

Genetics

Mark Scheme



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1. Genetics is the study of how characteristics are passed from parents to their offspring through genes. Below are **four** multiple choice questions. Circle the letter of the correct answer for each.

- a) Albinism is an inherited condition in which pigment does not develop in the skin, hair and eyes. The allele for albinism is **recessive**. What are the chances of albino parents having an albino child?

C – is the only correct answer.	1 mark
	Total: 1 mark

- b) Identify the term that is given to the observable features of an organism?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) In fruit flies, the allele for grey body, **G**, is dominant over the allele for black body, **g**. The result of a mating between two flies is shown in the figure below.

Parent fruit flies: grey bodied male × black bodied female

Offspring produced: 95 grey bodied flies + 88 black bodied flies

What were the genotypes of the parents?

C – is the only correct answer.	1 mark
	Total: 1 mark

- d) The figure below shows a maize cob with purple and yellow fruits (corns). The allele for purple colour (**P**) is dominant to the allele for yellow colour (**p**).

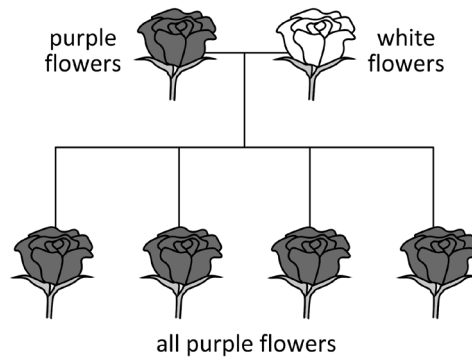
Determine the genotypes of both of the parents of the maize plant.

B – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

2. A botanist bred some pea plants that consistently produced purple flowers with some others that consistently produced white flowers.

All of the offspring from this cross had purple flowers, as shown in the figure below.



- a) Which allele was dominant and which was recessive and give a reason for your answer.

Dominant: Purple.	1 mark
Recessive: White.	1 mark
Reason: A cross between a purple and a white parent produces all purple offspring / the white characteristic disappears in the first generation.	1 mark
Accept 'the offspring are heterozygous but show the purple phenotype'.	
Total: 3 marks	

- b) The botanist used two of the offspring from the first cross in second cross.
The pea plants that were obtained from this second cross produced purple flowers and white flowers in a ratio of 3 : 1.

Calculate the number of pea plants with purple flowers that we would expect from this ratio if the number of pea plants produced from the second cross is 540.

Total parts in ratio = $3 + 1 = 4$	1 mark
$(540 \div 4) \times 3 = 405$	1 mark
Total: 2 marks	

- c) What percentage of the 540 pea plants are expected to have white flowers?

Ratio for white flowers is 1 part out of 4 $(1 \div 4) \times 100$	1 mark
= 25%	1 mark
Total: 2 marks	

(Total for Question 2 is 7 marks)

3. This question deals with inheritance of blood groups.

Two siblings are dealing with a situation involving organ transplant.

One sibling, with blood group AB, has total kidney failure and is being treated using dialysis.

The healthy sibling has agreed to donate one of their kidneys to their unwell sibling.

Before the transplant operation both siblings need to have a blood test to determine their blood groups.

The father of the siblings has blood group A and their mother has blood group B.

The siblings have another sibling, a sister who has blood group O.

- a) Explain how this girl has blood group O when both of her parents have different blood groups. You must use the space below for a punnet square diagram to help your answer.

Use the symbols I^A , I^B and I^O to represent the alleles involved in the inheritance of blood groups.

Parental phenotype	Blood group A		Blood group B
Parental genotype	$I^A I^O$	×	$I^B I^O$
Gametes	I^A I^O	×	I^B I^O
Sisters genotype	$I^O I^O$		
Sisters phenotype	Blood group O		

Award 1 mark for the correct parental genotypes.	1 mark
Award 1 mark for the correct gametes.	1 mark
Award 1 mark for the correct sisters genotype.	1 mark
Award 1 mark for the correct sisters phenotype.	1 mark
	Total: 4 marks

- b) State the three different **genotypes** that could have been produced from the cross of these two parents.

Any three from:	
$I^A I^B$ $I^A I^O$ $I^B I^O$ $I^O I^O$	
	Total: 3 marks

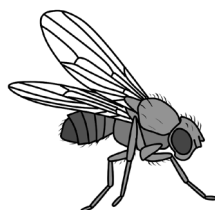
- c) Identify which genotype shows **codominance** and explain what is meant by this term.

Genotype: $I^A I^B$	1 mark
Explanation: Both alleles are expressed (in the phenotype).	1 mark
Accept 'neither allele is recessive' or 'both characteristics are shown'.	
	Total: 2 marks

(Total for Question 3 is 9 marks)

4. A scientist is investigating the inheritance of eye colour in fruit flies (*Drosophila*).
In fruit flies, red eyes (R) are dominant to brown eyes (r).

The figure shows a species of *Drosophila* fruit fly.



- a) Define the term allele.

A different / alternative form of a gene	1 mark
That codes for a different version of a characteristic.	1 mark
	Total: 2 marks

- b) Explain the difference between a homozygous genotype and a heterozygous genotype.

A homozygous genotype has two identical alleles for a particular gene / characteristic (e.g., RR or rr).	1 mark
A heterozygous genotype has two different alleles for a particular gene / characteristic (e.g., Rr).	1 mark
	Total: 2 marks

The scientist performs a cross between a heterozygous red-eyed fruit fly and a brown-eyed fruit fly.

- c) Complete the genetic diagram below for this cross.

Parental phenotype	Red eye		Brown eye
Parental genotype	Rr	×	rr
Gametes	R r	×	r r
Possible genotypes	Rr and rr		
Possible phenotypes	Red eyes and Brown eyes		

Award 1 mark for the correct parental genotypes.	1 mark
Award 1 mark for the correct gametes.	1 mark
Award 1 mark for the correct possible genotypes.	1 mark
Award 1 mark for the correct possible phenotypes.	1 mark
	Total: 4 marks

- d) From this cross, what is the probability of an offspring having brown eyes?

0.5 / 1/2 / 50% / 1 in 2	1 mark
	Total: 1 mark

In a different investigation, the scientist crosses two heterozygous red-eyed fruit flies. They expect a phenotypic ratio of 3 red eyed : 1 brown eyed offspring.

The scientist collects the offspring from this cross and counts them. The results are shown in the table below.

Phenotype	Number of offspring
Red eyes	156
Brown eyes	44
Total	200

- e) Calculate the expected number of brown-eyed offspring from a total of 200 offspring if the ratio was exactly 3 : 1. Show your working.

Total parts in ratio = $3 + 1 = 4$ $200 \div 4$	1 mark
Answer = 50	1 mark
	Total: 2 marks

- f) The observed number of brown-eyed offspring is slightly different from the expected number calculated in (e).

Suggest **one** reason, other than experimental error, why observed ratios in genetic crosses may differ from expected ratios.

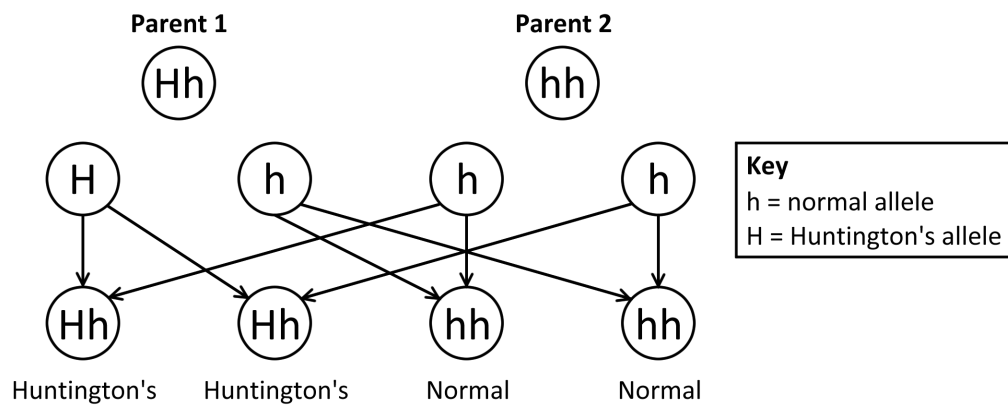
Fertilisation is a random process / due to chance.	1 mark
Reject 'experimental error' / 'miscounting' / 'some flies died' as this is excluded by the question.	
Accept 'sample size was too small'.	
	Total: 1 mark

- g) Eye colour in fruit flies is determined by genes. Outline the process by which a gene codes for a specific protein, such as an enzyme involved in producing eye pigment.

Any three from the following:	
The sequence of bases in the gene codes for a sequence of amino acids.	1 mark
A copy of the gene (mRNA) is made in the nucleus.	1 mark
This copy (mRNA) moves to a ribosome in the cytoplasm.	1 mark
The ribosome assembles the amino acids in the correct order to make the specific protein / enzyme.	1 mark
	Total: 3 marks

(Total for Question 4 is 15 marks)

5. Huntington's disease is a genetic disorder. The genetic diagram shows the inheritance of this disorder.



- a. Complete the Punnett square to show the potential offspring of two parents heterozygous for Huntington's disease.

		H	h		
	H	HH	Hh		
	h	Hh	hh		
Correct parental gametes on axes: H and h					1 mark
All four offspring genotypes correctly filled in: HH , Hh , Hh , hh					2 marks
					Total: 3 marks

- b) State the probability that a child of two parents, heterozygous for Huntington's disease, will have the disease.

0.75 / $\frac{3}{4}$ / 75%	1 mark
	Total: 1 mark

- c) Explain why, if both sets of parents are heterozygous, the chance of inheriting Huntington's disease is greater than the chance of inheriting cystic fibrosis.

An explanation to include:	
Huntington's is caused by a dominant allele, whereas cystic fibrosis is caused by a recessive allele.	1 mark
Therefore only one copy of the allele is needed for Huntington's, but two copies are needed for cystic fibrosis.	1 mark
Accept reference to genotypes (e.g., Hh has Huntington's but ff does not have cystic fibrosis).	
Accept reference to probabilities ($\frac{3}{4}$ chance for Huntington's vs $\frac{1}{4}$ for cystic fibrosis).	
	Total: 2 marks

(Total for Question 5 is 6 marks)

6. Sickle cell anaemia is a genetic disorder that primarily affects haemoglobin, the protein in red blood cells responsible for carrying oxygen. The faulty haemoglobin causes red blood cells to become stiff, sticky, and take on a crescent or "sickle" shape, especially when oxygen levels are low.

The gene for making haemoglobin exists in two alternative forms:

H^A codes for the normal form of haemoglobin.

H^S codes for the abnormal form of haemoglobin.

- a) State the name for the alternative forms of a gene.

Allele	1 mark
	Total: 1 mark

A child has sickle cell anaemia. The parents do not have this disorder.

- b) Complete the genetic diagram below to show how the child could have inherited sickle cell anaemia. Provide an explanation with your answer.

Parental phenotype	Normal / Unaffected		Normal / Unaffected
Parental genotype	$H^A H^S$	×	$H^A H^S$
Gametes	H^A H^S	×	H^A H^S

	H^A	H^S
H^A	$H^A H^A$	$H^A H^S$
H^S	$H^A H^S$	$H^S H^S$

Award 1 mark for the correct parental phenotypes. Award 1 mark for the correct parental genotypes. Award 1 mark for the correct gametes.	
Punnet square: Award 1 mark for the correct gametes. Award 1 mark for the correct genotypes of offspring.	
	Total: 5 marks

- c) From this cross, what is the probability of an offspring having sickle cell anaemia?

0.25 / $\frac{1}{4}$ / 25%	1 mark
	Total: 1 mark

(Total for Question 6 is 7 marks)

7. Gregor Mendel is often called the 'father of modern genetics' due to his groundbreaking work on inheritance.

a) Mendel concluded that 'factors' (now known as genes) are responsible for inherited characteristics and that these factors can be dominant or recessive.

i. Explain what is meant by a **dominant allele**?

An allele that is <u>always expressed</u> (in the phenotype) / even if only one copy is present.	1 mark
	Total: 1 mark

ii. Explain what is meant by a **recessive allele**?

An allele that is <u>only expressed</u> (in the phenotype) <u>if two copies are present</u> / if there is no dominant allele.	1 mark
	Total: 1 mark

b) One of Mendel's experiments involved crossing tall pea plants with dwarf pea plants.

i. Using **T** to represent the allele for tallness and **t** to represent the allele for dwarfness, state the genotype of the original true-breeding tall parent plant and the original true-breeding dwarf parent plant.

Tall parent: TT	Dwarf parent: tt	1 mark
		Total: 1 mark

ii. What was the genotype of all the F1 generation plants?

Tt	1 mark
	Total: 1 mark

iii. Explain why some dwarf plants appeared in the F2 generation.

An explanation to include:	
Both F1 parents were heterozygous / Tt / carried the recessive allele.	1 mark
So offspring can inherit a recessive allele from each parent / have the genotype tt.	1 mark
	Total: 2 marks

Despite the significance of his findings, Mendel's work was not widely accepted or understood by scientists at the time it was published in the 1860s.

Suggest **two** reasons why his work was not recognised until many years later.

Any two from:	
Scientists at the time did not know about genes / chromosomes / DNA.	1 mark
They did not understand the mechanism of inheritance.	1 mark
Mendel's work was published in an obscure journal / not communicated effectively to other scientists.	1 mark
The mathematical / statistical nature of his work was new and not understood by biologists.	1 mark
	Total: 2 marks

(Total for Question 7 is 8 marks)

8. The biological sex of a human is determined by X and Y chromosomes.

- a) Complete the Punnett square diagram in the figure below to show the inheritance of biological sex in humans. Use the symbols X and Y.

		X	X		
	X	XX	XX		
	Y	XY	XY		
Correct parental gametes on axes: X, Y and X, X					1 mark
Correct offspring genotypes in the grid: XX, XX, XY, XY					1 mark
					Total: 2 marks

- b) A woman is pregnant with **non-identical** twins.

Explain why it is possible for non-identical twins to be different sexes, whereas identical twins are always the same sex.

Non-identical twins result from two separate eggs being fertilised by two separate sperm, and each fertilisation has a 50% / equal chance of being male (XY) or female (XX).	1 mark
	Total: 1 mark

(Total for Question 8 is 3 marks)