IG.B8 Meiosis and the Causes of Variation

EDEXCEL 4BI1 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Define meiosis, as used in the production of gametes in animals and plants, naming the number of cells produced and whether they are genetically identical or different.

(Total for Question 1 is 2 marks)

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2 State the haploid and diploid chromosome numbers relationship that meiosis establishes for sexual reproduction, as required for fertilisation to restore chromosome number.

(Total for Question 2 is 1 mark)

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3 Describe, for the topic of meiosis in 4BI1, how the chromosome number is halved during the division process in a diploid cell.

(Total for Question 3 is 2 marks)

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4 Explain why it is necessary for meiosis to halve the chromosome number before fertilisation in sexual reproduction, referencing zygote chromosome number.

(Total for Question 4 is 2 marks)

5 Explain two ways in which genetic variation arises between gametes and therefore between offspring of the same species, naming meiosis and another source.

(Total for Question 5 is 2 marks)

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6 Distinguish between continuous and discontinuous variation, giving one clear example of each within the context of organisms of the same species.

(Total for Question 6 is 2 marks)

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7 Interpret the following histogram data for height in a plant population in a school biology class experiment. Heights (cm): 10 plants at 6-8 cm, 20 plants at 8-10 cm, 30 plants at 10-12 cm, 20 plants at 12-14 cm, 10 plants at 14-16 cm. (a) State whether this distribution is continuous or discontinuous. (b) Describe the shape of the histogram and what it suggests about typical plant height.

(Total for Question 7 is 3 marks)

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8 Define mutation, in the context of genetic variation, and state whether mutations are usually harmful, beneficial or neutral.

(Total for Question 8 is 2 marks)

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9 Explain briefly how a mutation can lead to variation within a species, using the effect on a protein or phenotype in your answer.

(Total for Question 9 is 2 marks)

10 Give one example of a variation caused mainly by genetics and one caused mainly by the environment, naming the organism or human trait in each example.

(Total for Question 10 is 2 marks)

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11 A student wants to investigate whether different amounts of fertiliser affect the height variation of identical fast-growing bean plants. Describe a simple method for this investigation, including the independent variable, dependent variable and two control variables to make the test fair.

(Total for Question 11 is 3 marks)

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12 In a population survey for blood groups, 18 out of 60 people sampled had blood group O. Calculate the percentage of people with blood group O to one decimal place.

(Total for Question 12 is 3 marks)

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13 State briefly why gametes produced by meiosis are genetically different from each other, in the context of producing variation within a species.

(Total for Question 13 is 1 mark)

14 Explain the causes of variation between organisms of the same species. In your answer include genetic causes and environmental causes, and explain how these together produce the variation seen in a population.

(Total for Question 14 is 6 marks)

Mark scheme · IG.B8 Meiosis and the Causes of Variation

Question 1

- **B1** a type of cell division that produces gametes
- **B1** produces four haploid cells that are genetically different from each other and from the parent cell
- **Answer: Meiosis is a cell division that produces four haploid gametes which are genetically different**

Question 2

- **B1** meiosis halves the diploid number to make haploid gametes so fertilisation restores the diploid number
- **Answer: Meiosis halves the diploid number to haploid so fertilisation restores the diploid number**

Question 3

- **B1** the cell divides twice (two successive divisions)
- **B1** sister chromatids or homologous chromosomes are separated so daughter cells have half the chromosomes
- **Answer: The cell undergoes two divisions so homologous chromosomes/sister chromatids are separated, producing cells with half the chromosome number**

Question 4

- **B1** halving prevents chromosome number doubling every generation
- **B1** fertilisation restores the diploid number so the zygote has the correct chromosome number
- **Answer: Halving prevents chromosome number doubling each generation, because two haploid gametes fuse at fertilisation to restore the correct diploid zygote chromosome number**

Question 5

- **B1** variation arises in meiosis because the four gametes are genetically different (award phrasing that meiosis produces different combinations)
- **B1** variation also arises from random fertilisation or mutation named as a second source
- **Answer: Meiosis produces genetically different gametes, and additional variation arises from random fertilisation or from mutations in DNA**

Question 6

- **B1** continuous variation: shows a range of values, e.g. height
- **B1** discontinuous variation: distinct categories, e.g. blood group
- **Answer: Continuous variation shows a range of values such as height; discontinuous variation falls into distinct categories such as blood group**

Question 7

- **B1** identifies the distribution as continuous
- **B1** describes the shape as roughly bell-shaped or symmetric with a peak in the 10-12 cm class
- **B1** states that most plants are around 10-12 cm (the mode), suggesting a typical or average height in that range
- **Answer: a) Continuous. b) Roughly bell-shaped with a peak at 10-12 cm, so most plants are around 10-12 cm tall**

Question 8

- **B1** a change in the DNA sequence (or gene) of an organism
- **B1** most mutations are neutral or harmful, with beneficial mutations being rare
- **Answer: A mutation is a change in an organism's DNA sequence; most mutations are neutral or harmful, beneficial ones are rare**

Question 9

- **B1** mutation can change a gene so it codes for a different protein or a nonfunctional protein
- **B1** this change can alter the organism's phenotype, producing variation among individuals
- **Answer: A mutation can alter a gene so a different or nonfunctional protein is made, changing the phenotype and so producing variation among individuals**

Question 10

- **B1** one genetic example, e.g. blood group in humans or flower colour determined by genes
- **B1** one environmental example, e.g. plant height affected by nutrient availability or tan in humans caused by sun exposure
- **Answer: Genetic example: human blood group. Environmental example: plant height affected by nutrient availability**

Question 11

- **B1** identifies independent variable: amount or concentration of fertiliser and how to vary it (e.g. none, low, medium, high)
- **B1** identifies dependent variable: plant height measured after a fixed time
- **B1** states two control variables, e.g. same light, same soil type and volume, same watering schedule, same number and age of seeds
- **Answer: Vary fertiliser amount (e.g. none, low, medium, high) as independent variable; measure plant height after a set time as dependent; keep seed type, soil, light and water the same as control variables**

Question 12

- **M1** forms the fraction 18/60 and multiplies by 100
- **A1** percentage = 30.0% cao
- **B1** gives answer to one decimal place as 30.0% or equivalent
- **Answer: 30.0%**

Question 13

- **B1** because meiosis produces different combinations of genes in each gamete (leading to genetic differences)
- **Answer: Because meiosis produces gametes with different combinations of genes so each gamete is genetically different**

Question 14

- **Level 1** (1-2): Simple statements about one or two causes of variation, with limited development. May list examples without clear explanation.
- **Level 2** (3-4): Clear explanation of genetic and environmental causes with some linking showing how they produce differences in traits. Some correct use of terminology.
- **Level 3** (5-6): Detailed explanation covering genetic causes, mutation and random fertilisation, plus environmental influences, and a coherent synthesis of how these factors interact to produce the range of variation in a population
- **Indicative content:**
  - Genetic causes: different alleles inherited from parents determine traits
  - Meiosis produces different combinations of alleles and gametes are genetically different
  - Random fertilisation of gametes mixes alleles from two parents producing new combinations
  - Mutation introduces new alleles or changes to genes that can alter traits
  - Environmental causes: factors such as nutrition, light, temperature, disease, and exercise can change phenotype without changing the genotype
  - Interaction: the same genotype can give different phenotypes in different environments, and genetic variation provides the raw material on which environmental selection acts, producing the observed range of traits in a population