B6aD DNA, Genetics and Inheritance: Exam Drill

AQA 8464 · Calculator allowed · about 95 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 The nucleus of a cell contains DNA arranged into structures called chromosomes.

(a) Name the molecule made from DNA that codes for a single protein. **(1)**

(b) Give the name of the four nitrogenous bases found in DNA (list any four). **(2)**

(Total for Question 1 is 3 marks)

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2 A student observes that in a species, a gene for blue eyes is dominant to a gene for brown eyes. Use B for blue and b for brown.

(a) Write the genotype of a homozygous blue-eyed individual. **(1)**

(b) A heterozygous blue-eyed individual (Bb) is crossed with a brown-eyed individual. Give the expected phenotype ratio for their offspring. **(1)**

(Total for Question 2 is 2 marks)

3 In fruit flies a gene for red eye (R) is dominant to white eye (r). Two heterozygous red-eyed flies are crossed.

(a) Complete the Punnett square and give the genotypic ratio of offspring. **(2)**

....

(b) Give the expected phenotypic ratio for eye colour. **(1)**

(Total for Question 3 is 3 marks)

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4 A pedigree shows a disorder that appears in every generation and affects both males and females equally. A student suggests the disorder is autosomal dominant.

(a) Give two features of the pedigree data that support an autosomal dominant inheritance. **(2)**

(b) State one additional observation that would further confirm autosomal dominant inheritance. **(1)**

(Total for Question 4 is 3 marks)

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5 During a required practical, students investigate variation in seed mass. They collect 30 seeds from Plant A and 30 seeds from Plant B and measure mass in mg. The class mean mass for Plant A seeds is 12.4 mg and for Plant B seeds is 10.2 mg.

(a) State one control variable the students should use when measuring seed mass and why it should be controlled. **(1)**

(b) A student claims the difference in mean seed mass shows Plant A is genetically different from Plant B. Give one reason why the data might not be sufficient to support this claim. **(2)**

(Total for Question 5 is 3 marks)

6 A gene mutation changes one base in a DNA coding sequence, causing a different amino acid in the protein. This is called a missense mutation.

(a) State what is meant by the term 'mutation'. **(1)**

(b) Explain why a missense mutation can affect the function of a protein. **(1)**

(Total for Question 6 is 2 marks)

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7 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)**

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(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 7 is 4 marks)

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8 Genetic engineering can be used to make bacteria produce a useful human protein, such as insulin.

(a) Describe how bacteria can be genetically engineered to produce human insulin. Your answer should include the roles of a restriction enzyme, a vector and a host cell. **(4)**

(Total for Question 8 is 4 marks)

9 Sickle cell anaemia is caused by a single base substitution in the β globin gene. This affects haemoglobin and red blood cells.

(a) Explain how a single base substitution can lead to red blood cells having a sickle shape. **(3)**

(Total for Question 9 is 3 marks)

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10 Genetic engineering is used to produce GM (genetically modified) crops with useful characteristics, such as resistance to insect pests or improved nutrient content.

(a) Give two potential benefits of growing genetically modified crops. **(2)**

(b) Give one concern some people have about growing GM crops. **(1)**

(Total for Question 10 is 3 marks)

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11 In humans, blood type O is recessive. A parent with blood type O has a child with blood type A. The other parent must have at least one A allele.

(a) Give the genotype of the parent with blood type O. **(1)**

(b) State one possible genotype of the other parent if the child is type A and one parent is type O. **(1)**

(Total for Question 11 is 2 marks)

12 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 12 is 3 marks)

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13 Crossing over during meiosis increases genetic variation. A student sketches homologous chromosomes swapping sections.

(a) Describe when during meiosis crossing over occurs and what structures are involved. **(2)**

(b) Explain how crossing over contributes to genetic variation in gametes. **(2)**

(Total for Question 13 is 4 marks)

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14 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 14 is 6 marks)

15 A genetic test uses PCR to amplify a 600 base pair region. The PCR protocol has 30 cycles. Assuming perfect doubling each cycle, calculate the theoretical fold increase in DNA copies and the final number of copies starting from 100 template molecules.

(a) Calculate the theoretical fold increase after 30 cycles (express as 2^{30}). **(1)**

....

(b) Calculate the final number of copies starting from 100 initial templates. **(1)**

....

(Total for Question 15 is 2 marks)

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16 Cystic fibrosis is caused by a recessive allele (f). Both parents in a family are unaffected carriers of the cystic fibrosis allele, with genotype Ff.

(a) Complete a genetic cross to calculate the probability that a child of these two parents has cystic fibrosis (ff). **(2)**

....

(b) The couple go on to have two children. Calculate the probability that both children have cystic fibrosis. Give your answer as a fraction. **(2)**

....

(Total for Question 16 is 4 marks)

Mark scheme · B6aD DNA, Genetics and Inheritance: Exam Drill

Question 1

- (a) **B1** mRNA (messenger RNA) cao
- **(a) Answer: mRNA**
- (b) **B1** one correct base: adenine, thymine, cytosine or guanine
- (b) **B1** a second correct base (a second distinct base from the list) cao
- **(b) Answer: Any two of: adenine, thymine, cytosine, guanine.**

Question 2

- (a) **B1** BB cao
- **(a) Answer: BB**
- (b) **B1** 1 blue : 1 brown (or 1:1) cao
- **(b) Answer: 1 blue : 1 brown**

Question 3

- (a) **M1** shows correct Punnett square entries: RR, Rr, Rr, rr or equivalent
- (a) **A1** genotypic ratio 1 RR : 2 Rr : 1 rr cao
- **(a) Answer: 1 RR : 2 Rr : 1 rr**
- (b) **B1** 3 red : 1 white (or 3:1) cao
- **(b) Answer: 3 red : 1 white**

Question 4

- (a) **B1** appears in every generation (affected parents have affected children), oe
- (a) **B1** affects males and females equally (not sex-linked) oe
- **(a) Answer: Any two: appears in every generation; affects males and females equally.**
- (b) **B1** one affected parent with unaffected child is uncommon; instead, affected parent often has affected child or presence of heterozygotes shown, oe (example: affected x unaffected gives about 50% affected)
- **(b) Answer: Seeing affected individuals in each generation and affected parent producing about 50% affected children when crossed with unaffected.**

Question 5

- (a) **B1** e.g. use seeds dried to the same moisture content or measured at same temperature, to ensure mass differences are due to genetic variation not water content or temperature, oe
- **(a) Answer: Ensure all seeds are dried to the same moisture content so differences in mass are not caused by water content.**
- (b) **B1** sample size or sampling method may not be representative (e.g. only 30 seeds, may be from limited plants) oe
- (b) **B1** environmental factors or measurement error could have affected mass (e.g. humidity, not controlled) or no statistical test done, oe
- **(b) Answer: Any two reasons: sample may not be representative; environmental effects or measurement error could explain difference; no statistical test done.**

Question 6

- (a) **B1** a change in the DNA sequence (one or more bases) cao
- **(a) Answer: A change in the DNA base sequence.**
- (b) **B1** different amino acid may change the protein folding or active site so function is altered, oe
- **(b) Answer: Because the different amino acid can change the protein's shape or active site, altering its function.**

Question 7

- (a) **M1** substitutes 32/200
- (a) **A1** 16% cao
- **(a) Answer: 16%**
- (b) **M1** states that both GG and Gg beetles show the green phenotype because G is dominant, oe
- (b) **A1** 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
- **(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 8

- (a) **M1** a restriction enzyme is used to cut the gene for insulin out of human DNA, and to cut open a vector such as a plasmid, oe
- (a) **M1** the insulin gene is inserted into the vector (plasmid) and joined using ligase, oe
- (a) **A1** the vector carrying the gene is inserted into a host cell, such as a bacterium, oe
- (a) **A1** the genetically modified bacterium expresses the inserted gene and produces human insulin, which can be collected and purified, oe
- **(a) Answer: A restriction enzyme cuts the insulin gene out of human DNA and cuts open a plasmid vector; the gene is inserted into the plasmid and joined using ligase; the plasmid is inserted into a bacterium (host cell), which expresses the gene and produces human insulin.**

Question 9

- (a) **M1** states base substitution changes codon and so a different amino acid is inserted
- (a) **M1** explains different amino acid alters the structure (folding) of haemoglobin or its properties
- (a) **A1** states altered haemoglobin molecules stick together or form fibres, changing red blood cell shape to sickle, oe
- **(a) Answer: The base substitution changes a codon so a different amino acid is in haemoglobin; this alters folding and causes haemoglobin molecules to stick together forming fibres, which distort red blood cells into a sickle shape.**

Question 10

- (a) **B1** higher yields or pest/disease resistance, which can reduce the need for pesticides, oe
- (a) **B1** can be engineered to have improved nutritional content, helping to address malnutrition (for example, extra vitamins), oe
- **(a) Answer: Any two: higher yields or pest resistance, reducing the need for pesticides; improved nutritional content, which can help address malnutrition.**
- (b) **B1** GM genes could spread to wild plant populations and reduce biodiversity, or uncertainty about long-term effects on human health/the environment, oe
- **(b) Answer: Some people worry that GM genes could spread to wild plant populations, reducing biodiversity, or about possible long-term effects on health or the environment.**

Question 11

- (a) **B1** ii or OO (either notation acceptable) cao
- **(a) Answer: ii (or OO)**
- (b) **B1** IAi or IAIA (IA is A allele), oe
- **(b) Answer: IAi (or IAIA)**

Question 12

- (a) **B1** continuous variation cao
- (a) **B1** 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
- **(a) Answer: Continuous variation, because height can take any value across a range rather than fitting into a small number of distinct categories.**
- (b) **B1** any valid example: blood group, ear lobe type (attached/free), ability to roll tongue, or sex, oe
- **(b) Answer: Blood group (or ear lobe type, or ability to roll the tongue).**

Question 13

- (a) **B1** occurs in prophase I of meiosis
- (a) **B1** involves homologous chromosomes/pairs of chromatids forming chiasmata and exchanging sections, oe
- **(a) Answer: Crossing over occurs in prophase I when homologous chromosomes form chiasmata and exchange sections between chromatids.**
- (b) **M1** states that exchanging sections creates new combinations of alleles on a chromosome
- (b) **A1** links this to producing genetically different gametes and increased variation in offspring, oe
- **(b) Answer: Because crossing over creates new combinations of alleles on chromosomes, gametes have novel allele combinations leading to greater genetic variation in offspring.**

Question 14

- **Level 3** (5-6): 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.
- **Level 2** (3-4): 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.
- **Level 1** (1-2): Simple statements about meiosis or sexual reproduction producing variation, limited linkage to natural selection.
- **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.

Question 15

- (a) **B1** 2^{30} stated as the fold increase (ca 1.07374182×10^{9}) or 1073741824
- **(a) Answer: 1073741824**
- (b) **B1** final number = $100 \times 2^{30} = 1.073741824 \times 10^{11}$ (or 107374182400) cao
- **(b) Answer: 107374182400**

Question 16

- (a) **M1** shows correct cross Ff x Ff giving genotypes FF, Ff, Ff, ff
- (a) **A1** 1/4 (or 25%) cao
- **(a) Answer: 1/4 (25%)**
- (b) **M1** recognises the two births are independent events and multiplies the probabilities: 1/4 x 1/4
- (b) **A1** 1/16 cao
- **(b) Answer: 1/16**