AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 4.6.1.4

Genetic inheritance

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**7**
Available paper years	**2018–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

4.6.1.4 Genetic inheritance

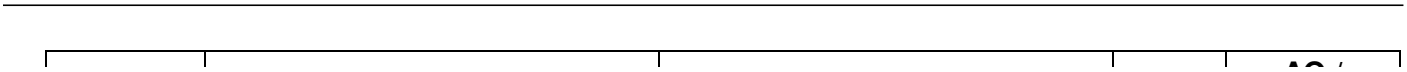
Answer 01 · Mark scheme June 2018 | 8464/B/2F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	<table><tr><th></th><th>Genes</th><th>Envi</th><th>Both</th></tr><tr><td>Brown...</td><td>✓</td><td></td><td></td></tr><tr><td>Light...</td><td></td><td></td><td>✓</td></tr><tr><td>Short ...</td><td></td><td>✓</td><td></td></tr></table>		1 1 1	AO2 4.6.2.1
05.2	bb		1	AO2 4.6.1.4
05.3	brown	allow light brown **or** dark brown	1	AO2 4.6.1.4
05.4	(using bb for mother's gametes) correct combination in all four boxes, eg <table><tr><td></td><td>*(b)*</td><td>*(b)*</td></tr><tr><td>*(B)*</td><td>Bb</td><td>Bb</td></tr><tr><td>*(b)*</td><td>bb</td><td>bb</td></tr></table>	allow any combination of mother's gametes as mark is for filling in boxes correctly	1	AO2 4.6.1.4
05.5	50%, 0.5, ½	the award of this mark is consequential to the answer in question **05.4** ignore ratios	1	AO2 4.6.1.4
05.6	phenotype		1	AO2 4.6.1.4
05.7	almost certainly have no effect		1	AO1 4.6.2.1
Total			**9**	

4.6.1.4 Genetic inheritance

Answer 01 · Mark scheme

June 2018 | 8464/B/2F | Original Q5



4.6.1.4 Genetic inheritance

Answer 02 · Mark scheme June 2019 | 8464/B/2F | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	mutation		1	AO1 4.6.2.1
04.2	any **three** from: • choose the cats with the blue tail • breed these cats together • choose offspring with blue tails and breed these together • repeat until all cats have blue tails	allow choose the cats with the desired characteristic allow breed for several generations	3	AO1 AO2 4.6.2.3
04.3	they are rare / beautiful / expensive	allow description e.g. the breeder will make (more) profit	1	AO3 4.6.2.3
04.4	they are produced by inbreeding		1	AO2 4.6.2.3
04.5	(male cat) XY **or** YX (female cat) XX	both required for the mark allow lower case letters	1	AO1 4.6.1.6
04.6	<table><tr><td></td><td>(X)</td><td>(X)</td></tr><tr><td>(X)</td><td>XX</td><td>XX</td></tr><tr><td>(Y)</td><td>XY</td><td>XY</td></tr></table>	allow 2 **or** 3 derivation squares correct for **1** mark	2	AO2 4.6.1.6
04.7	random (if X or Y goes into each sperm)	allow it is a chance event allow it is only a probability	1	AO3 4.6.1.6
Total			**10**	

4.6.1.4 Genetic inheritance

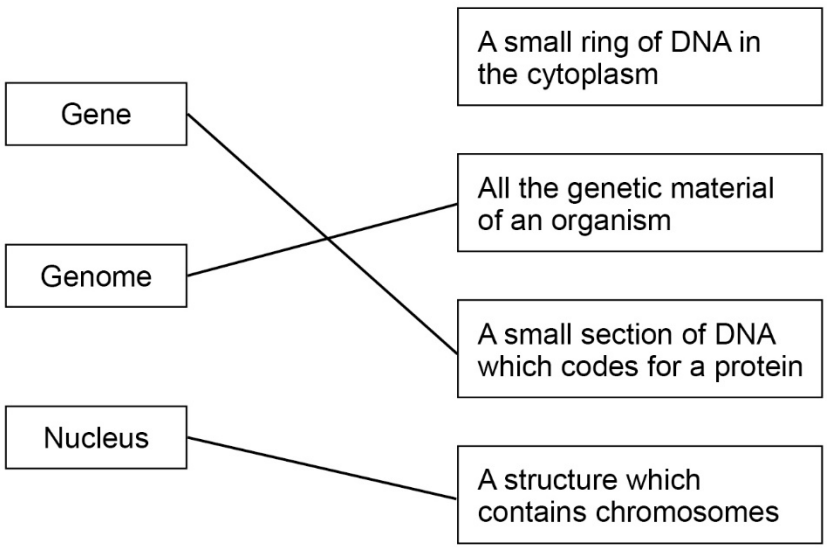
Answer 02 · Mark scheme

June 2019 | 8464/B/2F | Original Q4

4.6.1.4 Genetic inheritance

Answer 03 · Mark scheme

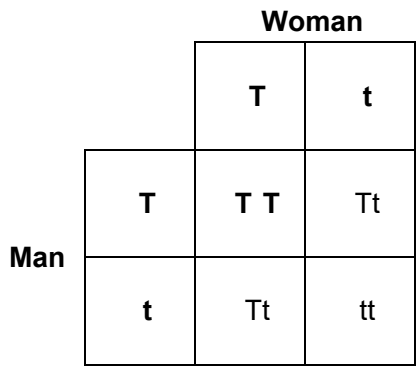
November 2021 | 8464/B/2F | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	23		1	AO1 4.6.1.2
01.2	 additional line from a box on the left negates the mark for that box		1 1 1	AO1 4.6.1.4 4.6.1.3
01.3	any **one** from: • to survive • so you do not eat the plants • to stop you being harmed / poisoned	allow to protect them allow stop you getting ill / dying	1	AO2 4.7.1.4
01.4	heterozygous		1	AO2 4.6.1.4
01.5	tt	allow homozygous recessive	1	AO2 4.6.1.4

4.6.1.4 Genetic inheritance

Answer 03 · Mark scheme

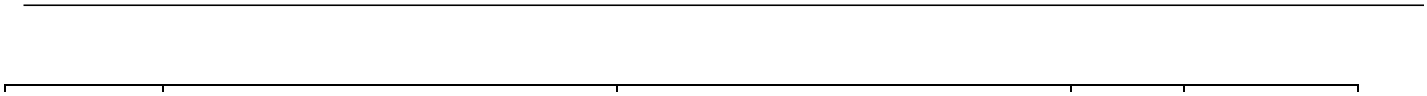
November 2021 | 8464/B/2F | Original Q1

01.6		allow 1 or 2 genotypes correct for **1** mark	2	AO2 4.6.1.4
01.7	75%	allow **only** a probability consistent with student's derivation if no answer to question **01.6** allow 75%	1	AO3 4.6.1.4
Total			**10**	

4.6.1.4 Genetic inheritance

Answer 03 · Mark scheme

November 2021 | 8464/B/2F | Original Q1



4.6.1.4 Genetic inheritance

Answer 04 · Mark scheme

June 2022 | 8464/B/2F | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	larger yields		1	AO1 4.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	GM crops will harm wildlife		1	AO1 4.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	gene(s)	allow allele(s)	1	AO1 4.6.1.3 4.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	protein		1	AO1 4.6.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	an allele that is only expressed if two copies are present		1	AO1 4.6.1.4

4.6.1.4 Genetic inheritance

Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	heterozygous		1	AO2 4.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.7 mark with 1.8	offspring genotypes correctly derived hh circled **Woman** / **H** / **h** **Man** / **H** / HH / Hh **h** / Hh / hh	allow **1** mark for 1 or 2 correct genotypes	2 1	AO2 4.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.8 mark with 01.7	25%	probability must match derivations (hh) in question **01.7**	1	AO3 4.6.1.4

4.6.1.4 Genetic inheritance

Answer 04 · Mark scheme

June 2022 | 8464/B/2F | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.9	any **one** from: • it might harm the embryo / baby / mother • it might cause a miscarriage • they do not want to make a choice about having an abortion • it is against their religious beliefs	ignore cost ignore harmful / dangerous unqualified allow against their religion	1	AO3 4.6.1.4 4.6.1.5

Total Question 1		11

4.6.1.4 Genetic inheritance

Answer 05 · Mark scheme

June 2023 | 8464/B/2F | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	meiosis	allow phonetic spelling	1	AO1 4.6.1.1 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	gametes / eggs / sperm are not (genetically) identical	allow gametes / eggs / sperm are (genetically) different allow cells produced by meiosis are not (genetically) identical	1	AO1 4.6.1.1 4.6.1.2
	(there is) mixing of genetic information / genes / DNA **or** genetic information / genes / DNA from two / both parents	allow genetic information / genes / DNA from each parent ignore gametes fuse unqualified ignore two parents unqualified if no other mark awarded allow **1** mark for mutations	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	heterozygous	ignore dominant / recessive	1	AO2 4.6.1.4

4.6.1.4 Genetic inheritance

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(parents gamete genotypes shown) **D d** and **d d**	allow in either position in Punnett square	1	AO2
	(possible offspring genotypes correctly derived) **Dd Dd dd dd**	allow correct derivation of offspring genotypes from incorrect gametes allow 3 correct offspring genotypes for **1** mark	2	AO2
	correct identification of **Dd** offspring as having polydactyly	if derivation not correct and shows **DD** and **Dd**, both must be identified as having polydactyly	1	AO2
	probability must match derived offspring genotypes	if no derivation shown allow 0.5 **or** 50% **or** 1 in 2 **or** 1:1 **or** ½ do **not** accept 1:2 allow correct probability from incorrectly derived offspring	1	AO3 4.6.1.4 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	any **two** from: • can find out if the embryo has an (inherited) disorder • can prepare for baby (with the disorder) • can decide whether to continue with the pregnancy • fewer people with (inherited) disorders over time	allow can find out if the embryo has inherited disease ignore can find out if the embryo has disease(s) allow description of preparation for the baby eg access to early treatment allow choice of (in vitro) embryos (to be implanted)	2	AO3 4.6.1.5

Total Question 6	**11**

4.6.1.4 Genetic inheritance

Answer 06 · Mark scheme

June 2024 | 8464/B/2F | Original Q1

Question 1

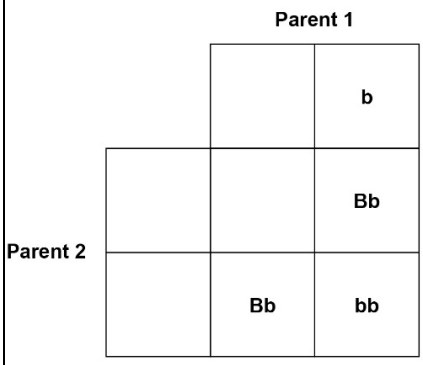
Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	cell membrane		1	AO1 4.1.1.2 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	dominant		1	AO2 4.6.1.4 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	heterozygous		1	AO2 4.6.1.4

4.6.1.4 Genetic inheritance

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4		allow **1** mark for **b** correct allow **2** marks for all 3 offspring genotypes correctly derived from gametes shown / given allow **1** mark for 1 or 2 offspring genotypes correctly derived from gametes shown / given derived genotypes must match parental gamete if given	1 2	AO2 4.6.1.4 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	25%	response must match question **01.4** if no answer in question **01.4** allow 25%	1	AO3 4.6.1.4 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	screening		1	AO1 4.6.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.7	mutation		1	AO1 4.6.2.1

4.6.1.4 Genetic inheritance

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.8	any **one** from: • diet • behaviour • infection • named environmental cause of variation such as sunlight	allow descriptions allow examples such as physical damage, scars, tattoos, (body) piercings, smoking, use of hair / nail colourings / dye allow air pollution ignore climate unqualified	1	AO2 4.6.2.1

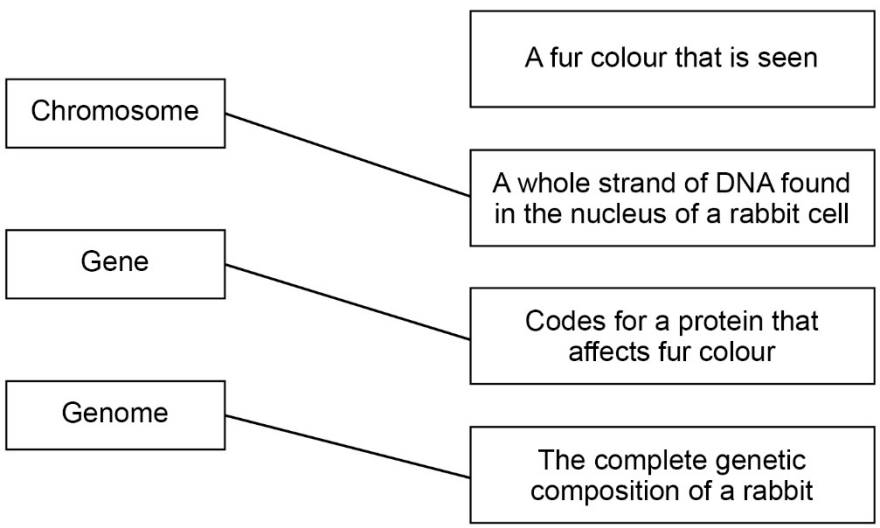
Total Question 1	10

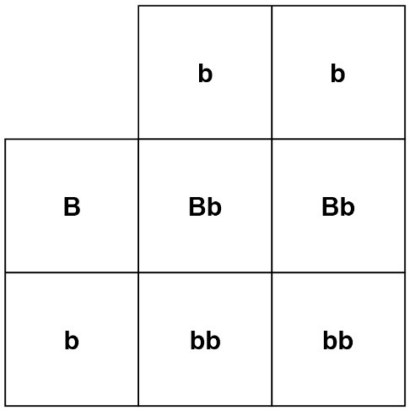
4.6.1.4 Genetic inheritance

Answer 07 · Mark scheme

June 2025 | 8464/B/2F | Original Q5

Question 5

Question	Answers	Mark	AO / Spec. Ref.
05.1	 do **not** accept more than one line from a box on the left	1 1 1	AO1 4.6.1.3 4.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2				
	gametes correct	allow in either position in Punnett square	1	AO2
	offspring genotypes correctly derived	allow correct derivation of offspring genotypes from incorrect gametes allow 3 correctly derived offspring genotypes for **1** mark	2	AO2
	any **bb** offspring identified as having white fur		1	AO2
	0.5	probability must match offspring genotypes if given allow 50% **or** 1 in 2 **or** 1:1 **or** $\frac{1}{2}$ do **not** accept 1:2	1	AO3 4.6.1.4

Answer 07 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3		allow gamete(s) **or** sex cells for sperm throughout		
	sperm have one of each chromosome (pair)	allow sperm have one **set** of chromosomes / genes allow sperm (only) have one allele for each gene allow sperm are haploid allow sperm have half the (number / amount of) chromosomes (compared with a body cell) allow sperm have 23 / 22 chromosomes ignore sperm have one allele ignore sperm have half the DNA / genes	1	AO2
	sperm are produced by meiosis **or** body cells have two of each chromosome	allow body cells have pairs of chromosomes allow body cells are diploid allow body cells have 46 / 44 chromosomes allow **B** and **b** are (alleles) on 2 chromosomes (of the same pair)	1	AO1 4.6.1.1 4.6.1.2 4.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	44	allow 22 pairs	1	AO2 4.6.1.6

4.6.1.4 Genetic inheritance

Answer 07 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	has two X (chromosomes)	allow XX allow the rabbit is not XY allow the rabbit does not have a Y (chromosome) allow the rabbit only has X (chromosomes) allow both (X) sex chromosomes are the same size	1	AO1 4.6.1.6

Total Question 5	**12**

4.6.1.4 Genetic inheritance

Answer 03 · Examiner comments — November 2021 | 8464/B/2F | Original Q1

Question 1 (low demand)

This question assessed the genetics section of the specification. Nearly all students could recall or calculate the number of chromosomes in a sperm cell when told the number of chromosomes in a human body cell. **01.2** was more challenging with few students being able to correctly link the words ‘gene’, ‘genome’ and ‘nucleus’ with the meaning of that word. Of these, nucleus was the most common correct response.

Most students knew the term heterozygous, but few could give the genotype in **01.5**. Many students correctly completed the Punnett square, however interpreting this to give the correct probability was more difficult, with an answer of 50% frequently seen.

Answer 04 · Examiner comments — June 2022 | 8464/B/2F | Original Q1

Question 1 (low demand)

01.1 72% of students could identify larger yields as a useful characteristic that crops are genetically modified for.

01.2 Around half of students could identify a concern about GM crops.

01.3 40% of students could name ‘gene’ or ‘allele’ as a piece of DNA that codes for a characteristic. Frequently seen incorrect answers were chromosome, genome and phenotype.

01.4 Just over half of students knew that protein was made using the DNA code.

01.5 50% of students knew the definition of a recessive allele.

01.6 52% of students could identify that heterozygous was the appropriate term.

01.7 A quarter of students could correctly derive the three missing possible genotypes of the child and draw a ring around hh. Many students could derive the genotypes, but did not draw a ring, or circled Hh or HH.

4.6.1.4 Genetic inheritance

Answer 04 · Examiner comments June 2022 | 8464/B/2F | Original Q1

01.8 The probability selected here needed to match the proportion of hh in their response to **01.7**. Half of students achieved this.

01.9 Many students gave the first marking point, for the idea that there may be harm to the embryo. Some responses were too vague, such as 'religion' unqualified. 'They might not want to know' was considered insufficient. Despite the question context relating to cystic fibrosis, many students only referred to screening identifying the gender of the embryo. Some misconceptions were seen, such as embryo screening causing cancer and incorrect references to radiation were common.

4.6.1.4 Genetic inheritance

Answer 05 · Examiner comments

June 2023 | 8464/B/2F | Original Q6

Question 6 (Standard demand)

06.1 Phonetic spelling was allowed, and variations of many phonetically correct spellings were seen. Hybrid terms between meiosis and mitosis were not credited. The list principle was applied when students stated both meiosis and mitosis. See page 4 of the mark scheme for an explanation of how lists within responses are marked.

Whilst mitosis was a common error, there were many students who simply put any word that they could relate to sexual reproduction such as fertilisation, ovum, sperm, hormones.

06.2 Few students could give two reasons why sexual reproduction causes variation in the offspring. Marking point 2 was seen more frequently than marking point 1.

Responses that did not gain credit only referred to the offspring having different characteristics, such as eye colour.

For marking point 1 we were looking for the idea of variation in gametes from one parent, or for the variation in gametes more generally, such as 'the genes from the egg and sperm are different'. The word genetically was bracketed and therefore is not required, but could not be contradicted, such as 'the egg and sperm look different'. We cannot put every variation of how students could phrase this in the mark scheme. For example, the mark scheme allowed 'cells produced by meiosis are not identical', so if a student wrote 'cells produced by meiosis are different' that was also worth the mark.

A few students referred to chromosomes crossing over in meiosis. This was a correct response that is beyond the specification and scored marking point 1. There is no expectation for teachers to teach this idea.

We did not credit vague answers that were open to different interpretations such as:

- egg and sperm contain 50% DNA
- half is from mother, half is from father
- genetics is from mother and father
- one gene from each parent.

Errors were seen in some responses that referred to chromosomes. The response needed to be biologically correct to gain the mark. 'They get chromosomes from each parent' or 'Chromosomes mix' or '2 sets of chromosomes mix' was acceptable. However, '2 chromosomes mix' or 'pairs of chromosomes come from each parent' are incorrect. Likewise, '2 genes mix' was incorrect.

There was a fallback mark for 'mutations'. This mark was awarded only if no other mark was given.

4.6.1.4 Genetic inheritance

Answer 05 · Examiner comments June 2023 | 8464/B/2F | Original Q6

0 1 . 2 Sexual reproduction produces offspring that are genetically different from each other.

Give **two** reasons why sexual reproduction causes variation in the offspring.

[2 marks]

1 The off spring is a combination of DNA from mother and father

2 The DNA taken from mother and father is not always the same

0 6 . 2 Sexual reproduction produces offspring that are genetically different from each other.

Give **two** reasons why sexual reproduction causes variation in the offspring.

[2 marks]

1 Each sperm and egg cell carry different genes.

2 Mother's and father's ~~are~~ genes are combined differently each time.

The first response (from a Higher tier paper) gave marking point 2 twice, therefore only 1 mark was awarded. The second response (from a Foundation tier paper) gave marking point 1 and marking point 2 for 2 marks.

06.3 This was very well answered. Phonetic spelling was allowed. See page 5 of the mark scheme for information on marking phonetic spelling.

06.4 On the Foundation tier, few students achieved all 5 marks, but partial credit was given frequently, such as correct derivation from incorrect gametes.

On the Higher tier, most students could complete the Punnett square and state the probability of the child having polydactyly. However, few students identified which offspring genotype would result in polydactyly. This could be indicated on any or all offspring, with a circle, line, key or label or any other clear method of identification.

06.5 Clear responses most frequently knew that embryo screening enables us to find out whether an embryo has an inherited disorder. Some confusion was seen between the term disorder and the terms diseases or disabilities.

Many responses were vague, such as 'to see if the embryo is healthy'. Some incorrect responses incorrectly implied that embryo screening is ultrasound screening.

Very few students took the marking point 4 approach of the implications to the population over time.

4.6.1.4 Genetic inheritance

Answer 05 · Examiner comments June 2023 | 8464/B/2F | Original Q6

A general misconception was that embryo screening is the same as genetic counselling, so students referred to finding out the likelihood of the embryo having an inherited disorder. The misconception that embryo screening can change DNA or treat inherited disorders was also seen.

Answer 06 · Examiner comments

Question 1 (low demand)

01.1 The vast majority of students could identify that the cell membrane controls the movement of substances into and out of cells.

01.2 More than half of the students could identify that the allele would be dominant.

01.3 More than half of the students correctly selected 'heterozygous' as the term that describes the genotype Bb.

01.4 Most students could interpret the question and use the Punnett square. The Punnet square had been partially completed to reduce the demand of this question. Where students made an error in their choice of gamete for Parent 1, they could still gain the 2 derivation marks using their incorrect gamete. The derivation marks could only be given if the derivation matched the gamete given by the student.

01.5 Students were told that cystic fibrosis is caused by a recessive allele, so the question tested their application of this fact to their Punnett square. The percentage had to match the derivations given in question 01.4. If no derivations were attempted in question 01.4, then an answer of 25% was awarded the mark.

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4.6.1.4 Genetic inheritance

Answer 06 · Examiner comments June 2024 | 8464/B/2F | Original Q1

0 1 . 4 Two people plan to have a child.

Both people have the genotype **Bb**.

Complete **Figure 1** to show the possible genotypes of the child. **[3 marks]**

Figure 1

Parent 2 \ Parent 1	B	b
B	BB	bb
b	bb	BB

0 1 . 5 What is the chance that a child of these parents will have cystic fibrosis?

Use **Figure 1**. **[1 mark]**

Tick (✓) **one** box.

0% ☐ 25% ☐ 50% ☑ 75% ☐

This student gave the correct Parent 1 gamete, but did not correctly derive any offspring genotypes, therefore 1 mark was awarded for question 01.4.

In question 01.5, the student gave a correct percentage from their Punnett square, therefore the mark was awarded.

01.6 Most students knew that screening was being described.

01.7 Nearly all students knew that mutation is the name of a change in DNA.

01.8 The mark scheme required a cause of environmental variation or the result of the cause. Where a student gave a result of the cause as their response, this was only given credit if it is from an environmental cause. For example, a tattoo would be the result of an environmental cause. However, weight, freckles, skin colour and hair colour are all also affected by genetic causes, so a student needed to qualify these to gain credit. Correct examples commonly seen were 'weight because you eat too much' and 'freckles/skin colour from being out in the sunlight'. Despite the prompt in the question *not* to refer to inheritance or to changes in DNA, these were frequently seen.

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Answer 07 · Examiner comments

June 2025 | 8464/B/2F | Original Q5

Question 5 (Standard demand)

05.1 The most common incorrect answer was a gene linked to 'a fur colour that is seen'. Students seemed to have a better understanding of the meaning of the term genome.

05.2 45% of students on Foundation tier gained 4 or more marks.

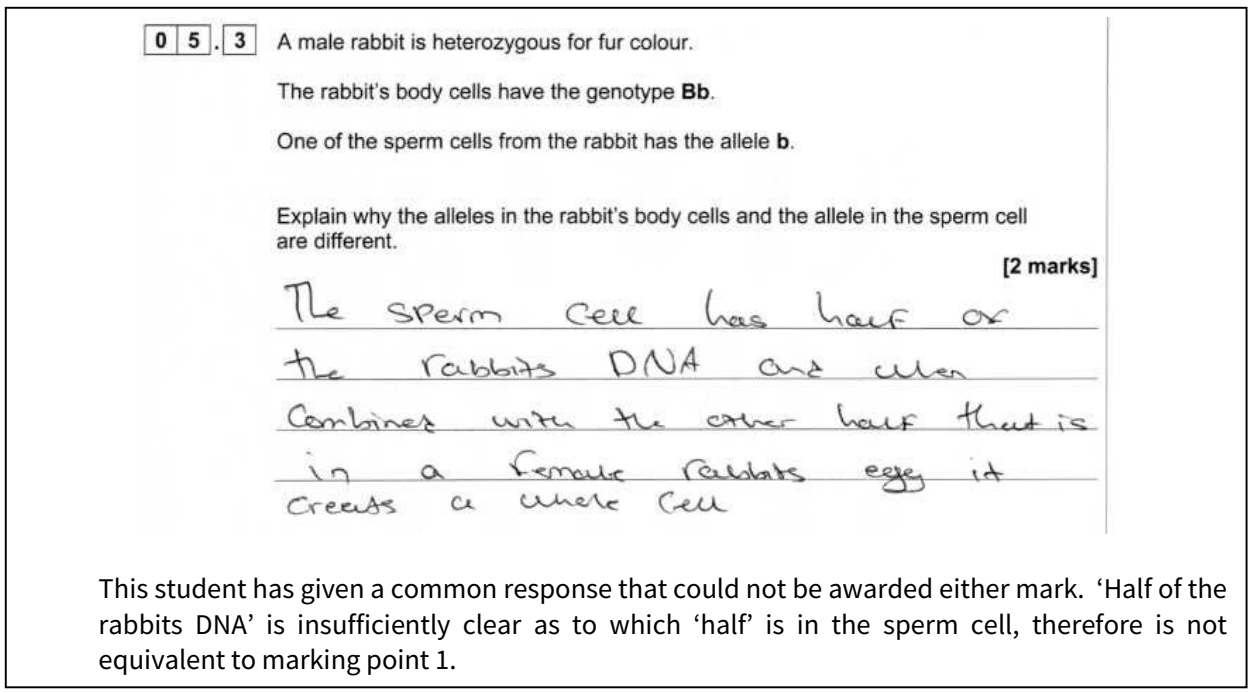
Those students who were able to put the gametes given in the question stem correctly into the Punnet square generally also achieved 2 marks for the correct derivations. Many students failed to identify the offspring that would have white fur and consequently could not be awarded marking point 4. However, the probability mark was often seen and was awarded if it was correct for the student's derivations.

Some students used the Punnet square incorrectly, with gametes given on the outside of the square and more than four derivations.
The most common error was students using both parent genotypes as Bb.

A number of 50/50 answers were seen despite this being highlighted in previous examiner reports as not being an equivalent probability to 0.5 or 50:50. Some students incorrectly gave the probability as 50, rather than 50% and therefore could not be awarded marking point 5.

05.3 This proved a very challenging question with relatively few students gaining a mark. Commonly, students tried to answer in terms of dominant and recessive alleles or genotypes, described the inheritance of alleles from parents, or described the different roles of sperm cells and body cells. Very few made any reference to chromosomes, and even fewer mentioned meiosis.

A frequently seen misconception was that 'sperm contain half a chromosome', illustrating that some students struggle with the abstract concepts relating to this part of the specification. Incorrect use of terminology was frequent, such as 'body cells are heterozygous, but sperm cells are homozygous'. Another frequent misconception was the idea that body cells contain maternal and paternal genes or chromosomes, but that sperm cells only contain paternal genes or chromosomes.



0 5 . 3 A male rabbit is heterozygous for fur colour.

The rabbit's body cells have the genotype **Bb**.

One of the sperm cells from the rabbit has the allele **b**.

Explain why the alleles in the rabbit's body cells and the allele in the sperm cell are different.

[2 marks]

The sperm cell has half of the rabbits DNA and when combines with the other half that is in a female rabbits eggs it creats a whole cell

This student has given a common response that could not be awarded either mark. 'Half of the rabbits DNA' is insufficiently clear as to which 'half' is in the sperm cell, therefore is not equivalent to marking point 1.

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4.6.1.4 Genetic inheritance

Answer 07 · Examiner comments June 2025 | 8464/B/2F | Original Q5

05.4 A small proportion of students correctly gave an answer of 44, and very few gave the correct equivalent answer of 22 pairs. The most common incorrect answers were 21, 22 and 42, although those also frequently seen included 1, 2, 11, 23 and 46.

05.5 This question asked for evidence from the figure that the rabbit was female. This was answered well with many students stating that there were 2 X chromosomes. A few students did not gain the mark because they stated '2 X genes' or '2 X alleles'. Some students recognised the absence of the Y chromosome which also gained the mark.