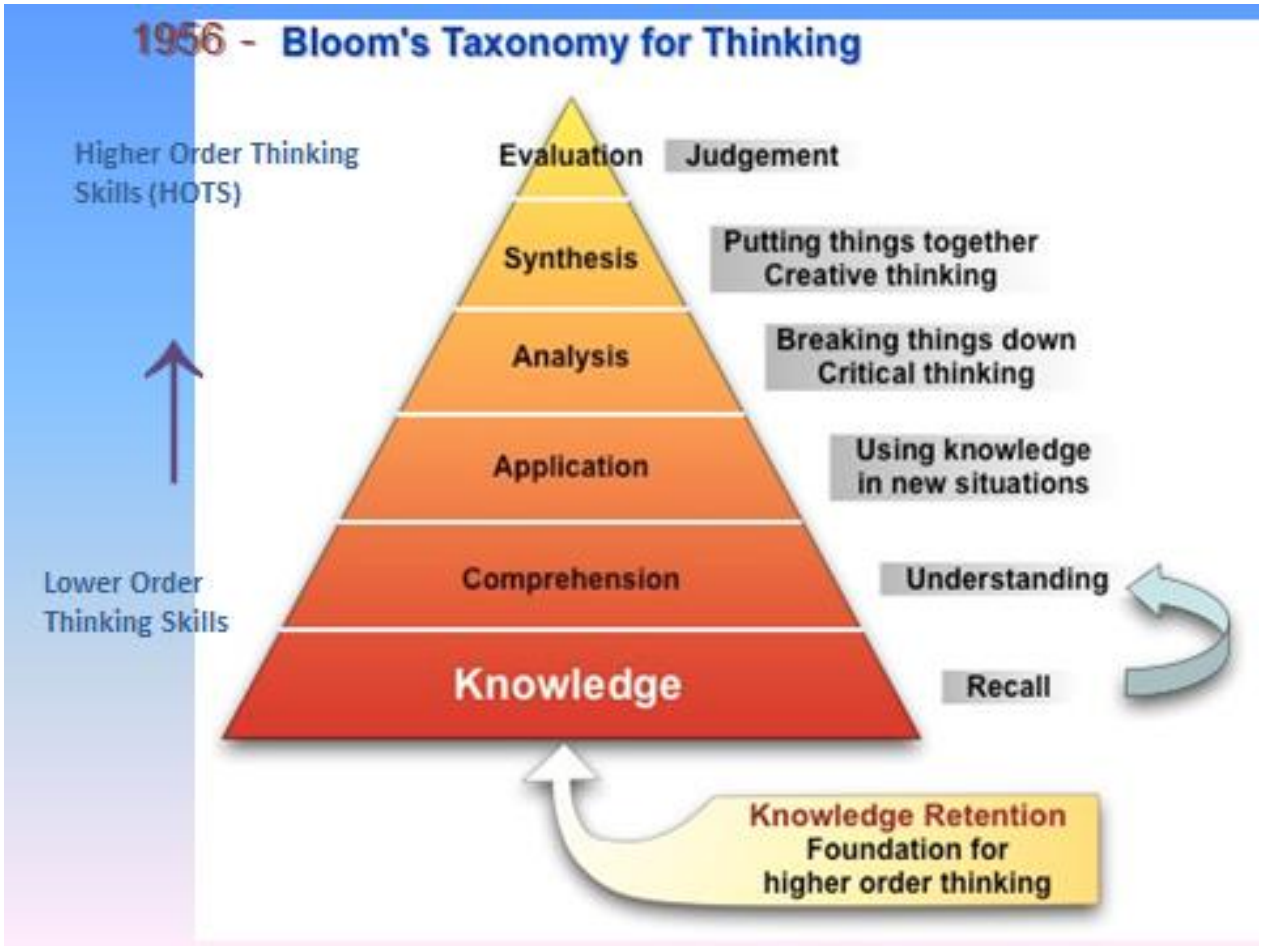
Assessment	**Informal Assessment:** Remediation	Questions from past papers, tests, scientific investigations	Past examination papers questions, tests	Past examination papers questions, tests	Questions from past papers, tests, scientific investigations	
	SBA (Formal)	*Preparation for test and trial examination*			**TEST (10%) (minimum 50 marks)** (Include practical investigation-type questions in the test)	

2020 Post – Covid: National Revised ATP: Grade 12 – Term 4: LIFE SCIENCES

TERM 4 (20 days)	**Week 1 (5 days)**	**Week 2 (5 days)**	**Week 3 (5 days)**	**Week 4 (5 days)**	**Final NSC Examination (29 days)**
CAPS Topics	**National Examination Guideline pg. 13) Evolution [95%]**		**(National Examination Guideline pg.16) Human impact on the environment [100%]**		
Topics /Concepts, Skills and Values	Evidence of common ancestors for living hominids, including humans	Out of Africa hypothesis	The atmosphere and climate change, water availability, water quality, Food security, Loss of biodiversity, solid waste disposal		

Requisite pre-knowledge		Revise genetics and variation (Grade 12). Human skeleton (Grade 10)	Human impact (Grade 11), Biodiversity (Grade 10)	
Resources (other than textbook) **to enhance learning**		Mind the Gap Study Guide, past examination papers, videos and power points	Mind the Gap Study Guide, past examination papers, videos and power points	
Assessment	**Informal Assessment:** Remediation	Questions from past papers, tests, scientific investigations	Data response questions, case studies, questions from past papers	
	SBA (Formal)	*Preparation for Final NSC Examination*		

COGNITIVE DEMAND LEVELS IN LIFE SCIENCES



In Life Sciences the last three levels are combined so that a FOUR level of cognitive demand is used:

Knowing science	Understanding science	Applying scientific knowledge	Evaluating, analysing and synthesising scientific knowledge
40%	25%	20%	15%
To **recall** or **recognise explicit** information, details, facts, formulas, terms, definitions, procedures, representations **from memory or from material provided**.	To **communicate understanding** of a Life Sciences concept, idea, explanation, model, or theory, for example to: **Interpret**: change from one form of representation to another (e.g. pictures to words; words to pictures; numbers to words, words to numbers, pictures to numbers) **Exemplify**: Find a specific example or illustration of a concept or principle **Classify**: Determine that something belongs to a category. **Summarize**: Abstract a general theme or major points. **Infer**: Draw a logical conclusion from presented information. **Compare**: Detect similarities and differences between two objects or concepts. **Explain why**: create a cause-and-effect model of a system or concept.	To use, **perform** or follow **a basic/** standard/ routine **procedure**/rule/method/ operation. To use/**apply understanding** of Life Sciences concepts, facts or details from a known context to an unfamiliar context.	**Analyse complex information** To adapt a variety of appropriate strategies to **solve** novel/ **non-routine**/complex/ open-ended **problems**. To **apply multi-step procedures.** **Evaluate** To evaluate or make critical **judgement** (for example, on qualities of accuracy, consistency, acceptability, desirability, worth or probability) using background knowledge of the subject. Judge, critique **Create a new product** To **integrate** life sciences concepts, principles, ideas and information, make connections and relate parts of material, ideas, information or operations to one another and to an overall structure or purpose.

COURSE TIMETABLE

DAY ONE			
SESSION	**TIME ALLOCATION**	**ACTIVITY**	**RESOURCES**
SESSION ONE	16:30 – 17:00	Plenary	
	17:00 – 18:00	Registration of participants	Registration forms
	18:00 – 18:30	Self-assessment – Pre-Test Feedback on self-assessment	MCQ
	18:30 -19:00	Administration and logistical arrangements	
	19:00 – 21:00	DINNER	

DAY TWO			
SESSION	**TIME ALLOCATION**	**ACTIVITY**	**RESOURCES**
SESSION ONE	08:00 – 10:30	Module 1: Unit 1: How do we teach terminology and what is evolution? Activity 1.1 – 1.2 Creating a cross word puzzle Module 1: Unit 2: Evidence of evolution and sources of variation Module 1: Unit 3: Lamarckism and Darwinism Activity 1.3	Course material and video clip Power Point Presentation
	10:30 – 10:45	TEA BREAK	
SESSION TWO	10:45 – 13:00	Module 1: Unit 3: Lamarckism and Darwinism Activity 1.4 – 1.6 (SBA task) Module 1: Unit 4: Punctuated equilibrium Activity 1.7	Course material Power Point Presentation Video clip
	13:00 – 14:00	LUNCH BREAK	
SESSION THREE	14:00 – 15:30	Module 1: Unit 5: Artificial selection Activity 1.8 Module 1: Unit 6: Speciation Activity 1.9	Course material Power Point Presentation Video
	15:30 – 15:45	TEA BREAK	
SESSION	16:00 – 18:00	Module 1: Unit 6: Speciation	Course material

FOUR		Activity 1.10 Module 1: Unit 7: Mechanisms of reproductive isolation Activity 1.11	Power Point Presentation
	18:00 – 19:00	Module 1: Unit 8: Evolution in present times Activity 1.12 Module 2: Unit 1: How do we teach phylogenetic trees? Activity 2.1 Module 2: Unit 2: What is the traits humans share with African apes and what are the anatomical differences between them? Activity 2.2	Course material Power Point Presentation Video clip
	19:00 – 21:00	DINNER	
DAY THREE			
SESSION	**TIME ALLOCATION**	**ACTIVITY**	**RESOURCES**
SESSION ONE	08:00 – 10:30	Module 2: Unit 3: What is used as evidence for common ancestors for living hominids? Activity 2.3 Activity 2.4, 2.5 Module 2: Unit 4: What is the 'out of Africa' hypothesis? Activity 2.6	Course material Power point Video clips
	10:30 – 10:45	TEA BREAK	
SESSION TWO	11:00 -13:30	Module 3: Unit 1: The general functions of auxins; gibberellins and abscisic acid. Module 3: Unit 2: The control of weeds using plant hormones. Module 3: Unit 3: The role of auxins in geotropism and phototropism. Activity 3.1 & 3.2 Module 3: Unit 4: The role of chemicals and thorns in plant defence mechanisms	Course material Power point Video clip
		Self-evaluation – Post Test Completion of evaluation forms Graphically presented Feedback on Pre and Post test	Post test
		Closing	
	13:30	Plenary followed by Lunch	

MODULE 1 – Evolution by Natural Selection

INTRODUCTION

Evolution is a process of gradual change that takes place over many generations, during which species of animals, plants, or insects slowly change some of their physical characteristics.

Theories of human evolution are based on research and scientific evidence that support the concept of **continual change.** Sources like geology, anatomy, embryology, genetics and physiology have been used as explanations for the theories. Further lines of evidence are fossil records, modification of descent, Biogeography and genetics.

Lamarck and Darwin are two of many scientists that have formulated theories about evolution. Lamarck's theory has been rejected while Darwin's theory of evolution through natural selection has been accepted.

At this point in time, you as the grade 12 teacher, have not yet taught Evolution as a topic. This training offered will assist in the teaching of the topic. It is also important that the Diagnostic report of November 2019 is also consulted to ensure we don't make the same mistakes as in the past. You will also notice that we have included terminology lists as these are crucial for good performance. Please ensure that your learners do regular terminology activities and tests.

OVERVIEW

This module deals with Evolution by natural selection. The module starts with notes and important "tips" for learners. There is a detailed terminology list, followed by evidence of evolution, Lamarckism and Darwinism, punctuated equilibrium, artificial selection, speciation, mechanisms of reproductive isolation and evolution in present times.

SPECIFIC OBJECTIVES

By the end of this session, participants will be able to:

- Teach the terminology associated with evolution
- Create a cross word puzzle on the computer
- Explain the following as evidence for evolution:
    - Fossil records
    - Biogeography
    - Modification by descent
    - Genetics
- Give a review of the contribution of each of the following to variation that exists amongst individuals of the same species:
    - Meiosis
      - Crossing over
      - Random arrangement of chromosomes
    - Mutations
    - Random fertilisation
    - Random mating
- Distinguish between continuous and discontinuous variation
- Describe and apply the evolutionary theories of Darwin and Lamarck
- Explain what Punctuated Equilibrium is

- Explain what artificial selection is
- Able to classify questions according Bloom's taxonomy
- Explain how speciation takes place through geographic isolation
- Give a brief outline of reproductive isolation mechanisms that help to keep species separate
- Describe and explain an example of natural selection and evolution in present times

CONTENT

You will study this module through the following units:

Unit 1: How do we teach terminology and define the concepts of evolution?
Unit 2: Evidence of evolution and sources of variation
Unit 3: Lamarckism and Darwinism
Unit 4: Punctuated equilibrium
Unit 5: Artificial selection
Unit 6: Speciation
Unit 7: Mechanisms of reproductive isolation
Unit 8: Evolution in present times

IMPORTANT notes:

- *Learners MUST understand the link between genetics and evolution.*
- *During the crossing over in prophase I of meiosis, chromosomes exchange information and then during metaphase I, arrange themselves on the equator randomly.*
- *This creates genetic variation in gametes.*
- *This determines the combination of chromosomes and genes that you have as an individual. Genetics determines individual variation (to be different) and survival of the fittest.*
- *Learners MUST have a clear understanding of the evolution terminology in order to study evolution and study the different theories and mechanisms of evolution.*
- *Lamarck and Darwin's theories are important for the understanding of how scientific knowledge developed and how the mechanisms of evolution occur.*
- *Be aware not to confuse the theories of Lamarck and Darwin. Lamarck's theory has been rejected and Darwin's theory of Natural Selection accepted. However, both theories may be asked for to explain specific case studies in evolution, so learners must be clear of the difference between these two theories.*
- *Questions on natural selection and speciation are often asked. The more examples of these two mechanisms that learners do, the better they will do in the exams.*
- *There are basically* ***FOUR types of questions on Evolution by Natural Selection asked*** :

    - **Natural selection**
    - **Speciation**
    - **Artificial selection**
    - **Evolution in present times**

UNIT 1 - How do we teach terminology and define the concepts of evolution

STRATEGIES TO TEACH TERMINOLOGY

1. In every lesson identify new terms/concepts and write it on the board.
2. Learners will take down terms/concepts at the back of their notebooks noting the correct spelling.
3. Learners must define/write down the meaning of these words from listening to the educator' lesson/finding meaning from the dictionary or textbook.
4. Break down the concept/term where possible- give the meaning of the prefix and suffix e.g. photo (light) synthesis (to build up).
5. Use the concept in a sentence.
6. Educators must check that learners have done the above, on a daily basis e.g. asks any learner to define a concept.
7. By the end of the year ALL learners have a comprehensive GLOSSARY of ALL terms /concepts.
8. ASSESSMENT: Biological terms to be included in all daily assessment tasks. Develop crossword puzzles. (Use various websites from the internet e.g. eclipse)
9. Learning terminology also helps in answering MCQs and matching questions, etc.

DEFINITIONS AND IMPORTANT TERMS AND CONCEPTS

Biological term	Description
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.
Alleles	Two alternative forms of a gene at the same locus
Analogous structures	Pertain to the various structures in different species having the same function but have evolved separately, thus do not share common ancestor.
Artificial selection/selective breading	The breeding of organisms over many generations in order to achieve a desirable phenotype
Biodiversity	The variety of plant and animal species on earth
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

Fossils	The mineralized remains of organisms that have lived in the past
Gene	A segment of DNA/a chromosome that codes for a particular characteristic
Genetic variation:	This includes a variety of different genes that may differ from maternal and paternal genes resulting in new genotypes and phenotypes.
Genome	The complete set of chromosomes in the cell of an organism
Harmful mutations	Causes changes in the DNA that can cause errors in protein sequencing that can result in partially or completely nonfunctioning proteins
Harmless mutations	Have no effect on the structure or functioning of the organism.
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
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
Useful mutations	Can be advantageous to the organism and are passed on from parent to offspring

ACTIVITY 1.1

AIM: To enable participants to create a quiz on google forms, crossword puzzles, or word search on the internet in order to enforce terminology activities in class

BACKGROUND: Learners have a general lack of terminology. Using other methods to learn these concepts and terms will result in improved performance.

METHOD: Complete the following crossword puzzle and word search.

The facilitator will then illustrate how to create your own quiz, crossword puzzle and word search, afterwhich you will then try to do it yourself.

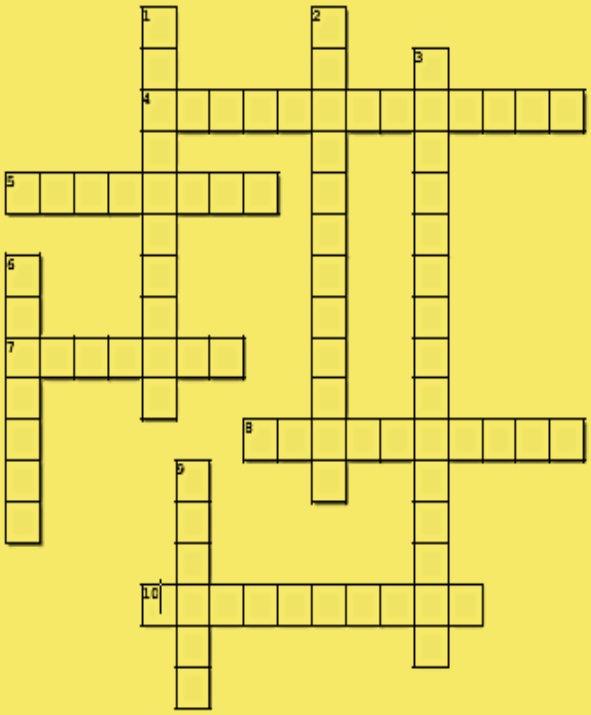
https://forms.gle/5a15txNoQQVvRPYU7

5/19/2019 Evolution by Natural Selection

Name:_____

Evolution by Natural Selection

Complete the crossword puzzle below



Created using the Crossword Maker on TheTeachersCorner.net

Across

4. Study of fossils
5. A sudden change in the sequence/order of nitrogenous bases of a nucleic acid
7. A group of organisms which can interbreed to produce fertile offspring
8. The permanent disappearance of a species from earth
10. A group of organisms of the same species living in the same habitat at the same time

Down

1. A tentative explanation of a phenomenon that can be tested and may be accepted or rejected
2. The variety of plant and animal species on earth
3. an ancestor that two or more descendants have in common
6. The mineralized remains of organisms that have lived in the past
9. Explanation of an observation that is supported by facts, models and laws

Name: _____

Created with TheTeachersCorner.net Word Search Maker

Evolution by Natural Selection

Identify the term from the description and then find the term in the word search

I	E	G	P	Y	J	I	X	H	O	H	M	K	V	X	F	V	G	F	I
M	E	Q	G	P	P	D	P	F	A	K	B	Y	L	F	E	A	P	T	I
K	X	K	R	X	K	Q	B	K	O	E	D	G	K	R	U	D	H	D	Y
H	Y	P	O	T	H	E	S	I	S	S	L	J	E	N	E	G	A	G	Y
V	T	H	Q	V	K	A	A	E	I	P	S	Z	E	B	X	O	A	Y	C
Z	X	E	R	S	B	Q	J	Q	G	D	J	I	N	A	V	G	M	A	O
X	F	H	R	R	V	E	N	P	Y	Y	W	P	L	M	K	W	G	Y	B
R	O	B	N	F	R	Q	Q	O	S	X	X	E	U	S	W	L	P	U	H
Y	T	K	Y	A	U	C	E	W	I	J	X	T	B	T	U	G	I	V	S
W	H	B	H	A	P	M	Z	P	P	T	A	F	D	S	B	R	V	E	J
E	N	P	L	K	Z	E	E	H	I	T	A	S	V	T	U	M	I	Y	A
W	M	T	F	K	R	V	V	N	I	O	P	L	A	W	D	C	J	R	N
B	S	O	K	T	T	E	C	O	F	T	Q	E	U	R	E	T	W	O	R
I	R	K	N	X	L	T	N	Y	H	C	I	O	Q	P	E	X	N	E	G
A	M	X	B	E	I	W	E	F	I	S	N	T	S	G	O	F	D	H	P
A	M	H	L	O	G	Y	P	N	W	Z	T	Q	X	L	V	P	V	T	L
I	G	L	N	F	G	E	S	F	J	V	Y	S	K	I	U	X	R	G	X
F	A	F	C	S	M	W	X	Q	G	D	Z	Q	R	J	O	K	P	Q	W
A	W	X	Q	N	Z	A	O	G	I	A	A	A	J	T	H	R	E	T	B
R	G	M	I	I	B	L	N	X	F	K	X	W	T	R	Q	L	Q	Y	R

Description

- Two alternative forms of a gene at the same locus
- The mineralized remains of organisms that have lived in the past
- A group of organisms of the same species living in the same habitat at the same time
- A tentative explanation of a phenomenon that can be tested and may be accepted or rejected
- A sudden change in the sequence/order of nitrogenous bases of a nucleic acid
- The complete set of chromosomes in the cell of an organism
- Explanation of an observation that is supported by facts, models and laws
- A segment of DNA/a chromosome that codes for a particular characteristic
- A group of organisms which can interbreed to produce fertile offspring
- The permanent disappearance of a species from earth

REFLECTION: Ensure that the terminology list is complete by revising previous question papers.
FOLLOW UP: Use the internet to create more activities. Several web addresses can be used:
TheTeachersCorner.net
Atozteacherstuff.com

INTRODUCTION TO EVOLUTION

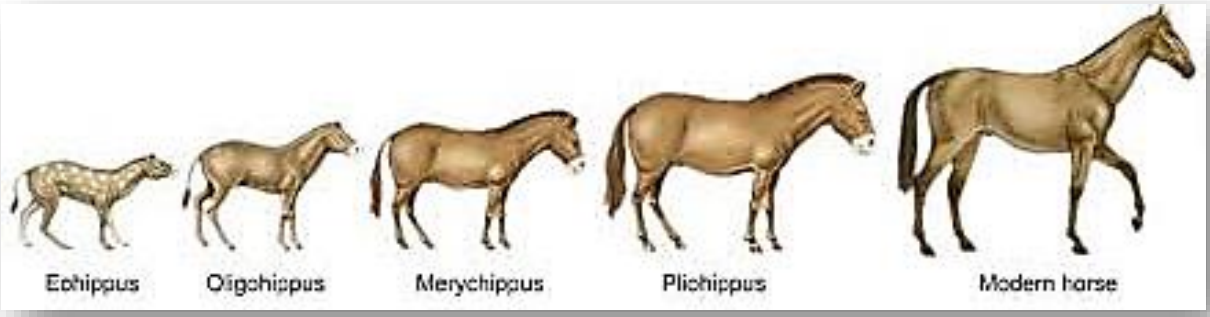
WHAT IS EVOLUTION?

The ***processes*** that have transformed life on earth from its ***earliest forms*** to the vast ***diversity*** that characterizes life on earth today.

A ***change*** in the ***genes!!!!!!!!***

WHAT IS BIOLOGICAL EVOLUTION?

All present-day forms of life have ***descended from***, and are ***related to***, those that lived in the past. They may look different because they became ***modified*** from one generation to another.



ACTIVITY 1.2

AIM: To distinguish between a hypothesis and scientific theory**.**
BACKGROUND: Learners are often asked to differentiate between the two terms.
METHOD: Complete the table below:

TERM	Hypothesis	Theory
DEFINITION		
EXAMPLE		

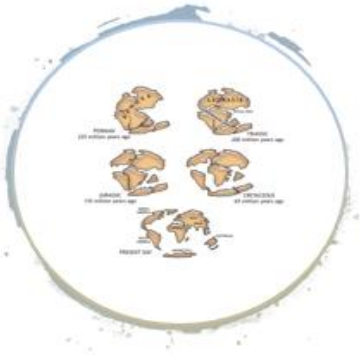
REFLECTION: To ensure understanding let learners give examples from daily life.
FOLLOW UP: Collect questions from past papers to practice answering similar questions.

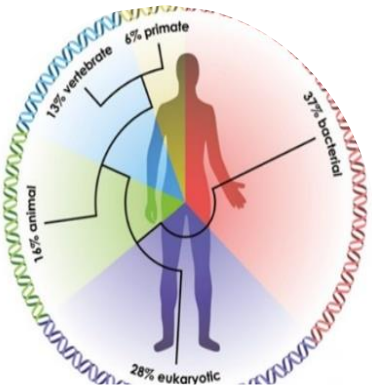
UNIT 2 – Evidence of evolution and sources of variation

EVIDENCE OF EVOLUTION

- **Fossil evidence**: The evidence that shows characteristics that makes us similar to, or different from African apes comes largely from a study of fossils (thousands of fossil fragments).
- **Genetic evidence**: Scientists state that organisms are closely related and are likely to have a common ancestor if they have:
  - Identical DNA structure
  - Similar sequence of genes
  - Similar portions of DNA with no functions and
  - Similar mutations (mitochondrial DNA)

  Species that are closely related have a greater similarity to each other than distant species.
- **Cultural evidence**: Cultural evidence from studies of tools and weapons, as well as language is also used to show similarities and differences between humans and African apes.



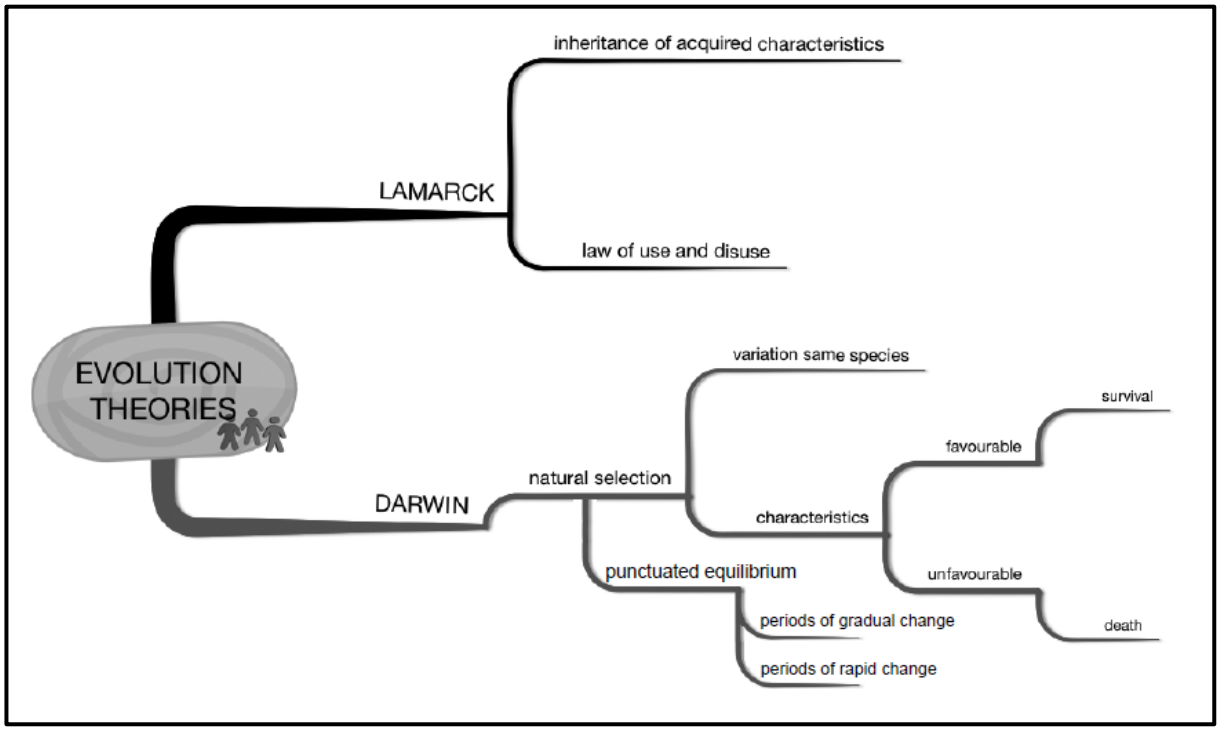


SOURCES OF VARIATION

The genotypes and therefore phenotypes (appearance) of individuals of the same species are different from each other because:

- **Crossing over** in Prophase I of meiosis involves an exchange of genetic material, leading to new combinations of maternal and paternal genetic material in each new cell resulting from meiosis.
- **Random arrangement** of maternal and paternal chromosomes at the equator during metaphase allows different combinations of chromosomes/chromatids to go into each new cell resulting from meiosis, making them different.
- **Random fertilisation** between different egg cells and different sperm cells formed by meiosis result in offspring that are different from each other.
- **Random mating** between organisms within a species leads to a different set of offspring from each mating pair.
- A **mutation** changes the structure of a gene or chromosome and therefore the organism's genotype. Since the genotype influences the phenotype, it creates organisms with new, different characteristics from one generation to the next.

UNIT 3 – Lamarckism and Darwinism



LAMARCK'S THEORY

Use and disuse of organs

- 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

Inheritance of acquired characteristics

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

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?

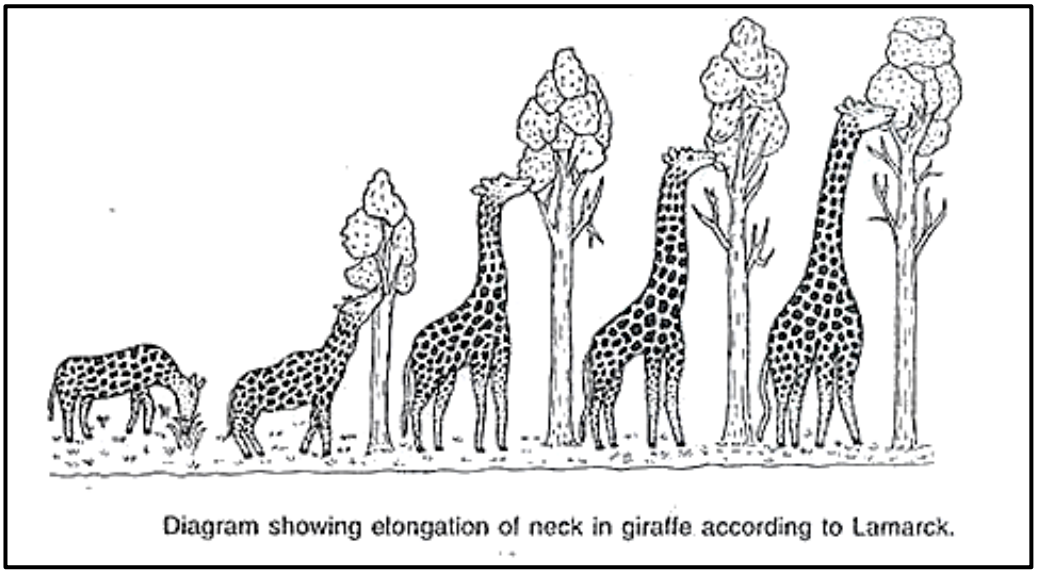


Diagram showing elongation of neck in giraffe according to Lamarck.

ACTIVITY 1.3

AIM: To enable participants to apply Lamarck's theory to a case study.
BACKGROUND: It is important to be able to apply knowledge to a new situation.
METHOD: Complete the following questions:
Read the extract below **(DBE/Feb.–Mar. 2018)**

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

1. **Name Lamarck's laws.** **(2)**
2. **How would Lamarck have explained the development of a small jaw size in the snakes?** **(4)**

REFLECTION: How could Lamarck have reworded his theory if he had all the knowledge available today?
FOLLOW UP: Use any diagram showing the evolutionary process in a species and apply Lamarck's theory to explain the process observed.

REJECTION OF LAMARCK'S 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

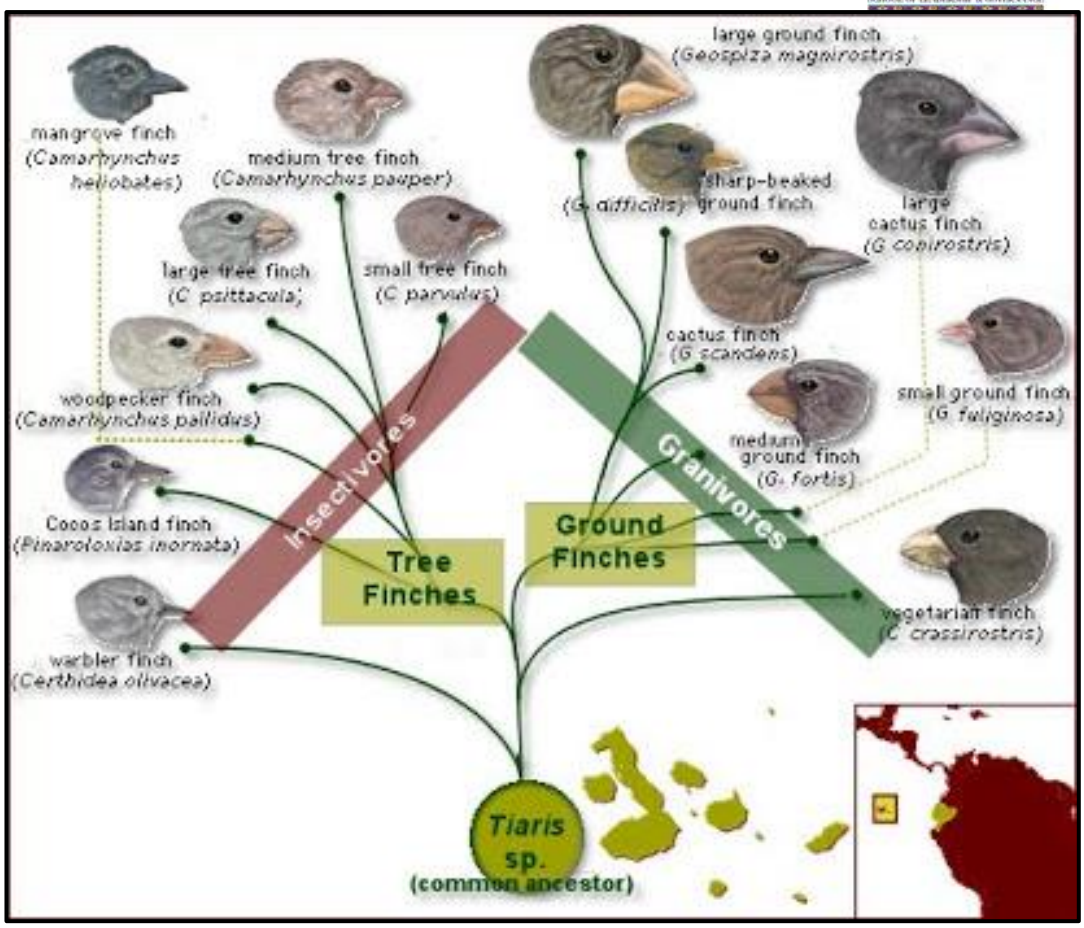
DARWIN'S THEORY

- Darwin's book published in 1859 called ***"On the Origin of Species by Means of Natural Selection"*** put forward two main ideas:

1. Species were not created in their present form but evolved from ancestral species**.**
2. Proposed a mechanism for evolution **- *NATURAL SELECTION***

Darwin's theory of evolution by natural selection:

- Organisms produce a large number of offspring.
- There is a great deal of variation amongst the offspring.
- Some have favourable characteristics, and some do not.
- When there is a change in the environmental conditions or 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.
- In this way, the characteristics of a population gradually change over a long period of time.



ACTIVITY 1.4

AIM: To enable participants to apply Darwin's theory to a case study.
BACKGROUND: It is important to be able to apply knowledge to a new situation.
METHOD: Complete the following question:

Read the extract below **(Adapted from DBE/Feb.–Mar. 2018)**

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

1. How would Darwin have explained the development of a small jaw size in the snakes? (6)

REFLECTION: Are there any new theories for the evolutionary process?

FOLLOW UP: Use any diagram showing the evolutionary process in a species and apply Darwin's theory to explain the process observed.
Past papers
SSIP high-flyers booklet

ACTIVITY 1. 5

AIM: To enable participants to answer questions on natural selection.
BACKGROUND: Questions on natural selection appear in every exam paper II. These questions can be found in every section of the papers (A, B or C) and on all levels of Bloom's taxonomy.
METHOD: Answer the following questions:

1.5.1 Who formulated the law of use and disuse? Choose the correct answer.

A. Lee Berger
B. Rosalind Franklin
C. Gregor Mendel
D. Jean Baptiste de Lamarck

1.5.2 Indicate whether each of the descriptions in COLUMN I apply 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 numbers (1.5.2.1 to 1.5.2.3).

COLUMN I		COLUMN II	
1.5.2.1	Law of inheritance of acquired characteristics	A: B:	Darwinism Modification by descent
1.5.2.2	Humans select the characteristics when breeding organisms	A: B:	Artificial selection Natural selection
1.5.2.3	A testable statement that may be accepted or rejected	A: B:	Theory Law

Question 1.5.3 **(EC/SEPTEMBER 2018)**
Salmonberry plants produce ripe fruits that occur in two colours, red and orange.
These fruits are eaten by birds and in so doing, they assist in seed dispersal.
Birds appear to choose fruits based on colour.

Scientists investigated the preference for red and orange fruit amongst four bird species.

The procedure for the investigation was as follows:

- 10 birds of each species were captured and housed in separate cages of equal size
- Each bird was presented with an identical single petri dish containing four pieces of fresh salmonberry, two red and two orange
- The first choice of fruit colour made by the bird was recorded

The results are shown in the table below:

Species	Number of birds that chose red	Number of birds that chose orange
Common raven	10	0
American robin	5	5
Swainson's thrush	7	3
Hermit thrush	8	2

1.5.3.1 Name the:
(a) Independent variables (2)
(b) Dependent variable (1)
1.5.3.2 Identify TWO factors that were kept constant in this investigation. (2)
1.5.3.3 Explain why the investigators used 10 birds of each species instead of 1 bird of each species. (2)
1.5.3.4 Calculate as a percentage, the number of birds that preferred red fruit. Show ALL working. (3)
1.5.3.5 Use the theory of evolution through natural selection to explain why you would expect an increase in the proportion of salmonberry plants that produce red fruit. (6)

REFLECTION: Any topic can be used to set investigative type of questions.
FOLLOW UP: Use questions from past papers to compile an activity for learners to practice the skill of answering investigative type of questions.

Activity 1.6

AIM: To enable participants to administer and assess the grade 12 SBA on natural selection successfully

Method: Follow the instructions.

LIFE SCIENCES Grade 12
Practical Task Term 3: Natural selection

Total	
	30

Date: _____

Name: _____

Duration: 1 hour

INSTRUCTION TO LEARNERS – THIS IS AN INDIVIDUAL TASK
Watch the following video: Rock pocket mouse: https://youtu.be/sjeSEngKGrg

BACKGROUND INFORMATION
A typical rock pocket mouse is about 170 millimetres long from its nose to the end of its tail, shorter

than an average pencil. And at just 15 grams, this tiny mouse weighs about as much as a handful of paper clips. You can find populations of rock pocket mice all over the Sonoran Desert in the southwestern United States.
There are two common varieties: a light-coloured variety and a dark-coloured variety. There are also two major colours of substrate, or surface materials, which make up the desert floor. Most of the landscape consists of light-coloured sand and rock, but patches of dark volcanic rocks that formed from cooling lava flows are found, separated by several kilometres of light-coloured substrate.

ACTIVITY 1

1. View the images of the rock pocket mouse populations in each location and record the numbers for each colour. (Your teacher will either display these in class or you will be given a set)

Card 1
Location A: Number of mice with light-coloured fur _____ Dark-coloured fur _____
Location B: Number of mice with light-coloured fur _____ Dark-coloured fur _____

Card 2
Location A: Number of mice with light-coloured fur _____ Dark-coloured fur _____
Location B: Number of mice with light-coloured fur _____ Dark-coloured fur _____

Card 3
Location A: Number of mice with light-coloured fur _____ Dark-coloured fur _____
Location B: Number of mice with light-coloured fur _____ Dark-coloured fur _____

Card 4
Location A: Number of mice with light-coloured fur _____ Dark-coloured fur _____
Location B: Number of mice with light-coloured fur _____ Dark-coloured fur _____ (8)

2. Arrange the cards in what you think is the correct order from the oldest to the most recent.
Write only the number of the cards to show the order you choose:
_____ (4)

3. What are the two types of substrate that these mice live on?

_____ (2)

Hand in this activity BEFORE you start the next activity.

ACTIVITY 2

The table below shows the data recorded for each location:

		Sequence (oldest to newest)			
		1st (Oldest)	**2nd**	**3rd**	**4th (Most recent)**
Location A (Light desert sand)	# of Light Mice	**10**	**11**	**10**	**11**
	# of Dark Mice	**2**	**1**	**2**	**1**
Location B	# of Light	**10**	**9**	**6**	**2**

(Dark volcanic rock)	Mice				
	# of Dark mice	**2**	**3**	**6**	**10**

Draw two BAR GRAPHS; one for each location to show the numbers and colour of mice at Location A and Location B.

(8)

ACTIVITY 3

1. Compare the graphs at Location A and B. What is the difference between the two?

_____

_____

_____ (2)

2. Explain why a rock pocket mouse's colour influences its overall ability to survive and produce offspring in these environments.

_____

_____

_____(2)

3. Explain the presence of dark-coloured mice at location A. Why is this **phenotype** (appearance) not more common in the population at that location?

_____

_____

_____(2)

4: "**Mutation** is random, but natural selection is not random." Explain how the number of dark mice increased in Location B, according to this statement.

_____

_____

_____(2)

[30]

REFLECTION: At the rate humans are misusing the earth, the possibiliy to have a very different earth in 100 year's time is very strong. What impact will this have on the animal and plant specie on earth?
FOLLOW UP: Find similar examples of natural selection on the internet and use them to expose learners to other situations in which they must use their knowledge.

ACTIVITY 1: CARDS OF LOCATIONS TO BE USED TO DETERMINE NUMBER OF EACH COLOUR MOUSE IN A LOCATION

1

2

3

4

UNIT 4 – Punctuated Equilibrium

PUNCTUATED EQUILIBRIUM

Eldredge and Gould 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 there is 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.

ACTIVITY 1.7

AIM: To enable participants to do an activity based on punctuated equilibrium.
BACKGROUND: This activity provides a practical way in which the concept of punctuated equilibrium can be demonstrated to learners.
METHOD: Follow the instructions and make two stratigraphic timelines showing gradualism and punctuated equilibrium.

A PEEK AT THE PAST
Fossil Patterns, Gradualism, or Punctuated Equilibria?

Every now and then, palaeontologists uncover what appears to be a complete series of fossils. They find batches of fossils which seem to represent a population of one species, living at one period of time, and showing a typical range of variation, but still clearly members of one species. As they search layers of sediment above and below, they find more fossil groups of what appear to be the same species.

As palaeontologists study the entire series of fossils, they tend to find two kinds of patterns. Sometimes there appear to be slight shifts in the average features of the fossils over time, eventually becoming so different from the earliest form that they have to say a new species has formed. But with another series of fossils (may be a totally different kind of organism), they find very little difference for long periods of time, then, all of a sudden, they begin to find fossils similar to the earlier ones, but showing some striking differences, clearly a new species. Sometimes, in both cases, the original species continues to exist along with the new species, and sometimes the original species can no longer be found.

The purpose of this exercise is to reconstruct these patterns, compare and contrast them with each other, and arrive at some conclusions about what happens to the species over time. (The "fossils" in this study are imaginary, for easier analysis, but they do accurately represent what we find in the fossil record). One group of fossils represents the genus *Molluscaformis* (elongated, sausage shaped), the other represents the genus *Pedivarious* (short thick body, with thick black markings on it).

You will be provided with a collection of fossils representing one of these genera. You will also be provided with a two-page layout which shows the layers of sedimentary rock from which the fossils were taken (the "Stratigraphic Sequence"). Each layer ("Formation") is identified with a unique name, and an indication of how long it took to form (its "duration").

INSTRUCTIONS

1. Place the two "Stratigraphic" sheets so that the title sheet is above the other, and the identical parts of their ends overlap perfectly.
2. Place the fossils (in the Fossil Sequence" column) according to the "Formation" from which they were taken. "Upper" means it was found in the upper (more recent) portion of that formation; "Lower" means it was found in the lower (older) portion of that formation. (The little numbers in parentheses indicate the number of fossils which are represented by that one "average" fossil shown).
3. Once all the fossils are arranged chronologically (from the oldest at the bottom, to the youngest near the top), start adjusting their horizontal positions (representing their overall morphology, or appearance of form). This usually works best if you place the lowest (oldest) fossil in the lower left corner of the workspace column. If the next fossil above it is identical in appearance, place it directly above the first. If it appears slightly different, place it above and slightly to the right of the one below it. If there is a major difference in form (appearance), shift it even more to the right. Repeat this with each fossil as you move up the column.
4. If there appears to be two kinds of fossils at the same level, check the fossils further up, and look for a consistent pattern of change away from (different from) the lower sequence; locate those fossils further to the right. If the differences are very slight, show this with very slight shifts to the right. If they have major differences shift them even more to the right.
5. Once you have your pattern developed, ask your teacher to check it. If it represents the arrangement described above, then diagram the pattern on the appropriate chart, using simple lines to represent the sequence of fossils through time. The result may look like a leaning branching tree, or it may look like a couple of vertical or near vertical lines.
6. Assign a proper species name to the original species, and to any other species which may have formed. You can invent the trivial part of the name, reflecting some unique feature of that species, e.g. "*M. megawings*". Print their names next to each somewhat vertical line on your chart. Use the form "*M. species*" or *P*.

species" in each case.
7. Answer the discussion questions for that particular genus.

A PEEK AT THE PAST: DISCUSSION

Molluscaformis Fossils

1. How would you describe these fossils generally through time (except for any "sudden" major change)?

[ ] static (generally unchanging), **or** [ ] non static (gradually changing)?

2. Have any new species evolved? _____. If so, how many?_____. In which formation did it/they first appear?

3. Have any species apparently become extinct?_____ If so, which one(s)?

(For each extinction, indicate in which formation its last fossils were found.)

4. Which pattern of evolution seems to be occurring here?
[ ]"Gradualism", in which changes to new species are gradual, followed by continuous little changes, or

[ ]"Punctuated Equilibrium", in which changes to new species appear to be sudden, followed by little or no change

5. Would you be likely to find any intermediate or transitional fossils if we searched more thoroughly in the formation just below the first appearance of changed fossils?_____ Why?

Pedivarious Fossils

1. How would you describe these fossils generally through time (except for any "sudden" major change)?

[ ] static (generally unchanging), **or** [ ] non static (gradually changing)?

2. Have any new species evolved? _____. If so, how many?_____. In which formation did it/they first appear?

3. Have any species apparently become extinct?_____ If so, which one(s)?

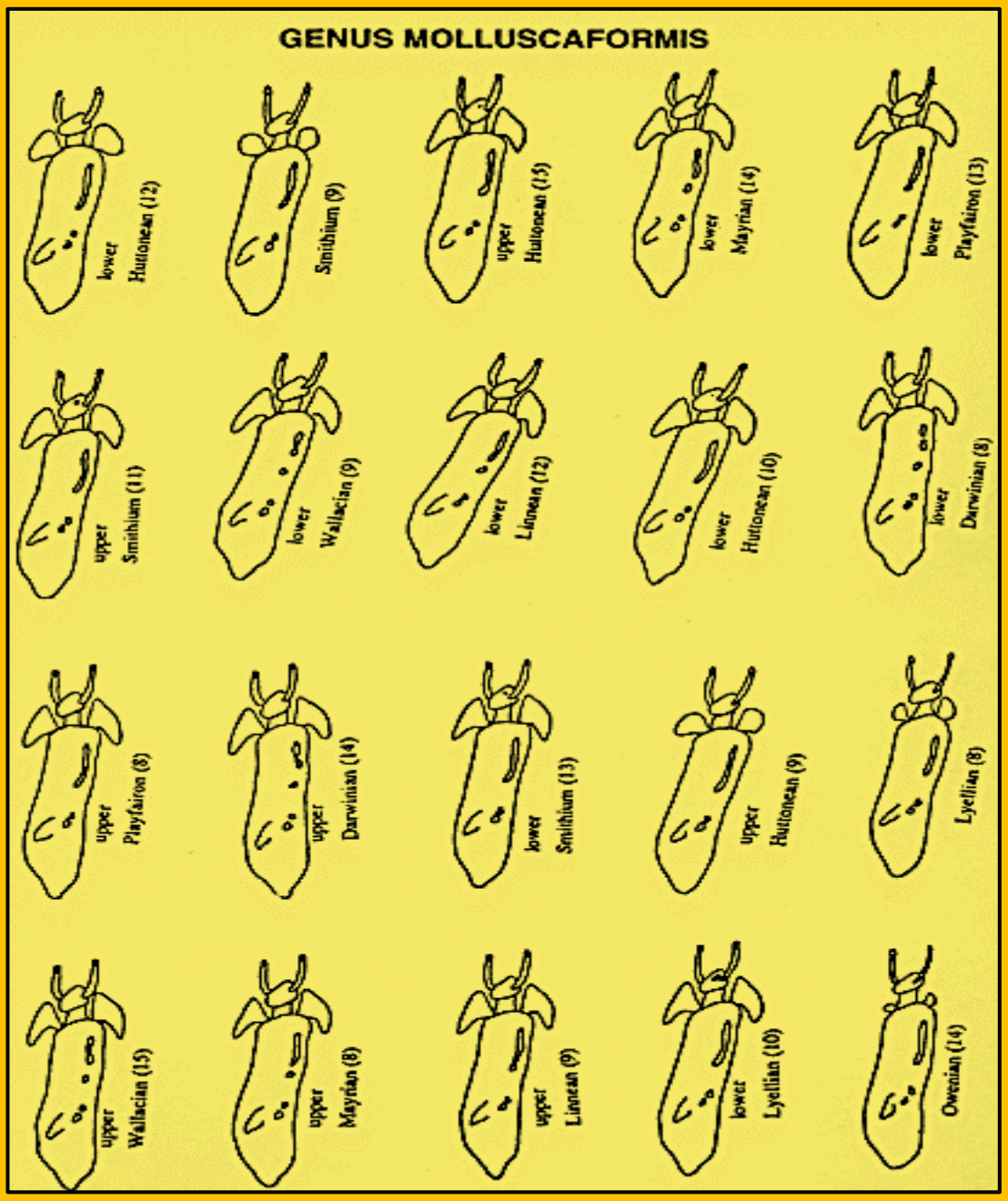
(For each extinction, indicate in which formation its last fossils were found?)

4. Which pattern of evolution seems to be occurring here?

[ ]"Gradualism", in which changes to new species are gradual, followed by continuous little changes, or

[ ]"Punctuated Equilibrium", in which changes to new species appear to be sudden, followed by little or no change

5. Would you be likely to find any intermediate or transitional fossils if we searched more thoroughly in the formation just below the first appearance of changed fossils?_____ Why?

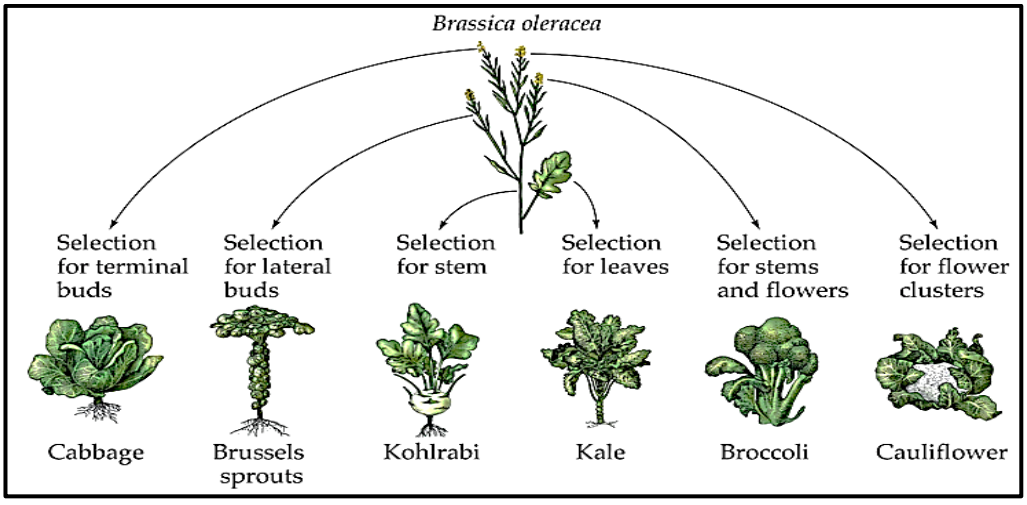


REFLECTION: What other species can you think of where punctuated equilibrium has occurred? What role does the environment plays in punctuated equilibrium?
FOLLOW UP: Learners must be able to apply their knowledge to new situations. Look for application questions in past papers.
https://biologos.org/common-questions/what-does-the-fossil-record-show/
https://courses.lumenlearning.com/boundless-biology/chapter/evidence-of-evolution/

UNIT 5 – Artificial Selection

ARTIFICIAL SELECTION

- Artificial selection is the intentional reproduction of individuals in a population that have desirable traits.
- Some consider domesticated animals to be the ultimate products of artificial selection.
  - Food crops – many of the green leafy vegetables have been selectively bred from the 'wild mustard' plant
  - Thoroughbred racehorses are one example of artificial selection of animals.
  - The meats we eat are the result of the careful selective breeding of cows, pigs, sheep, and chickens.
  - Our pets are a far cry from their "wild" ancestors. Cats and dogs, which were originally domesticated for pest control, hunting, or shepherding, eventually were bred to become companion animals.
- There can be a downside to artificial selection.
  - Because this process essentially removes variation in a population, selectively bred organisms can be especially susceptible to diseases or changes in the environment that would not be a problem for a natural population.
  - Inbreeding — the mating of closely related individuals — is also a problem.
  - In dogs, this has resulted in breeds that have health issues ranging from decreased life span to hip dysplasia.



ACTIVITY 1.8

AIM: To enable participants to answer questions based on artificial selection.
To enable participants to classify questions according to Bloom's taxonomy.

BACKGROUND: Questions on artificial selection appear in every exam paper II. These questions can be found in every section of the papers (A, B or C) and on all levels of Bloom's taxonomy.

METHOD: Classify the questions according to Blooms Taxonomy in the weighting grid provided below.

Answer the following questions based on artificial selection.

Question 1.8.1 ***DBE/November 2015***

An investigation was done by Grade 12 learners to determine which chickens grow faster: chickens that are selectively bred for laying eggs or chickens that are selectively bred for meat production.

The following steps were carried out:

- The learners bought 30 one-day-old chickens from a commercial supplier.
- Fifteen of the chickens had been selectively bred for laying eggs and 15 of the chickens had been selectively bred for meat production.
- All the chickens were kept under the same environmental conditions. This included being fed the same chicken feed, made mostly from cereal grains and protein sources.
- The chickens were weighed regularly for a period of 45 days.

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

[Adapted from www.chicken.org.au]

1.8.1.1 Formulate a hypothesis for this investigation. (2)

1.8.1.2 State the independent variable in this investigation. (1)

1.8.1.3 Calculate the percentage weight increase of the chickens that Were selectively bred for meat between day 8 and day 45. Show ALL working. (2)

1.8.1.4 State ONE advantage of repeating the investigation with 100 chickens. (2)

1.8.1.5 State THREE factors that the learners should keep constant in this investigation. (3)

1.8.1.6 Write a suitable conclusion for the investigation based on the results in the graph. (2)

1.8.1.7 State TWO benefits of the selective breeding of chickens, other than for increasing meat production. (2)

1.8.1.8 Explain ONE reason why selective breeding of chickens for better meat production may not be an advantage for the chickens if they were to live in the wild. (2)
(16)

Question 1.8.1.9: Complete the weighting grid using the questions above.

Weighting grid

LIFE SCIENCES									
ANALYSIS GRID			**NOVEMBER Paper II 2015**					**GRADE 12**	
	COGNITIVE LEVELS				**KNOWLEDGE STRANDS**				
Question no	**A**	**B**	**C**	**D**	**Life at Molecular, Cellular and Tissue Level**			**Diversity, Change and Continuity**	
	Knowing Science	Understanding Science	Applying Scientific knowledge	Evaluating, analysing & synthesizing scientific knowledge	DNA: code of life	Meiosis	Genetics and inheritance	Evolution by natural Selection	Human evolution
1.8.1.1									
1.8.1.2									
1.8.1.3									
1.8.1.4									
1.8.1.5									
1.8.1.6									
1.8.1.7.									
1.8.1.8									
Sub total									

Question 1.8.2 ***DBE/November 2017***

Read the extract below.

Long before the development of agricultural crops, South African villagers would pick the sweetest and largest fruits of the marula tree and scatter them around their camps. The seeds of these fruit would germinate and grow into fruit-bearing trees. The best fruit would then be chosen from these trees and the process would be repeated.

In recent times, farmers use a process called marcotting. This involves peeling away the bark in one area around a branch. This area is stimulated to form roots. The branch is then removed from the tree and planted in the soil to produce more marula trees.

1.8.2.1	Name the characteristics that the villagers were selecting.	(2)
1.8.2.2	Explain how this practice is an example of artificial selection.	(3)
1.8.2.3	Give ONE environmental factor that could affect the characteristics named in QUESTION 1.8.2.1.	(1)
1.8.2.4	Explain ONE disadvantage of a plantation of marula trees grown through marcotting compared to a population of marula trees that have reproduced naturally.	(2)
1.8.2.5	Explain whether the fruits from marcotted marula trees could be classified as genetically modified (GM).	(2)
		(10)

REFLECTION: Any topic can be used to set investigative type of questions and questions based on an extract. Reading with understanding comes with practice. Scientific reading material should be made available to learners in the classroom.

FOLLOW UP: Use questions from past papers to compile an activity for learners to practice the skill of answering investigative type of questions and questions based on an extract.

The format of the weighting grid provided should be used when setting Life Sciences question papers.

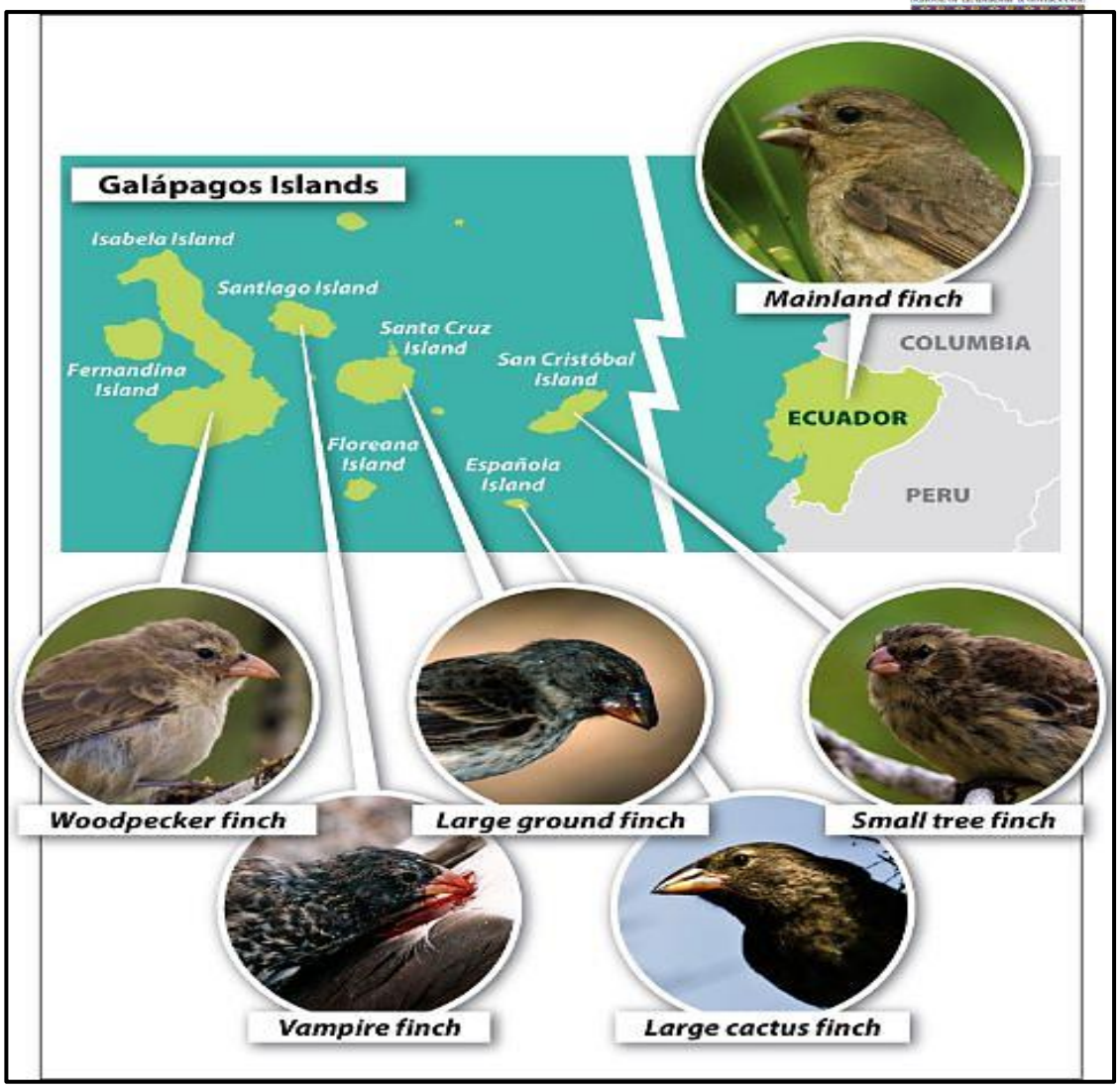
UNIT 6 – Speciation

SPECIATION

- ***Population:*** individuals of the same species living in the same area that can randomly interbreed
- ***Species:*** organisms that have the same characteristics, capable of random interbreeding and producing fertile offspring
- ***Speciation:*** is the evolutionary process by which populations evolve to become distinct species.
- ***Geographical isolation*** and ***reproductive isolation*** mechanisms isolate the gene pool of a species resulting with formation of new species.

Speciation through geographic isolation:

- If a population of a single species
- becomes separated by a geographical barrier (sea, river, mountain, lake)
- then the population splits into two.
- There is now no gene flow between the two populations.
- Since each population may be exposed to different environmental conditions/the selection pressure may be different
- natural selection occurs independently in each of the two populations
- such that the individuals of the two populations become very different from each other
- genotypically and phenotypically.
- Even if the two populations were to mix again
- they will not be able to interbreed.
- The two populations are now different species.

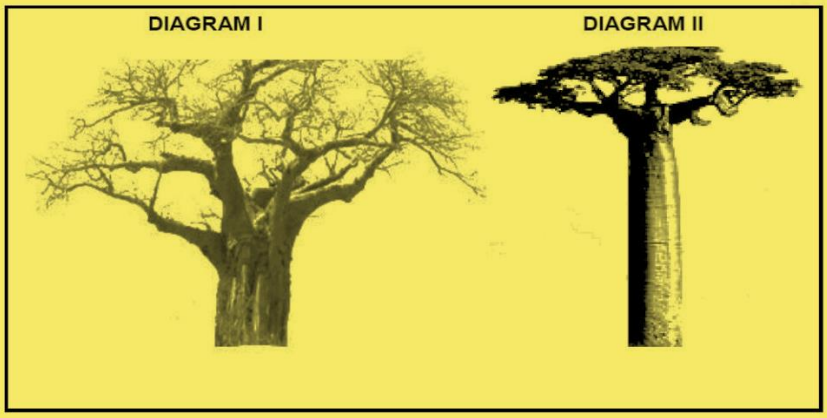


ACTIVITY 1.9

AIM: To enable participants to answer questions based on speciation
BACKGROUND: Questions on artificial selection appear in every exam paper II.
METHOD: Answer the following questions.

Question 1.9.1 ***(Adapted from F/State P 2 Sept.2016)***

Earth originally existed as one large land mass that later drifted apart and formed the continents as we know it today. The following two pictures are those of baobab trees found on the continent of Africa (Diagram I) and found on the continent of Australia (Diagram II).

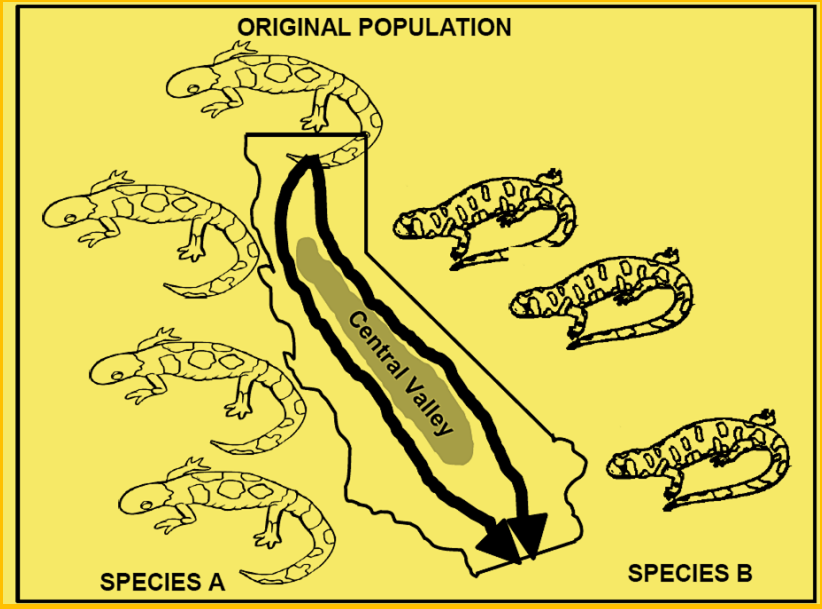


Explain how the two species of baobab trees shown above might have formed.

(6)

Question 1.9.2 ***(EC/SEPTEMBER 2017)***

The diagram below shows an evolutionary process taking place in a population of salamanders in California. The process took place gradually, millions of years ago. Study the diagram and answer the questions that follow.



1.9.2.1 What evolutionary process is illustrated in the diagram above? (1)

1.9.2.2 Use the diagram to explain how the Species **B** evolved from the original population. (6)

1.9.2.3 Explain why this is not an example of punctuated equilibrium. (3)

(10)

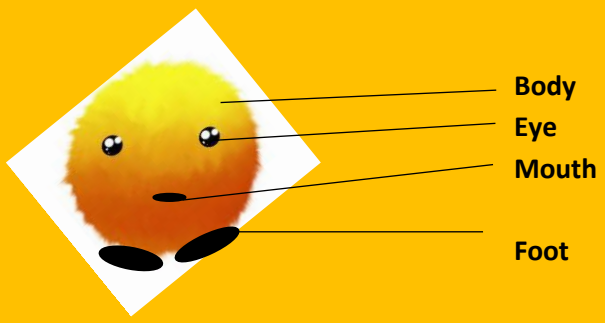
REFLECTION: What is the difference between speciation and natural selection?

FOLLOW UP: The more learners practice to answer questions on speciation and natural selection, the easier it would become to differentiate between the two concepts.

ACTIVITY 1. 10

AIM: To enable participants to carry out a group practical task based on speciation successfully.
BACKGROUND: Learners get easily confused between speciation and natural selection. This hands-on activity will assist in making a clear distinction between the two concepts.
METHOD: Follow the instructions.

Zeebo Instructions (for learners):



A standard Zeebo

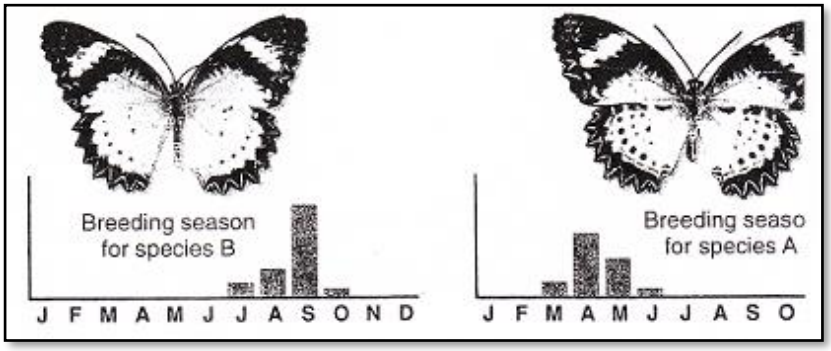
1. Zeebos are fictional animals that travel with sailors on boats and sometimes land up on different island. These islands are divided by large stretches of ocean and once zeebos land on an island they will never be able to mix with the other zeebo who landed on the other islands.
2. You will be divided in groups and each group will be "living" on their own island.
3. You will receive a card with information on the island that you landed on.
4. After you have received your islands' card you will look at the different environmental conditions and decide what your Zeebo will have to look like to survive (for example look at legs, arms, teeth, size of eyes, fur/no fur and many other things that you think your zeebo will need).
5. Draw your new Zeebo that will result because of natural selection after 500 thousand years**.**
6. Your teacher will call out "Random Mutation time" - when this happens you will receive a mutation which you will have to incorporate in your Zeebo's look.
8. Draw your new Zeebo that will result after the random mutation. Give your Zeebo a new name. Base it on its looks.
9. Present this new Zeebo as well as the one without mutations to the other islands.
10. Look at the different Zeebos, would they be able to recognise each other? Do you think they are still the same species?

REFLECTION: You can see the divergent evolution of the Zeebos. Choose two Zeebos from different islands – do you think these Zeebos would recognise each other? Could they successfully breed? Nope – they are now separate species.
FOLLOW UP: Let the learners write down the sequence of speciation.

MECHANISMS OF REPRODUCTIVE ISOLATION

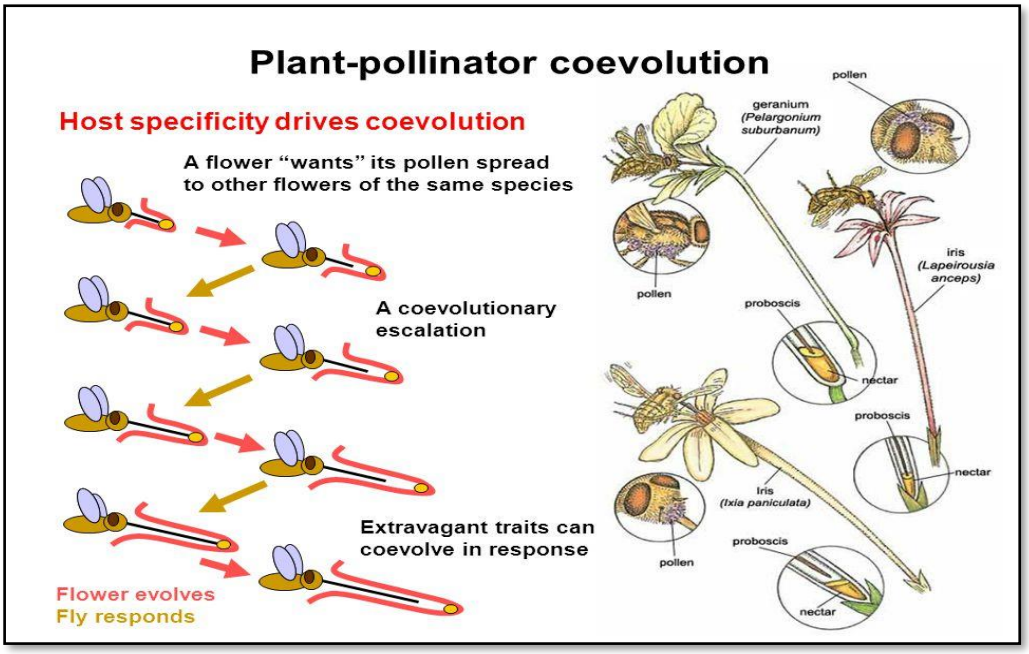
Besides geographical barriers, other ways of isolating species is through various reproductive strategies.

- **Breeding at different times of the year**
  - **E.g.** Two species of mayflies emerge during different weeks in springtime.



- **Species-specific courtship behaviour**
  - **E.g.** Two similar species of birds have different mating rituals**.**

- **Adaptation to different pollinators**
  - **E.g.** Two species of orchid have different length nectar tubes and are pollinated by different species of moths.



- **Infertile offspring**
  - **E.g.** A donkey and a horse are mated and produce a viable mule, however, it is sterile .

- **Prevention of fertilization due to lack of fit between sexual organs. The species will have specialized genitalia for mating and when it is not the correct size, mating will not be possible.**
  - **E.g.** Two different breeds of dog.

ACTIVITY 1.11

AIM: To enable participants to identify reproductive isolating mechanisms
BACKGROUND: These are easy marks to get in the exam papers.
METHOD: Answer the following questions:

Question 1.11.1 ***(EC/SEPTEMBER 2017)***

1.11.1.1 Scientists visiting a group of four islands P, Q, R and S found similar spiders on each island. They carried out investigations to see if the spiders from the different islands belonged to the same species.
The results are in the table below (✓indicates successful interbreeding. **X** indicates unsuccessful interbreeding)

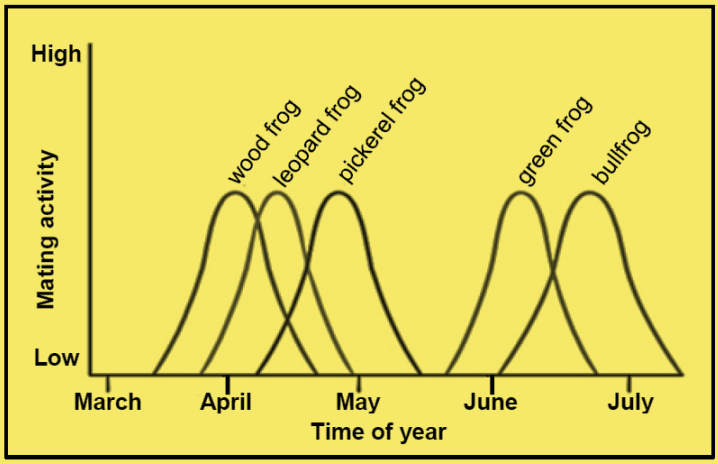
	Spiders from			
	P	**Q**	**R**	**S**
P	✓	✓	X	X
Q	✓	✓	X	X
R	X	X	✓	X
S	X	X	X	✓

Which two populations belong to the same species?

A **Q and R**
B **R and S**
C **Q and S**
D **P and Q**

DBE/Feb.–Mar. 2018

1.11.1.2 Different frogs, which all belong to the genus *Lithobates*, are found in the same forest. The graph below shows their mating activity



Based on the information, what kind of isolating mechanism is most likely keeping the bullfrogs and wood frogs as separate species?

A Geographic isolation through the presence of geographic barriers
B Reproductive isolation through species-specific courtship behaviour
C Reproductive isolation through breeding at different times of the year
D Reproductive isolation through the production of infertile offspring

1.11.1.3 Which ONE of the following is a reproductive isolating mechanism?

A Breeding at different times of the year
B Same pollinators for different species of plants
C Absence of a geographic barrier
D Cloning

QUESTION 1.11.2 ***DBE/May–Jun. 2019***

A group of students observed that the mating calls of a population of frogs at the local dam had recently become much louder. The dam is close to a highway, where the traffic noise has increased over the years.

They wanted to investigate if the increase in traffic noise from the highway had an evolutionary effect on the loudness of the frogs' mating calls in the mating season.

They recorded the following:

- Average level of traffic noise over a period of 6 years
- Average loudness of the frogs' mating calls during the same period

The results are shown in the table below:

YEAR	AVERAGE LOUDNESS OF TRAFFIC NOISE (dB)	AVERAGE LOUDNESS OF MATING CALLS (dB)
2006	30	36
2007	32	38
2008	36	40
2009	40	48
2010	55	68
2011	62	74

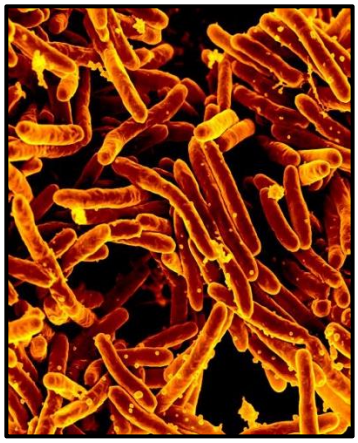
1.11.2.1 Explain the advantage of a louder mating call. (2)
1.11.2.2 State why these results may be considered to be reliable. (1)
1.11.2.3 State the conclusion for this investigation. (2)
1.11.2.4 Give TWO variables that should be kept constant in this investigation. (2)
1.11.2.5 Draw line graphs on the same set of axes to show the change in average loudness of traffic noise and mating calls for the period 2006 to 2009. (7)
(14)

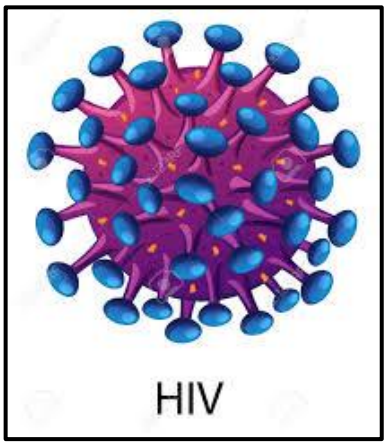
REFLECTION: This content is assessed by using examples of the different strategies.
FOLLOW UP: Expose learners to as many as possible examples.

UNIT 8 – Evolution in present times

EVOLUTION IN PRESENT TIMES

- Malaria mosquitoes became resistant to insecticide.
- Small finches on Galapagos died out during drought because plants with small seeds died, big finches survived because plants with big seeds were still around.
- Tuberculosis bacteria became resistant to TB drugs because of mutations.
- HIV virus became resistant to ARV





Activity 1.12

AIM: **to enable participants to identify and describe case studies of evolution taking place in current times**

Method: **Answer the following questions**:

DBE/Nov 2019 P2

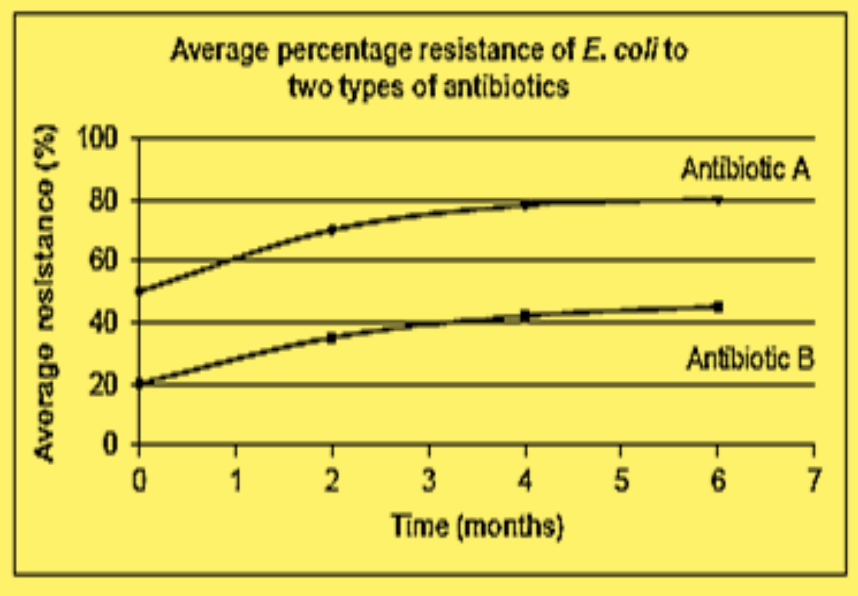
1.12.1 The *E. coli* bacterium lives in the intestines of pigs where they reproduce rapidly. Certain strains of *E.coli* cause diarrhoea in young pigs (piglets).

Scientists carried out an investigation using 100 piglets to determine the resistance of *E.coli* to two antibiotics, **A** and **B**.

The scientists:

- Injected the piglets with antibiotic **A** and antibiotic **B**
- Took a sample of *E.coli* from the intestines of each piglet a week later and placed them in separate petri dishes
- Allowed the bacteria to grow for 24 hours
- Added antibiotic **A** to one petri dish and antibiotic **B** to the other petri dish
- Measure the growth of the bacteria in each petri dish after 24 hours
- Used the growth measurement as an indication of the resistance of the bacteria to each antibiotic
- Repeated the process over a period of six months
- Calculated the average percentage resistance to both antibiotics

The results are shown in the graph below



1.12.1.1 Identify the independent variable in this investigation. (1)

1.12.1.2 Identify TWO factors that should be kept constant during the investigation (2)

1.12.1.3 State TWO ways in which the scientists ensured the reliability of the investigation. (2)

1.12.1.4 Which antibiotic will you recommend for controlling *E.coli* in piglets? (1)

1.12.1.5 Support your answer to QUESTION 1.12.1.4 using evidence in the graph. (2)

1.12.1.6 Explain the results that are shown in the graph for antibiotic **A** in terms of natural selection. (5)

(13)

DBE/Feb.–Mar. 2018

1.1 Study the extract and the information provided

2.2

An insecticide is used by farmers to control insect populations of *Plodia interpunctella* which feeds on stored grain. Farmers treat the grain with the insecticide to prevent an insect infestation.

This insecticide is extremely poisonous to certain insects, yet causes little or no harm to humans and beneficial insects.

In recent years it has been noticed that this insecticide is no longer effective in controlling insect populations of *Plodia interpunctella.*

Scientists hypothesized that insect populations that had previously been exposed to the insecticide had a higher survival rate when the grain was treated again.
In an investigation to test this hypothesis, they:

- Identified storage bins that had previously been treated with the insecticide and bins that had never been treated with the insecticide
- Collected a sample of 300 insects from each bin
- Kept each sample in a separate container of equal size and the same conditions
- Sprayed the same concentration and volume of insecticide over both containers
- Allowed 24 hours for the insecticide to take effect
- Counted the number of insects that survived in each container

The results are given in the table below:

PREVIOUS EXPOSURE TO INSECTICIDE	NUMBER OF INSECTS THAT SURVIVED
With previous exposure to insecticide	182
No previous exposure to insecticide	66

2.1 Give the:

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

2.2 State THREE factors that were kept constant in this investigation. (3)

2.3. Give TWO reasons why the scientists' results may not be reliable. (2)

2.4 State a conclusion for this investigation. (2)

(9)

RESOURCES

https://wordmint.com/public_puzzles/200551

https://worksheets.theteacherscorner.net/make-your-own/crossword/

https://biologydictionary.net/common-descent/

https://necsi.edu/gradualism-and-punctuated-equilibrium

https://bit.ly/2YbySBm

Download the free SCOP genetics app on Android from Wits University:

https://play.google.com/store/apps/details?id=scoping.genetics&hl=en

MODULE SUMMARY

Life exists in a variety of life forms and it is in the study of Evolution through Natural Selection that enables learners to understand where the biodiversity that exists today evolved from and how the millions of species came about.
In order to understand species, speciation, biodiversity and change, it is **essential to understand the theories of Darwin and Lamarck and why we reject Lamarck's theory and accept Darwin's theory.** This module covers all the requirements for the DBE NSC exams w.r.t. the topic: Evolution by Natural Selection.

REFERENCES

- DBE Exam guidelines for learners
- GDE ATP
- 2015-2019 NSC past papers
- 2014-2019 national diagnostic report on learner performance
- Approved grade 12 national textbooks
- 'Mind the Gap'
- Internet
- Gauteng grade 12 Life Sciences Revision booklet

MODULE 2: Human evolution

INTRODUCTION

After learning about speciation and natural selection it is time to move closer to home namely human evolution. This module deals with the evolution of the family Hominidae. There are many characteristics that humans share with African apes but also many anatomical differences between humans and African Apes. This point to a common ancestor.

There are many lines of evidence that points to the idea of a common ancestor and human evolution. These lines include fossil evidence, genetic evidence, and the use of tools.

The out of Africa hypothesis states that humans evolved in Africa and slowly moved out of Africa and spread throughout the Earth.

OVERVIEW

This module deals with human evolution. The module starts with notes on how phylogenetic trees work. It is followed by the characteristics that humans and Africa apes share and their anatomical differences. The evidence for common ancestors for living hominids is then discussed in detail. After this it is followed by the out of Africa hypothesis.

SPECIFIC OBJECTIVES

By the end of this session, participants will be able to:

- Interpret a phylogenetic tree to show the place of the family Hominidae in the animal kingdom
- List the characteristics that humans share with African apes
- Explain the anatomical differences between African Apes and humans with the aid of diagrams
- Describe the lines of evidence that support the idea of common ancestors for living hominids including humans
- Explain the out of Africa hypothesis with evidence
- Set questions on different levels of Bloom's taxonomy

CONTENT

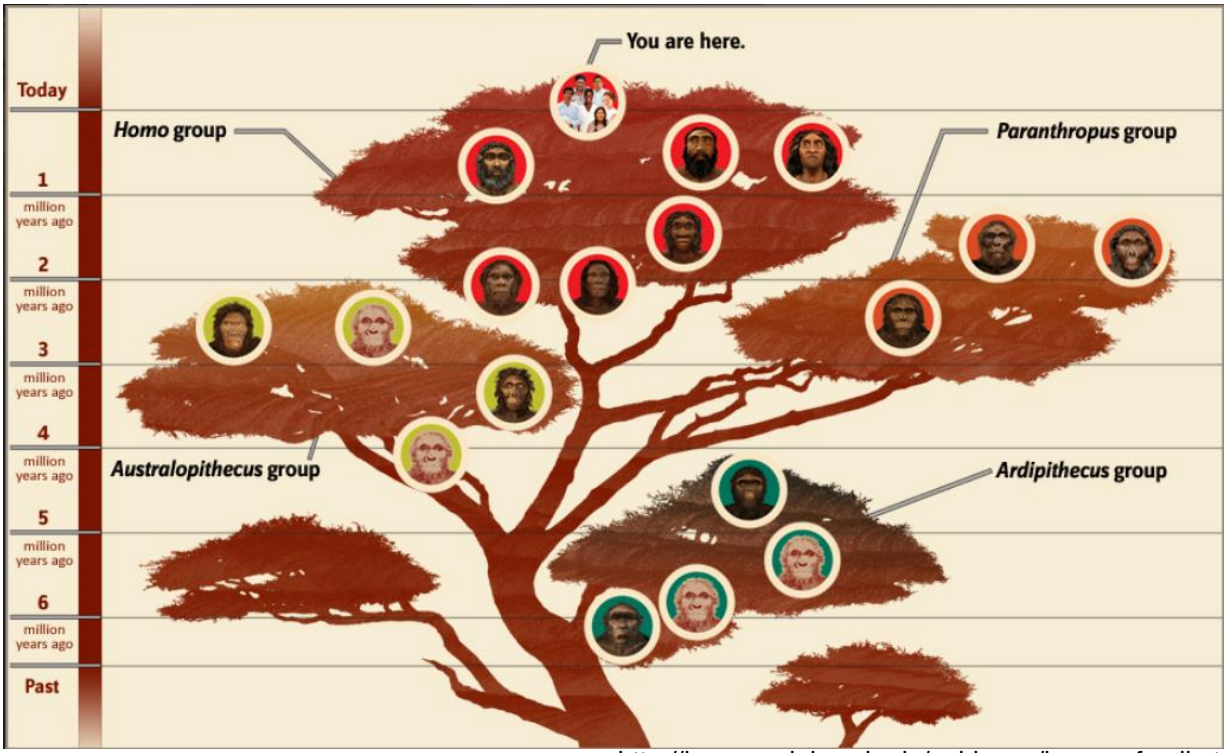
You will study this module through the following units:

Unit 1: How do we teach phylogenetic trees?
Unit 2: What is the traits humans share with African apes and what are the anatomical differences between them?
Unit 3: What is used as evidence for common ancestors for living hominids?
Unit 4: What is the "out of Africa" hypothesis?

Phylogenetic trees:

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

The hominin family bush: a simplified version

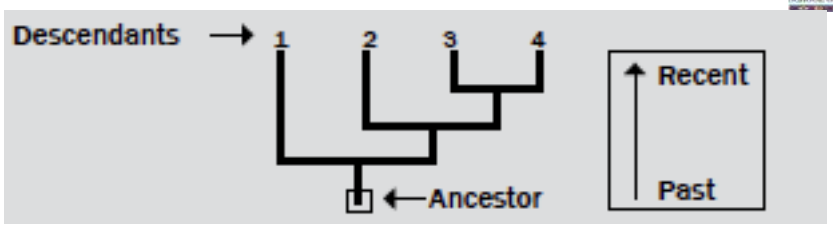


http://humanorigins.si.edu/evidence/human-family-tree

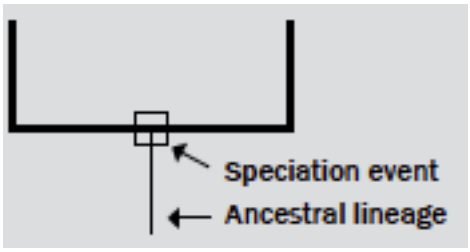
Hints on interpreting phylogenetic trees:

(Modified from Mind the Gap: Grade 12 Life Sciences)

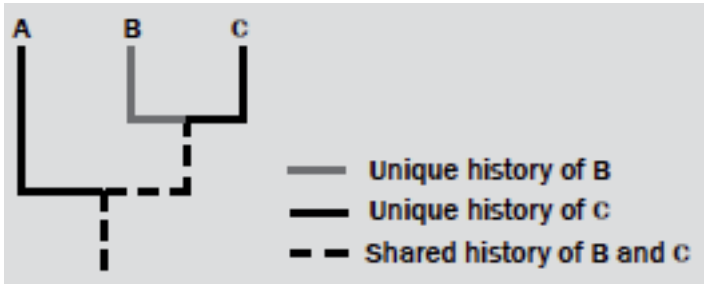
Reading a phylogenetic tree is similar to understanding a family tree. The base of the tree represents the oldest ancestor and the tips of the branches represent the most recent descendants of that ancestor. As you move from the base of the tree, to the tips of the branches, you are moving forward in time.



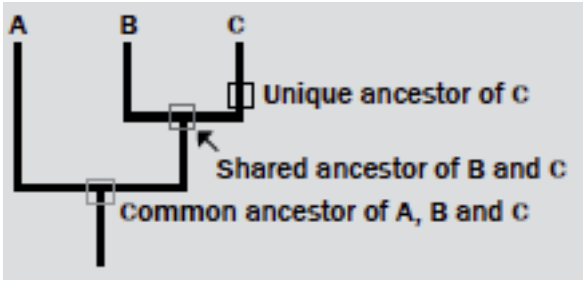
When speciation occurs, it is represented as branching on the tree.



Each lineage has a part of its history that is unique and parts that are shared with other lineages.



Similarly, each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.



ACTIVITY 2.1

AIM- To interact with a phylogenetic tree in order to understand how it works.
BACKGROUND: Phylogenetic trees are used in all NSC papers and learners have difficulty in answering questions relating to this concept.
METHOD:
Use the table below and cut out the hominids (including their names). Paste each hominid on the correct place on the phylogenetic tree page given to you. (You have to look at the time period first.) Paste each hominid on the circle provided at the end of the time line.

Time period (mya= million years ago)	Hominid
20 0000 ya - present	 Homo sapiens
400 000ya - 40 000ya	 Homo neanderthalensis
1.8 – 0.5mya	 Homo erectus
2.4 -1.4mya	 Paranthropus boisei
2 - 1.2mya	 Paranthropus robustus
2.1 - 1.5mya	 Homo habilis
3.3 - 2.1mya	Australopithecus africanus 
3.9 - 2.9mya	 *Australopithecus afarensis*
5mja - present	 Chimpanzee

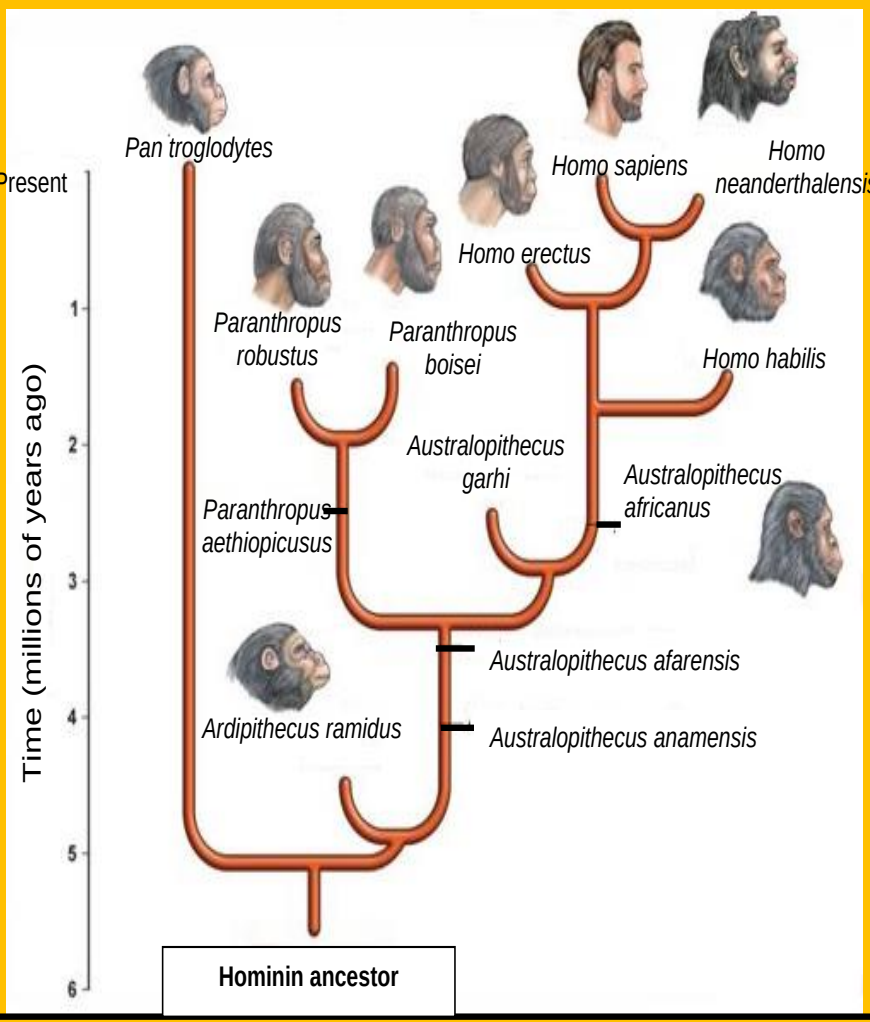
4.35- 4.45 mya	 Ardepithecus ramidus

Paste the correct homonid in the circles on the phylogeneitc tree below:

Indicate where the following could be found on the phylogenetic tree above:

- Number 1: the common ancestor of all hominids
- Number 2: the common ancestor of all organisms of the genus *Homo*

2.1.2. The diagram below shows possible evolutionary relationships among some hominids.



[Adapted from: *www.humanevolutionofficial.wee*

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

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

(a) Genera (1)

(b) Homo species (1)

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

2.1.2.4. Name the:

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

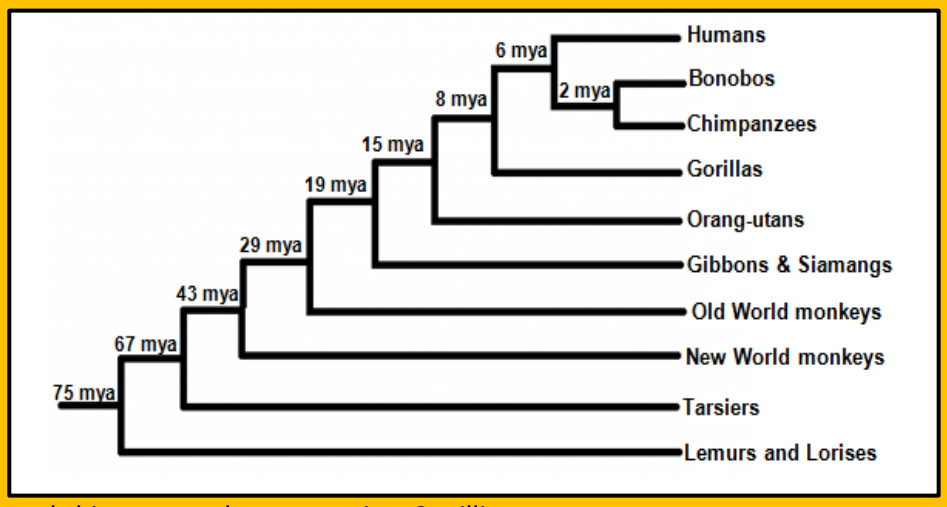
(b) First *Homo* species to appear (1)

(7)

2.1.3

Choose the correct answer:

According to the phylogenetic tree, the most recent common ancestor of …



A humans and chimpanzees became extinct 2 million years ago.
B humans and gorillas became extinct 15 million years ago.
C humans and chimpanzees became extinct 6 million years ago.
D gorillas and chimpanzees became extinct 2 million years ago.

REFLECTION:
Think about Bonobos and Chimpanzees. They are able to make fire, draw pictures, carry out difficult tasks. Relate this to the phylogenetic tree. What does this tell you?

FOLLOW UP:
Follow up on the newest findings on National Geographic website, Sciencenewsforstudnets.org. www.maropeng.co.za. humanorigins.si.edu.
Almost every day new discoveries are made.

UNIT 2 – What are the traits humans share with African apes and what are the anatomical differences between them?

Characteristics that humans share with African apes:

- Olfactory brain centres reduced/ reduced sense of smell
- Eyes in front/ Binocular vision / stereoscopic vision
- Eyes with cones/ colour vision
- Freely rotating arms
- Elbow joints allowing rotation of forearm
- Flat nails instead of claws/ bare, sensitive fingertips
- Opposable thumbs
- Bipedal/ upright posture / foramen magnum in a more forward position
- Sexual dimorphism/ distinct differences between males and females
- Parts of the brain that process information from the hands and eyes are enlarged
- Longer upper arms
- Large brains / skulls compared to their body mass
- Five digits per limb

Anatomical differences between Humans (*Homo sapiens*) and African Apes

FEATURE	Humans (*Homo sapiens*)	African Apes
Cranium	Large cranium/brain	Small cranium/brain
Brow Ridges	Brow ridges are not well developed	Brow ridges well developed
Spine	More curved spine	Less curved spine
Pelvic girdle	Short, wide pelvis	Long, narrow pelvis
Canines	Small canines	Large canines
Palate shape	Small and semi-circular	Long and rectangular
Jaws	- Small jaws - Less protruding jaws/less-prognathous	- Large jaws - More protruding jaws/ more prognathous
Cranial ridges	No cranial ridge	Cranial ridge across the top of the cranium
Foramen Magnum	Foramen magnum in a forward position	Foramen magnum in a backward position

ACTIVITY 2.2

AIM: To analyse the differences between humans and African apes.
BACKGROUND: It is important for participants to recognize the differences and similarities between African apes and humans.
METHOD: Answer questions based on diagrams.

Study the diagrams below showing the different anatomical structures of a chimpanzee and a human. The diagrams are not drawn to scale.

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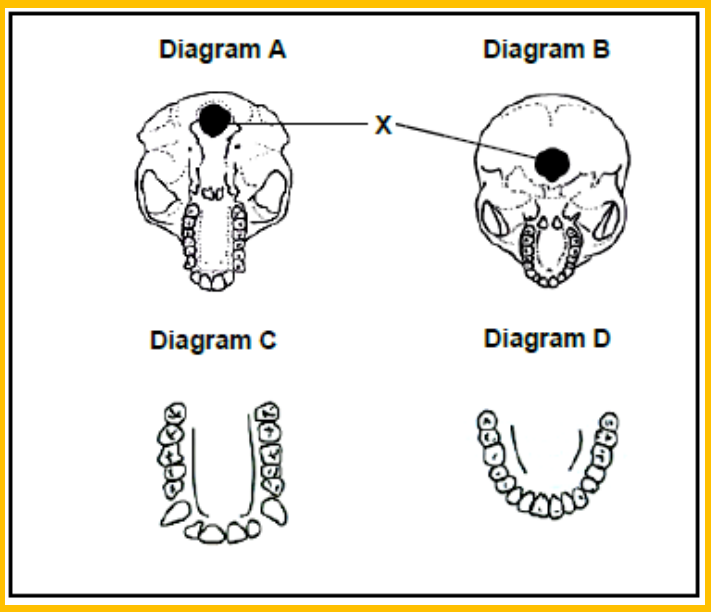


1. Provide a label for X. (1)

2. Tabulate TWO anatomical differences between the jaws in diagrams C and D which represent trends In human evolution. (5)

3. Give the LETTER ONLY of the diagram that represents:

   (a) The skull with a larger brain capacity. (1)

   (b) A more prognathous skull (1)

4. Account for the position of X in the skull in diagram B. (2)

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

REFLECTION:

How would you go about teaching the differences and similarities to learners?

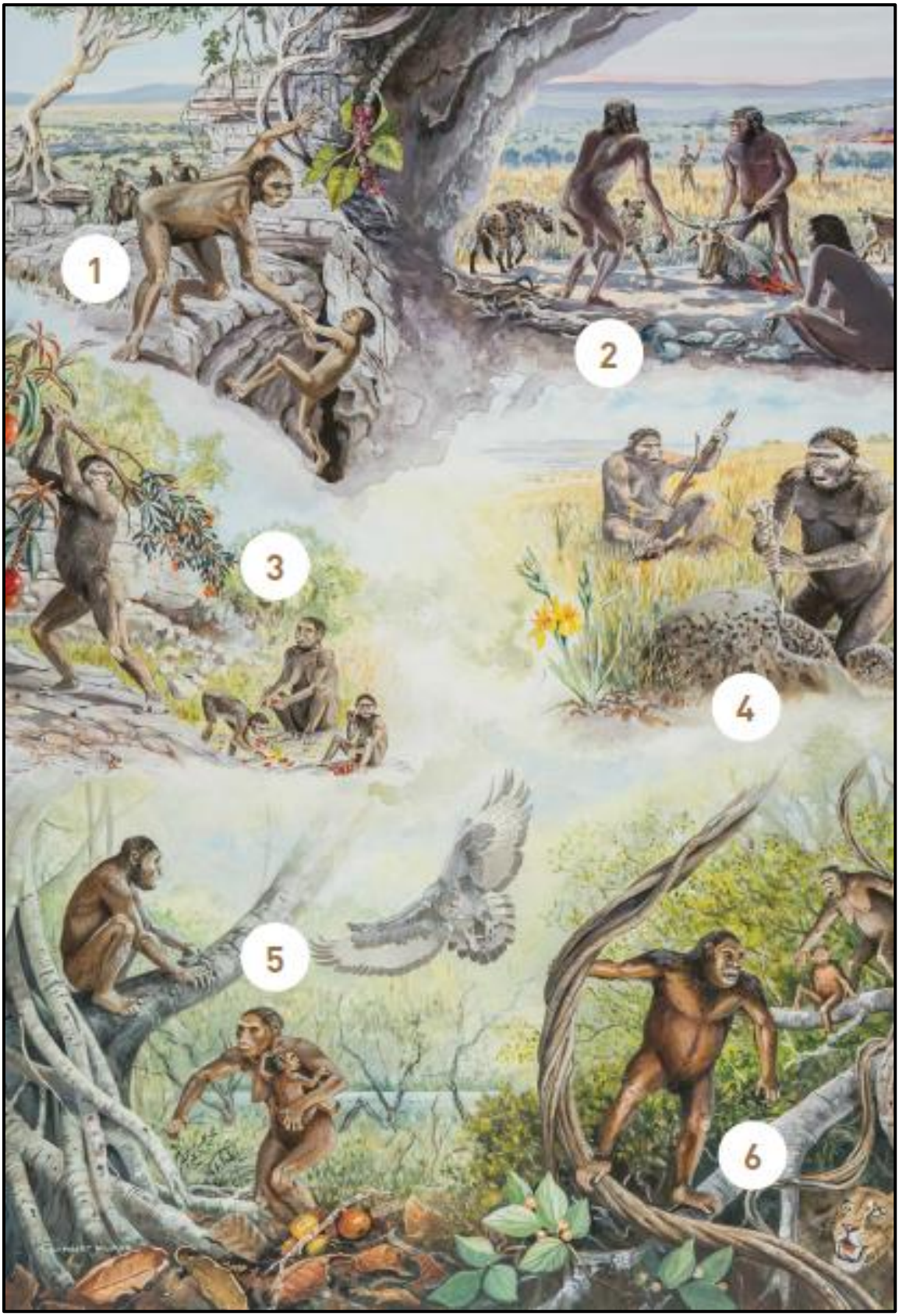
FOLLOW-UP:

Read articles on Wikipedia (consult reference list to ensure reputable references were used in the article. this should include university references), National Geography on the differences between Humans and African apes.

UNIT 3 – What is used as evidence for common ancestors for living hominids?

Evidence of common ancestors for living hominids, including humans

The term '*Homo*' refers to the genus and means 'human'. Studies of human evolution must include hominids such as the Australopithecines, as it is theorized that the *Homo* genus diverged (split) from them about four million years ago in Africa. Scientists have estimated that humans branched from their common ancestor with the chimpanzee about five to six million years ago. Other species of *Homo* like *Homo erectus* and *Homo neanderthalensis* have all become extinct. Substantial fossil proof exists to explain hominid evolution, although it is not enough to make specific conclusions. The poster below was constructed by Wits university to explain human ancestry to students:


1
2
3
4
5
6

How are humans classified?

Humans are classified as primates. Examples of primates are lemurs, bush babies, monkeys and baboons. Within the primates there are many classifications of humans and their close relatives. A typical classification which was produced by the palaeoanthropologist Bernhard Wood , is given here. According to this classification we belong to the family Hominidae. Examples of hominids are the great apes which include the orangutans, gorillas, humans and chimpanzees. The Hominidae are divided into two subfamilies the Ponginae (orangutans) and the Homininae. The Homininae is divided into three tribes, the Gorillini (gorillas), the Panini (common chimpanzees and pigmy chimpanzees or bonobos) and the Hominini. The Hominini include humans and their fossil ancestors. Characteristics which all hominins share include walking upright and having small canine teeth. Although humans are the only hominin species alive, the fossilised remains of many other hominins have been found in South Africa. These hominins belong to the genera *Homo*, *Australopithecus* and *Paranthropus*. Many examples of hominins are found in other parts of Africa (especially East Africa) and a few in other parts of the world. One other species which may also have occurred in South Africa is *Homo habilis* but as yet no good specimens have been recovered.

1. Naledi or Neo (*Homo naledi*)

This species may have been very social because so many individuals have been found in one place. A total of 1,550 fossil bone fragments from 15 individuals were found in the Dinaledi Chamber in the Rising Star Cave System in 2013/2014. In May 2017, a new almost complete *Homo naledi* skeleton was announced. The new skeleton was nicknamed Neo which means 'gift' in Sesotho.

In 2017, scientists published the age of *Homo naledi*. The fossil remains are surprisingly young – between 226 thousand and 335 thousand years ago. This means that they may have lived at the same time as modern humans. One mystery that surrounds *Homo naledi* is why so many of the remains were found in a pitch dark chamber with a narrow entrance tunnel accessible only to experienced cave explorers. The Dinaledi chamber is approximately 80 m from the cave entrance and 30 m below the surface.

Homo naledi had a relatively small brain compared to modern humans (about 550 cc). It had a foot with a heel and an arch like modern humans and was probably a good walker. The foot lacked a gap between the big toe and the rest of the toes so it could not have been used for gripping branches, for example like the foot of Little Foot. *Homo naledi* walked upright – probably on the ground and along branches. Its' powerful upper body suggested that it spent a great deal of time living in trees. No stone tools have been found along with the remains of *H. naledi* but it is possible, because of the young age of the fossils, that they made tools which scientists would previously have said were made by modern humans. The plants and landscape of the Cradle of Humankind have hardly changed over the last hundred thousand years. The trees in the picture are large-leaved rock figs (*Ficus abutilifolia*) and the rocks are the typical dolomite rocks found in the area today.

Meaning of Name: *Homo naledi* means 'man' or 'person' (Latin: homo) 'from the star' (Sesotho: naledi). The star part of the name comes from the Rising Star cave system where the fossils were found.

Discovery: Prof Lee Berger had a student Pedro Boshoff searching for fossils in caves in the Cradle of Humankind. Pedro couldn't fit into some of the caves and asked specialist cave explorers to be on the lookout for fossils. Around midnight on Friday 13, 2013 Rick Hunter and Steve Tucker were exploring the inaccessible Dinaledi Chamber, not far from Sterkfontein Caves when they came upon the first remains of Homo naledi. Two months later there was an international team systematically recovering the remains. Neo's remains were recovered from another chamber in the same cave system called the Lesedi Chamber.

2. Upright man (*Homo ergaster* or early African *Homo erectus*)

Scientists call the fossilised remains of this species *Homo ergaster* or early African *Homo erectus*. Like us and Little Foot, it had longer legs and shorter arms. Its brain volume was about 900 cc, bigger than *Homo naledi* but still small compared to *Homo sapiens*, which is about 1400 cc. Like modern humans, *Homo ergaster/erectus* was mainly ground dwelling and did not live in trees. *Homo ergaster/erectus* made a variety of different tools some of the most common are pear-shaped tools called Acheulian hand axes. There is also evidence from the Wonderwerk Cave near Kuruman in the Northern Cape that they cooked with fire more than a million years ago. They probably didn't make their own fire but could have used natural veld fires to start cooking fires. In this scene they are about to cook a now-extinct giant wildebeest (*Megalotragus priscus*). They are chasing away hungry laughing hyaenas (*Crocuta crocuta*).

Homo ergaster/erectus fossils have been found in both East Africa and South Africa. Their fossil remains are rare but the tools that they made are more common and found in other parts of Africa. Outside of Africa, *Homo erectus* has also been found in many parts of Asia including the islands of Indonesia. The oldest members of this species lived about 1.9 million years ago and the youngest disappeared about 70 000 years ago.

Meaning of name: *Homo erectus* means man or person (Latin: Homo) that walks upright (Latin: erectus or upright). *Homo ergaster* means the man (Latin: Homo) that works (Greek: ergasia or work).

Discovery: *Homo erectus* was first discovered by Eugene Dubois on the island of Java in 1891. The first fossil of *Homo ergaster* came from Lake Turkana in Kenya and was named by Colin Groves and Vratislav Mazák in 1975. In South Africa, part of an upper jaw and two lower jaws were found at Swartkrans in 1949 by Robert Broom and John Robinson who identified them as a new genus called *Telanthropus*. Later, John Robinson changed the name to *Homo erectus*.

3. Sediba or Karabo (*Australopithecus sediba*)

It has been suggested that this species is more like us than other *Australopithecus* because it was a more confident upright walker and had smaller teeth and a narrower, less protruding face. *Sediba* also had a small hand with a precision grip that it could have used to made simple stone tools.

Sediba had a small brain (about 420 cc). It possibly, had a small gap between its big toe and the rest of the foot to help it grip branches. *Australopithecus sediba* is reconstructed as having a powerful upper body with longer arms and shorter legs adapted for climbing trees.

Two specimens from Malapa, a site in the Cradle of Humankind, have been described: a male child known as MH1 and an adult female (MH 2) which stood about 1.27 m tall and weighed about 30 kg.

They lived between about 1.977 million years ago at a time when the Cradle of Humankind had more trees. The family in this picture is eating stamvrug fruit (*Englerophytum magalismontanum*). There are karee trees (*Searsia lancea*) in the background.

Meaning of name: *Australopithecus sediba* means the southern (Latin: australis) ape (Greek: pithekos) which is possibly the source (Sesotho: sediba) of the genus Homo.

Discovery: *Australopithecus sediba* was found by nine-year-old Matthew Berger and his father Prof. Lee Berger in 2008.

4. Robust man (*Paranthropus robustus*)

Paranthropus robustus had a broad (robust) face. It had powerful biting and chewing muscles with massive cheek teeth and jaws to grind and chew coarse food. Its brain size was between 500 – 530 cc. *Paranthropus robustus* lived between 1.8 and 1.2 million years ago.

The researchers Bob Brain and Lucinda Blackwell suggested that this species may have made and used bones as tools. The *Paranthropus* in the picture are using sharpened bones to dig up edible roots and open termite mounds to harvest termites, a rich source of protein. The flowers in the background are an edible corm (Hypoxis rigidula).

Meaning of name: *Paranthropus robustus* means the besides (Ancient Greek: paras) human (Ancient Greek: anthropus) with the strong (Latin: robustus) jaw

Discovery: *Paranthropus robustus* is unique to South Africa. The first *Paranthropus robustus* was found at Kromdraai in 1938 by Dr Robert Broom. Since then fossils have been found at other Cradle of Humankind sites, such as Swartkrans and Drimolen.

5. Taung Child and Mrs Ples (*Australopithecus africanus*)

The Taung Child was the very first fossil hominin discovered in Africa and was described in 1925 by Prof. Raymond Dart as the "missing link" between apes and humans. Many years later, Professors Lee Berger and Ron Clarke presented evidence that the child, which still had its milk teeth, was killed by an eagle. Probably the most famous *Australopithecus* adult skull is Mrs Ples from the Sterkfontein Caves.

Australopithecus africanus was a hominin with a protruding (prognathous face) and a brain with a volume of about 450 cc. The trees in the picture are broom-cluster figs (Ficus sur) and the eagle chasing the mother with her baby is a Verreaux's eagle (*Aquila verreauxii*).

Meaning of name: *Australopithecus africanus* southern (Latin: australis) ape (Greek: pithekos) from Africa (africanus)

Discovery: In 1924 the Taung Child was discovered by lime miners at Buxton Lime Quarry near Taung in North West province. It was described by Prof. Raymond Dart in 1925 and is unusual in that there is a cast of the brain preserved with the skull and lower jaw. The world had to wait many years for the discovery of an adult specimen.

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6. Little Foot (*Australopithecus prometheus*)

Little Foot is the oldest hominin found in South Africa and it lived about 3.67 million years ago. This specimen is the most complete *Australopithecus* specimen ever discovered.

Little Foot had small feet (compared to humans) with a gap between its big toe and the rest of its toes. This gap may have been useful for for gripping branches and suggests that it was a good climber. However, Little Foot had arms and legs in similar proportion to modern humans and the "upright man" which suggests that it could walk confidently on the ground. Little Foot had a flatter, less prognathous face and larger cheek teeth than Australopithecus africanus. The tree in the scene is a white stinkwood (*Celtis africana*) covered with lianas. The hungry big cat is a sabre-tooth (*Homotherium crenatidens*).

Meaning of name: *Australopithecus* means the southern (Latin: australis) ape (Greek: pithekos). Little Foot has been placed in the species prometheus. The species was named by Prof. Raymond Dart based on fossils from Makapansgat in the Limpopo Province. He thought that this species might have made fire and named it after "Prometheus" the Greek Titan who stole fire and gave it to the humans. Today scientists do not agree there is evidence for the use of fire by hominins at Makapansgat or as long ago as 3.67 Ma.

Discovery: In 1994, Prof. Ron Clarke found the remains of small four foot bones (hence the name Little Foot) in a box containing fossils blasted out by lime miners in the 1920's. The fossils came from the Silberberg Grotto, a large chamber in the Sterkfontein caves. In 1997 Prof. Clarke found another eight foot and leg bones from the same individual. One of the bones looked as if it had been broken directly out of the cave deposit so Prof. Clarke sent two of his assistants, Messrs. Stephen Motsumi and Nkwane Molefe with a replica of the broken bone to search for the rest of the skeleton. After a two day search in the dark with hand-held lamps they found it. It took 15 years to excavate the entire skeleton because the bones were extremely delicate and the rocks in which they are embedded are so hard.

Acknowledgements

Scientific and technical advice: Prof. Marion Bamford, Prof. Lee Berger, Dr Bonita de Klerk, Dr Marina Elliott, Prof. Amanda Esterhuysen, Prof. John Hawkes, Prof. Francis Thackeray, Dr Christine Steininger and Dr Bernard Zipfel of the DST-NRF Centre of Excellence in Palaeosciences and Evolutionary Studies Institute at the University of the Witwatersrand.

Text: Dr Ian McKay and Dr Mirriam Tawane

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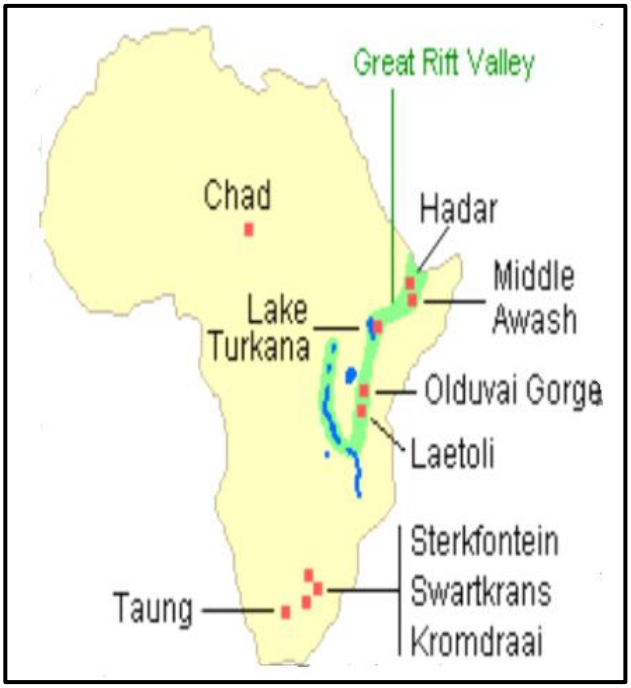
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Following is the evidence that is used to explain human evolution.

3.1. Fossil Evidence:

- Archaeologists have provided **fossil evidence** to prove that relationships existed between the Early Stone Age cultures in Europe and Northern Africa.
- Discoveries in South Africa, Kenya and Zimbabwe have been used to prove and validate that Africa was the home of early man.
- Fossil sites in Africa:



Fossil records:

Organism	When organism existed	Fossil site	Discovered by	Characteristics
Ardipithecus ramidus	5-4 mya	North-East Ethiopia	Tim White	Brain size: 300-350 ml Forward position of foramen magnum. Very prognathous (more protruding jaws). Heavy brow ridges. Pelvis structure: bipedal and tree climbing.
Australopithecus afarensis	4-2,7 mya	Ethiopia Kenya Tanzania	Donald Johanson	Brain size: 375 – 550 ml Forward position of foramen magnum Very prognathous

Organism	When organism existed	Fossil site	Discovered by	Characteristics
				Heavy brow ridges Canines large and pointed Long arms No cranial ridge
Australopithecus africanus	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	1,9-1,8 mya	Malapa Cave – in the cradle of humankind	Lee Burger	Brain Size: 420 ml Lee prognathous Brow ridges Large teeth; canines not long Long arms No cranial ridge
Homo habilis	2,2-1,6 mya	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges Human-like teeth; smaller canines Long arms
Homo erectus	2-0,4 mya	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter

Organism	When organism existed	Fossil site	Discovered by	Characteristics
				arms
Homo sapiens	200 000 years ago - present	Makapansgat in Limpopo Border Cave in KZN Blombos Cave in the Western Cape	Tim White	Brain size: 1200-1800 ml No brow ridges Small teeth Short arms

ACTIVITY 2.3

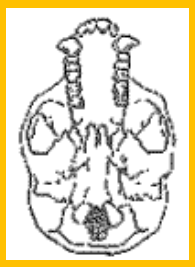
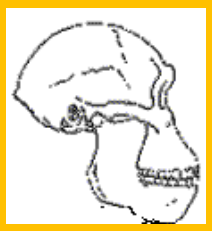
AIM: To classify the anatomical differences between hominids.
BACKGROUND: This content is asked in a number of different ways in the NSC papers. Learners should be able to take any data, interpret it and classify it accordingly.
METHOD: Using diagrams to indicate the anatomical differences between hominids

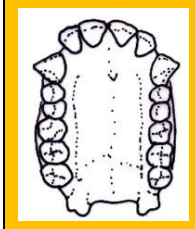
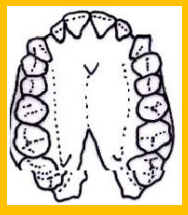
Question 2.3.1
Cut the diagrams on the diagram sheet provided. The correct diagram must be pasted in the correct row and column in the table below. Label where required. In the case of the spine, only two diagrams are available; paste them under the correct headings.

Features	**Chimpanzee (*Pan troglodytes*)**	***Australopithecus***	**Human (*Homo sapiens*)**
Skull Indicate brow ridges, cranial ridges and prognathous where applicable			
Dentition and palate (indicate differences with labels)			
Position of Foramen magnum			

Position of spine in skull			
Shape of spine			
Pelvic girdle and pelvis bone			

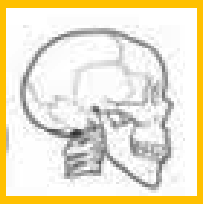
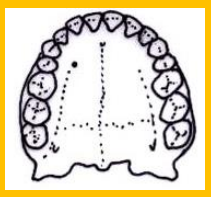
Template of diagrams FOR HUMAN EVOLUTION

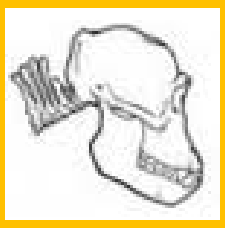




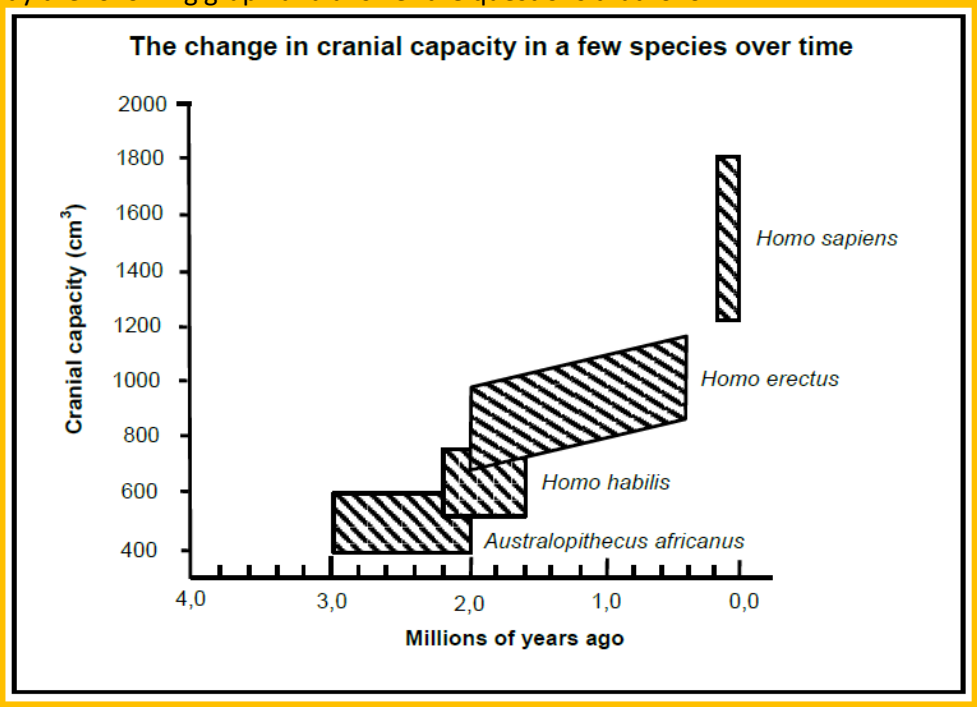





2.3.2. Study the following graph and answer the questions that follow.



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

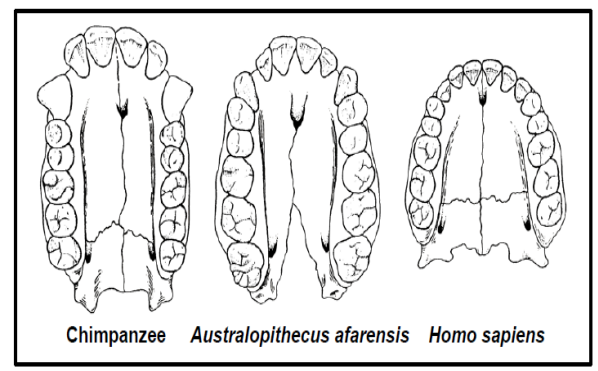
2.3.2.2. What is the largest cranial capacity (in cm^3) of *Australopithecus africanus*? (1)

2.3.2.3. When did *Homo habilis* become extinct? (1)

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

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

2.3.3



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

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

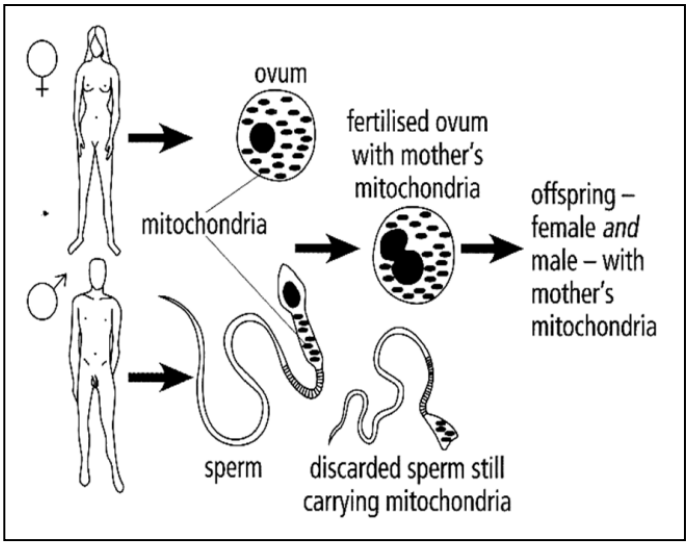
(a) Define a *transitional species.* (1)

(b) Use ONE visible feature of the jaw to explain why *A. afarensis may be described as a transitional species*. (2)

REFLECTION:
How would you teach your learners this content? Would you use this activity to enforce the content knowledge?
FOLLOW-UP:
Ensure that your learners have access to pass papers in order to see how this content can be assessed.

3.2. Genetic Evidence:

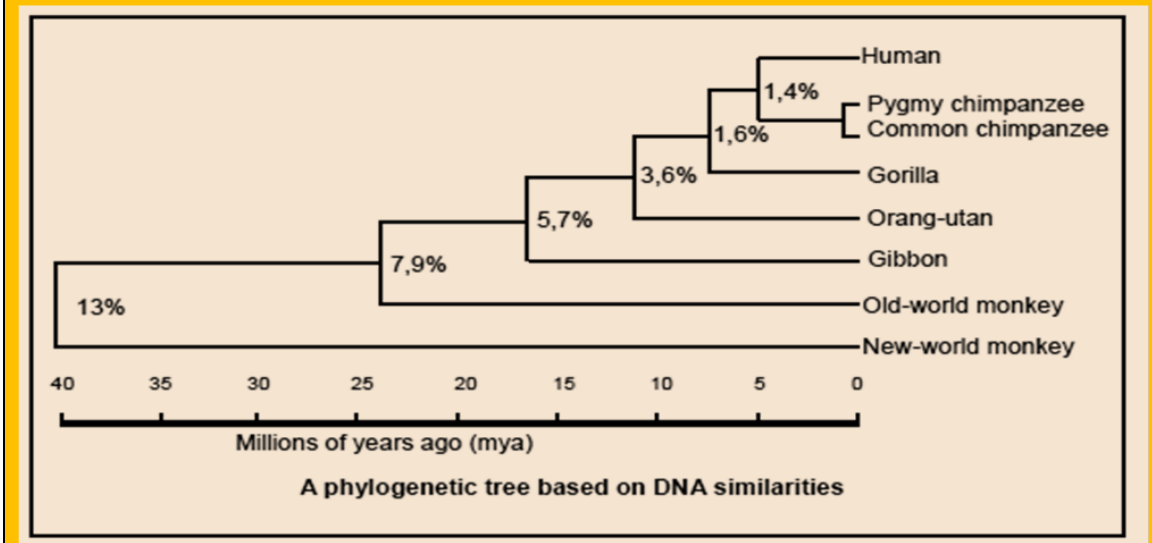
- **Mitochondrial DNA:** MtDNA is the smallest chromosome located in the mitochondria and forms part of the organisms' genome. In most species, mtDNA is inherited from the mother (maternal inheritance). The sequencing of the mtDNA shows a link in **phylogenetics** and **evolutionary relationships** between species. The age of the common ancestral mtDNA can be estimated to have existed approximately 140,000 to 290,000 years ago linking humans to **Mitochondrial Eve**.



ACTIVITY 2.4

AIM: To combine phylogenetic trees with genetic evidence of human evolution.
BACKGROUND: Participants should be able apply their knowledge on phylogenetic trees to solve questions based on genetic evidence.
METHOD: Answering questions based on diagrams.

The diagram below shows a phylogenetic tree based on DNA similarities. The percentage next to each branch shows the amount of difference in the genome (DNA nucleotide sequence) of the two relevant groups.



A phylogenetic tree based on DNA similarities

[Adapted from: *Senior Biology 2*]

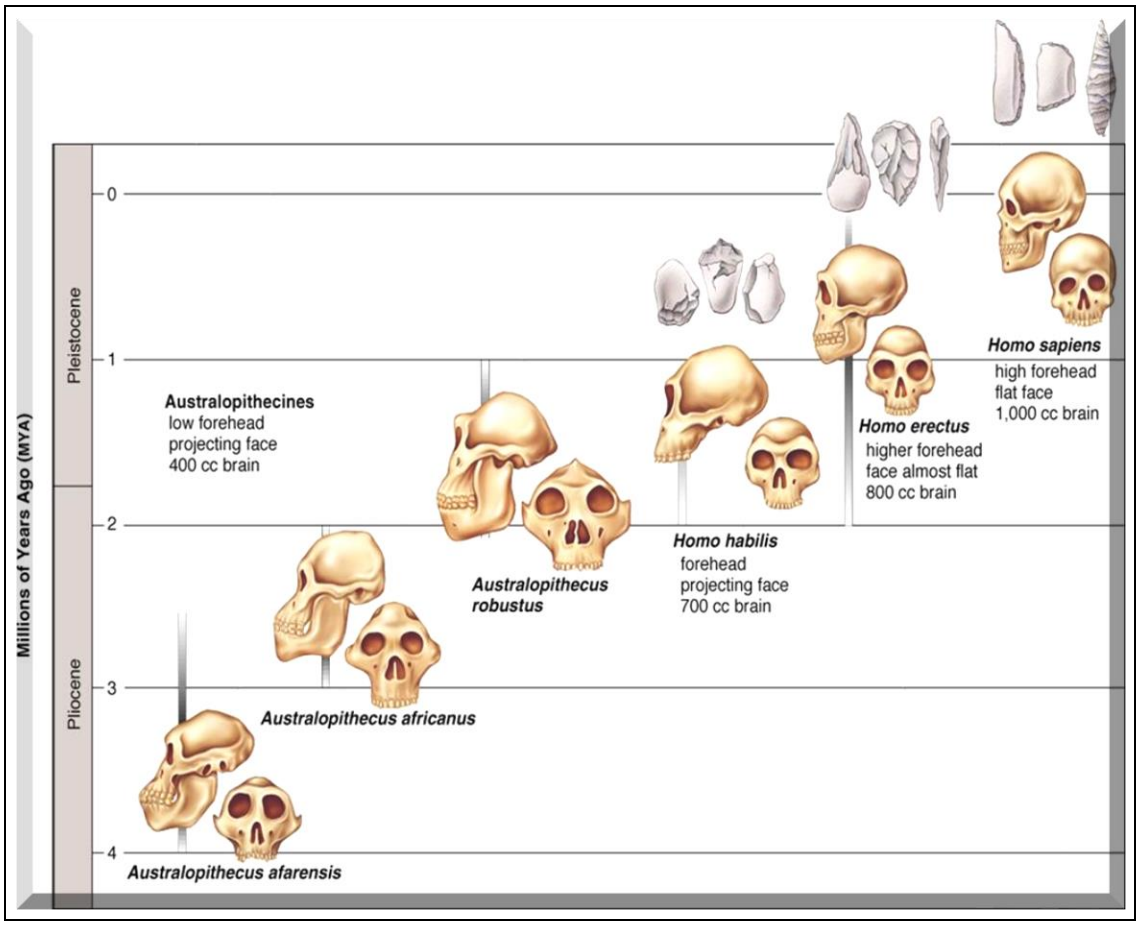
1. From the diagram, determine how long ago the chimpanzees split from the line to humans. (2)
2. Which organism is most closely related to humans? (1)
3. Calculate the DNA similarity between the genome of the chimpanzee and the human. (2)

REFLECTION:
How would you teach genetic evidence to your learners?
FOLLOW-UP:
Follow up on the newest findings on National Geographic website,
Sciencenewsforstudnets.org. www.maropeng.co.za. humanorigins.si.edu.
Almost every day new discoveries are made.

3.3. Cultural evidence: tool-making

- The earliest hominids to use simple tools known as **Oldowan stone tools**, were *Homo habilis* that lived around 2.6 Ma and signifies the start of the Stone Age.
- *Homo habilis* fossils have been found in many parts of Africa with tools that were made of stone and used to aid hunting and cutting of food.
- *Homo erectus* developed more advanced tools that included **sharpened stones** placed on wooden handles, like an axe.
- They were also the first species to use **flints** and quartzite to make fire.

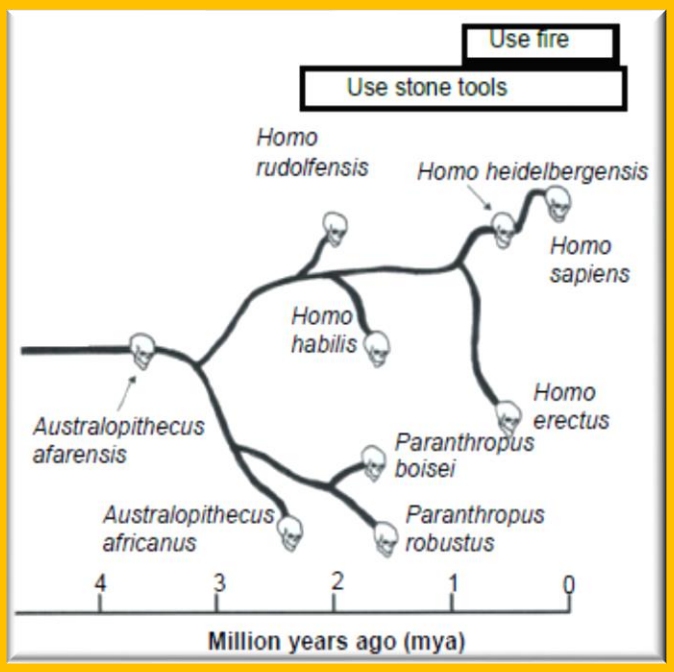
- Later fossil evidence shows tools like **scrapers** probably used to clean animal skins, slicers and **needles** used to sew animal pelts into the first form of clothes.
- From this point, tools progressed to **knives and blades** used by the Neanderthals used for hunting and protection.
- Fossil evidence shows that as the different species developed larger brains and greater intelligence, so their tools became more complex.



ACTIVITY 2.5

AIM: To link the use of tools to the different hominins.
BACKGROUND: Phylogenetic trees are a popular way of assessing learner's knowledge on the different human evolution topics. It is important to link different topics with the use of phylogenetic trees.
METHODS: Answering questions on a phylogenetic tree.

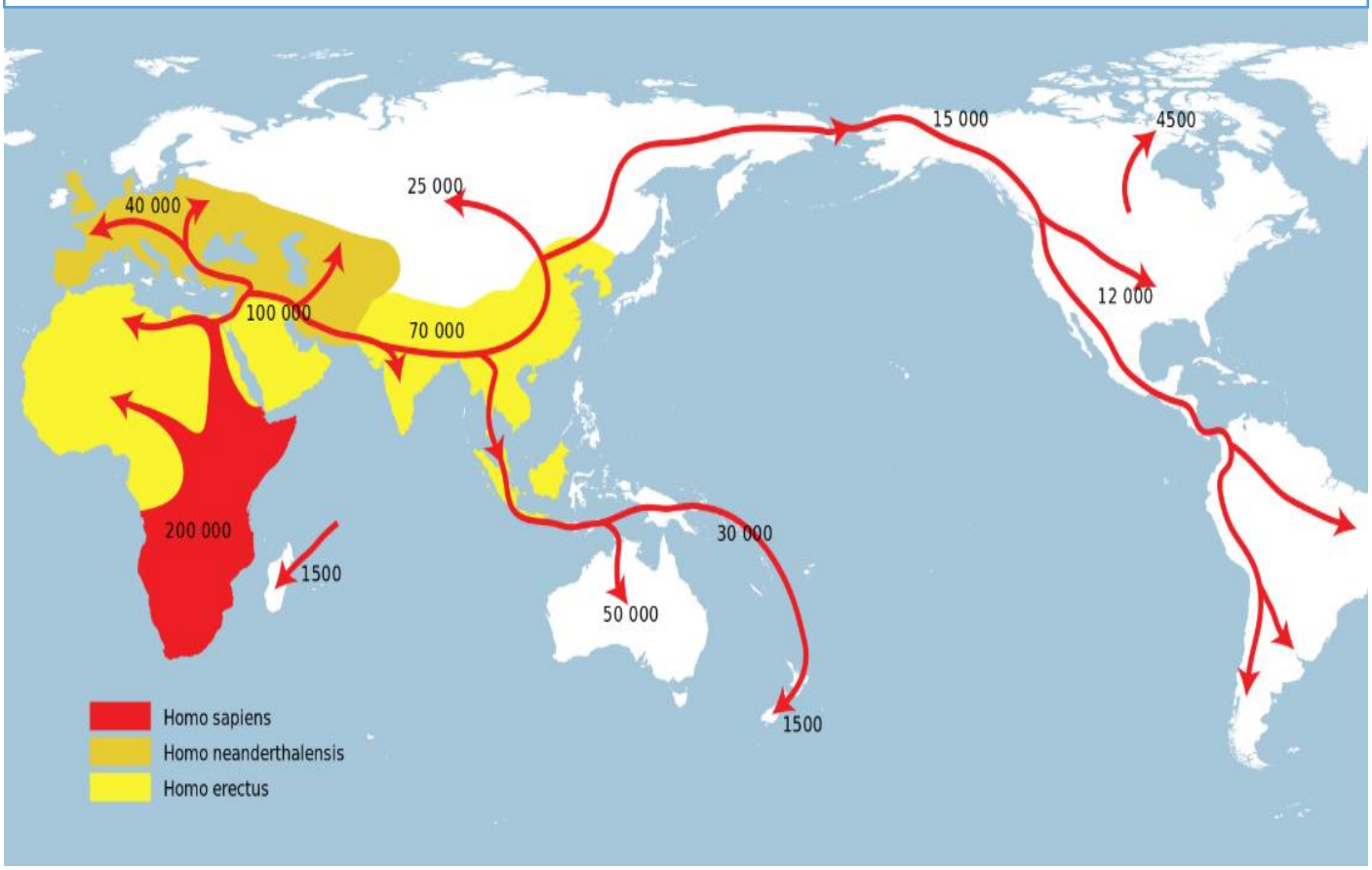
Study the phylogenetic tree below which shows a possible representation of human evolution. The solid lines represent the origin and extinction of the species. The skulls are not representative of the species and are not drawn to scale.



2.5.1. According to the phylogenetic tree, which species was the first to use simple stone tools? (1)

2.5.2. Name THREE species represented that used simple stone tools and fire. (3)

REFLECTION:
How would you teach cultural evidence to your learners?
FOLLOW-UP:
Follow up on the newest findings on National Geographic website,
Sciencenewsforstudnets.org. www.maropeng.co.za. humanorigins.si.edu.
Almost every day new discoveries are made.



source: wikipedia

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
- Analysis of Y chromosome shows that the oldest male ancestors of humans are from Africa

Fossil Evidence:

- *Ardipithecus* fossil were found in Africa ONLY, nowhere else in the world
- *Australopithecus* fossils found in Africa only (Karabo, Littlefoot, Taung child and Mrs Ples)
- Oldest fossils of australopithecines, *Homo habilis and* other bipedal organisms were found in Africa
- Oldest fossils of *Homo erectus* were found in Africa, followed by Asia and the youngest fossils of Homo erectus were found in Europe.

Genetic Evidence:

- Analysis of mutations in mtDNA trace oldest female ancestor to East Africa

ACTIVITY 2.6

AIM: To discuss the Out of Africa hypothesis.
BACKGROUND: Learners in the past have struggled to questions relating to this topic. It is important that they are able to order the content.
METHOD: Answering questions.

Question 2.6.1

5.1. Read the following and draw a flow chart to discuss the possible answers.

Fossils of the bipedal primates *Ardipithecus*, *Australopithecus* and early *Homo* species are used to support the 'Out of Africa' hypothesis.

State the 'Out of Africa' hypothesis. Describe the evidence that supports the 'Out of Africa' hypothesis and the evidence that shows that the three primate genera mentioned above, were all bipedal.

Question 2.6.2

Analyse the data in the table and follow the instructions that follow the table.

NAME	Key	Area where fossils were found
Australopithecus africanus	1	South Africa
Australopithecus afarensis	2	East Africa Ethiopia Rift valley
Ardipithecus ramidus	3	East Africa, Ethiopia Rift valley
Australopithecus sediba	4	South Africa
Homo erectus	5	Africa, China Indonesia, Rep of Georgia, Arabia, India, Thailand
Homo habilis	6	East Africa, Olduvai Gorge Tanzania

1. Use the key given in the table above and indicate where the fossils were found on the world map provided.
2. Use a coloured pen to indicate, with arrows, the route that illustrate the Out of Africa hypothesis. Also indicate the *Homo sapiens* exodus from Africa with different colour pen.
3. Arrange the genus groups from oldest to youngest.

4. Which genus groups' fossils are only found in Africa?

5. Which specie's fossils are found in Africa as well as the rest of the world? What does this tell us about this species?

6. On which continent are the oldest fossils of *Homo sapiens* and *Homo erectus* found?

7. State how fossils provide evidence for the Out of Africa hypothesis.

Question 2.6.3

Use the table below, which indicates some of the hominid fossils found in different parts of the world and set questions on the FOUR levels of Bloom's taxonomy (p.11) used in Life Sciences.

SPECIES	AREA WHERE IT WAS FOUND	PERIOD OF EXISTENCE
Australopithecus afarensis	Eastern Africa	3,4–2,8 mya
Australopithecus africanus	Southern Africa	2,1–2,8 mya
Australopithecus sediba	Southern Africa	2,0–1,9 mya
Homo habilis	Sub-Saharan (Africa)	2,3–1,4 mya
Homo erectus	Africa, Europe, Asia	1,5–0,2 mya
Homo heidelbergensis	Europe, China	0,6–0,35 mya
Homo neanderthalensis	Europe, Western Asia	0,35–0,03 mya
Homo sapiens	Worldwide	0,2 mya–present

REFLECTION: How would you teach this topic to your learners?

FOLLOW-UP:

Follow up on the newest findings on National Geographic website, Sciencenewsforstudnets.org. www.maropeng.co.za. humanorigins.si.edu. Almost every day new discoveries are made.

THE PERFECT EXAMPLE OF EXPLAINING THE OUT OF AFRICA HYPOTHESIS: (NOV 2016 P2 ESSAY MEMO)

HYPOTHESIS

All modern humans /*Homo sapiens* originated in Africa
-and migrated to other parts of the world

FOSSIL EVIDENCE

- Fossils of *Ardipithecus* were found ONLY in Africa /Rift Valley/Ethiopia/South Africa
- Fossils of *Australopithecus* were found ONLY in Africa /Rift Valley/Ethiopia/South 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

GENETIC EVIDENCE

- Mitochondrial DNA is inherited only from the maternal lines
- Analysis of mutations on this mitochondrial DNA
- shows that the oldest female ancestor were located in Africa
- and that all humans descended from her /mitochondrial Eve
- The Y chromosome shows the paternal line

CULTURAL EVIDENCE

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

BIPEDALISM

The fossils of all three genera indicate that: The foramen magnums are located in a more forward position
- The pelvis is wider and shortened
- The spine is S-shaped

RESOURCES

The article below is a good summary of some recent work published about a human skeleton found in Ballito Bay.
https://www.thetimes.co.uk/edition/comment/it-took-10-000-generations-to-make-an-iphone-8phfggzqz

Exploring evolution: http://www2.edc.org/weblabs/ExploringEvolution/ExploringEvolutionMenu.html

Biology in Motion – Evolution Lab: http://biologyinmotion.com/evol/

Wonderful animations: http://www.sumanasinc.com/webcontent/animation.html

Evolution: http://evolution.berkeley.edu/

Evolution: www.maropeng.co.za

For videos: www.eChalk.ca.uk.
Human Evolution: The Fossil Evidence in 3D (requires Shockwave plug-in):
http://www.anth.ucsb.edu/projects/human
Hominid Evolution: Distinguishing Features and
Characteristics: http://www.geocities.com/SoHo/Atrium/ 1381/hominids2.html

Human Evolution: A Look at Our Ancestors: http://www.humboldt.edu/~mrc1
Human Evolution: You Try It: http://cgi.pbs.org/wgbh/aso/ tryit/evolution

MODULE SUMMARY

In order to understand human evolution it is important to know the different kind of evidences that are used to substantiate this claim namely fossil evidence, genetic evidence and cultural evidence. Special care has been taken to focus on phylogenetic trees as this has been pointed out as being a problematic topic. This module covers all the requirements for the DBE NSC exams w.r.t. the topic: Human evolution.

REFERENCES

- DBE Exam guidelines for learners
- GDE ATP
- 2015-2018 NSC past papers
- 2014-2018 national diagnostic report on learner performance
- Approved grade 12 national textbooks
- Internet
- Gauteng grade 12 Life Sciences Revision booklet

MODULE 3 – Responding to the Environment: Plants

INTRODUCTION

Plants respond to the environment by either growing towards or away from a stimulus. Various plant growth substances (hormones) that are produced in the plant control this growth movement. This type of growth movement is called tropic movement. The word tropism means 'to turn'. A tropism is the response to an external stimulus, causing a plant to grow towards (positive tropism) or away (negative tropism) from the stimulus. Only phototropism, which is a response to light, and geotropism, which is a response to gravity, needs to be covered in the DBE gr.12 syllabus.

Auxins are **growth hormones** found in plants. Auxins stimulate or inhibit (prevent) growth in areas. A high concentration of auxins in an area will **stimulate cell elongation** and **cell differentiation**, especially in stem tips (growth tips). This results in **apical dominance,** when the growth point at the **tip** of the stem grows **upwards**. This action **inhibits** the development of axillary buds on the lateral branches below so they don't grow because all the plant's energy is used to grow **upward**. If the tip is removed the **axillary buds** develop into lateral branches causing the plant to grow **thicker** on the sides (like when cutting a hedge).

Only about three days are allocated on the ATP for the teaching of plant responses to the environment. It is important to use diagrams for the teaching and learning of this topic. You will also notice that we have included terminology lists as these are crucial for good performance. Please ensure that your learners do regular terminology activities and tests.

A clinostat can be used to demonstrate plant growth responses to an external stimulus.

OVERVIEW

This module deals with the responses of plants to light and gravity as an external stimulus. There is a detailed terminology list, followed by the general functions of the auxins, gibberellins and abscisic acid. The use of plant hormones in controlling weeds is described as well as the role of auxins in geotropism and phototropism.

SPECIFIC OBJECTIVES

By the end of this session, participants will be able to:

- Describe the general functions of auxins; gibberellins and abscisic acid.
- Briefly describe the use of plant hormones in controlling weeds.
- Briefly describe the role of auxins in geotropism and phototropism.
- Interpret and conduct investigations based on the role of plant hormones.

CONTENT

You will study this module through the following units:

Unit 1: The general functions of auxins; gibberellins and abscisic acid
Unit 2: The control of weeds using plant hormones
Unit 3: The role of auxins in geotropism and phototropism
Unit 4: the role of chemicals and thorns in plant defense mechanisms

UNIT 1 - The general functions of auxins; gibberellins and abscisic acid

Terminology & definitions:

Biological term	Description
Abscisic acid	The plant hormone that promotes seed dormancy A plant hormone that causes leaves to fall off trees in autumn.
Apical dominance	Is the phenomenon whereby the main, central stem of the plant is dominant over other side stems
Auxins	The plant hormone that promotes root and stem growth
Geotropism	The growth of part of a plant in response to gravity.
Gibberellins	A plant growth hormone that stimulates seed germination.
Herbicide	Chemical used to kill weeds
Hormone	Chemicals that allow a plant to respond to some stimulus in the environment
Phototropism	The growth of a plant in response to light
Tropism	The growth movement of a plant or part of a plant in response to an environmental stimulus
Uniform light	A plant receives light of the same quality from all directions
Unilateral light	A plant received light from one direction only

Growth development in plants

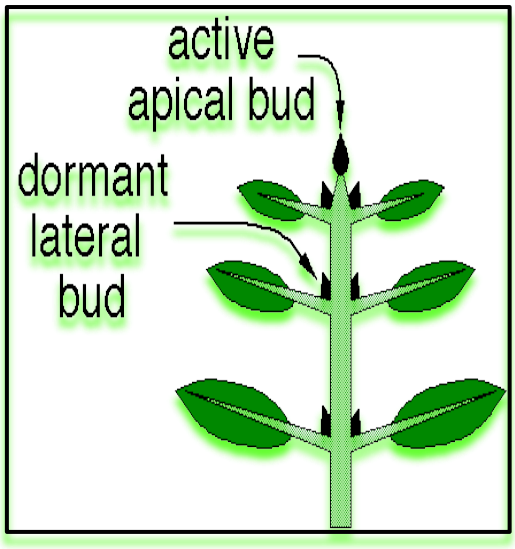
- Plants respond to stimuli in the environment by growing towards or away from the stimulus.
- This growth movement is controlled by plant hormones such as auxins, gibberellins, and abscisic acid.
- These substances are not true hormones because they work in the part of the plant where they are produced.
- Therefore, they are also referred to as plant growth substances.
- These allow plants to respond to certain stimuli in the environment:
    - allow plants to bloom at an appropriate time
    - allow plants to grow toward a light source
    - allow seeds to germinate at the appropriate time
    - induce dormancy in plants at the appropriate time

https://www.youtube.com/watch?v=PxSkuyjZ3MM

The role of auxins

- Auxins stimulate the following responses in plants:
    - Cell division
    - Cell elongation (growth in stem length)
    - The development of fruit
    - The abscission of leaves and fruit
    - The development of adventitious root in stem cuttings

- Tropic movement in stem and roots
- Apical dominance: it suppresses the growth of the lateral buds.



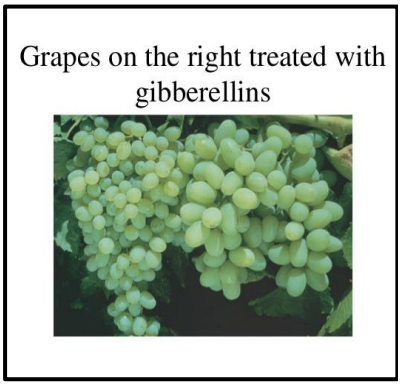
Apical dominance

Phototropism

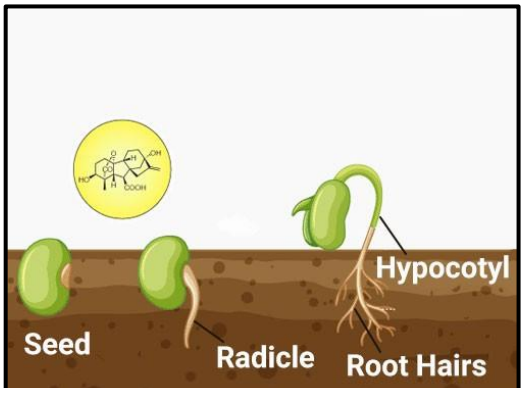
The role of gibberellins

- Gibberellins stimulate the following responses in plants:
  - Stem elongation
  - Root growth
  - The germination of seeds
  - Promotes flowering
  - Fruit growth

https://www.youtube.com/watch?v=EZ5tU45Ti_g&t=29s



Fruit growth



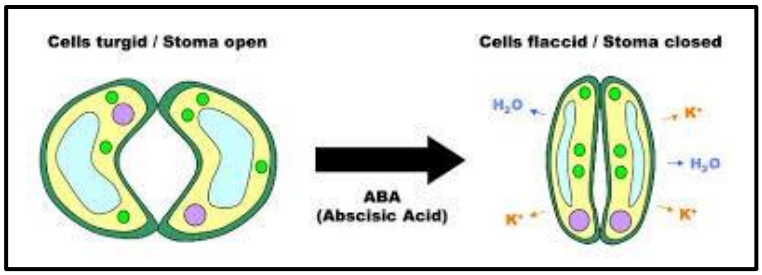
Seed germination

Stem elongation

The role Abscisic Acid

- Abscisic Acid stimulate the following responses in plants:
    - Is an inhibitor of growth
    - Causes plants to become dormant in winter
    - It causes abscission in leaves and fruit (they fall off the tree)
    - Lack of water (water stress) stimulates the production of Abscisic acid
    - Causes the closing of stomata when the plant wilts

Leaf fall



Stomatal closing

Activity 3.1

AIM: Testing terminology

METHOD: Completion of a table

Complete the table below:

Term	Description
a)	Chemical messenger in the plant
b)	Growth of a plant stem towards light
Geotropism	c)
Tropism	d)

UNIT 2 - The control of weeds using plant hormones

Use of auxins as weed killers

- Hormone weed killers are auxin-based selective herbicides.
- The auxins used in these weed killers are made by chemical synthesis.
- The main factor that controls the weed growth in these herbicides are the auxins.
- These herbicides can only kill weeds.

Advantages of Hormone Weed-killers…

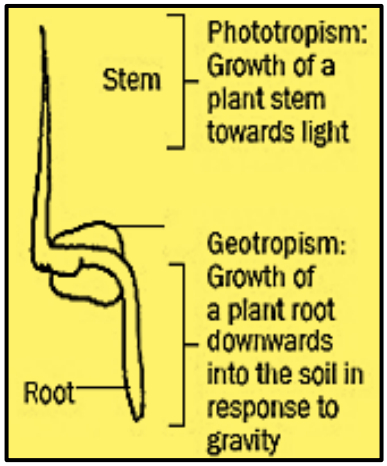
- They are non-toxic to animals and humans.
- There is no longer the need for weeding the garden.

https://www.youtube.com/watch?v=TTLgTIipmA8

UNIT 3 - The role of auxins in geotropism and phototropism

Role of auxins in phototropism and geotropism

- Hormones control growth and development in plants.
- Auxin is an example of a hormone.
- Phototropism is the growth of a plant in the direction of a light source.
- Geotropism is the growth of a plant in response to gravity.
- The growth movement of phototropism and geotropism is due to chemical messengers (hormones) called auxins in a plant.

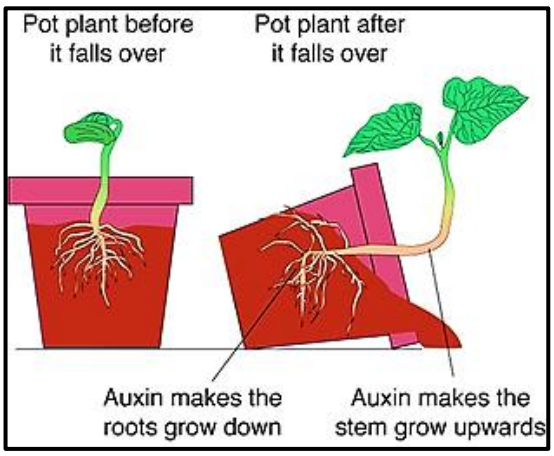


Role of auxins in phototropism	Role of auxins in geotropism
Produced at the tip of the stem/shoot	Produced at the tip of the roots
Auxins move downward evenly	Auxins move upward evenly
This even distribution brings about equal growth on all sides of the stem	This even distribution brings about equal growth on all sides of the root
As a result the stem grows upward	As a result the root grows downward
When the stem is exposed to a unilateral light (light from one side)	When the root is placed horizontally (only one side exposed to gravity)
The auxin concentration will be high on the dark side of the stem – light destroys auxins	The auxin concentration will be high on the lower side of the root – gravity attracts auxins
More growth occurs on the dark side because auxins stimulate growth on the dark side	More growth occurs on the upper side because auxins inhibit growth on the lower side
As a result the stem bends towards the light	As a result the root bends downwards

Mnemonic:
P A S D
In **P**hototropism **A**uxins **S**timulate growth In **D**ark side of stem and the stem bends towards the light

G A I L
In **G**eotropism **A**uxins **I**nhibit growth in the **L**ower side of the root and the root bends towards gravity

Remember: In plant stems/shoots, a high concentration of auxins STIMULATES cell division and growth, BUT in roots, a high concentration of auxins INHIBITS cell division and growth.



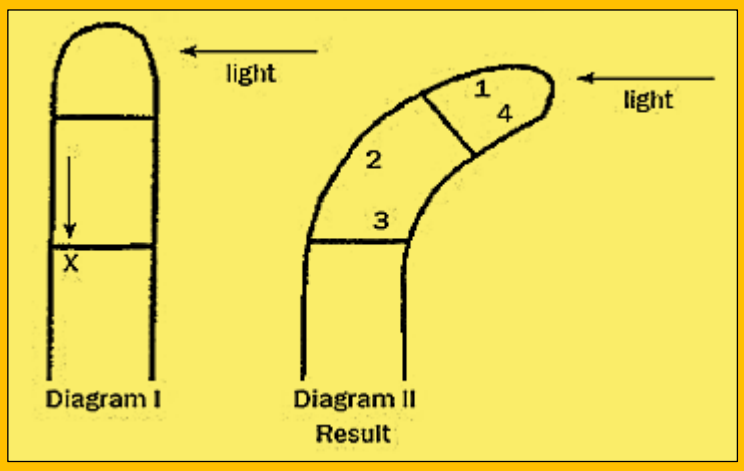
Activity 3.2

AIM: To be able to answer questions on plant responses to the environment

METHOD: Question and answer

Question 1

Various options are given as possible answers to the following questions. Choose the answer and circle only the letter (A to D).
Questions 1.1 and 1.2 are based on Diagrams I and II, which illustrate the response of the tip of a young shoot to a light stimulus.



1.1. The arrow X represents the unequal distribution of …

A Abscisic acid.
B Mineral salts.
C Gibberellins.
D Auxins.

1.2. The curving of the shoot in Diagram II is due to more rapid cell growth in region(s) …

A 1.
B 2.
C 1 and 4.
D 3 and 4.

1.3. The diagram above represents …

A Geotropism.
B Apical dominance.
C Phototropism.
D Gravity.

Question 2 (Taken from Life Sciences P1 DBE/Feb-March 2015)

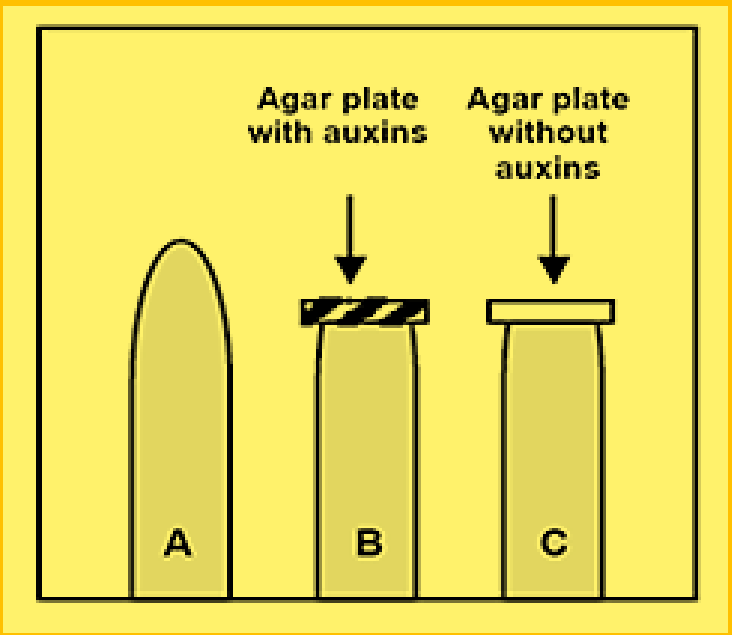
Nthabiseng investigated the effect of auxins on the growth of three plant shoots. (**A, B** and **C**). The plant shoots were treated as follows:

- Shoot **A** – Not treated in any way
- Shoot **B** – Tip removed and agar plate with auxins placed on top
- Shoot **C** - Tip removed and agar plate without auxins placed on top

All shoots were exposed to the same light conditions.

NOTE: Agar is a jelly-like substance that allows auxins to diffuse through it.

The diagram below illustrates the set-up at the beginning of the investigation.



2.1. Identify the independent variable in this investigation.

2.2. State TWO factors that must be kept constant in this investigation.

2.3. Explain the results observed in:

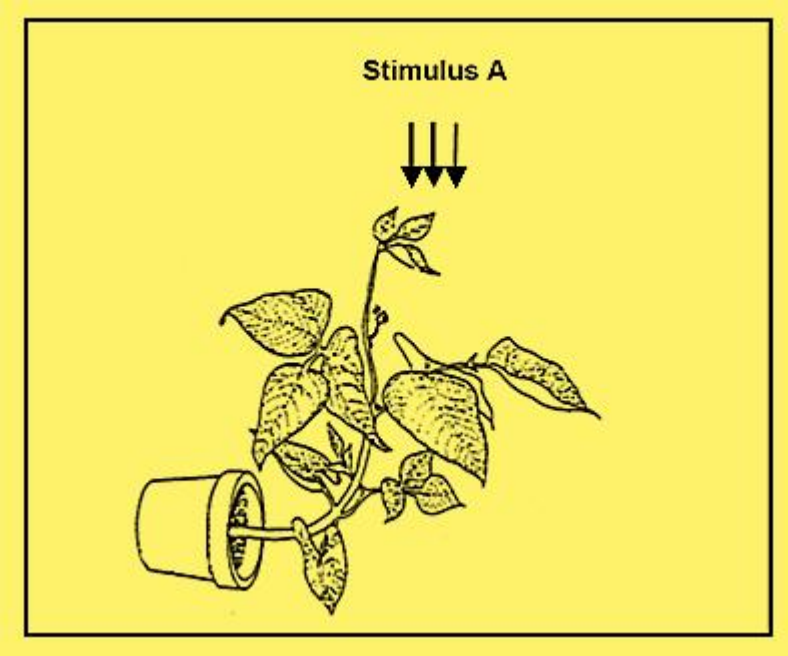
(a) Shoot **B** after a few days

(b) Shoot **C** after a few days

2.4. Suggest TWO ways in which Nthabiseng could have improved the reliability of her investigation.

Question 3 (Taken from Life Sciences P1 DBE/Nov 2015)

The diagram below shows the growth movement of a part of a plant towards a stimulus.



3.1. What growth movement is represented in the diagram?

3.2. Identify the stimulus labelled **A**.

3.3. Name the growth hormone that is responsible for the growth movement named in QUESTION 3.1.

3.4. Will a high concentration of the growth hormone named in QUESTION 3.1 **stimulate** or **inhibit** growth in the roots?

3.5. Name the phenomenon where the buds at the tip of the plant regulate the growth of the lateral branches.

Question 4 (Taken from Life Sciences P2 DBE/Nov 2018)

Weeds are problematic to farmers because they invade farm fields and outcompete crop plants for space. This reduces the crop yield.

Farmers spray their fields with chemicals, known as herbicides, to kill the weeds. Some weeds, however, have evolved to be resistant to herbicides.

Scientists investigated the time it took for a species of weed to develop resistance to five types of herbicides. The results are shown in the table below.

TYPES OF HERBICIDE	TIME TAKEN FOR WEEDS TO DEVELOP RESISTANCE (years)
2,4-D	9
Dalapon	9
Picloran	25
Dicloflop	7
Triflularin	26

4.1 Refer to the passage above and state how weeds act to reduce crop yield.

4.2 Identify the:

(a) Independent variable

(b) Dependent variable

4.3 Name the herbicide:
(a) To which the weeds developed resistance the fastest
(b) That remained effective for the longest period of time

4.4 The scientists used the same weed species when investigating resistance to the different herbicides.
(a) Describe how the scientists would have determined the resistance of the weeds to the herbicides.
(b) Explain how the use of the same weed species improved the validity of the investigation.

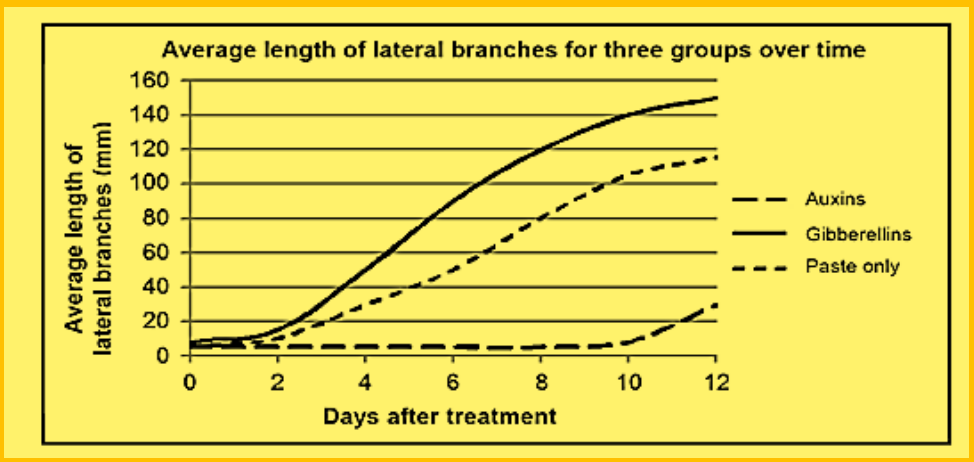
4.5 Draw a bar graph to show the time taken for the evolution of resistance to the herbicides.

Question 5 (Taken from Life Sciences P2 DBE/Nov 2013)

A learner investigated the effects of two plant growth substances, gibberellins and auxins, on apical dominance. The apical buds of nine pea plants of the same species, age and height were removed. These plants were then divided equally into three groups.
In each group the cut surface of the remaining shoot (growing stem) of the pea plants was treated in one of the following ways:
Group 1: Coated with a paste containing gibberellins of the same concentration.
Group 2: Coated with a paste containing auxins of the same concentration.
Group 3: Coated with a paste only (containing no plant growth hormones)

The hormones diffuse into the plant until no more hormones remain in the paste.
The treated plants were all grown under the same conditions in the laboratory. The length of the lateral branches of each plant was measured after every two days for a period of 12 days. Measurements were taken at the same time for all treated plants and the average for each group was calculated.

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



5.1 State ONE function of the gibberellins that led to the results obtained in the investigation.

5.2	Calculate the difference in the average length of the lateral branches between the plants treated with gibberellins and the plants treated with the paste only on the 8th day after the treatment. Show ALL working.

UNIT 4 - The role of chemicals and thorns in plant defence mechanisms

Plants have adapted to prevent herbivores from eating them.

- **Chemical defences**: plants produce chemicals called phytoecdysteroids to defend against insects. The chemicals cause insects to moult prematurely, lose weight and if enough is ingested, metabolic damage and death. Cultivated tobacco plants produce nicotine. The leaves are eaten by insects and kills them. The leaves of mopane trees contain high levels of tannins making the leaves distasteful to herbivores.

Cultivated tobacco plants

Leaves of the mopane tree

- **Thorns:** this is a common term for a sharp structure found on plants for protection against herbivores. There are various types of sharp structures:
  o ***Prickles*** are modified extensions of the cortex and epidermis of a plant that shape into a sharp, needle-like structure, for example rose bushes.
  o ***Thorns*** are modified branches or stems that form hard, pointed and sharp ends that can pierce the skin of herbivores. Examples are acacia trees, kei apples and lemon trees.
  o ***Spines*** are modified leaves that have a cylindrically shaped hard and sharp point, for example aloes and cacti. Spines also reduce water loss by the plant.

Prickles of a rose bush

Thorns of Acacia tree

Spines of cacti

RESOURCES

http://www.scholastic.com/browse/article.jsp?id=3757140

Life: The Science of Biology - useful website with animated tutorials, activities, flash cards, self-quizzes, glossary etc

Dr. Saul's Biology in Motion - original, entertaining, interactive biology learning activities

Biology-Online - useful site for biological information, ideal for homework, research projects, and general interest

www.biologymad.com/

https://www.khanacademy.org

https://www.youtube.com/channel/UCS3wWlfGUijnRIf745lRl2A

MODULE SUMMARY

This module covers all the requirements for the DBE NSC exams w.r.t. the topic: plant responses to the environment. It is important to use diagrams to explain observations made w.r.t. the response of a plant on an external stimulus.

REFERENCES

- DBE Exam guidelines for learners
- GDE ATP
- 2013-2019 NSC past papers
- 2014-2019 national diagnostic report on learner performance
- Approved grade 12 national textbooks
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