

Western Cape Education Department

LIFE SCIENCES

Grade 12 Term 2
2026

Learner Material

TOPIC: GENETICS AND INHERITANCE

PAPER 2: GENETICS AND INHERITANCE (48 Marks)

GENETICS AND INHERITANCE Paper 2: 48 marks	Term 1 & 2	3½ weeks
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CONTENT	ELABORATION
Introduction	❑ Mention of Mendel as the 'father' of genetics
Concepts in inheritance	❑ Chromatin and chromosomes ❑ Genes and alleles ❑ Dominant and recessive alleles ❑ Phenotype and genotype ❑ Homozygous and heterozygous ❑ The Law of Dominance- • When two homozygous organisms with contrasting characteristics are crossed, all the individuals of the F₁ generation will display the dominant trait • An individual that is heterozygous for a particular characteristic will have the dominant trait as the phenotype.

CONTENT	ELABORATION
Monohybrid crosses	❑ Format for representing a genetics cross ❑ Mendel's Principle of Segregation –An organism possesses two 'factors' which separate or segregate so that each gamete contains only one of these 'factors' ❑ Types of dominance: • Complete dominance – one allele is dominant and the other is recessive, such that the effect of the recessive allele is masked by the dominant allele in the heterozygous condition • Incomplete dominance – neither one of the two alleles of a gene is dominant over the other, resulting in an intermediate phenotype in the heterozygous condition • Co-dominance – both alleles of a gene are equally dominant whereby both alleles express themselves in the phenotype in the heterozygous condition ❑ Genetics problems involving each of the three types of dominance ❑ Proportion and ratio of genotypes and phenotypes

GENETICS AND INHERITANCE continue... Paper 2: 48 marks		Term 1 & 2	3½ weeks
CONTENT	ELABORATION		
Sex determination	☐ 22 pairs of chromosomes in humans are autosomes and one pair of chromosomes are sex chromosomes/gonosomes ☐ Males have XY chromosomes and females have XX chromosomes ☐ Differentiate between sex chromosomes (gonosomes) and autosomes in the karyotypes of human males and females ☐ Representation of a genetic cross to show the inheritance of sex		
Sex-linked inheritance	☐ Sex-linked alleles and sex-linked disorders ☐ Genetics problems involving the following sex-linked disorders: • Haemophilia • Colour-blindness		
Blood grouping	☐ Different blood groups are a result of multiple alleles ☐ The alleles I ^A , I ^B and i in different combinations result in four blood groups ☐ Genetics problems involving the inheritance of blood type		
CONTENT	ELABORATION		
Dihybrid crosses	☐ Mendel's Principle of Independent Assortment – The various 'factors' controlling the different characteristics are separate entities, not influencing each other in any way, and sorting themselves out independently during gamete formation. ☐ Dihybrid genetics problems ☐ Determination of the proportion/ratio of genotypes and phenotypes		
Genetic lineages/pedigrees	☐ A genetic lineage/pedigree traces the inheritance of characteristics over many generations ☐ Interpretation of pedigree diagrams		
Mutations	☐ Definition of a mutation ☐ Effects of mutations: harmful mutations, harmless mutations and useful mutations ☐ Mutations contribute to genetic variation ☐ Definition of gene mutation and chromosomal mutation ☐ Two types of mutations that can alter characteristics leading to genetic disorders: Gene Mutations • Haemophilia – absence of blood-clotting factors • Colour-blindness – due to absence of the proteins that comprise either the red or green cones/photoreceptors in the eye Chromosomal mutation • Down syndrome – due to an extra copy of chromosome 21 as a result of non-disjunction during meiosis		
Genetic engineering	☐ Biotechnology is the manipulation of biological processes to satisfy human needs. ☐ Genetic engineering is an aspect of biotechnology and includes: • Stem cell research – sources and uses of stem cells • Genetically modified organisms – brief outline of process (names of enzymes involved are not required) and the benefits of genetic modification • Cloning – brief outline of process and benefits of cloning		
Paternity testing	☐ The use of each of the following in paternity testing: • Blood grouping • DNA profiles		
Genetic links	☐ Mutations in mitochondrial DNA used in tracing female ancestry		

SESSION 1

SECTION A QUESTION 1

- 1.1 Various options are given as possible answers to the following questions.
Choose the answer and write only the letter (A to D) next to the question number.

1.1.1 An individual that has received an identical allele from each parent is described as ...

- A homologous.
- B dominant.
- C homozygous.
- D heterozygous.

1.1.2 The table below shows the results of the F₁ generation after an investigation into the inheritance of eye colour in fruit flies was carried out.

EYE COLOUR	NUMBER OF FLIES
Red	182
White	61

The genotypes of the parents were ...

- A RR x Rr.
- B Rr x rr.
- C Rr x Rr.
- D RR x rr.

1.1.3 When two plants heterozygous for a characteristic are crossed, the expected ratio is:

	Dominant phenotype		Recessive phenotype
A	3	:	1
B	1	:	3
C	1	:	2
D	1	:	1

1.1.4 An organism has the genotype **tt**.
The CORRECT term which describes this organism's genotype is ...

- A heterozygous dominant.
- B heterozygous recessive.
- C homozygous dominant.
- D homozygous recessive.

1.1.5 A genetic cross where both alleles of a gene are equally dominant is an example of ...

- A codominance.
- B a dihybrid cross.
- C incomplete dominance.
- D complete dominance.

(5 x 2) (10)

1.2 Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number.

1.2.1 A genetic cross involving one gene and its alleles

1.2.2 Mendel's principle which states that an organism possesses two factors which separate so that each gamete contains only one of these factors

1.2.3 The position of a gene on a chromosome

1.2.4 The type of inheritance where the dominant allele masks the expression of the recessive allele in the heterozygous condition

1.2.5 The type of inheritance which produces an intermediate phenotype

1.2.6 An individual having two non-identical alleles for a characteristic

1.2.7 The study of heredity and variation in organisms

1.2.8 The type of dominance where both alleles of a gene are expressed in the phenotype in the heterozygous condition

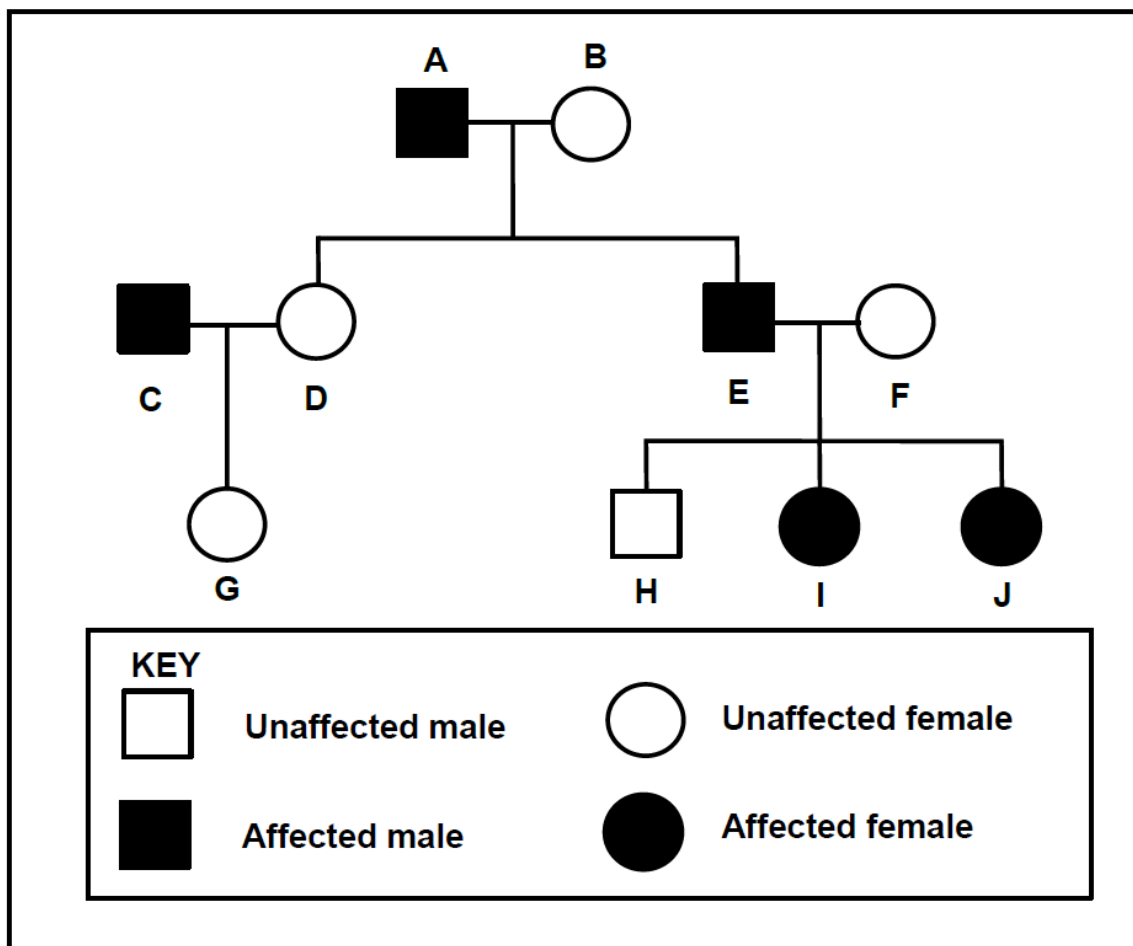
(8 x 1) (8)

1.3 Indicate whether each of the descriptions in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B** or **none**, next to the question number.

COLUMN I	COLUMN II
1.3.1 The scientist who proposed the law of segregation	A: Darwin B: Lamarck
1.3.2 An organism possesses two factors which separate so that each gamete contains only one of these factors	A: Law of dominance B: Principle of independent assortment
1.3.3 All the genes in a species	A: Genome B: Genotype
1.3.4 A plant with white flowers that is crossed with a plant with red flowers and produces offspring with pink flowers	A: Incomplete dominance B: Complete dominance

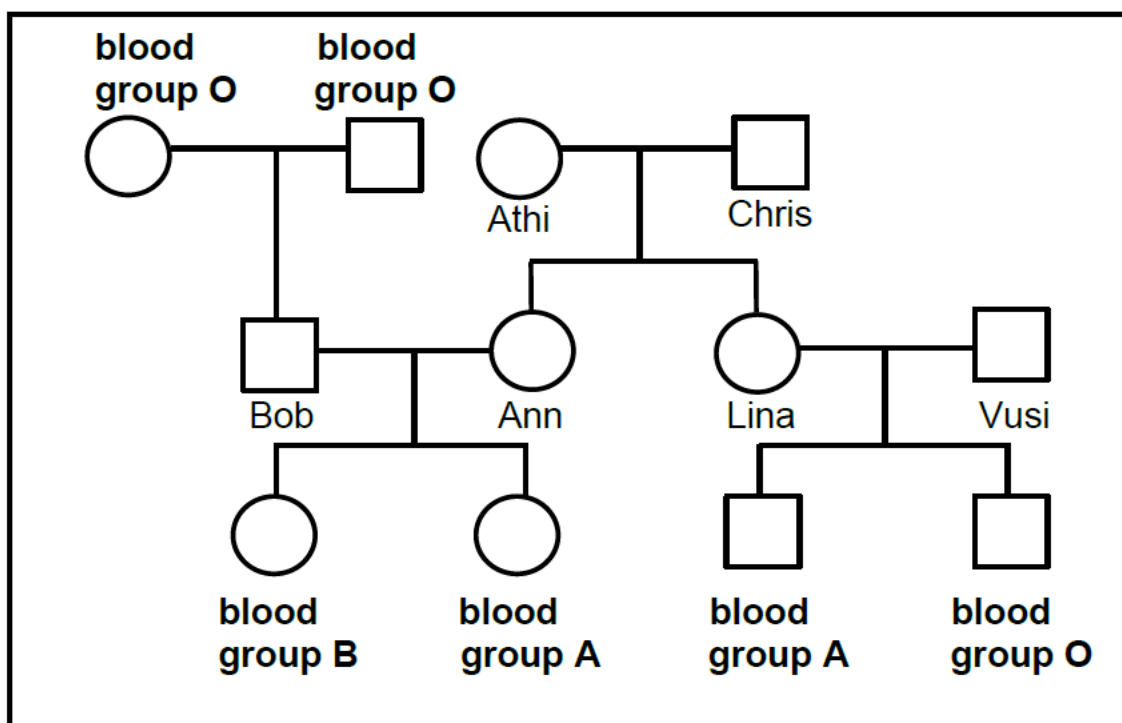
(4 x 2) (8)

- 1.4 Moyamoya is a disorder caused by a dominant allele (R). This disorder damages the arteries supplying blood to the brain. The pedigree diagram below shows the inheritance of Moyamoya in a family.



- 1.4.1 How many generations are represented in the diagram? (1)
- 1.4.2 Give the:
- (a) LETTER(S) of unaffected males (1)
 - (b) Genotype of individual **A** (1)
 - (c) LETTER(S) of individuals not biologically related to **A** and **B** (2)
- (5)**

1.5 The diagram below shows the inheritance of blood groups in a family.



1.5.1 Name the type of diagram shown. (1)

1.5.2 Give the number of alleles that control blood groups. (1)

1.5.3 How many generations are represented in the diagram? (1)

1.5.4 Lina's genotype is $I^A i$.

State ALL the possible genotypes of Vusi. (2)

1.5.5 Give the genotype of Bob. (1)

1.5.6 Give the name of the individual which displays co-dominance. (2)

(8)

SECTION B

QUESTION 2

- 2.1 Polydactyly is a condition that leads to extra fingers or toes. It is caused by a dominant allele.

A man who is heterozygous for polydactyly has a wife who is not polydactyl.

Using the letters **R** and **r**, do a genetic cross to show the percentage chance that their children will have polydactyly. **(6)**

- 2.2 The table below shows the percentage of blood donors for each of the blood groups in South Africa for 2018.

BLOOD GROUP	% DONORS
O	48
A	38
B	10
AB	4

- 2.2.1 According to the data, which is the most common blood group among the donors?? **(1)**

- 2.2.2 Name the type of dominance shown by the inheritance of blood group **A**. **(1)**

- 2.2.3 Explain how it is possible for a man with blood group **A** and a woman with blood group **AB** to have a child with blood group **B**. **(5)**

- 2.2.4 Plot a bar graph to represent the data in the table. **(6)**
(13)

- 2.3 In rabbits, fur colour may be black, white or grey. The inheritance of fur colour is controlled by two alleles namely:

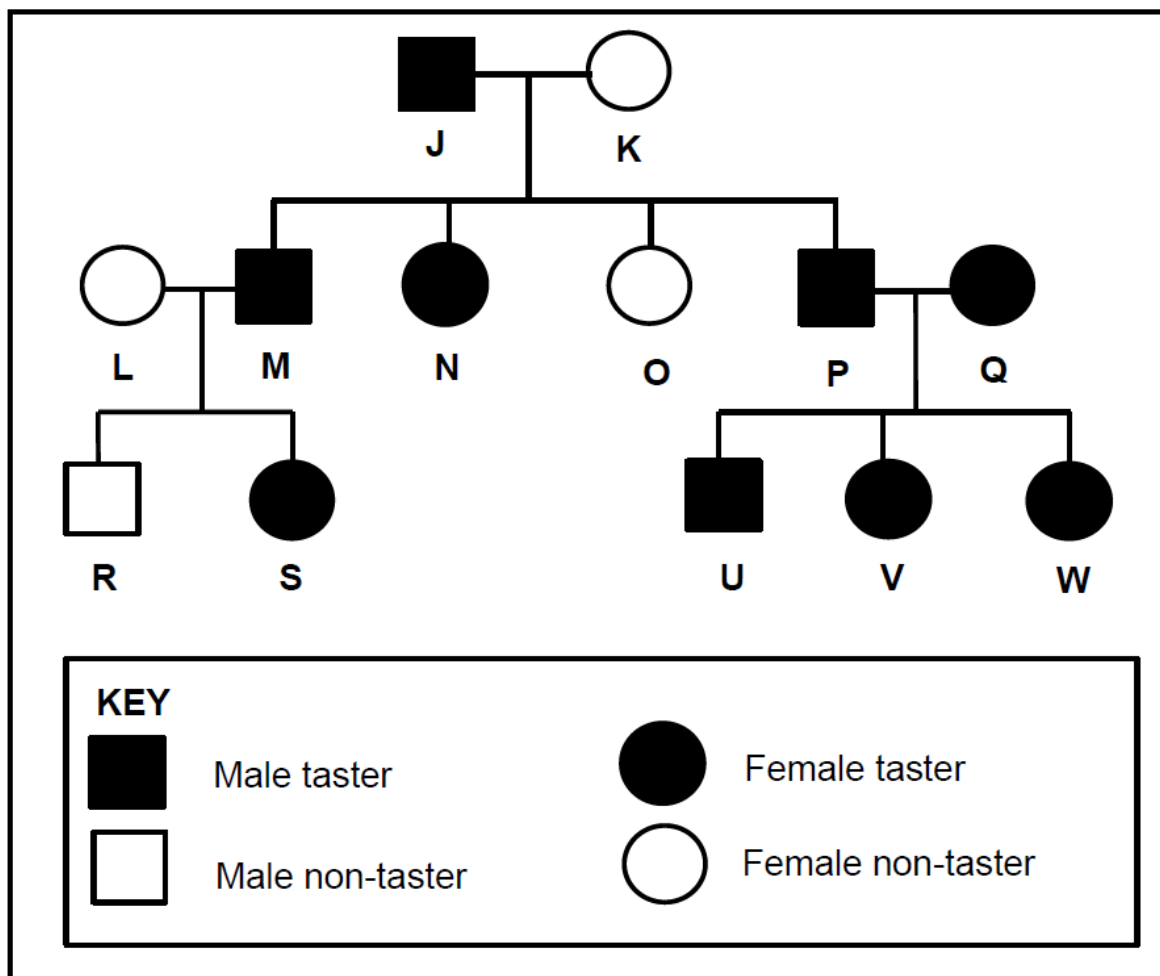
Black fur (**B**) and White fur (**W**)

- 2.3.1 Explain why fur colour in rabbits is an example of inheritance with incomplete dominance. **(2)**

- 2.3.2 Use a genetic cross to show the expected genotypes and phenotypes of the offspring when a grey male mates with a black female. **(6)**
(8)

- 2.4 In humans, the ability to taste a certain substance is inherited and is controlled by the dominant allele **T**. People who are able to taste this substance are called tasters, while those who cannot, are called non-tasters.

The pedigree diagram below shows the inheritance of this trait in a family.



2.4.1 What does the term dominant allele mean? (2)

2.4.2 Give the:

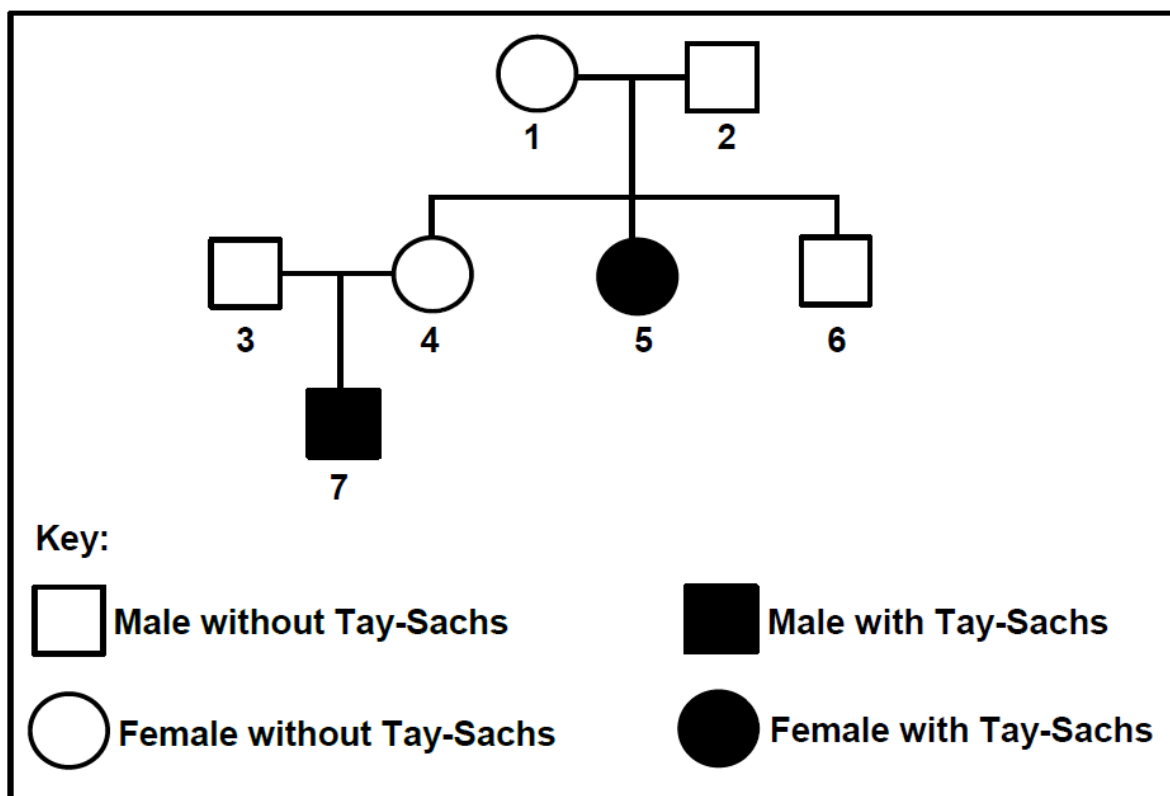
(a) LETTER of a female in the F_1 -generation who is a taster (1)

(b) Genotype of individual **J** (1)

2.4.3 Use evidence from the diagram to support your answer to QUESTION 2.4.2(b). (4)

(8)

- 2.5 The diagram below shows the inheritance of Tay-Sachs, a rare disease which leads to the destruction of neurons. It is inherited as an autosomal disorder, controlled by two alleles, **(T)** and **(t)**.



- 2.5.1 Describe what is meant by an autosomal disorder. (2)
- 2.5.2 How many sons do individuals **1** and **2** have? (1)
- 2.5.3 Using individuals **3**, **4** and **7**, explain why it can be concluded that Tay-Sachs disease is controlled by a recessive allele. (5)
- 2.5.4 Individuals **1** and **2** can produce children with three possible genotypes. List ALL the genotypes that have a 25% chance of being produced. (2)

(10)

- 2.6 Flower colour (purple or white) in a particular plant species is controlled by two alleles, **D** and **d**. Four crosses were carried out to determine which allele is dominant.

Forty (40) offspring were produced in each cross. The phenotypes of the parents and offspring in each cross were recorded.

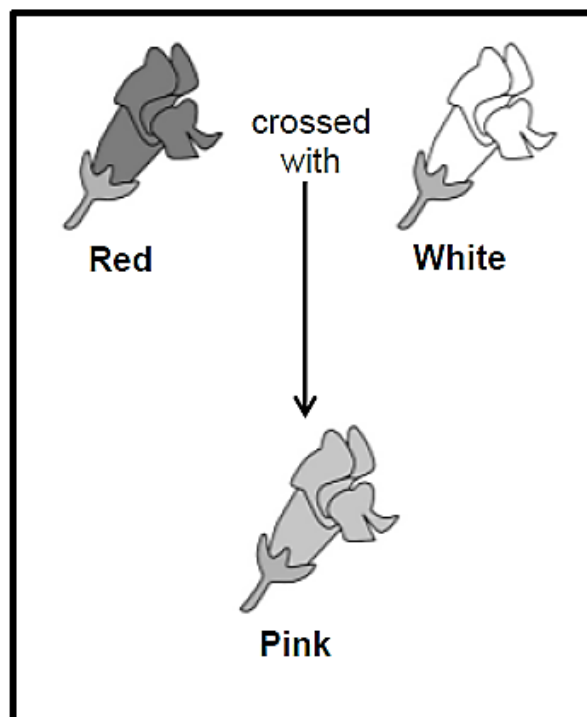
The results are shown in the table below.

CROSS	PHENOTYPE		
	PARENT 1	PARENT 2	OFFSPRING
1	purple	white	40 purple
2	purple	purple	31 purple, 9 white
3	white	white	40 white
4	purple	white	21 purple, 19 white

- 2.6.1 State the dominant flower colour. (1)
- 2.6.2 Use cross **1** to explain your answer to QUESTION 2.6.1. (2)
- 2.6.3 State Mendel's Law of Segregation. (3)
- 2.6.4 Use a genetic cross to show how the crossing of two purple flowering plants can produce white offspring, as in cross **2**. (6)
- (12)**

2.7 The diagram below shows the inheritance of flower colour in snapdragon plants.

The two alleles controlling flower colour are red (**R**) and white (**W**).



2.7.1 State the type of dominance shown by the snapdragon plants. (1)

2.7.2 Give a reason for your answer to QUESTION 2.7.1. (2)

2.7.3 A gardener crossed two pink-flowered snapdragon plants.
Use a genetic cross to show the ratio of the expected phenotypes in the offspring. (6)
(9)

SESSION 2 AND SESSION 3

SECTION A QUESTION 1

- 1.1 Various options are given as possible answers to the following questions.
Choose the answer and write only the letter (A to D) next to the question number.

- 1.1.1 A plant with yellow (**y**) and round (**R**) peas is crossed with a plant with green (**Y**) and wrinkled (**r**) peas.

Which ONE of the following are the possible genotypes of the parents (P1)?

- A yyRR x YYRr
- B YyRR x yyrr
- C Yyrr x YYRR
- D yyRR x YYrr

- 1.1.2 An individual is heterozygous for a harmful recessive allele but is unaffected by it.

Which ONE of the following best represents the genetic composition of this individual?

- A Two dominant normal alleles
- B One harmful recessive allele and one harmful dominant allele
- C One harmful recessive allele and one normal dominant allele
- D One harmful dominant allele and one normal recessive allele

- 1.1.3 The statements below describe the steps in the process of cloning an animal.

- (i) The embryo is implanted into the uterus of an adult female for development.
- (ii) The nucleus from a somatic cell of the donor is extracted.
- (iii) The nucleus from the somatic cell is inserted into the ovum.
- (iv) The nucleus from the ovum of another individual is removed.
- (v) The ovum with the new nucleus is given an electric shock to stimulate cell division and the formation of the embryo.

- A (ii) → (iv) → (iii) → (v) → (i)
- B (ii) → (iii) → (iv) → (v) → (i)
- C (i) → (ii) → (iii) → (iv) → (v)
- D (ii) → (iv) → (v) → (iii) → (i)

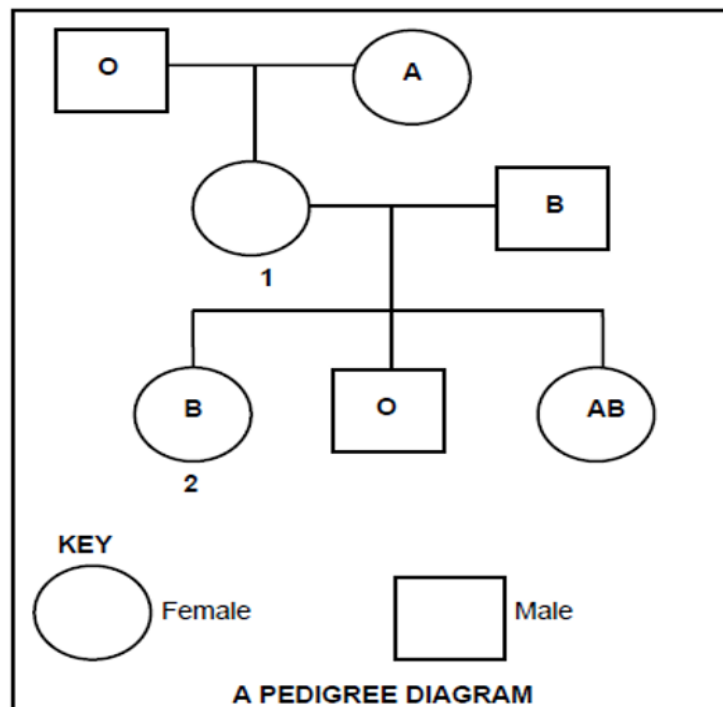
- 1.1.4 A pedigree diagram shows ...

- A how organisms evolve.
- B the inheritance of characteristics over many generations.
- C sex-linked characteristics only.
- D the number of children in a family only.

1.1.5 How many sex chromosomes does a normal human female inherit from her mother?

- A 1
- B 2
- C 23
- D 46

QUESTIONS 1.1.6 and 1.1.7 are based on the pedigree diagram below. The pedigree diagram shows the inheritance of blood groups in a family. The blood groups of the individuals are represented by the letters.



1.1.6 Which ONE of the following represents the genotype and phenotype of individual number **1** above?

- A ii and blood group O
- B $I^A i$ and blood group A
- C $I^A i$ and blood group O
- D $I^B i$ and blood group B

1.1.7 If individual **2** has a child with blood group AB, then her partner could have blood group A or...

- A A
- B B
- C O
- D AB

1.1.8 Four different phenotypes are possible in the F₁-generation if the parents' blood groups are ...

- A B and B.
- B A and B.
- C O and AB.
- D AB and AB.

(8 x 2) **(16)**

1.2 Give the correct **biological term** for each of the following descriptions.
Write only the term next to the question number.

- 1.2.1 The manipulation of an organism's genes to obtain a desired characteristic
- 1.2.2 Undifferentiated cells that may form any other cell in the human body
- 1.2.3 A genetic disorder where blood does not clot
- 1.2.4 A genetic disorder that results in a person who cannot distinguish between the colours red and green
- 1.2.5 The biotechnological process that produces genetically identical organisms
- 1.2.6 The use of living organisms and their biological processes to improve the quality of human life
- 1.2.7 The type of inheritance which produces an intermediate phenotype
- 1.2.8 A breeding process used for the domestication of animals

(8)

1.3 Indicate whether each of the descriptions in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B** or **none**, next to the question number.

COLUMN I	COLUMN II
1.3.1 The manipulation of biological processes to satisfy human needs	A: Biogeography B: Biotechnology
1.3.2 The type of dominance in which neither of the two alleles is dominant over each other, resulting in an offspring with an intermediate phenotype	A: Complete dominance B: Co-dominance
1.3.3 An organism possesses two factors which separate so that each gamete contains only one of these factors	A: Law of dominance B: Principle of independent assortment
1.3.4 Humans select the characteristics when breeding organisms	A: Artificial selection B: Natural selection
1.3.5 Type of inheritance where both alleles are expressed equally in the phenotype	A: Co-dominance B: Complete dominance

(5 x 2) **(10)**

- 1.4 In rabbits, brown fur (**B**) is dominant to white fur (**b**) and long ears (**E**) is dominant to short ears (**e**).

A rabbit, that is heterozygous for both characteristics, is crossed with a white rabbit with short ears.

1.4.1 Name the type of cross represented. (1)

1.4.2 Give the:

(a) Phenotype of a rabbit that is dominant for both characteristics. (2)

(b) Genotype of the white rabbit with short ears (2)

(c) Genotype of the gametes of a heterozygous brown rabbit with short ears (2)
(7)

- 1.5 Coat colour in mice is controlled by two alleles, black (**B**) and grey (**b**). Tail length is controlled by two alleles, long (**T**) and short (**t**).

The Punnett square below shows a part of the cross between two mice. Genotype (**i**) has been left out.

		Parent 1			
					
Parent 2	Gametes	BT	Bt	bT	bt
	Bt	BBTt	BBtt	BbTt	Bbtt
	Bt	BBTt	BBtt	BbTt	Bbtt
	Bt	BBTt	BBtt	(i)	Bbtt
	Bt	BBTt	BBtt	BbTt	Bbtt

1.5.1 Give The:

(a) Genotype of parent 1 (2)

(b) Phenotype of parent 2 (2)

(c) Genotype of offspring (**i**) (1)

1.5.2 What percentage of the offspring above is grey with short tails? (1)

1.5.3 State the genotypes of TWO gametes from the table above that will result in offspring that are heterozygous for both traits, if fertilisation occurs. (2)
(8)

SECTION B

QUESTION 2

- 2.1 Learners conducted an investigation to determine which blood group was the most common in their community.

They collected information about the blood groups of 200 blood donors in each of the three blood donor clinics in their community. They did not include first-time donors in the investigation.

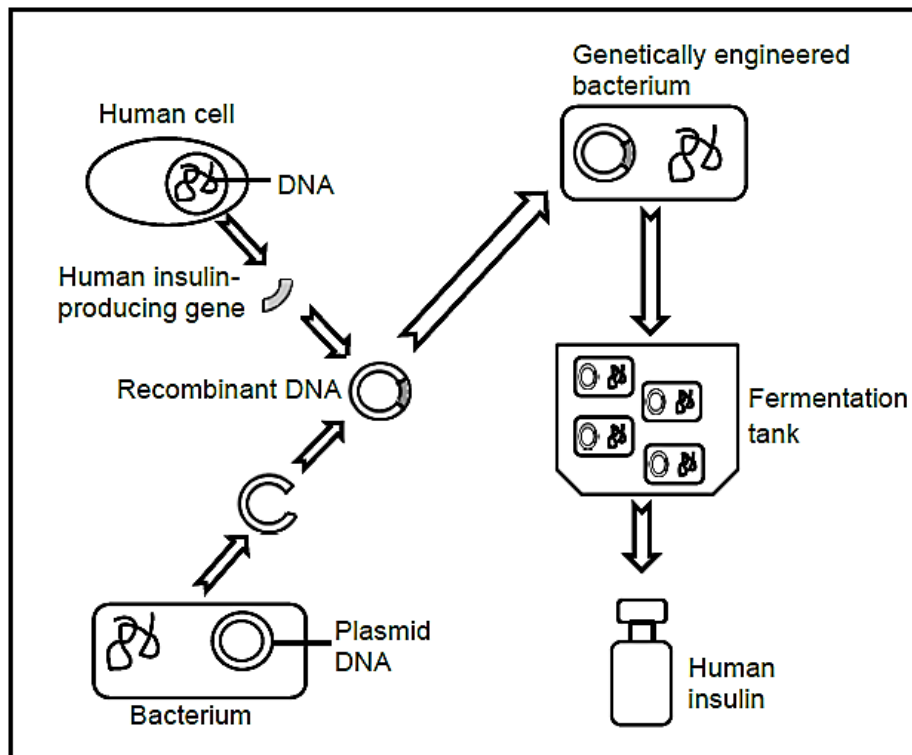
The table below shows the results of the investigation.

BLOOD GROUP	PERCENTAGE OF EACH BLOOD GROUP IN THE SAMPLE
O	55
A	25
B	15
AB	5

- 2.1.1 State the aim of the investigation. (2)
- 2.1.2 Answer the following questions:
- (a) State THREE planning steps to consider when conducting this investigation. (3)
- (b) State ONE way in which the learners ensured the reliability of the results. (1)
- (c) Give ONE reason why they did not include first-time donors. (1)
- 2.1.3 Calculate the number of participants that had blood group **B**. Show ALL workings. (3)
- 2.1.4 Name the blood group which:
- (a) Has only recessive alleles in the genotype (1)
- (b) Is a result of co-dominance (1)
- 2.1.5 Give ALL the possible genotypes of the blood group represented by 25% of the donors. (2)
- 2.1.6 Draw a bar-graph to represent the results of this experiment. (6)
- (20)**

- 2.2 Synthetic insulin is used to treat diabetes and is produced by genetic engineering technology.

The diagram below represents the process.



- 2.2.1 Define *genetic engineering*. (2)

- 2.2.2 Describe the steps involved in producing the recombinant DNA. (4)

- 2.2.3 Explain why bacteria are most suitable for genetic engineering. (2)

- 2.2.4 Suggest THREE objections that some people might have to genetic engineering. (3)

(11)

2.3

- 2.3.1 In humans, haemophilia is caused by a recessive allele on the X-chromosome (x^h).

A woman, who is heterozygous for haemophilia, marries a man with haemophilia.

Use a genetic cross to show the percentage chance of the couple having a daughter who is homozygous for normal blood clotting.

(7)

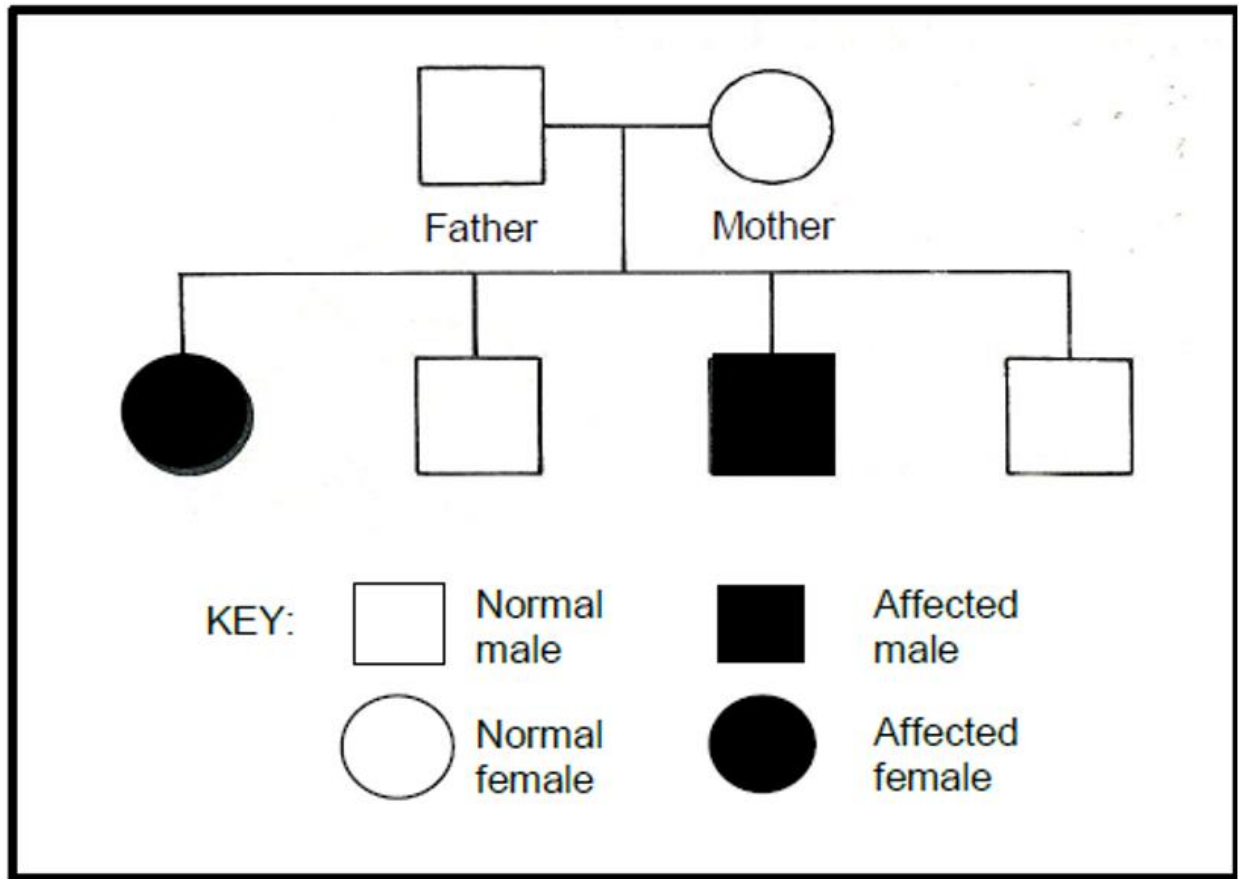
- 2.3.2 Lindiwe has two sons and she is now pregnant for the third time.

Use a genetic cross to show the percentage chance that this child could be a boy.

(6)

(13)

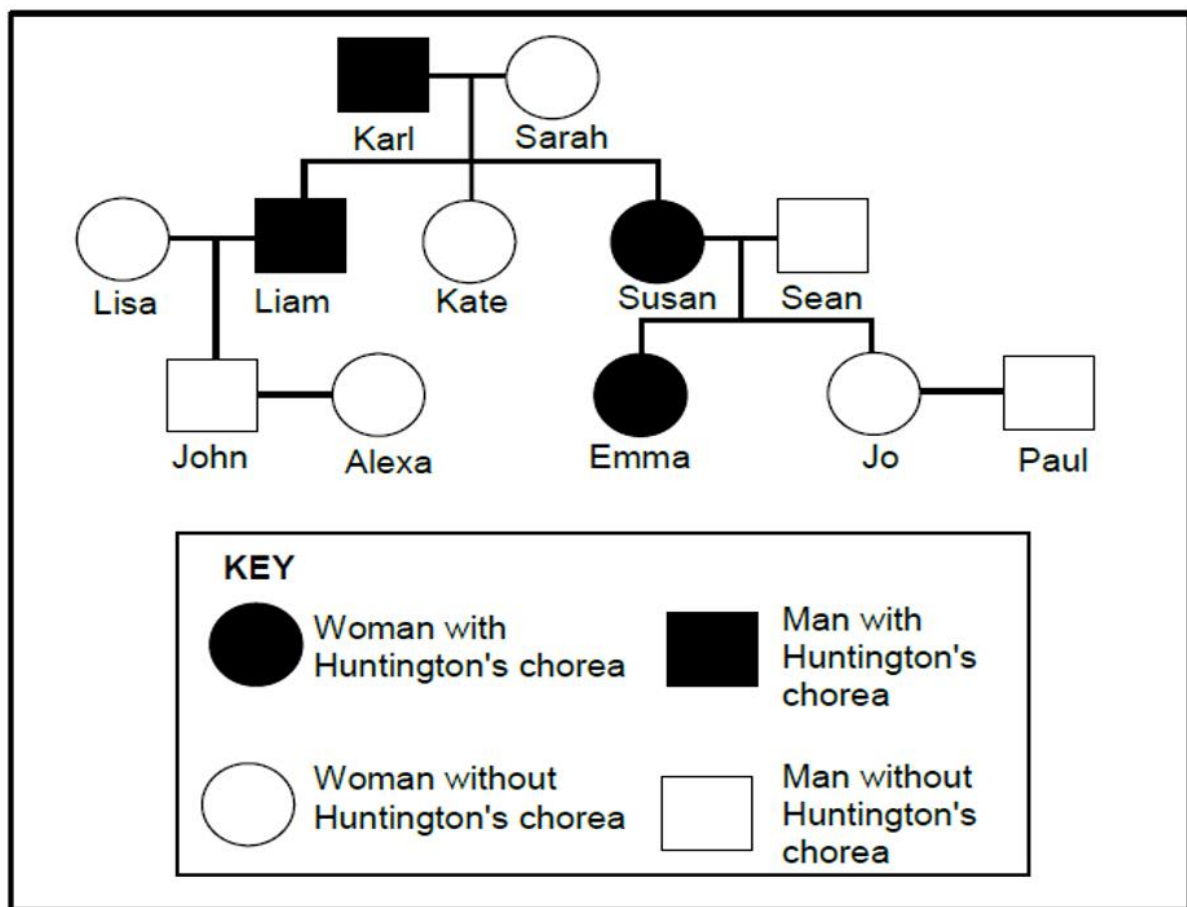
- 2.4 The pedigree diagram below shows the pattern of inheritance of a certain genetic disorder controlled by a recessive allele. The dominant allele is represented by **N** and the recessive allele by **n**.



- 2.4.1 Explain why both parents must be heterozygous for this characteristic. (2)
- 2.4.2 Give the possible genotype(s) of the normal children. (2)
- 2.4.3 Provide evidence from the pedigree diagram to show that this characteristic is not sex-linked. (2)
- (6)

- 2.5 Huntington's chorea is a disease caused by a gene mutation that results in the degeneration of brain tissue. It is caused by a dominant allele (**H**).

The pedigree diagram below shows the inheritance of this disorder in a family.



- 2.5.1 What is:
- (a) Susan's phenotype (1)
- (b) Sarah's genotype (1)
- 2.5.2 Emma plans to have a baby. What must the father's genotype be so that there is a 50% chance that their child will not have Huntington's chorea (1)
- 2.5.3 Explain your answer to QUESTION 2.5.2. (3)
- (6)**

2.6 Read the extract below.

When a child is born, the umbilical cord is cut and stem cells can be obtained from it. Many people think that the stem cells for treating human conditions should be obtained from umbilical cords, rather than from human embryos.

Recently, stem cells have also been obtained from bone marrow. These stem cells are used to treat conditions such as heart disease and spinal injuries.

- 2.6.1 Name THREE sources of stem cells mentioned in the extract. (3)
- 2.6.2 Explain why the characteristics of stem cells make them useful for treating some disorders. (2)
- 2.6.3 Name ONE condition in the extract that can be treated with stem cells. (1)
- 2.6.4 Explain why some people prefer the use of umbilical cords as a source of stem cells rather than the use of embryos. (2)

(8)

- 2.7 In holly trees, red fruit (**R**) is dominant over white fruit (**r**) and spiny leaves (**L**) are dominant over smooth leaves (**l**).

The Punnett square below shows the possible results of a cross between two individual plants. The genotype at **X** is not given.

GAMETES	RL	RI	rL	rl
RL	X	RRLI	RrLL	RrLI
RI	RRLI	RRII	RrLI	RrII
rL	RrLL	RrLI	rrLL	rrLI
rl	RrLI	RrII	rrLI	rrII

- 2.7.1 Give the:
- (a) Genotype of **X** (1)
- (b) Phenotype of the parents (2)
- 2.7.2 In a population of 128 plants, how many plants with red fruit and smooth leaves are expected from the Punnett square above?
Show ALL working. (3)
- 2.7.3 A farmer wanted to produce plants with only white fruit and spiny leaves. Give the genotype of the plants that he should use in the cross. (2)

(8)

2.8 Some horses have straight hair and others have curly hair. A scientist wanted to clone a straight-haired male horse to meet the demand for horses with straight hair.

The scientist used the following procedure:

- The nucleus of a somatic cell was taken from a straight-haired male horse (horse **S**).
- An unfertilised ovum was removed from a curly-haired female horse (horse **T**).
- The nucleus from the somatic cell of horse **S** was placed into the ovum taken from horse **T**.
- This ovum was then placed into the uterus of a female surrogate horse (horse **R**).

2.8.1 Explain why a somatic cell and NOT a sperm cell from horse **S** would provide the nucleus for the procedure. (3)

2.8.2 Before inserting the nucleus from the somatic cell of horse **S**, the nucleus from the ovum of horse **T** was removed.
Explain the significance of this procedure. (2)

2.8.3 To which of the three horses (**S**, **T** or **R**) will the cloned offspring be genetically identical? (1)

2.8.4 State TWO benefits of cloning. (2)
(8)