1.4 Genetic Information, Variation and Relationships: 30-minute Pack

AQA 7402 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question is about the structure of DNA.

(a) State the three components of a single DNA nucleotide. **(3)**

(b) Describe how individual nucleotides join together to form a polynucleotide strand. **(2)**

(c) Explain why DNA is a chemically stable molecule, well suited to storing genetic information over long periods of time. **(3)**

(d) A section of DNA contains 5,200,000 bases in total. 30% of these bases are adenine. Calculate the number of guanine bases in this section of DNA. **(2)**

(Total for Question 1 is 10 marks)

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2 Structure and replication. A short section of a DNA molecule has the base sequence on one strand: 5 prime - ATG CCT GAA TTA - 3 prime. For the questions below assume standard base pairing and that transcription follows the usual directionality.

(a) Write down the sequence of the complementary strand in 3 prime to 5 prime orientation. **(1)**

(b) State the sequence of the mRNA transcribed when the original 5 prime strand is the coding (sense) strand, written 5 prime to 3 prime. **(1)**

(c) Translate the mRNA sequence into the three-letter amino acid code (use standard codon table: AUG = Met, CCU = Pro, GAA = Glu, UUA = Leu). **(2)**

(Total for Question 2 is 4 marks)

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3 Explain how meiosis and random fertilisation increase genetic variation within a species, and explain why this genetic variation is important for the survival of the species.

(Total for Question 3 is 6 marks)

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4 Recombination mapping. In Drosophila a geneticist measures recombination between three loci A, B and C on the same chromosome. She finds 120 recombinants between A and B, 30 recombinants between B and C and 150 recombinants between A and C, out of 1000 total progeny. Assume no interference for the simple map estimate.

(a) Calculate the map distance in centiMorgans between A and B, B and C, and A and C. Give each to 1 decimal place. **(3)**

(b) Using these distances, deduce the most likely gene order and explain briefly how the three numbers support that order. **(3)**

(Total for Question 4 is 6 marks)

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Mark scheme · 1.4 Genetic Information, Variation and Relationships: 30-minute Pack

Question 1

(a) a phosphate group **B1**

(a) a (deoxyribose) pentose sugar **B1**

(a) a nitrogen-containing (organic) base **B1**

(a) Answer: Phosphate group, deoxyribose sugar, nitrogen-containing base

(b) a condensation reaction occurs (releasing a water molecule) **B1**

(b) forms a phosphodiester bond between the phosphate group of one nucleotide and the sugar of the next **B1**

(b) Answer: Condensation reaction forms a phosphodiester bond between adjacent nucleotides.

(c) hydrogen bonds form between specific complementary base pairs (A with T, C with G), holding the two strands together **B1**

(c) the double helix is a large, coiled molecule that protects the bases (which carry the genetic code) on the inside of the molecule from chemical/physical damage **B1**

(c) the sugar-phosphate backbone is held together by strong covalent (phosphodiester) bonds, so the molecule does not break down easily **B1**

(c) Answer: DNA is stable due to complementary H-bonding, a protective coiled double-helix structure, and a strong covalent backbone.

(d) recognises %A = %T = 30%, so %G = %C = (100 - 60) / 2 = 20% oe **M1**

(d) 1,040,000 (guanine bases) cao **A1**

(d) Answer: 1,040,000 guanine bases

Question 2

(a) 3 prime - TAC GGA CTT AAT - 5 prime **B1**

(a) Answer: 3 prime - TAC GGA CTT AAT - 5 prime

(b) 5 prime - AUG CCU GAA UUA - 3 prime **B1**

(b) Answer: 5 prime - AUG CCU GAA UUA - 3 prime

(c) correct identification of each amino acid from codons **M1**

(c) Met-Pro-Glu-Leu cao **A1**

(c) Answer: Met-Pro-Glu-Leu

Question 3

Level 3 A detailed and coherent explanation that links specific mechanisms (independent assortment, crossing over, random fertilisation) to genetic variation, and clearly explains the importance of this variation for the survival of a species facing a changing environment. Appropriate scientific terminology is used accurately throughout. **5-6**

Level 2 The explanation includes several relevant mechanisms of variation and makes some link to the importance of variation for survival, but the explanation may lack detail, full accuracy or coherence in places. **3-4**

Level 1 Basic or isolated statements that meiosis and/or fertilisation cause variation, with little or no explanation of why this variation is important. Scientific detail is limited. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- Independent assortment of homologous chromosomes during meiosis I produces many combinations of maternal and paternal chromosomes in gametes.
- Crossing over (chiasmata formation) between non-sister chromatids in prophase I creates new combinations of alleles on chromosomes (recombinants).
- Meiosis therefore produces genetically different (non-identical) gametes.
- Fertilisation is random: any one of millions of genetically different gametes from one parent can fuse with any one of millions from the other parent.
- This creates a very large number of possible genetically different offspring (zygotes).
- Genetic variation means some individuals in a population may possess alleles/characteristics better suited to a changing environment.
- Variation provides the raw material for natural selection; without variation a population cannot evolve or adapt.
- If the environment changes (for example a new disease or climate change), a genetically varied population is more likely to contain individuals that survive and reproduce, reducing the risk of extinction of the species.

Question 4

(a) compute distances as recombinant proportion x 100 **M1**

(a) A-B = 120/1000 x 100 = 12.0 cM; B-C = 30/1000 x 100 = 3.0 cM **M1**

(a) A-C = 150/1000 x 100 = 15.0 cM cao **A1**

(a) Answer: A-B = 12.0 cM; B-C = 3.0 cM; A-C = 15.0 cM

(b) state likely order A - B - C because A-B + B-C = 12.0 + 3.0 = 15.0 which equals A-C **M1**

(b) explain that sum of adjacent distances equals total distance when no interference **M1**

(b) conclusion that B is between A and C, so order A-B-C cao **A1**

(b) Answer: Order A - B - C because A-B (12.0 cM) + B-C (3.0 cM) = 15.0 cM which equals A-C, indicating B lies between A and C.

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