1.6 Inheritance, Variation and Evolution: 1-hour Pack

AQA 8461 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

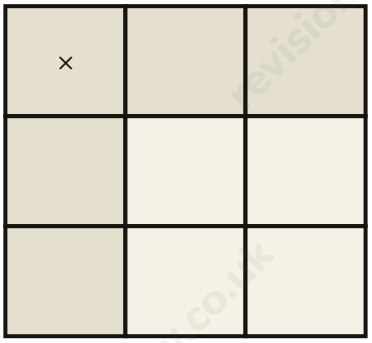
1 State two reasons why a species might become extinct.

(Total for Question 1 is 2 marks)

2 The sex of a human baby is determined by one pair of chromosomes. Females have the genotype XX and males have the genotype XY.

(a) Complete a genetic cross diagram to show the probability of a baby being male or female, and state this probability. **(2)**

Cross: XX × XY



(b) Explain why it is the father's gamete, and not the mother's, that determines the sex of the child. **(2)**

(Total for Question 2 is 4 marks)

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3 Cystic fibrosis is caused by a recessive allele, f. Two parents who are both unaffected carriers have the genotype Ff.

Draw a Punnett square for the cross Ff x Ff and use it to calculate the percentage chance that a child of these two parents has cystic fibrosis (genotype ff).

(Total for Question 3 is 3 marks)

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4 Extended response (6 marks).

A hospital ward has a population of bacteria. A patient is treated with an antibiotic. A few days later, doctors find that most of the bacteria on the ward are now resistant to that antibiotic.

Explain how the bacteria on the ward evolved to become resistant to the antibiotic. Refer to variation, natural selection and reproduction in your answer.

(Total for Question 4 is 6 marks)

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5 In a population of moths, a survey recorded the percentage of moths with a dark-coloured allele over three generations, as air pollution in the area decreased.

Generation 1: 92 % dark-coloured
Generation 2: 74 % dark-coloured
Generation 3: 45 % dark-coloured

(a) Calculate the total percentage point decrease in dark-coloured moths from Generation 1 to Generation 3.
(b) Suggest an explanation, in terms of natural selection, for this trend as pollution decreased.

(Total for Question 5 is 4 marks)

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6 Explain why genetic variation within a species is important for the long-term survival of that species when the environment changes.

(Total for Question 6 is 3 marks)

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7 Required practical: Two students, Amara and Josh, from a school near Bristol investigated variation in the shell banding pattern of the land snail Cepaea nemoralis. This snail's shell can be plain (unbanded) or striped (banded), a characteristic controlled by a gene. The students sampled snails from two habitats: a short grassland meadow and a hedgerow with variable light and shade. Their results are shown below. Grassland: 32 banded out of 40 snails sampled. Hedgerow: 45 banded out of 60 snails sampled.

Habitat	Banded snails	Snails sampled
Grassland	32	40
Hedgerow	45	60

(a) Describe how the students could use quadrats to obtain an unbiased, random sample of snails within each habitat. **(2)**

(b) Suggest one variable, other than the species sampled, that the students should try to keep the same when comparing the two habitats. **(1)**

(c) Calculate the percentage of snails that were banded in the grassland habitat. **(2)**

(d) Calculate the percentage of snails that were banded in the hedgerow habitat. **(1)**

(e) Using your answers to (c) and (d), and the idea of natural selection, explain why banded snails might be more common in the grassland than in the hedgerow. **(3)**

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(f) Explain why increasing the sample size from 40-60 snails per habitat to 400-600 snails per habitat would make the students' conclusion more valid. **(2)**

(g) Suggest one reason, other than camouflage and predation, why the frequency of the banded allele might differ between two separate snail populations. **(1)**

(h) State what is meant by 'natural selection', using this investigation as an example. **(1)**

(i) Explain one limitation of using shell-banding percentage alone as evidence that natural selection is acting on this population. **(2)**

(Total for Question 7 is 15 marks)

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8 Genetically modified (GM) crops, such as crops engineered to be resistant to insect pests, are grown in some countries.

(a) State two advantages of growing GM crops that are resistant to insect pests. **(2)**

(b) State two disadvantages or concerns associated with growing GM crops. **(2)**

(Total for Question 8 is 4 marks)

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9 Embryos created by IVF can be screened for the alleles that cause serious genetic disorders, such as cystic fibrosis, before being implanted in the mother. Evaluate the use of embryonic screening to prevent genetic disorders being passed on to children.

(Total for Question 9 is 6 marks)

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Mark scheme · 1.6 Inheritance, Variation and Evolution: 1-hour Pack

Question 1

the environment changes too quickly for the species to adapt/evolve, oe	**B1**
a new predator, new disease, or a new, more successful competitor for resources appears, oe	**B1**

Answer: For example: the environment changes too rapidly for the species to adapt; a new disease or predator, or a more successful competitor, appears.

Question 2

(a) correct gametes shown: X and X from mother, X and Y from father	**M1**
(a) correct offspring genotypes shown (XX, XX, XY, XY) with probability of male = probability of female = 50% (1:1)	**A1**

(a) Answer: Offspring are XX, XX, XY, XY; probability of a boy = 50%, probability of a girl = 50%.

(b) the mother can only produce gametes containing an X chromosome	**B1**
(b) the father produces gametes containing either an X or a Y chromosome, so whichever gamete fertilises the egg determines whether the child is XX (female) or XY (male)	**B1**

(b) Answer: The mother's eggs always carry an X chromosome, but the father's sperm carry either an X or a Y chromosome, so it is the father's gamete that determines the child's sex.

Question 3

correctly combines gametes F and f from each parent to give genotypes FF, Ff, Ff, ff	**M1**
identifies that 1 out of 4 offspring has genotype ff	**M1**
25 % cao	**A1**

Answer: 25 % chance of a child having cystic fibrosis.

Question 4

Level 3 A clear, logically sequenced explanation linking random mutation, variation in resistance, survival advantage of resistant bacteria, and their preferential reproduction, leading to a resistant population. Uses scientific terms accurately throughout.	**5-6**
Level 2 A mostly correct explanation covering variation and survival of resistant bacteria, with some detail missing or not fully linked, e.g. reproduction of survivors not clearly explained.	**3-4**
Level 1 Simple or partial statements, e.g. 'the strong bacteria survived', with little reference to variation, mutation or reproduction.	**1-2**

Indicative content:

- Within the bacterial population there is variation: due to random mutation, a small number of bacteria already happen to carry a gene (allele) that makes them resistant to the antibiotic, before the antibiotic is given.
- When the antibiotic is used, the non-resistant bacteria are killed or cannot reproduce, but the resistant bacteria survive because they are not affected by the antibiotic.
- The surviving resistant bacteria have a survival advantage and go on to reproduce (bacteria reproduce very rapidly by simple cell division).
- The resistance allele is passed on to the offspring of the resistant bacteria, so more of the next generation are resistant.
- Over repeated rounds of antibiotic use and reproduction, the proportion of resistant bacteria in the population increases until most or all of the population is resistant.
- This is an example of natural selection: the environment (presence of the antibiotic) selects for bacteria best suited to survive it, and this characteristic becomes more common over time.

Question 5

substitutes: 92 - 45	**M1**
47 percentage points cao	**A1**
as pollution decreases, tree bark becomes lighter, so dark moths are more visible to predators and are eaten more often, oe	**B1**
light-coloured moths are now better camouflaged, so they survive and reproduce more, passing on the allele for light colour, so the light allele becomes more common (dark allele becomes less common) over generations, oe	**B1**

Answer: A decrease of 47 percentage points. As pollution fell, bark became lighter, so dark moths were more visible and eaten more, while light moths were better camouflaged, survived and reproduced more, making the light-colour allele more common.

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Question 6

different individuals in the population have different alleles/characteristics, oe **B1**

if the environment changes, some individuals may already have characteristics that make them better suited to the new conditions, oe **B1**

these individuals are more likely to survive and reproduce, passing on the advantageous alleles, so the species is more likely to survive as a whole (rather than becoming extinct), oe **B1**

Answer: Variation means some individuals may already suit the new conditions; they are more likely to survive, reproduce and pass on their alleles, so the species as a whole is more likely to survive rather than become extinct.

Question 7

(a) lay a tape measure/grid across the habitat and use a random number generator (or random number table) to choose coordinates for quadrat placement **B1**

(a) place the quadrat at each random coordinate and count/record the snails found inside it, repeating this for a suitable number of quadrats across the habitat **B1**

(a) Answer: Use random numbers to choose coordinates along a grid laid across the habitat, then place the quadrat at each coordinate and record the snails found, repeating for several quadrats.

(b) e.g. time of day, time of year/season, weather conditions, or sampling effort (number of quadrats/area sampled) - any one sensible controlled variable **B1**

(b) Answer: For example, sampling at the same time of year and in similar weather conditions in both habitats.

(c) (32 / 40) x 100 **M1**

(c) 80% cao **A1**

(c) Answer: 80%

(d) 75% cao [(45/60) x 100] **B1**

(d) Answer: 75%

(e) predators (e.g. thrushes) hunt snails by sight, and snails that are less well camouflaged in their habitat are more likely to be seen and eaten **B1**

(e) in the hedgerow, the patchy light and shade mean plain (unbanded) shells are better camouflaged, while in the short grassland, banded shells are better camouflaged against the streaky grass background **B1**

(e) in the grassland the banded/striped shell gives better camouflage against the streaky grass background, so banded snails are less likely to be predated by birds, more likely to survive and reproduce, and pass on the allele for banding; this selection pressure explains the higher percentage of banded snails in the grassland (80%) than in the hedgerow (75%) (oe reasoning credited) **B1**

(e) Answer: Grassland has 80% banded snails versus 75% in the hedgerow. Banded shells might be better camouflaged against the streaky grassland background, while plain shells might be better camouflaged in the patchy light and shade of the hedgerow. Birds hunt snails by sight, so better-camouflaged banded snails in grassland are less likely to be eaten and more likely to survive and reproduce. They pass the banding allele to their offspring, increasing its frequency over generations.

(f) a larger sample size reduces the effect of chance/random variation on the results (e.g. from sampling a few snails in one patch by chance) **B1**

(f) so the calculated percentages are more likely to be representative of the true population in each habitat, making the comparison between habitats more valid **B1**

(f) Answer: A bigger sample reduces the effect of chance, so the percentages calculated are more likely to reflect the true population, making the comparison more valid.

(g) e.g. the populations may be isolated with little migration between them (so allele frequencies can drift apart by chance), or one population may have started with a different allele frequency by chance (founder effect) - any sensible alternative explanation **B1**

(g) Answer: For example, the two populations may be isolated from each other, so random chance (genetic drift) or the starting allele frequencies could differ, independent of camouflage.

(h) the process by which organisms with characteristics (e.g. shell pattern) best suited to their environment are more likely to survive and reproduce, passing those characteristics on to their offspring (oe, in context) **B1**

(h) Answer: The process by which the best-camouflaged (best-adapted) snails are more likely to survive, reproduce and pass on their shell-pattern allele.

(i) other factors could also affect the observed percentages, e.g. differences in predator density between the two sites, or migration of snails between habitats, which are not measured in this investigation (oe) **B1**

(i) so a difference in banding percentage alone does not prove that camouflage/predation (natural selection) is the cause, without ruling out these other factors **B1**

(i) Answer: Other factors, such as differences in predator numbers or migration between sites, could also explain the pattern; the data alone cannot rule these out as the true cause.

Question 8

(a) fewer crops are lost/damaged by pests, increasing crop yield **B1**

(a) less pesticide/insecticide needs to be sprayed on the crop, reducing costs and environmental impact **B1**

(a) Answer: GM pest-resistant crops lose less yield to pests and need less pesticide spraying, reducing costs and environmental impact.

(b) the introduced gene could be transferred to wild plant species (e.g. via pollen), possibly creating herbicide-resistant or otherwise problematic 'superweeds' **B1**

(b) some people have concerns about the long-term effects of eating GM crops on human health, or about the reduction in biodiversity from growing large areas of a single GM variety, or the cost of GM seed to farmers (any one further concern) **B1**

(b) Answer: For example, the modified gene could spread to wild plants, or there may be concerns about long-term health effects, reduced biodiversity, or seed cost.

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Question 9

Level 1 Simple statements are made for or against embryonic screening, with little reasoning and no real balance. **1-2**

Level 2 Points are made on both sides of the argument, with some reasoning or justification, though the discussion may be one-sided or lack a clear conclusion. **3-4**

Level 3 A balanced, well-reasoned evaluation is given, covering benefits and drawbacks with scientific and ethical reasoning, leading to a justified conclusion. **5-6**

Indicative content:

- Benefit: prevents parents passing on a serious genetic disorder to their child, reducing the child's future suffering
- Benefit: can reduce long-term emotional and financial strain on families and on healthcare services (e.g. NHS) from caring for a child with a severe genetic condition
- Benefit: gives parents who are known carriers the chance to have genetically related, unaffected children
- Drawback: the procedure (embryo biopsy, IVF) carries some risk and is expensive, and is not available to everyone
- Drawback: raises the ethical concern of 'designer babies' - screening could in principle be extended beyond serious disorders to select other, non-medical characteristics
- Drawback: some people view discarding embryos with a genetic disorder as ethically unacceptable, or as suggesting that people currently living with that disorder are less valued
- A balanced conclusion should weigh the reduction in suffering/cost against the ethical concerns and limited access, without necessarily coming down firmly on one side

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