1.16 Variation, Evolution and Selection: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A hospital microbiology laboratory monitored the percentage of Staphylococcus aureus samples that were resistant to meticillin (MRSA) over four decades. Year 1990: 2% resistant. Year 2000: 15% resistant. Year 2010: 42% resistant. Year 2020: 68% resistant.

Year	Samples resistant to meticillin (%)
1990	2
2000	15
2010	42
2020	68

(a) Calculate the percentage increase in the proportion of meticillin-resistant samples between 1990 and 2020. **(2)**

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(b) Calculate the mean rate of increase in resistance, in percentage points per decade, between 1990 and 2020. **(1)**

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(c) Use the theory of natural selection to explain the trend shown in the data above. **(3)**

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(Total for Question 1 is 6 marks)

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2 A population of bacteria in a wound reproduces by binary fission, doubling in number every 20 minutes under favourable conditions. A student begins observing a population of 4 bacteria.

(a) Calculate the size of the bacterial population after 2 hours. **(2)**

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(b) Calculate the minimum time taken for the population to first exceed 1000 bacteria. **(2)**

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(c) Suggest why this rapid rate of reproduction contributes to bacterial populations evolving resistance to antibiotics relatively quickly, compared with organisms such as mammals. **(1)**

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(Total for Question 2 is 5 marks)

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3 Explain one disadvantage of selective breeding for the long-term health of a population of farm animals.

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(Total for Question 3 is 3 marks)

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4 Bacteria can be genetically engineered to produce useful human proteins, such as human growth hormone (HGH), which is used to treat children with a growth hormone deficiency. Describe how a bacterium can be genetically engineered to produce human growth hormone.

(Total for Question 4 is 5 marks)

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5 Charles Darwin published his theory of evolution by natural selection in 1859. Before this, Jean-Baptiste Lamarck had proposed a different theory: that characteristics an organism developed or used during its lifetime, and lost through disuse, could be passed on directly to its offspring.

(a) Give two reasons why Darwin's theory of natural selection was not immediately accepted by other scientists at the time. **(2)**

(b) Explain, using an example, why Lamarck's theory of inheritance of acquired characteristics is not accepted today. **(2)**

(Total for Question 5 is 4 marks)

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Mark scheme · 1.16 Variation, Evolution and Selection: 30-minute Pack

Question 1

(a) correct substitution shown: (68 - 2) / 2 x 100 **M1**

(a) 3300% cao **A1**

(a) Answer: 3300%

(b) 22 (percentage points per decade) cao; ecf allowed from a correctly divided total increase carried forward from (a) **B1**

(b) Answer: 22 percentage points per decade.

(c) mutations occurring in the bacterial population meant some individual bacteria already carried a gene/allele giving resistance to meticillin, even before it was widely used **B1**

(c) when meticillin was used, non-resistant bacteria were killed, while resistant bacteria survived and faced less competition for resources **B1**

(c) resistant bacteria reproduced (by binary fission), passing on the resistance allele to their offspring, so the proportion of resistant bacteria in the population increased over each decade, oe **B1**

(c) Answer: Some bacteria already carried a resistance mutation before meticillin was used; non-resistant bacteria were killed by the antibiotic while resistant ones survived with less competition; resistant bacteria reproduced and passed on the resistance allele, so the proportion of resistant bacteria increased each decade.

Question 2

(a) number of divisions = 120 / 20 = 6 (or 2^6 identified) **M1**

(a) 256 cao **A1**

(a) Answer: 256 bacteria.

(b) correct number of doublings identified = 8 (population = 4 x 2^8 = 1024, the first value to exceed 1000); ecf from a correct doubling calculation carried forward from (a) **M1**

(b) 160 minutes cao (accept 2 hours 40 minutes) **A1**

(b) Answer: 160 minutes (2 hours 40 minutes).

(c) bacteria reproduce (and produce new generations, including any new mutations) far more quickly and frequently than slower-reproducing organisms, so natural selection can act, and resistant strains can become established, over a much shorter timescale, oe **B1**

(c) Answer: Because bacteria produce new generations, and therefore new mutations, far more quickly than slower-reproducing organisms, so natural selection can act over a much shorter timescale.

Question 3

selective breeding reduces the genetic variation within the population, because only individuals with the desired characteristic(s) are bred from **B1**

this can lead to inbreeding, increasing the chance that individuals inherit two copies of a harmful recessive allele (inbreeding depression) **B1**

reduced genetic variation also makes the population less able to adapt to a new environmental change, or to resist a new disease, which could threaten the whole population, oe **B1**

Answer: Selective breeding reduces genetic variation, which can cause inbreeding depression (an increased chance of inheriting two copies of a harmful recessive allele) and leaves the population less able to adapt to new diseases or environmental change.

Question 4

the gene for human growth hormone is identified/isolated from human DNA, often using a restriction enzyme to cut the DNA at specific points either side of the gene **B1**

a plasmid (a small circular piece of bacterial DNA) is removed from a bacterium and cut open using the same restriction enzyme, leaving matching/complementary ends **B1**

the growth hormone gene is inserted into the cut plasmid using an enzyme called ligase, joining the two pieces of DNA together to form recombinant DNA **B1**

the recombinant plasmid (acting as a vector) is inserted into a new bacterial cell **B1**

the genetically modified bacteria are grown/cultured in large numbers (e.g. in fermenters); as they reproduce, they express the inserted gene, producing human growth hormone, which is then extracted and purified, oe **B1**

Answer: The HGH gene is cut from human DNA and a bacterial plasmid is cut open, both using the same restriction enzyme; the gene is inserted into the plasmid using ligase to form recombinant DNA; the recombinant plasmid (vector) is inserted into a bacterium, which is then cultured in large numbers to express and produce human growth hormone.

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Question 5

(a) the theory challenged the widely held religious belief that God had created all species and that species did not change **B1**

(a) there was not enough evidence available at the time to fully convince other scientists, as the mechanism of inheritance (genes/DNA) was not yet known/understood; or the theory contradicted Lamarck's well-established theory of inheritance of acquired characteristics; any two for 2 marks, oe **B1**

(a) Answer: It challenged widely held religious beliefs about the fixed creation of species, and there was not yet enough scientific evidence (the mechanism of inheritance was unknown) to fully convince other scientists.

(b) characteristics acquired during an organism's lifetime are not caused by a change to the genes/alleles in its sex cells (gametes), so they cannot be passed on to offspring through inheritance **B1**

(b) example, e.g. a giraffe that stretches its neck to reach higher leaves does not produce offspring with longer necks, because stretching does not change the DNA/genes passed on in its gametes, oe (accept other valid example) **B1**

(b) Answer: Characteristics gained during a lifetime do not change the alleles in an organism's gametes, so they cannot be inherited; for example, a giraffe stretching its neck does not change the genes passed on to its offspring.

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