1.15 DNA, Genetics and Inheritance: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

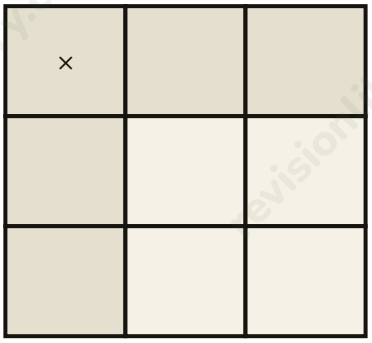
Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Sickle-cell anaemia is an inherited blood disorder caused by a recessive allele, a. The dominant allele, A, produces normal red blood cells. A person with genotype Aa is described as having 'sickle-cell trait'; they do not have sickle-cell anaemia, but carry one copy of the sickle-cell allele. Kwame and Naomi are both known carriers (Aa) of the sickle-cell allele, and are expecting their first child.

(a) Complete a genetic cross diagram to find the possible genotypes of their child, and use it to state the probability, as a fraction, that the child will have sickle-cell anaemia. **(2)**

Cross: Aa × Aa



(b) State the probability that the child will have sickle-cell trait (genotype Aa) rather than sickle-cell anaemia. **(1)**

(c) State the probability that the child will have genotype AA (unaffected, and not a carrier). **(1)**

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(d) Higher tier only. Kwame and Naomi plan to have a second child. Calculate the probability, as a percentage, that both of their children will have sickle-cell anaemia. **(2)**

.....

(Total for Question 1 is 6 marks)

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2 Albinism is a condition in which a person's skin, hair and eyes lack the pigment melanin. In one family, both parents, Grace and Michael, are unaffected by albinism. They have three children: Aisha (unaffected), Tomasz (who has albinism), and Ellie (unaffected).

(a) Use this information to explain whether the allele that causes albinism is dominant or recessive. **(2)**

(b) Using A for the dominant (normal) allele and a for the recessive (albinism) allele, state the genotypes of Grace and Michael. **(2)**

(c) State the genotype of Tomasz. **(1)**

(d) Aisha does not have albinism. State the possible genotype(s) of Aisha. **(1)**

(Total for Question 2 is 6 marks)

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3 In fruit flies, grey body colour is caused by a dominant allele, G. Black body colour is caused by the recessive allele, g. A genetics student crosses two heterozygous fruit flies (Gg x Gg) and rears 320 offspring from the cross.

(a) State the expected phenotype ratio of the offspring. **(1)**

(b) Calculate the expected number of black-bodied flies among the 320 offspring. **(2)**

(c) The student actually counted 68 black-bodied flies. Calculate the percentage difference between the expected number of black-bodied flies (from part (b)) and the actual number counted, as a percentage of the expected number. **(2)**

(Total for Question 3 is 5 marks)

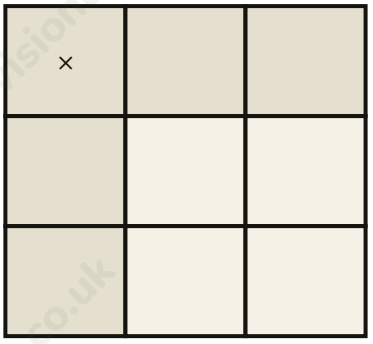
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4 Higher tier only. Red-green colour blindness is caused by a recessive allele carried on the X chromosome. The dominant allele, X^B, gives normal colour vision; the recessive allele, X^b, causes colour blindness. Sofia has normal colour vision but is a carrier (genotype $X^B X^b$). Her partner, Tom, has normal colour vision (genotype $X^B Y$).

(a) State the genotype of a man with red-green colour blindness. **(1)**

(b) Complete a genetic cross diagram to show the possible genotypes of Sofia and Tom's children. **(2)**

Cross: X^B X^b × X^B Y



(c) Calculate the probability that a son of Sofia and Tom will be colour-blind. **(1)**

.....

(d) Calculate the probability that a daughter of Sofia and Tom will be colour-blind. **(1)**

.....

(e) Explain why red-green colour blindness is much more common in men than in women. **(2)**

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(Total for Question 4 is 7 marks)

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5 Higher tier only. Cystic fibrosis is an inherited disorder caused by a recessive allele. When both parents are carriers, each of their children has a probability of 1/4 of having cystic fibrosis. A couple, who are both carriers, are expecting a baby.

(a) State the rule used to combine the probabilities of two independent genetic events, such as a baby's sex and whether it inherits a genetic disorder. **(1)**

(b) Using the probability that the baby has cystic fibrosis (1/4) and the probability that the baby is born male (1/2), calculate the probability that the baby will be a boy with cystic fibrosis. **(2)**

(c) Explain why this combined probability is lower than the probability of the baby having cystic fibrosis alone. **(1)**

(Total for Question 5 is 4 marks)

6 Explain how the processes of meiosis and fertilisation can produce brothers and sisters (siblings) who are genetically different from each other, even though they share the same two parents.

(Total for Question 6 is 6 marks)

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7 Gametes (sex cells) are produced by a type of cell division called meiosis. A normal human body (somatic) cell contains 46 chromosomes, arranged in 23 pairs.

(a) Name the type of cell division that produces gametes. **(1)**

(b) State the number of chromosomes found in a normal human sperm cell. **(1)**

(c) State the number of chromosomes that will be present in a fertilised egg cell (zygote) formed from this sperm cell and a normal human egg cell. **(1)**

(d) Explain why gametes must contain half the number of chromosomes of a normal body cell. **(1)**

(Total for Question 7 is 4 marks)

8 Variation between individuals of the same species can be continuous (a whole range of values) or discontinuous (a small number of distinct categories).

(a) A student measures the height of 30 plants of the same species and records values ranging continuously from 12 cm to 45 cm. State whether height in this example is continuous or discontinuous variation, and give a reason for your answer. **(2)**

(b) Give one example of a human characteristic that shows discontinuous variation. **(1)**

(Total for Question 8 is 3 marks)

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9 A population of beetles has two colour alleles: G (green, dominant) and g (brown, recessive). In a sample of 200 beetles, 32 are brown.

(a) Calculate the percentage of beetles in the sample that are brown. **(2)**

(b) Explain why you cannot calculate the percentage of beetles that are homozygous green (GG) directly from these phenotype data alone. **(2)**

(Total for Question 9 is 4 marks)

10 Explain how meiosis and sexual reproduction together generate genetic variation and why that variation is important for natural selection. In your answer include details of independent assortment, crossing over and random fertilisation.

(Total for Question 10 is 6 marks)

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Mark scheme · 1.15 DNA, Genetics and Inheritance: 1-hour Pack

Question 1

(a) correct offspring genotypes shown: AA, Aa, Aa, aa **M1**

(a) 1/4 cao **A1**

(a) Answer: 1/4

(b) 1/2 (50%), ft from (a) **B1**

(b) Answer: 1/2 (50%)

(c) 1/4 (25%), ft from (a) **B1**

(c) Answer: 1/4 (25%)

(d) 1/4 x 1/4, ft from (a) **M1**

(d) 1/16 (6.25%) cao **A1**

(d) Answer: 1/16 (6.25%)

Question 2

(a) the allele must be recessive **B1**

(a) because two unaffected parents (who do not show albinism) have had a child, Tomasz, who does have albinism; this can only happen if the allele is recessive and both parents are unaffected carriers (heterozygous), masking the allele, oe **B1**

(a) Answer: The allele must be recessive, because two unaffected parents produced a child with albinism, which can only happen if both parents are unaffected carriers masking a hidden recessive allele.

(b) Grace: Aa **B1**

(b) Michael: Aa **B1**

(b) Answer: Both Grace and Michael are Aa.

(c) aa **B1**

(c) Answer: aa

(d) AA or Aa, ft from (b) **B1**

(d) Answer: AA or Aa

Question 3

(a) 3 grey : 1 black **B1**

(a) Answer: 3 grey : 1 black

(b) (1/4) x 320, ft from (a) **M1**

(b) 80 cao **A1**

(b) Answer: 80

(c) (80 - 68) / 80 x 100, ft from (b) **M1**

(c) 15% cao **A1**

(c) Answer: 15%

Question 4

(a) X^b Y **B1**

(a) Answer: X^b Y

(b) correct gametes shown: X^B and X^b from Sofia, X^B and Y from Tom **M1**

(b) correct offspring genotypes shown: X^B X^B, X^B X^b, X^B Y, X^b Y **A1**

(b) Answer: Offspring genotypes: X^B X^B, X^B X^b, X^B Y, X^b Y.

(c) 1/2 (50%), ft from (b) **B1**

(c) Answer: 1/2 (50%)

(d) 0%, ft from (b) **B1**

(d) Answer: 0%

(e) colour blindness is caused by a recessive allele on the X chromosome; a man has only one X chromosome, so if he inherits the recessive allele he will be colour-blind, as there is no second X chromosome carrying a dominant allele to mask it **B1**

(e) a woman has two X chromosomes, so she would need to inherit the recessive allele on both X chromosomes to be colour-blind; if she inherits just one recessive allele she is an unaffected carrier, because the dominant allele on her other X chromosome is expressed instead, oe **B1**

(e) Answer: Men have only one X chromosome, so a single recessive allele causes colour blindness; women have two X chromosomes, so they need the recessive allele on both to be affected, otherwise they are unaffected carriers.

Question 5

(a) multiply the individual probabilities together, oe **B1**

(a) Answer: Multiply the individual probabilities together.

(b) 1/4 x 1/2, ft from (a) **M1**

(b) 1/8 (12.5%) cao **A1**

(b) Answer: 1/8 (12.5%)

(c) the combined event requires two separate, independent conditions to both occur; multiplying two probabilities that are each less than 1 always produces a smaller value than either probability alone, oe **B1**

(c) Answer: Because it requires two independent conditions to both happen, and multiplying two probabilities that are each less than 1 always gives a smaller result than either probability on its own.

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Question 6

Level 3 A detailed, logically sequenced answer that correctly explains how independent segregation during meiosis produces genetically different gametes AND how random fertilisation combines gametes from each parent, clearly linking both processes to why siblings (other than identical twins) are genetically different from one another. **5-6**

Level 2 The answer describes meiosis producing genetically different gametes, or random fertilisation, with only partial or one-sided linkage to why siblings differ genetically; some scientific detail may be missing or muddled. **3-4**

Level 1 One or two isolated, relevant points are made about meiosis or fertilisation, with little or no linkage to genetic differences between siblings. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- Meiosis is the type of cell division that produces gametes (sperm cells and egg cells).
- During meiosis, each pair of chromosomes separates (segregates) independently and randomly into different gametes.
- This means each gamete produced contains a different, random mixture of the parent's chromosomes (and therefore alleles), so gametes produced by the same parent are genetically different from one another.
- Meiosis also halves the chromosome number, producing haploid gametes (23 chromosomes in a human gamete) from a diploid parent cell (46 chromosomes).
- Fertilisation is the fusion of a haploid sperm cell with a haploid egg cell, which restores the full (diploid) chromosome number in the resulting zygote.
- Fertilisation is random: any one of millions of genetically different sperm cells could fuse with the egg cell, adding a further random/unpredictable element.
- Because each parent produces many genetically different gametes, and fertilisation randomly combines one gamete from each parent, each zygote receives a unique combination of alleles.
- This is why siblings, although they inherit their alleles from the same two parents, are not genetically identical to one another (except identical twins, who develop from a single zygote).

Question 7

(a) meiosis **B1**

(a) Answer: Meiosis.

(b) 23 **B1**

(b) Answer: 23 chromosomes.

(c) 46, ft from (b) doubled **B1**

(c) Answer: 46 chromosomes.

(d) so that when two gametes fuse at fertilisation, the normal (diploid) chromosome number is restored in the offspring, rather than the chromosome number doubling every generation, oe **B1**

(d) Answer: So that fertilisation restores the normal chromosome number, instead of it doubling every generation.

Question 8

(a) continuous variation cao **B1**

(a) reason: height can take any value across a range rather than falling into a small number of distinct categories, and is usually affected by both genes and the environment, oe **B1**

(a) Answer: Continuous variation, because height can take any value across a range rather than fitting into a small number of distinct categories.

(b) any valid example: blood group, ear lobe type (attached/free), ability to roll tongue, or sex, oe **B1**

(b) Answer: Blood group (or ear lobe type, or ability to roll the tongue).

Question 9

(a) substitutes 32/200 **M1**

(a) 16% cao **A1**

(a) Answer: 16%

(b) states that both GG and Gg beetles show the green phenotype because G is dominant, oe **M1**

(b) so counting green beetles cannot separate the two genotypes; more information (such as a test cross) is needed to find how many are GG, oe **A1**

(b) Answer: Because green is dominant, both GG and Gg beetles look green, so counting green beetles cannot tell you how many are GG; a test cross or other extra information would be needed.

Question 10

Level 3 Detailed explanation that links mechanisms of meiosis (independent assortment and crossing over) and random fertilisation to the production of genetic variation and explains why variation is necessary for natural selection, with clear examples or logical connections. **5-6**

Level 2 Clear explanation including at least two mechanisms (for example independent assortment and either crossing over or random fertilisation) and a statement that variation is raw material for natural selection. **3-4**

Level 1 Simple statements about meiosis or sexual reproduction producing variation, limited linkage to natural selection. **1-2**

Indicative content:

- Independent assortment: during metaphase I homologous pairs line up randomly so different combinations of maternal and paternal chromosomes go into gametes; this increases possible allele combinations.
- Crossing over: in prophase I homologous chromatids exchange segments at chiasmata producing new allele combinations on chromosomes.
- Random fertilisation: any sperm can fuse with any egg so combining different gametes multiplies variation produced by meiosis.
- Variation is important for natural selection because it provides individuals with different traits; some traits may increase survival and reproduction in a changing environment, leading to differential reproductive success.
- Examples or quantitative comments: independent assortment alone can produce 2^n combinations (where n is haploid chromosome number) and combining with random fertilisation greatly increases possible genotypes.

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