Western Cape Government
FOR YOU

CAPE WINELANDS EDUCATION DISTRICT

LIFE SCIENCES PAPER 2

SURVIVAL KIT

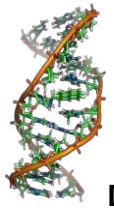
2022 The year of learning
Leadership driving resilience

DNA, RNA, Protein Synthesis (Paper 2- 27 marks)

DNA is the **basic unit of genetics**.
DNA provides the code for production of proteins, a process called **protein synthesis.**
There are **two types of nucleic acids**: **DNA and RNA**

- **DNA** is **found (or located) in** the **nucleus** of cells
  is also **found** in the **mitochondria** of cells
- ***RNA*** is **found in** the ***nucleus***
  also found at the ***ribosomes*** *in the cytoplasm* of a cell.
- ***RNA*** plays a role in ***protein synthesis by joining amino acids*** in the correct sequence, according to the instructions which DNA provides

STRUCTURE OF DNA: <u>Double helix</u>
Consists of two strands of nucleotides that form a twisted ladder (**double helix**)

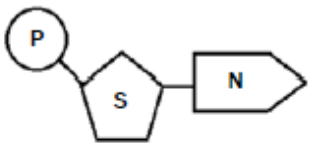


Double Helix

A **DNA molecule** is made up of **building-blocks** or **monomeres**, called **nucleotides**

NB : Each DNA **nucleotide** is made up of **three components:**

1. **Nitrogenous bases** linked by **weak hydrogen bonds**
   The four nitrogen bases: adenine (A)
   thymine (T)
   cytosine (C)
   guanine (G)
2. Sugar portion (**deoxyribose** in DNA)
3. Phosphate portion



P – Phosphate group
S – Deoxyribose or ribose sugar
N – Nitrogenous base (adenine, thymine, guanine, cytosine or uracil)

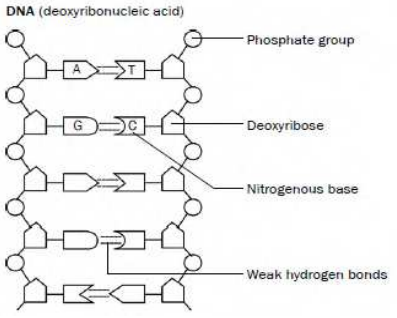
Specific base pairing arrangement are known as complimentary bases.

A always pairs with T (A-T)
C always pairs with G (C-G)

NB!!: Nitrogen bases attach to **the <u>sugar portion</u> of the nucleotide**

Know the stick diagram of DNA to illustrate its structure:

<u>When you learn this topic</u>, **practice to draw a nucleotide** AND
be able to **label the different parts of the DNA stick diagram**



FUNCTIONS OF DNA:

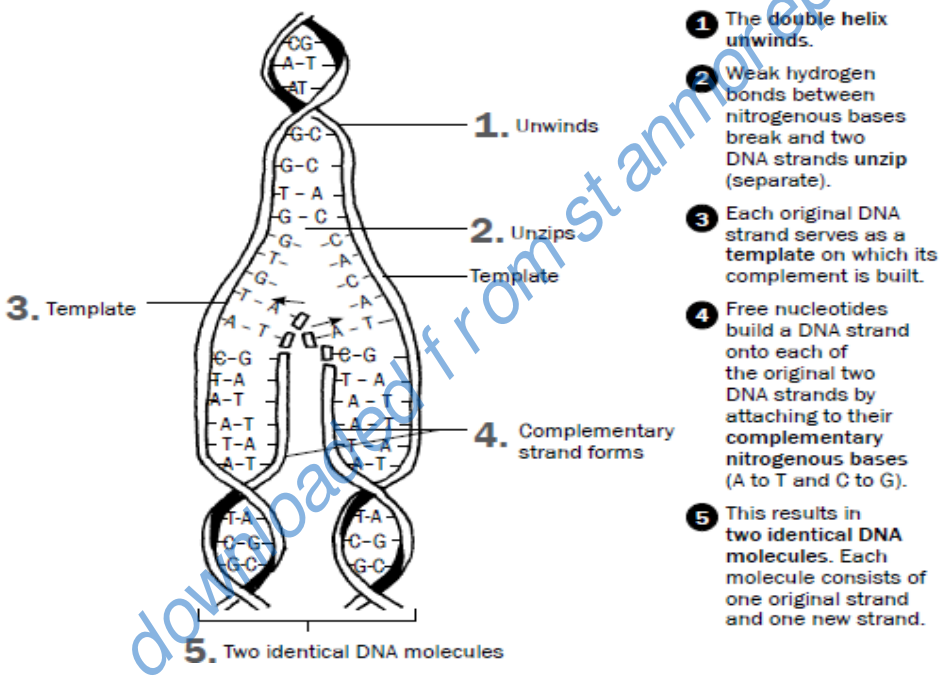
1. Sections of DNA-forming genes **carry hereditary information**
2. DNA **contains coded information for protein synthesis**

PROCESS OF DNA REPLICATION
(Meaning of **replicate** = to make an **exact copy** of)

When does DNA replication take place?
During **INTERPHASE**
Where does DNA replication take place?
In the **nucleus**

Significance (or importance) of DNA replication:
• Doubles the genetic material so it can be shared between the resulting daughter cells during cell division.
• Results in the formation of identical daughter cells during mitosis

How DNA replication takes place:
(*you must be able to **describe** this process*)

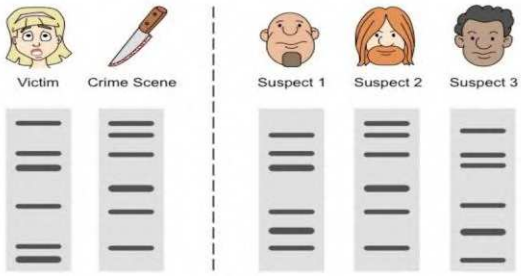


Definition of a DNA profile:

It can be described as an arrangement of black bars representing DNA fragments of the person.

Uses of DNA profiles:
• Identify criminals
• Identify dead bodies
• Identify relatives
• Identify paternity

Interpretation of DNA profiles:
Compare the DNA profile found at the crime scene to the DNA profile of the suspects.

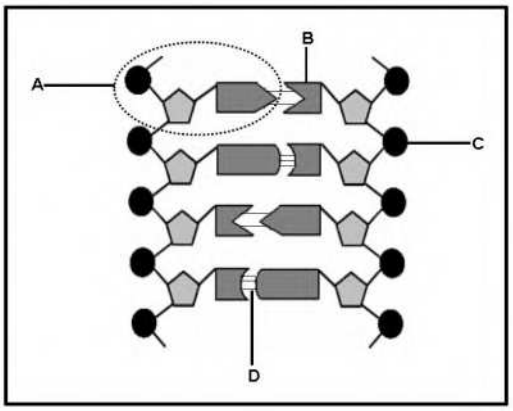


Suspect 2 is most probably guilty as all the bars on his DNA profile are the same as the bars of the DNA profile found at the crime scene.

Exemplar Questions on DNA

Question 1:

1. The diagram below represents a portion of a **DNA molecule**.



1.1 Identify parts **B, C** and **D**. (3)

1.2 Name:
(a) Monomer **A** (1)
(b) ONE organelle in a cell where DNA is located (1)

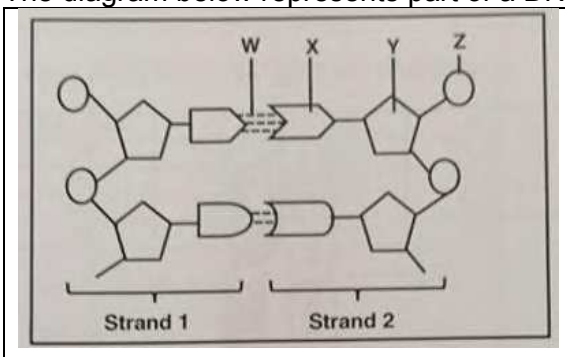
1.3 How many nucleotides are shown in the diagram? (1)

Answer:

1.1 B – nitrogen base
C – phosphate group
D - hydrogen bonds *(weak)*
1.2 (a) nucleotide *(monomere = building block)*
(b) nucleus or mitochondria
1.3 8

Question 2

The diagram below represents part of a DNA molecule.



2.1 Identify the:
(a) Molecule **X**
(b) Sugar at **Y**
(c) Bond **W** (3)
2.2 Give the collective name of the parts **X, Y** and **Z.** (1)
2.3 State the natural shape of the DNA molecule. (1)
2.4 Name the process wherebyDNA makes a copy of itself. (1)
2.5 Name TWO places in an animal cell where DNA is located. (2)

Answer:

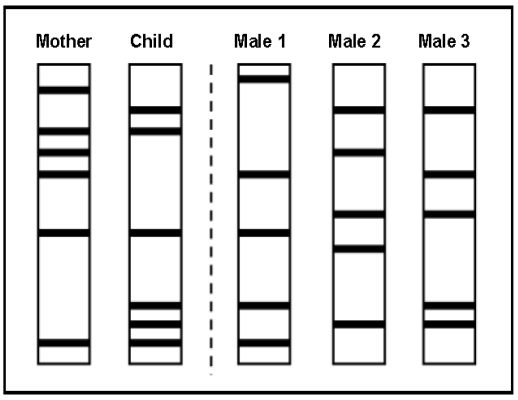
2.1 (a) X - nitrogen base
(b) Y – deoxyribose
(c) W – hydrogen bond
2.2 nucleotide
2.3 double helix
2.4 replication
2.5 nucleus
mitochondria✓

3.1 **Describe** the process of DNA replication. (5)

- ***The double helix unwinds***
- ***Weak hydrogen bonds between the nitrogen bases break, DNA unzips (separates)***
- ***<u>Both</u> of the original strands serve as a template on which the complement is built***
- ***Free DNA nucleotides build a strand onto each of the two DNA strands, attaching to their complementary bases***
- ***<u>Two identical DNA molecules</u> are formed, each consisting of one original and one new strand***

<u>Question 4:</u>

4.The diagram below shows a technique used in paternity testing.

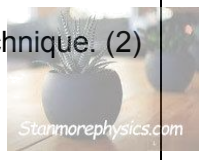


4.1 Identify the technique shown above. (1)

4.2 Which male is the biological father of the child? (1)

4.3 Explain your answer to QUESTION 4.2 (3)

4.4 State TWO other uses of this technique. (2)



<u>Answer:</u>

4.1 DNA profiling
4.2 Male 3
4.3 We first compare the bands that the mother and the child have in common and then check which of the males have the rest of the bands that overlap with the rest of the child's bandson the profile, which in this case is male 3.
4.4 Identify criminals
Identify dead bodies
Identify relatives

RNA - (Ribonucleic Acid)

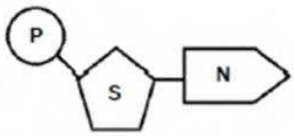
RNA is also a nucleic acid.
It is **found in the nucleus**
and in **the cytoplasm**
and plays a very important role during **protein synthesis**
RNA is a **single-stranded** nucleic acid.
Two types of RNA that you will learn more about - **mRNA** and **tRNA**

Location of RNA:
mRNA is formed in the **nucleus** and functions on the ribosomes
tRNA is found in the cytoplasm at the **ribosomes**

RNA is also **made up of building-blocks** (monomeres) called **nucleotides**.

RNA nucleotides are made of 3 parts:

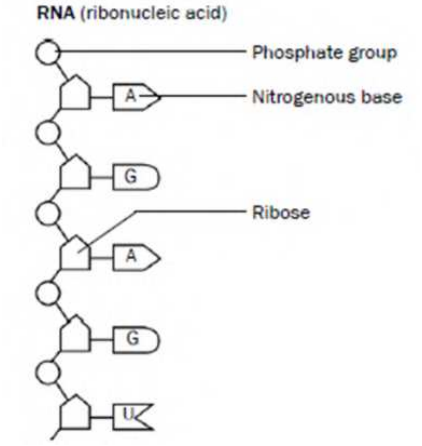
phosphate,
ribose sugar and a
nitrogen base (adenine, cytosine**, uracil** and guanine)



P – Phosphate group
S – Deoxyribose or ribose sugar
N – Nitrogenous base (adenine, thymine, guanine, cytosine or uracil)

Figure 1.1 A nucleotide

Stick diagram of a RNA molecule:



How to recognise an RNA molecule

- Single-stranded molecule
- Contains the nitrogenous base uracil (U) instead of thymine (T)

Question 1:

1.1 **Tabulate** three differences between DNA and RNA. (7)
T✓

DNA	*RNA*
Double-stranded molecule	*Single-stranded molecule*
Contains deoxyribose (sugar)	*Contains ribose (sugar)*
Contains the nitrogenous base, ***thymine***	*Contains the nitrogenous base,* ***uracil***

1.2 Give the **correct biological term** for each of the following descriptions.

1. The **sugar** found in **RNA**.
2. The **bond** that forms **between** two **amino acids**
3. The **stage of protein synthesis** during which mRNA forms from DNA.
4. The **type of RNA** containing anticodons.
5. The **organelle** in a cell where translation occurs.
6. The **type of nucleic acid** that carries a specific amino acid.
7. **Nitrogenous base** found **only in RNA** molecules. (7)

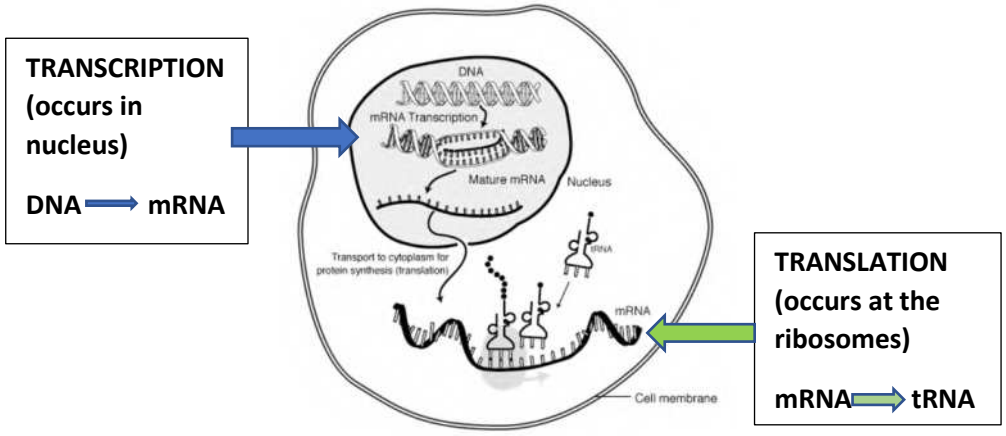
Answer:

1. ***Ribose***
2. ***Peptide bond***
3. ***Transcription***
4. ***tRNA***
5. ***ribosome***
6. ***tRNA***
7. ***uracil***

1.3 State **TWO differences** between a DNA **nucleotide** and an RNA **nucleotide**. (4)

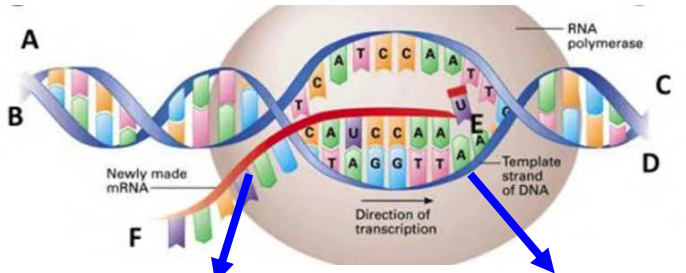
DNA contains the sugar deoxyribose
RNA contains the sugar ribose
DNA contains the nitrogen base thymine
RNA contains the nitrogen base URACIL

PROTEIN SYNTHESIS
The involvement of RNA in protein synthesis:



mRNA rewrites the code **from DNA** to form a mRNA molecule which leaves the nucleus and will carry that 'code' to the ribosomes.
This process is called **TRANSCRIPTION,** and occurs in the **nucleus**
tRNA carries a specific amino acid to the ribosomes,
where the amino acids will join to form a protein.
This process is called **TRANSLATION,** and occurs **at the ribosomes**

The **involvement of DNA** in protein synthesis:
DNA provides the code so that a **mRNA molecule is formed** which leaves the nucleus and will carry that 'code' to the ribosomes.
This process is called **TRANSCRIPTION.**



mRNA is formed Only <u>one strand</u> of DNA serves as a template

<u>You must be able to: ***Describe*** **TRANSCRIPTION** as follows:</u>

- The double-helix unwinds
- The double stranded DNA unzips as weak hydrogen bonds break
- To form two separate strands
- **Only ONE strand** serves as a template
- To form mRNA
- Using free RNA nucleotides from the nucleoplasm
- mRNA is complementary to DNA
- mRNA now has the coded message for protein synthesis

You must be able to describe the process of TRANSCRIPTION and label diagrams representing this process.
Practice how to use the code on a DNA molecule to rewrite it as a mRNA molecule.

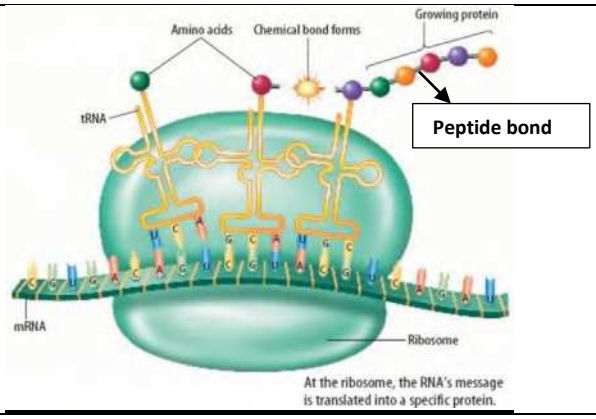
<u>TRANSLATION:</u>
This process occurs in the cytoplasm at the RIBOSOMES

<u>You must be able to: Describe **TRANSLATION** as follows:</u>

- Each tRNA carries a specific amino acid
- When the anticodon on the tRNA
- matches the codon on the mRNA
- then the tRNA brings the required amino acid to the ribosome
- Amino acids become attached by **peptide bonds** to form the required protein

<u>Use the diagram of translation to **identify:</u>**

- mRNA
- tRNA
- the ribosome
- amino acids
- peptide bonds



Go back to the previous paragraph and read through the steps of translation again, memorise the description

Questions:

1.1 **Practice the following:**

1.1.1 Write down the complementary strand of **mRNA** which the **DNA strand** codes for.

DNA: ACC GTC TAT CCA CTA
mRNA: **UGG CAG AUA GGU GAU**
(Remember: NO T's in mRNA!!!)

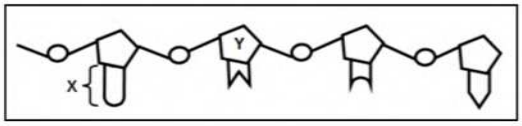
1.1.2 Rewrite **mRNA** back to **DNA**.

mRNA: GCA CCC UAA UCU AAG GAC
DNA: **CGT GGG ATT AGA TTC CTG**

1.1.3 Use the given mRNA(**codons**) strand to write down the **anti-codons** of the tRNA.

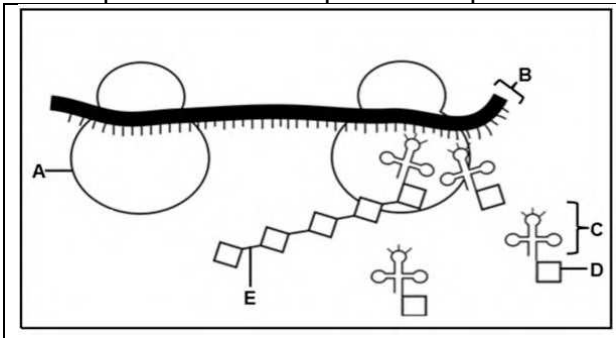
mRNA: UUU AGC AUC CCU AAG GAU (codons on mRNA)
tRNA/oRNS: **AAA UCG UAG GGA UUC CUA** **(anti-codons on tRNA)**

Question 2

2.1 The diagram below represents a single-stranded nucleic acid found in the nucleus.  2.1.1 Identify the molecule represented in the diagram. (1) 2.1.2 Identify: (a) Part **X** (1) (b) Sugar **Y** (1) 2.1.3 Describe the process of *transcription*. (5) **(8)**	**Answer** ***2.1.1 RNA*** ***2.1.2 (a) nitrogen base*** ***(b) ribose*** ***2.1.3 TRANSCRIPTION:*** ***The double-helix unwinds*** ***The double stranded DNA unzips as weak hydrogen bonds break*** ***To form two separate strands*** ***Only ONE strand of the DNA serves as a template*** ***To form mRNA*** ***Using free RNA nucleotides from the nucleoplasm*** ***mRNA is complementary to DNA*** ***mRNA now has the coded message for protein synthesis✓***

Question 3

31.The process below represents a process that occurs during protein synthesis.

 	3.1.1 Identify the process above. (1) 3.1.2 Identify: (a) organelle **A** (b) molecule **B** (c) bond at **E** (3) 3.1.3 Give only the LETTER of the molecule that: (a) carries the amino acid (b) is copied from DNA (c) is the monomer/building block of proteins (3)

Answer:

3.1.1 translation

3.1.2 (a) ribosome

(b) mRNS

(c) peptide bond

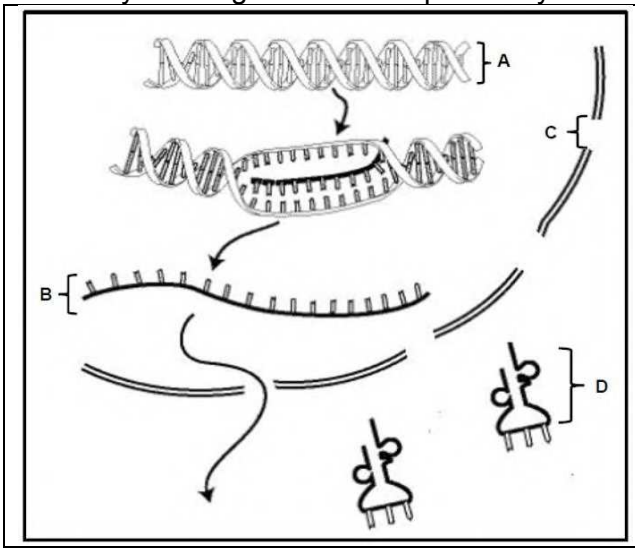
3.1.3 (a) C

(b) B

(c) D

Question 4

4.1 Study the diagram below of protein synthesis.



4.1.1 **Identify**
(a) structure **C**
(b) molecule **D** (2)

4.1.2 **Name** molecule:
(a) **A**
(b) **B** (2)

4.1.3 **Tabulate** TWO differences between the monomers of the two molecules in QUESTION 4.1.2 (a) and (b). (5)

4.1.4 Describe the role of A in transcription. (2)

Answer:

4.1.1 (a) nucleopore

(b) tRNA

4.1.2 (a) DNA

(b) mRNA

4.1.3 DNA contains the sugar deoxyribose

RNA contains the sugar ribose

DNA contains the nitrogen base thymine

RNA contains the nitrogen base URACIL

4.1.4 *Role of DNA in* ***TRANSCRIPTION****:*

The DNA double-helix unwinds

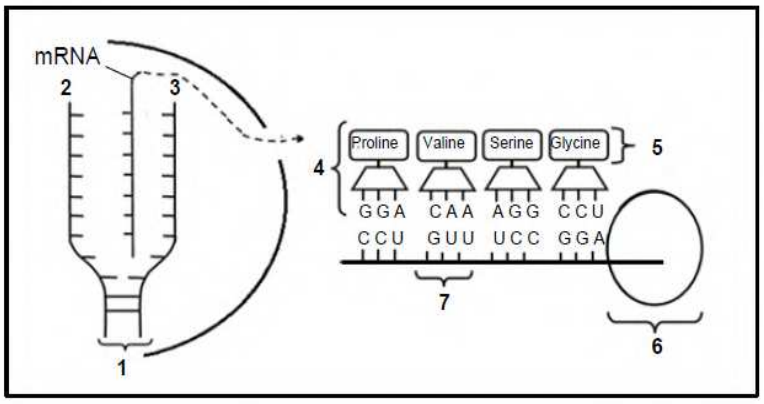
The double stranded DNA unzips as weak hydrogen bonds break

To form two separate strands

Only ONE strand *serves as a template*

To form mRNA

5.1 The diagram below represents two stages of protein synthesis.



5.1.1 Provide labels for:
(a) Molecule **1** (1)
(b) Organelle **6** (1)

5.1.2 Give only the NUMBER of the part which represents:
(a) **DNA template** strand (1)
(b) Monomer of proteins (1)
(c) Codon (1)

5.1.3 Describe the role of DNA during protein synthesis. (3)

5.1.4 **Describe** the stage of protein synthesis that occurs at organelle **6.** (6)

5.1.5 Provide the:
(a) DNA sequence that codes for glycine (1)
(b) Codon for proline (1)

Answer:

5.1.1 (a) DNA (1)
(b) Ribosome (1)

5.1.2 (a) 2 (1)
(b) 5 (1)
(c) 7 (1)

5.1.3 DNA codes for a particular protein
but cannot leave nucleus
One strand of DNA is used as a template
to form mRNA (3)

5.1.4 According to the codons on mRNA
tRNA molecules with matching anticodons
bring the required amino acids to the ribosome
This is called translation
The amino acids become attached by peptide bonds
to form the required protein (6)

5.1.5 (a) CCT (1)
(b) CCU (1)
(16)

MEIOSIS – Paper 2, 21 marks

Is a type of cell division whereby **diploid cells** (body cells) undergo **two divisions** to produce **four genetically different haploid cells** - called **sex cells or gametes** (female gamete=ovum; male gamete= sperm cell)

Revision of cell structure:
Give special attention to the following parts:

Nucleus: the part that contains all the DNA (chromosomes)
Centrosome: is **made up of 2 centrioles** which move to the poles of the cell during cell division
Cytoplasm: the gel liquid that fills the inside of the cells, and contains organelles

Structure of chromosomes:

What is a chromosome? 

Highly condensed form of DNA which becomes visible as chromosomes just before the cell divides
One chromosome is made of **2 chromatids joined by a centromere**

Differentiate between (*which means you need to know **the difference** between):*

Haploid (n) and diploid (2n) cells in terms of chromosome number
All body cells are **diploid (2n)**, which has the full chromosome number in each cell (2 sets of chromosomes, one set from your mother and the other set from your father)

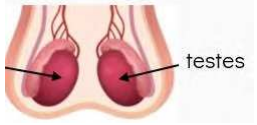
Only **sex cells(gametes)** are **haploid(n)** as the chromosome number has been halved by meiosis.

Somatic cells and gametes
Somatic cells – are body cells
Gametes – are sex cells used for sexual reproduction (female sex cells=ovum; male sex cells=sperm cells)

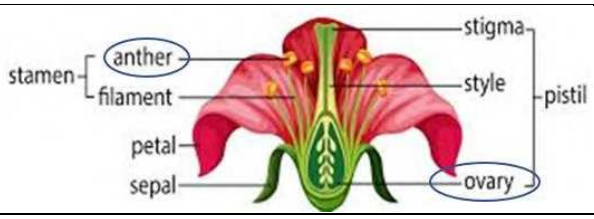
Sex chromosomes (gonosomes) and autosomes
Sex chromsomes - **gonosomes** determine your sex/gender (male XY chromosomes; female XX chromosomes)
All other chromosomes in your cells are called **autosomes**
In humans we have **23 pairs of chromosomes**, **22 pairs of autosomes** and **1 pr of gonosomes**

Definition of meiosis:
Meiosis is a process where a single **cell divides twice** to **produce four cells** containing half the original amount of genetic information **(haploid chromosome number)**.
These cells are our sex cells – sperm cells in males, egg cells in females

Site of meiosis (place where it occurs)
Meiosis **only** occurs **in reproductive organs**
In humans:

males - in the **testes** for the formation of male gametes (sperm cells) 	females - in the **ovaries** for the formation of female gametes (ova) 

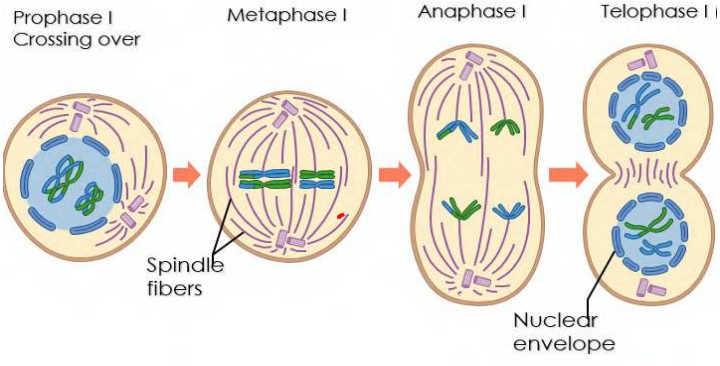
In plants:

Male part - **anthers** with pollen grains to produce male gametes **Female part** - **ovaries** to produce female gametes	

Phases of Meiosis
Meiosis I - the number of chromosomes is halved
diploid number (2n) is **halved** to the **haploid number (n)**
Meiosis II
Similar to mitosis
Number of chromosomes do not reduce

Interphase -part of the cell cycle that occurs just before Meiosis I
DNA replication takes place
Chromosomes which are single threads, become double (2 chromatids)
Each **chromosome** will now consist **of two chromatids joined** by a **centromere**
DNA replication helps to double the genetic material so that it can be shared by the new cells arising from cell division

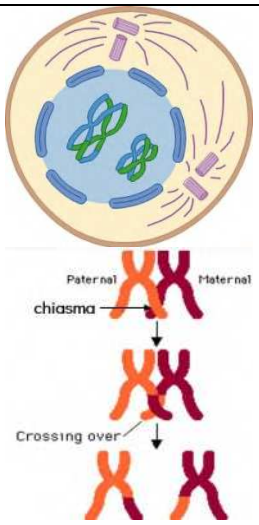
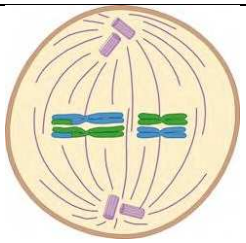
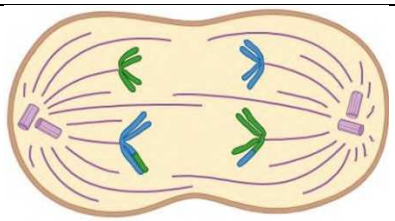
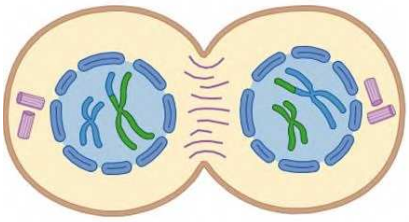
Phases of Meiosis
Know the following phases of **Meiosis I**, by using diagrams:



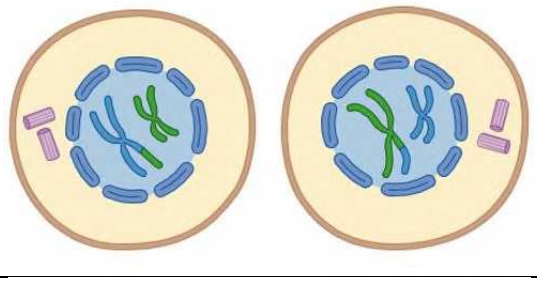
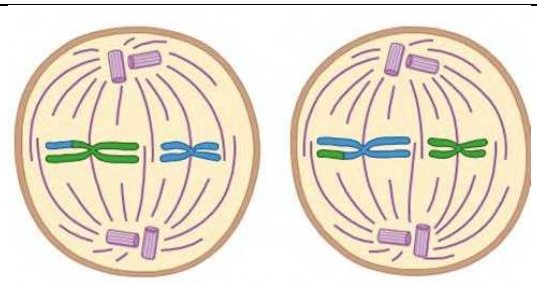
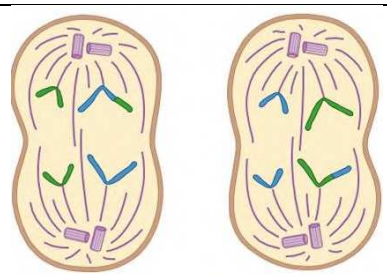
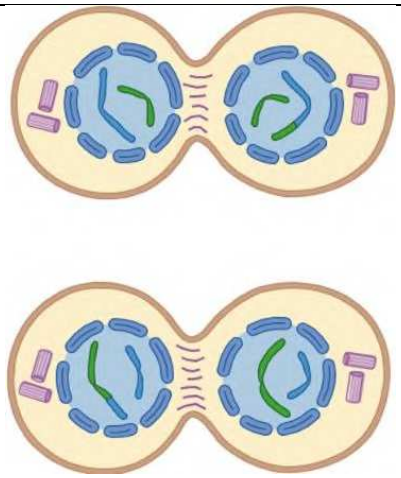
(Phases: **P M A T)**

Prophase I
Including a description of crossing over
Metaphase I
Including the random arrangement of chromosomes
Anaphase I
Telophase I

Phases of Meiosis I:

PROPHASE I Chromatin network becomes shorter and thicker Chromosomes become visible Chromosomes of lie **in pairs** lie next to one another - called **homologous chromosomes** Homologous chromosomes exchange segments of their chromosomes during **CROSSING OVER** **In Prophase I – crossing over** Chromatids touch at chiasmata on homologous of chromosomes *where crossing-over takes place.* Chromatids break at chiasmata Chromosomes of homologous pairs recombine Homologous chromosomes exchange segments of the chromatids **(pieces of chromosomes / genes)** **What is the importance of crossing over?** This **leads to genetic variation**	
METAPHASE I Spindle fibers are spread over the whole cell Homologous chromosomes arrange themselves **randomly (no set pattern)** in homologous pairs on the metaphase plate(equator) **This is called random arrangement** **It also contributes to genetic variation** Spindle fibers are attached to the centromeres of the chromosomes	
ANAPHASE I Spindle fibres contract and pull homologous pairs apart One full chromosome (2 chromatids joined by a centromere) of each pair moves to opposite pole	
TELOPHASE I Chromosomes reach the poles of the cell Poles only have half of the original chromosome number Cell membrane invaginates(pinches) in the middle and the **cytoplasm divides** (called **cytokinesis**)	
The result at the **end of Meiosis I is TWO cells with half the chromosome number (n)**	

Meiosis II - use diagrams to identify the different phases

Prophase II Every cell that is formed during Meiosis I divides again Each chromosome has 2 chromatids joined by a centromere Spindle fibres start to form between the poles in each cell	
Metaphase II **Individual chromosomes** arrange themselves on the equator (metaphase plate) of each cell Random arrangement of chromosomes can also occur during Metaphase II Centromeres are attached by the spindle fibers	
Anaphase II Spindle fibers start to contract Pulling the centromeres apart, **centromeres divide** **Chromatids** are pulled to the opposite poles of each cell	
Telophase II **Single stranded (unreplicated) chromosomes** reach the poles A new nucleus is formed Cell membrane of each cell pinches at the middle Cytoplasm divides **(cytokinesis)** Four **haploid(n)** cells are formed Each cell (gamete) only has half the chromosome number of the original cell (in humans 23 chromosomes) 4 Gametes are all **genetically different**	

Importance of Meiosis

Production of haploid gametes

The halving effect of meiosis overcomes the doubling effect of fertilisation, thus maintaining a constant chromosome number from one generation to the next

Genetic variation is introduced through:

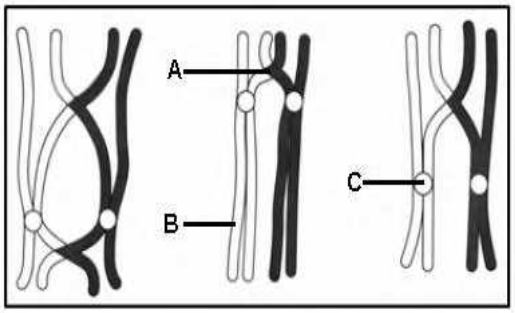
- Crossing over (during prophase I)
- The random arrangement of chromosomes at the equator (during metaphase I and II)

Similarities between Mitosis and Meiosis:
Cell division occurs
Creates new cells
Starts with a parent cell

Differences between Mitosis and Meiosis: (be able to tabulate the differences)

Mitosis	**Meiosis**
Only occurs in somatic cells	Only occurs in reproductive organs
Creates body cells	Creates gametes (sex cells)
Only one cell division occurs	Two cell divisions occur
Creates 2 diploid cells that are identical	Creates 4 haploid cells which are all genetically different

Questions: Meiosis
Question 1
1. The diagram below represents ALL the chromosomes in a cell that is undergoing normal cell division.

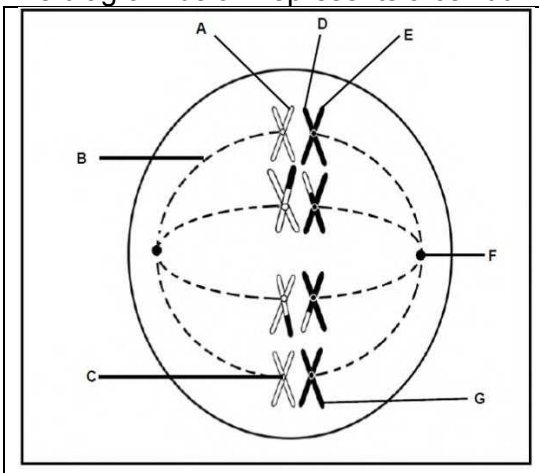


1.1 **Name** the:
(a) **Type** of cell division that is occurring in the cell in the diagram
(b) **Phase** of cell division during which the chromosomes behave as shown in the diagram.
1.2 Where in the human **female** body would the type of cell division named in QUESTION 1.1(a) take place?
1.3 Give the LETTER and NAME of the structure that attaches to the spindle fibres.
1.4 How many chromosomes will be found in each daughter cell at the end of this cell division?

Answer:
1.1 (a) Meiosis
(b) Prophase I
1.2 ovaries *(Meiosis only occurs in the reproductive organs)*
1.3 C- centromere
1.4 *(There are 6 chromosomes in the diagram)*
So at the end of meiosis
6 (diploid number) divided by 2 = 3 (haploid number)

Question 2

The diagram below represents a cell during cell division.



2.1 What **type of cell division** is shown in the diagram above? (1)

2.2 **Identify** the phase represented by this diagram. (1)

2.3 Give the **LETTER/S** that represent/s:

(a) The structure that moves/pulls chromosomes /chromatids to the poles during cell division (1)

(b) The part that is responsible for forming spindle fibres (1)

(c) TWO chromatids that are identical (2)

2.4 How many chromosomes will be found in each daughter cell at the end of this cell division? (1)

2.5 **Give the name** of the cells that will be formed as a result of this type of cell division in a male. (1)

Answer:

2.1 Meiosis

2.2 Metaphase 1

2.3 (a) B✓

(b) F✓

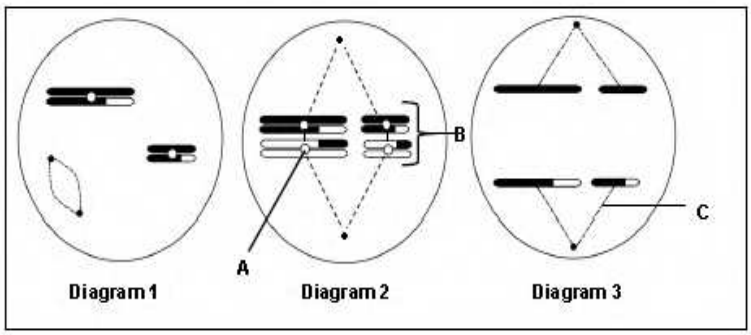
(c) D and E✓

2.4 4✓

2.5 sperm cells✓

Question 3:

3. The diagrams below represent different phases of meiosis in an organism



3.1 **Identify** parts:

(a) **A**

(b) **B**

(c) **C**

3.2 Identify the **phase** represented in DIAGRAM **3**.

3.3 Write down the numbers of the diagrams to show the sequence(order) in which the phases occur.

3.4 State ONE difference between **metaphase I** and **metaphase II**

Answers:

3.1 A - centromere

B - homologous chromosome

C - spindle fibres

3.2 Anaphase II

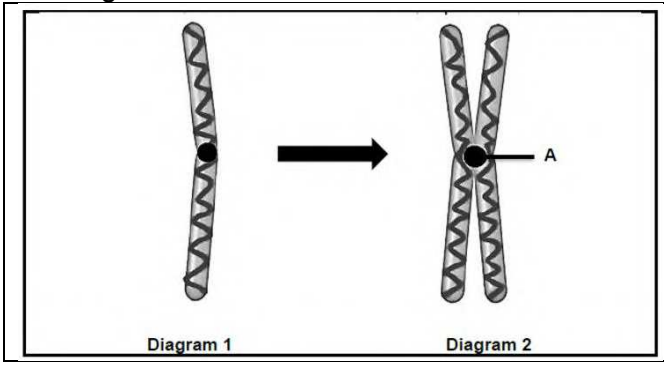
3.3 2 – 1 - 3

3.4 Metaphase I – chromosomes arrange themselves in homologous pairs on the equator

Metaphase II – single chromosomes on the equator

Question 4

The diagrams below show two forms of a chromosome.



4.1 Identify part A.

4.2 Identify the process that lead to the formation of the chromosome represented by Diagram 2.

Answer:

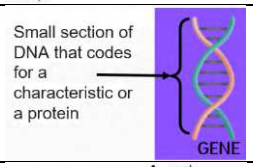
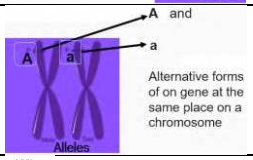
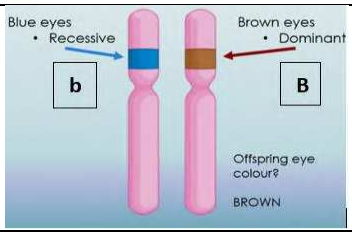
4.1 Centromere

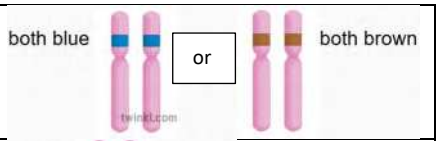
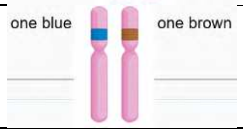
4.2 DNA replication

GENETICS, Paper 2 – 48 marks

Genetics is the **study of inheritance** and the variation of **inherited characteristics.**

TERMINOLOGY: GENETICS

Chromosomes:	DNA condensed (tightly wound) and now visible as chromosomes	
Gene:	small section of DNA (chromosome) that codes for a specific characteristic or protein	
Alleles:	alternative forms of a gene found at the same place on a chromosome.	
Locus:	the position of the gene on the chromosome	
Dominant allele:	An allele if present, is ALWAYS expressed in the phenotype	
Recessive allele:	An allele that is hidden (overshadowed by dominant allele) in the phenotype. **Can only be expressed(seen) if both alleles are recessive**	
Phenotype:	Physical **appearance** of an organism determined by the genotype (**what we can see/observe from the outside)**	Represented by words eg brown, blue, blonde, red and white etc.
Genotype:	Genetic **composition of the alleles of the gene** for a particular characteristic	Represented by the use of letters eg. **BB; Bb and bb**

Homozygous:	Two alleles **the same** for a particular characteristic (**BB or bb)**	
Heterozygous:	Two **different alleles** for a particular characteristic (**Bb**)	
Monohybrid crosses:	A genetic cross involving only **ONE characteristic**, eg colour of fur	

NB!! Every Paper 2 Question Paper WILL include a genetic cross, which normally counts out of 6 marks. You will get 2/6 marks if you are able to write down this template/format for a genetic cross. Practice it many times before you write Paper 2.

Format for representing a genetic cross:

P1 – generation Phenotype _____ x _____
Genotype _____ x _____

Meiosis
Possible Gametes ___, ___ x ___, ___

Fertilization (Punnet diagram)

F1 – generation Genotype _____
Phenotype _____

You are awarded marks for: P1 generation+ F1 generation✓
Meiosis + fertilization✓

Complete Dominance:

The genotypes will always be represented by ONE letter eg. B, but could include upper case B and lower case b to represent the different combinations for the two alleles.

Possible phenotypes for parents (P1 generation): brown hair and red hair
Possible genotype combinations for parents (P1 generation): BB (homozygous dominant);
Bb (heterozygous dominant)
and bb (homozygous recessive)
eg. B - brown is completely dominant over b - red

Now let's practice :

1. **In dogs rough hair (H) is dominant to smooth hair(h). A heterozygous rough-haired dog is mated with a smooth-haired dog.**

Represent a genetic cross to show the phenotypic ratio of the puppies. (6)

Step 1: Write down the template for a genetic cross
Step 2: Fill in the (a) phenotype and (b) genotype of the P1 generation
Now complete the cross.

P1 – generation Phenotype: heterozygous rough hair x smooth hair
Genotype: x

Meiosis
Possible Gametes ____, ____ x _____, _____

Fertilisation

F1 – generation Genotype:
Phenotype:
***Phenotypic ratio is -** _____ : _____

1.Answer:
P1 – generation Phenotype: heterozygous rough hair x smooth hair
Genotype: Bb x bb

Meiosis
Possible Gametes ___B_, __b__ x __b___, __b___

Fertilisation

	B	b
b	Bb	bb
b	Bb	bb

F1 – generation Genotype: 2Bb; 2bb
Phenotype: 2 rough hair; 2 smooth hair
***Phenotypic ratio is** **2:2**

2. Next example to practice:

In rabbits, **black** fur is produced by the allele **(B)** and *white* fur by the allele *(b).*
The table below shows the genotypes of some rabbits.

Rabbit	Genotype
1	BB
2	Bb
3	bb

Use a genetic cross to show the **percentage chance** of rabbits **1** and **3** having offspring with **white fur**

Step 1: Write down the template for a genetic cross
Step 2: Fill in the (a) phenotype and (b) genotype of the P1 generation
Now complete the cross.

P1 – generation Phenotype: Rabbit 1 - black fur x Rabbit 3 - white fur
Genotype: BB x bb

Meiosis
Possible Gametes _____, _____ x ____, _____

Fertilisation

F1 – generation Genotype:
Phenotype:

% chance of white fur offspring: _____

2.Answer:
P1 – generation Phenotype: Rabbit 1 - black fur x Rabbit 3 - white fur
Genotype: BB x bb

Meiosis
Possible Gametes __B___, ___B__ x __b__, __b___

Fertilisation

	B	B
b	Bb	Bb
b	Bb	Bb

F1 – generation Genotype: 4 Bb
Phenotype: 4 black fur

% chance of white fur offspring: 0%

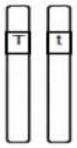
Questions:

1. Curly hair is dominant over straight hair. A woman **homozygous** for curly hair (**CC),** marries a man homozygous for straight hair (**cc)**?

   What is the possibility of them producing a child with straight hair?
   A 25%
   B 50%
   C 100%
   D 0%

2. When an individual that is **homozygous dominant**(**DD)** for a particular characteristic is crossed with an individual that is **homozygous recessive**(**dd)** for the characteristic, all the offspring would be …
   A. Homozygous dominant
   B. Homozygous recessive
   C. Heterozygous
   D. Pure-bred

3. The diagram on the right shows the alleles **for height** in a flowering plant: (T =tall dominant**;** t=short - recessive)



The plant is..

A. Homozygous dominant for height
B. Heterozygous for height
C. Homozygous recessive for height
D. Incompletely dominant for height

4. The allele for black fur **(B)** is dominant over the allele for brown fur **(b).** Which of the following crosses will result in a ratio of 50% homozygous black to 50% heterozygous black?

A Bb X bb
B BB X bb
C BB X Bb
D Bb X Bb

Answers:

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

Terminology questions:

1. An allele that **does not** influence the **phenotype** when found in the heterozygous condition.
2. The **position** of a gene on a chromosome.
3. The **physical** and functional **expression** of a gene.
4. A **section of a DNA** molecule that **codes** for a specific characteristic.
5. Two or more **alternative forms of a gene** at the same locus.
6. A genetic cross involving **ONE** characteristic.
7. The type of inheritance where the **dominant allele** masks the expression of the recessive allele in the heterozygous state.
8. A genetic cross involving only ONE characteristic.

Answer:

1. **Resessive**
2. **Locus**
3. **Phenotype**
4. **Gene**
5. **Allele**
6. **Monohybrid**
7. **Complete**
8. **monohybrid**

EVOLUTION Paper 2 – 54 marks

Evolution is: **change over time** ….
It is the **environment that determines** which **individuals** of the species **will survive** and then reproduce
Evolution: can **lead to the development of a new species** (Speciation)

Biological evolution:
The genetic changes in populations over many generations which lead to development of new species.

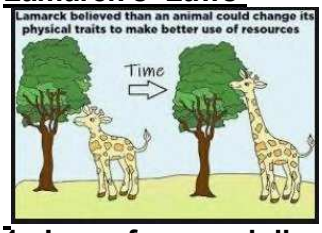
Evolution:
is a process of **change over time** where species/populations survive their changing environment.

NB!! SPECIES:
A group of organisms with the similar characteristics, that can reproduce AND produce fertile offspring.

NB!! POPULATION:
A group of similar organisms with similar characteristics, which **occur in the same area**, can reproduce and produce fertile offspring.

Sources of variation that occur between individuals of the same species:
1. Meiosis
-Crossing over (prophase 1)
-Random arrangement of chromosomes (metaphase 1)
2. Mutations
-Mutations are changes in the DNA of chromosomes
3.**Random fertilisation** ('random' fertilisation of gametes)
4. **Random mating (which males and female mate)**

Lamarck's 'Laws'



1. Law of use and disuse:
-Organs' become modified or adapted according to use, if used more- became bigger, if not used – they become smaller and disappeared

2. Law of inheritance of acquired characteristics:
-modifications brought about by use or disuse were able to be transmitted to offspring
-i.e animals adapted to their environment and passed these characteristics on to next generation

His laws **were REJECTED**: Only genetic characteristics (in your DNA) can be inherited and not something that you acquired in your lifetime.

NB!!! **Darwin's theory of evolution by natural selection:** ***Know this very well!!***

• 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 characteristics that make them **less suited, die.**
• The organisms that **survive, reproduce**
• and **pass on the favourable allele** to their offspring.
• The **next generation will therefore have a higher proportion of individuals with the favourable characteristic.**

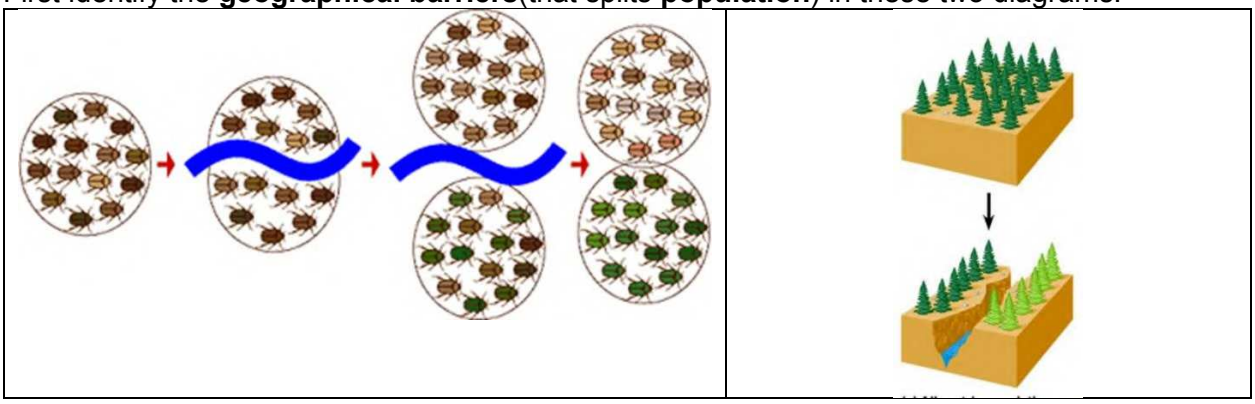
Punctuated Equilibrium: *explains the speed at which evolution takes place*:
Evolution involves **long periods of time where species do not change** or change gradually through natural selection (known as equilibrium).
This **alternates** with (is punctuated by) **short periods of time where rapid changes occur** through natural selection during which new species may form in a short period of time.

ARTIFICIAL SELECTION
For many years, **humans** have been doing breeding experiments to develop organisms with a **selected set of desirable characteristics**

Differences between Natural Selection and Artificial Selection (prepare this for a possible question)

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

DEFINITION OF SPECIATION:
Formation of a new species
First identify the **geographical barriers**(that splits **population**) in these two diagrams.



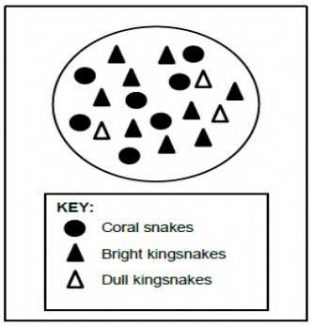
Speciation through geographic isolation: **(Know this very well!!)**

- If a **<u>population</u> of a single species** becomes **separated by a geographical barrie**r (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 condition**s/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**

EVOLUTION: Questions
1 Describe how Darwin explain natural selection by using the <u>giraffe population</u> referring to the length of their necks. (6)

KEYWORDS	**ANSWER**
Variation in population	There is a great deal of **variation** amongst the giraffe population.
Favourable characteristics and some not	Some have long necks and some do not.
Change in environmental conditions	When there is a **change in the environmental conditions** or if there is competition,
Organisms more suited characteristics, survive	then giraffes **with long necks which make them more suited, survive**
Those with unfavourable characteristics, die	whilst giraffes with short necks, which make them **less suited, die.**
Survive, reproduce	The giraffes with long necks **that survive, reproduce**
pass alleles of favourable characteristic	and thus **pass on the favourable <u>allele</u> of long necks** to their offspring
Next generation higher proportion individuals with favourable characteristics	The **next generation will** therefore have a **higher proportion of individuals with long necks.**

2.

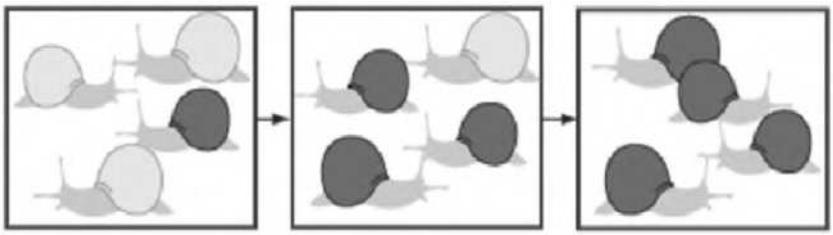
*There are two variations in the colour of **kingsnakes**. Some have a **bright colourful** pattern and others have a **dull** pattern. Kingsnakes are non-poisonous to their predators. * ***Coral snakes*** also have a ***bright colour pattern***, but are poisonous to their predators. This is a defence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

Use Darwin's theory of evolution through natural selection to explain why there are <u>more brightly coloured kingsnakes</u> in this habitat.

KEYWORDS	ANSWER
Variation in population	There is a great deal of **variation** amongst the kingsnake population.
Favourable characteristics and some not	Some have bright coloured patterns and some do not.
Change in environmental conditions	When there is a **change in the environmental conditions** or if there is competition,
Organisms more suited characteristics, survive	then kingsnakes **with bright patterns which make them more suited, survive**
Those with unfavourable characteristics, die	whilst dull kingsnakes, which make them **less suited, die.**
Survive, reproduce	The kingsnakes with bright patterns **that survive, reproduce**
pass alleles of favourable characteristic	and thus **pass on the favourable <u>allele</u> of bright patterns** to their offspring
Next generation higher proportion individuals with favourable characteristics	The **next generation will** therefore have a **higher proportion of kingsnakes with bright patterns.**

3.

The snails in this population show variation of black shells and white shells because of mutations. The characteristics of shell colour allow them to survive better in their environment. Hence, they will reproduce to pass on these favourable characteristics to their offspring. This phenomenon is called natural selection.



1. Who identified this phenomenon first? (1)
2. **State** the **favourable characteristic** for this snail population to survive. (1)
3. Describe TWO different types of mutations that may cause variation in a population. (4)

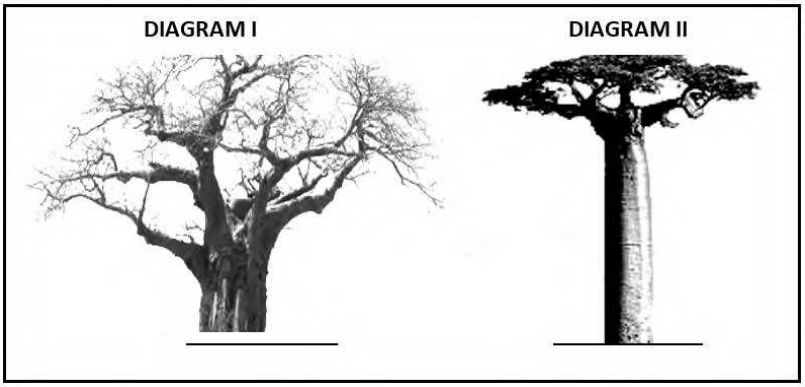
Answer:

1. **Darwin**
2. **Snails with black shells**
3. **<u>Gene mutation</u>**
   Result of a change in the nucleotide sequence in the DNA molecule
   <u>Chromosome mutation</u>
   Results in the number or structure of the chromosome change during meiosis .

4. **Tabulate** THREE differences between **natural** selection and **artificial** selection. (7)

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

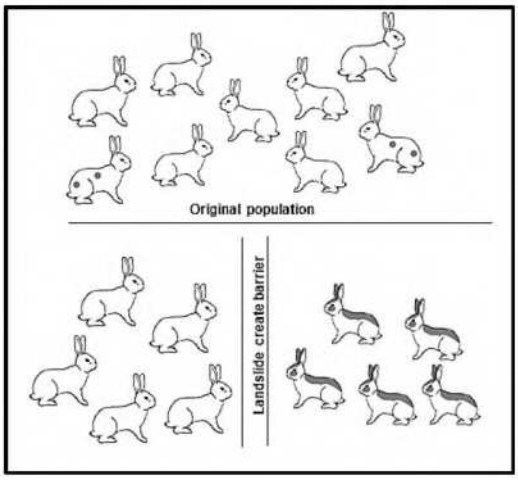
5. Earth originally existed as one large land mass that later drifted apart and formed the continents as we know it today. The following two pictures are those of baobab trees found on the continent of Africa (Diagram I) and found on the continent of Madagascar (Diagram II).



Explain how the two species of baobab trees shown above might have formed. (6)

Answer:

KEYWORDS	ANSWER
population separates by geographical barrier	If a **population** of baobab trees becomes separated by continental drift (a geographical barrier -sea) then the **population splits into two**.
No gene flow	There is now **no gene flow** between the two baobab populations.
different environmental conditions	Since each population may be exposed to **different environmental conditions**/the selection pressure may be different
natural selection occurs independently	**natural selection occurs independently** in each of the two baobab populations
individuals differ	such that the individuals of the **two populations become very different** from each other
Genotypically and phenotypically	**genotypically and phenotypically**.
Should the populations mix	Even if the two baobab populations **were to mix again**
Not interbreed	they will **not be able to interbreed**.
different species have been formed	The **two populations are now different** baobab species in Africa and Madagascar

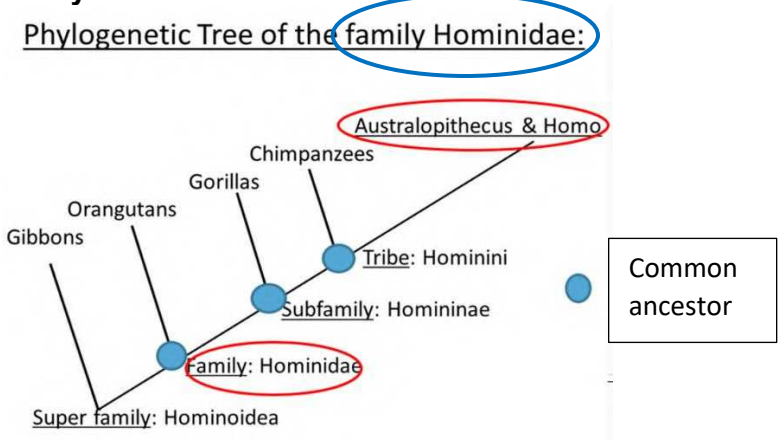
6. The diagrams below show a process of evolution. The diagrams illustrate the events that occurred in the rabbit population over many years. Study them and answer the questions that follow. **Use the diagram to explain how the two new species evolved from the original population. (6)**	

Answer:

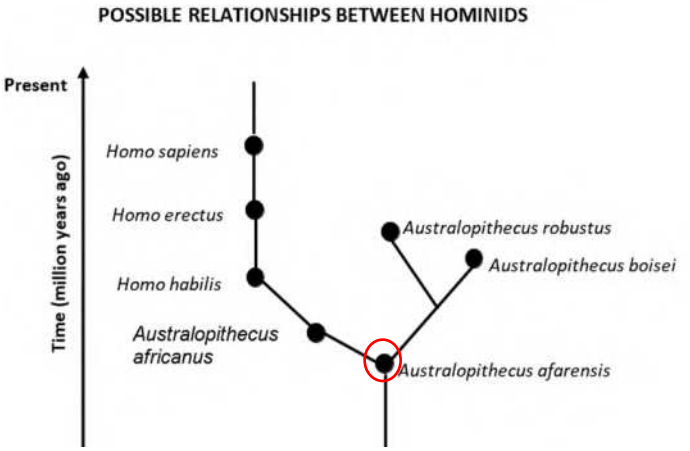
KEYWORDS	**ANSWER**
population separates by geographical barrier	If a **population** of rabbits becomes **separated** by a **geographical barrier** (sea, river, mountain, lake) then the **population splits** into two.
No gene flow	There is now **no gene flow** between the two rabbit populations.
different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

HUMAN EVOLUTION

Phylogenetic tree to show the place of the **family Hominidae.** All hominids belong to this **family.**



A **phylogenetic tree** shows possible relationships between members of the **family Hominidae**.



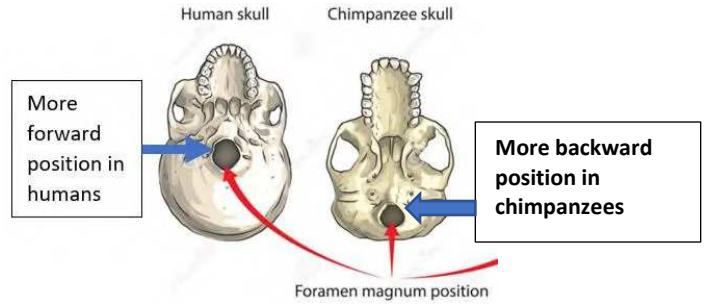
What is the name given to the **type of diagram** below? **Phylogenetic tree**
A typical question:
Name the **common ancestor** in this diagram (*other organisms branch from here*)
Answer: Australopithecus afarensis

Characteristics that humans **share** with African apes:
Large brain
Eyes in front
Freely rotating arms
Long upper arms
Rotation around elbow joints
Bare fingertips, no claws
Opposable thumbs
Upright posture

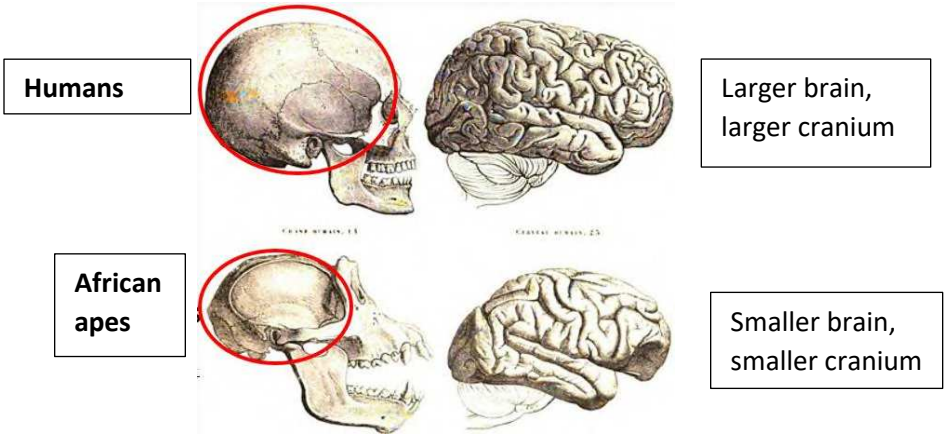
Anatomical **differences** between African apes and human:

Feature	Humans	African apes
Foramen magnum	Foramen magnum in a forward position	Foramen magnum in a backward position
Cranium	Larger cranium size	Smaller cranium size
Spine	More curved/S-shaped	Less curved/C-shaped
Teeth	Smaller teeth/canines	Larger teeth/canines
Jaws	Less protruding jaws/non-prognathous	More protruding jaws/prognathous
Palate shape	Small and semi-circular	Long and rectangular
Cranial ridges	No cranial ridges	Cranial ridges across the top of the cranium
Brow ridges	Brow ridges less pronounced	Brow ridges pronounced

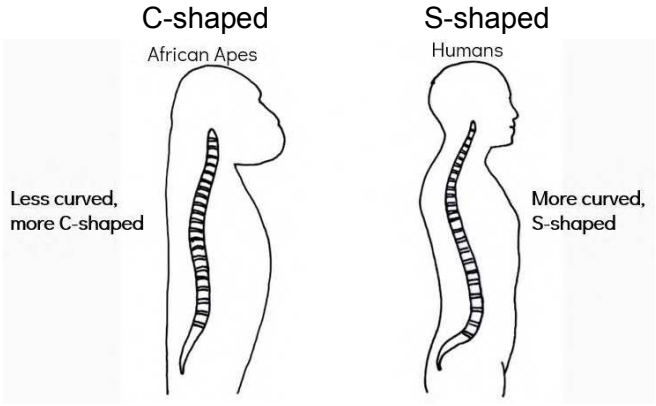
Foramen magnum



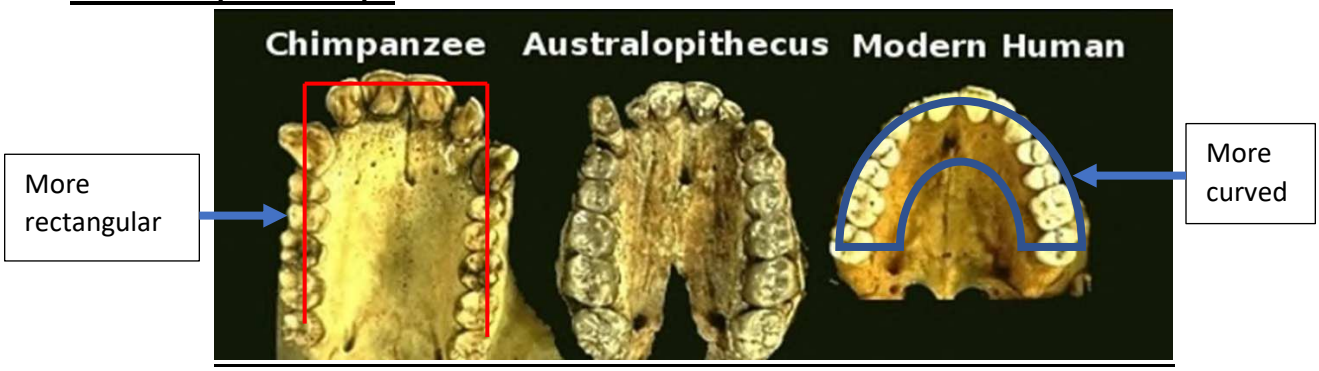
Cranium - the area that the brain fits into



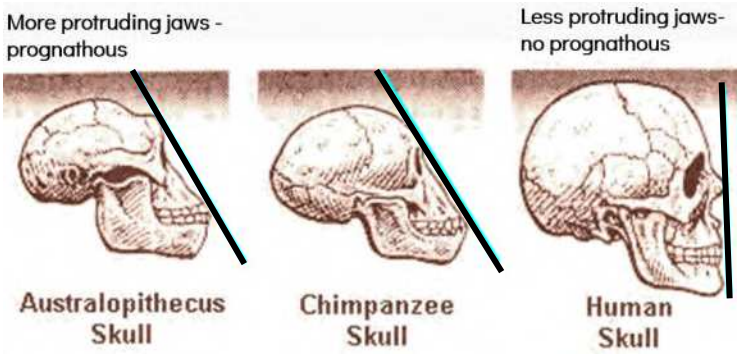
Spine:



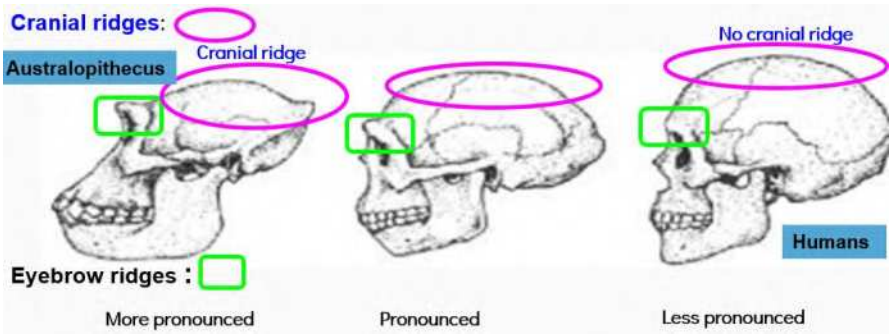
Teeth and palate shape



Jaws

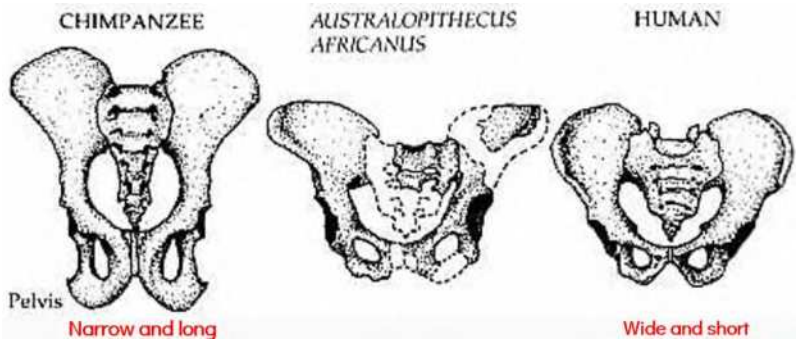


Cranial ridges and eyebrow ridges



Pelvic girdle

Narrow, long **Wide, short**



Fossil evidence show the anatomical differences over time in the following **genera (one genus, many genera):**

Genus: Ardipithecus
Genus: Australopithecus
Genus: Homo

Note: be able to identify the ***Genus*** and the ***Species*** of organisms
Look at these examples to practice identifying the **Genus** and the **Species** *(asked in the exams)*
Give the genus and the species of:

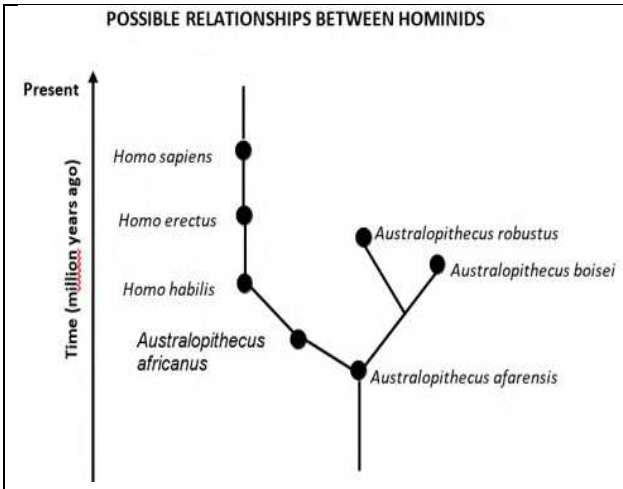
1. **Australopithecus Sediba:** Answer *Genus*- Australopithecus; *Species*- Sediba
2. **Homo Habilis**: Answer *Genus*- Homo; *Species* - Habilis

Out of Africa Hypothesis: Evidence for the 'Out-of-Africa' hypothesis:
Fossil evidence: *(You must know this well. Take note of the bold and underlined facts as these must be stated to get marks.)*

1. Ardipithecus fossils **found in Africa only**
2. Australopithecus fossils **found in Africa only**, including Karabo, Little Foot, Taung Child, Mrs Ples
3. Homo fossils of **Homo habilis found in Africa only**; **oldest** fossils of **Homo erectus** and **Homo sapiens found in Africa**, while the **younger fossils** were **found in other parts** of the world

QUESTIONS Human Evolution:

1. The diagram below shows possible relationships between members of the family ***Hominidae***.



1.1 What is the name given to the type of diagram above? (1)

1.2 How many of each of the following are represented in the diagram?

(a) Genera (1)

(b) Species (1)

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

1.4 Which of the hominids in the diagram above is considered to have been the first to use tools? (1)

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

1.6 *Explain* how the location and the age of *Homo* fossils are used as evidence for the 'Out of Africa' hypothesis. (3)

Answers:

1.1 phylogenetic tree

1.2 (a) 2

(b) 7

1.3 There is a common ancestor of boisei and robustus on the phylogenetic tree that is younger than A.afarensis, therfore boisei and robustus are more closely related

1.4 homo habilis

1.5 Mrs Ples

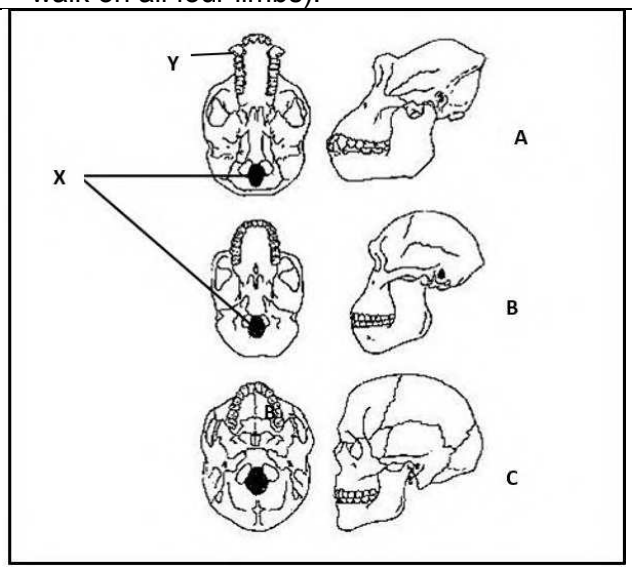
Little foot

Taung kind

Sediba Any 2

1.6 Homo (fossils of **Homo habilis found in Africa <u>only</u>**;
oldest fossils of **Homo erectus** and **Homo sapiens found in Africa**,
while the **younger fossils** were **found in other parts** of the world

2. The diagram below represents the fossilised skulls of three different species of primates. They were either bipedal or quadrupedal (organisms that habitually walk on all four limbs).



2.1 ***Label*** part **X** and the type of teeth at **Y**. (2)

2.2 ***Explain*** the **significance(importance)** of the location of structure **X** in organism **C**. (3)

2.3 Which of the skulls (**A**, **B** or **C**) belongs to:

(a) An *Australopithecine* (1)

(b) A quadrupedal primate (1)

2.4 **Explain** how the change in the skull from B to C could indicate a change in intelligence. (3)

2.5 ***Tabulate*** TWO **observable differences**, other than those mentioned in QUESTIONS 2.2 and 2.4, between skulls **B** and **C** that represent trends in human evolution. (5)

Answer:

2.1 **part X** - foramen magnum
Type of teeth Y - canines

2.2 The foramen magnum (X) is more central in organism C which indicates that organism C bipedal and walks upright

2.3 (a) B
(b) A

2.4 The cranium of C is much larger than B. This indicates that the brain size of C is larger than B for more advanced thought processes, language and intelligence.

2.5

Skull B	**Skull C**
Eye ridges more prominent	Eye ridges less prominent
More prognathous	Less prognathous
Formation of palate is more rectangular	Formation of the palate is more rounded

Q.3 Humans and African apes share many characteristics, yet each is a distinct species.

3.1 ***Name*** FIVE characteristics that humans **share** with African apes. (5)

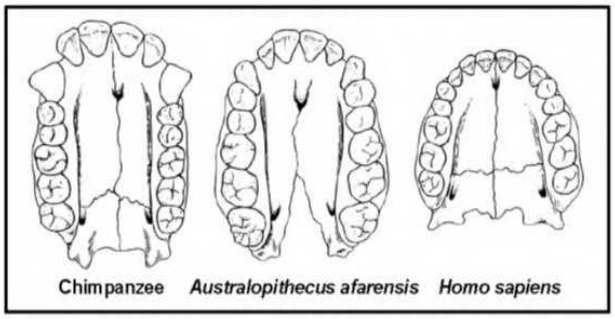
Large brain
Eyes in front
Freely rotating arms
Long upper arms
Rotation around elbow joints
Bare fingertips, no claws
Opposable thumbs
Upright posture

Any 5

3.2 Describe how each of the following structures is different between humans and apes:
(a) Spine (2)
(b) Pelvic girdle (2)

	Humans	**Apes**
Spine	*S-shaped (less curved)*	*C-shaped (more curved)*
Pelvic girdle	*Short and wide*	*Long and narrow*

4. The diagrams below show the upper jaws of some fossils. These diagrams are drawn to scale.



4.1 *Describe* ONE **visible difference** between the jaw of a chimpanzee and that of Homo sapiens which show trends in human evolution.
4.2 Based on the differences in dentition, what **conclusion** can be made about the change in diet from Australopithecus afarensis to Homo sapiens?
4.3 Australopithecus may be described as a **transitional species** between the chimpanzee and Homo sapiens.
(a) Define a transitional species.
(b) Use ONE **visible feature** of the jaw to explain why A. afarensis may be described as a transitional species.

Answer:
4.1

Chimpanzee	**Homo sapiens**
More rectangular	More rounded
Larger jaw	Smaller jaw
Larger spaces between teeth	Small/ no spaces between teeth
Larger canines/teeth	Smaller canines/teeth

4.2
Because the canines Homo sapiens are smaller than the teeth of A.Afarensis, this indicates a diet that is cooked before it is eaten and therefore they do not need large canines.
A.Afarensis's diet still includes raw food which needs to be torn by canines
4.3
(a) Is a fossil that exhibits characteristics of both ancestral and derived forms, characteristics before and after the species on the timeline
(b) The jaw of the chimpanzee is rectangular and the jaw of Homo sapiens is more rounded
A.afarensis's jaw's shape is not as rectangular as the chimp, and not as rounded as Homo, but in between.
The jaw is smaller than the chimp but larger than Homo sapiens
The canines/teeth are smaller than the chimp, but larger than Homo sapiens