Populations and the Hardy-Weinberg Principle: AQA A Level Biology Exa

14 questions · 26 marks · about 34 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · A level Paper 3 · June 2024 · Q06.1 · 2 marks

0 6 . 1 Define the biological term **population**.

[2 marks]

Question 2 · A level Paper 2 · June 2017 · Q09.1 · 1 mark

0 9 . 1 What is a gene pool?

[1 mark]

Question 3 · A level Paper 2 · June 2022 · Q06.4 · 1 mark

Scientists determined the frequencies of the ABO alleles and ABO phenotypes in a large population. They then used a statistical test to determine if the frequencies of the four phenotypes differed significantly from the frequencies expected according to the Hardy–Weinberg equation.

0 6 . 4 The frequencies of the I^A and I^O alleles were 0.15 and 0.65. What is the frequency of the I^B allele?

[1 mark]

Frequency of I^B allele _____

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Question 4 · A level Paper 2 · June 2022 · Q06.6 · 2 marks

0 6 . 6 The scientists concluded that the observed frequencies of the four phenotypes differed significantly from the expected frequencies. Use your knowledge of the Hardy–Weinberg principle to suggest **two** reasons why.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

Question 5 · A level Paper 3 · June 2023 · Q06.6 · 2 marks

0 6 . 6 In mice, one type of autoimmune disease is inherited as a dominant allele. Would the Hardy–Weinberg principle hold true for a population of mice, some of which had this autoimmune disease?

Explain your answer.

[2 marks]

_____

_____

_____

_____

_____

_____

Section B

Answer **one** question.

You are advised to spend no more than 45 minutes on this section.

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0 5 Cleft lip and palate (CLP) is a split in the upper lip and/or the roof of the mouth. CLP is present from birth.

CLP can be caused by various genetic and environmental factors.

CDH1 is a gene involved in lip and mouth development in a fetus before a baby is born.

Scientists hypothesised that CLP is caused by a 'two-hit' model:

- a 'genetic hit' through loss of *CDH1* function
- an 'environmental hit' leading to *CDH1* methylation caused when inflammation affects a fetus.

Inflammation can result from the mother having an infection or diabetes.

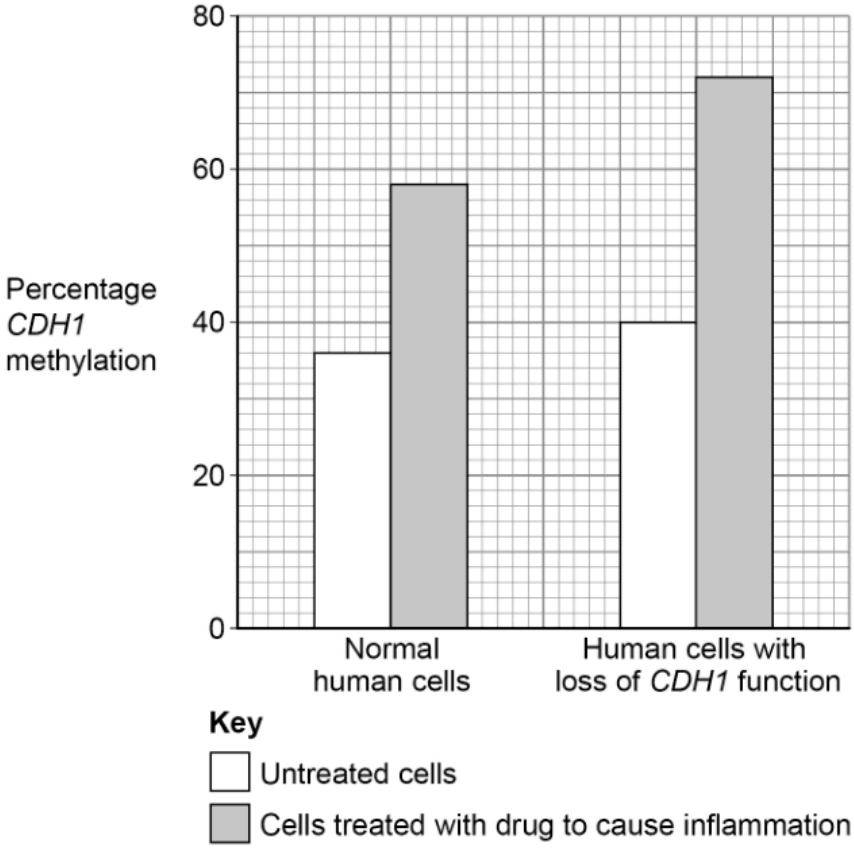
Scientists investigated the 'two-hit' model using human cells grown *in vitro*.

They:

- grew normal cells and cells with a loss of *CDH1* function
- treated some of each type of cell with a drug to cause inflammation and left some of each type of cell untreated
- measured the percentage *CDH1* methylation of the cells.

Figure 4 shows the scientists' results.

Figure 4



0 5 . 1 The frequency of live births with CLP is 1 in 700

Despite knowing this frequency, the Hardy–Weinberg equation **cannot** be used to estimate **any** allele frequencies for CLP.

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Question 7 · A level Paper 2 · June 2019 · Q06.5 · 2 marks

0 6 . 5 A population of fruit flies contained 64% grey-bodied flies. Use the Hardy–Weinberg equation to calculate the percentage of flies heterozygous for gene **G**.

[2 marks]

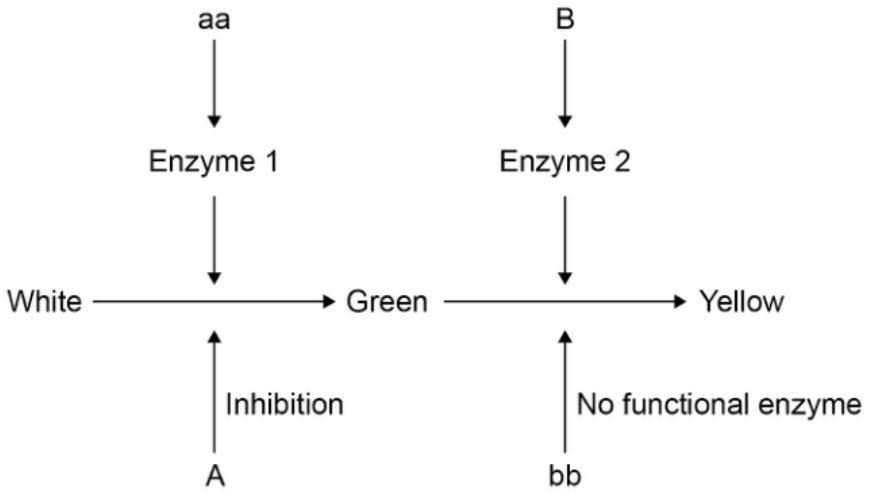
Answer = _____ %

Question 8 · information from earlier in the question

0 7 . 2 The inheritance of fruit colour in summer squash plants is controlled by two genes, **A** and **B**. Each gene has two alleles.

Figure 7 shows the interaction of these two genes in controlling fruit colour in summer squash plants.

Figure 7



Name the type of gene interaction shown in **Figure 7**.

[1 mark]

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Question 8 · A level Paper 2 · June 2017 · Q07.5 · 2 marks

0 7 . 5 A population of summer squash plants produced only green and yellow fruit. The percentage of plants producing yellow fruit in this population was 36%.

Use the Hardy–Weinberg equation to calculate the percentage of plants that were heterozygous for gene **B**.

[2 marks]

Answer = _____ %

Question 9 · A level Paper 2 · June 2024 · Q04.3 · 2 marks

0 4 . 3 A population of fruit flies contained 19% grey-bodied flies.

Use the Hardy–Weinberg equation to calculate the percentage of flies heterozygous for gene **G**.

Show your working.

[2 marks]

Answer _____ %

Question 10 · information from earlier in the question

0 4 In cats, males are XY and females are XX. A gene on the X chromosome controls fur colour in cats. The allele **G** codes for ginger fur and the allele **B** codes for black fur. These alleles are codominant. Heterozygous females have ginger and black patches of fur and their phenotype is described as tortoiseshell female.

The two alleles, **F** and **f** of a different gene, which is **not** sex-linked, interact with the gene controlling fur colour. The allele **F** is dominant and stops the formation of pigment in the fur, resulting in white fur. The allele **f** is recessive and has no effect on fur colour.

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Question 10 · A level Paper 2 · June 2023 · Q04.4 · 2 marks

0 4 . 4 In a population, 36% of cats had the **F** allele and had white fur.

Use the Hardy–Weinberg equation to calculate the frequency of the **f** allele in this population.

Show your working.

[2 marks]

Answer _____

Question 11 · information from earlier in the question

In a species of flowering plant, the **T** allele for tallness is dominant to the **t** allele for dwarfness. In the same species, two alleles $\mathbf{C^R}$ (red) and $\mathbf{C^W}$ (white) code for the colour of flowers. When homozygous red-flowered plants were crossed with homozygous white-flowered plants, all the offspring had pink flowers.

Question 11 · A level Paper 2 · November 2020 · Q06.4 · 2 marks

0 6 . 4 A population of this species of plant contained 9% of red-flowered plants.

Use the Hardy–Weinberg equation to calculate the percentage of pink-flowered plants in this population.

Show your working.

[2 marks]

Answer _____ %

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Question 12 · A level Paper 3 · November 2021 · Q01.1 · 2 marks

0 1 In one species of squirrel, *Sciurus carolinensis*, fur colour is controlled by one gene, with two codominant alleles. C^G represents the allele for grey fur colour, and C^B represents the allele for black fur colour.

Table 1 shows the three possible phenotypes.

Table 1

Genotype	Phenotype
C^GC^G	Grey fur
C^GC^B	Brown-black fur
C^BC^B	Black fur

0 1 . 1 In a population of 34 *S. carolinensis*, 2 had black fur.

Use the Hardy–Weinberg equation to estimate how many squirrels in this population had brown-black fur. Show your working.

[2 marks]

Answer _____

Question 13 · A level Paper 3 · November 2021 · Q01.2 · 1 mark

0 1 . 2 The actual number of squirrels in this population that had brown-black fur was 16.

Use all of the information to calculate the **actual** frequency of the C^G allele.

Do **not** use the Hardy–Weinberg equation in your calculation.

Give your answer to 2 decimal places.

[1 mark]

Answer _____

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Question 14 · information from earlier in the question

0 5 Leigh syndrome (LS) is a rare, recessive, inherited condition.

LS is caused by a mutation in any one of more than 75 different genes coding for proteins involved in oxidative phosphorylation.

In 80% of people with LS, these mutations occur in nuclear DNA. In 20% of people with LS, these mutations occur in mitochondrial DNA (mtDNA).

15% of the nuclear DNA mutations that cause LS occur in the *SURF1* gene. A mutated *SURF1* gene codes for a shorter polypeptide than a non-mutated *SURF1* gene.

Question 14 · A level Paper 3 · June 2024 · Q05.2 · 3 marks

Globally, the frequency of LS is 1 in 40 000

In the Faroe Islands, which are 18 isolated islands, the frequency of LS is 1 in 1700

0 5 . 2 The population of the Faroe Islands is 49 053

Estimate the number of people in the Faroe Islands with LS caused by a mutation in the *SURF1* gene.

Use information in this question and the information on page 12.

Give your answer to the nearest whole number.

Show your working.

[3 marks]

Answer _____ people

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Mark schemes

Question 1 · A level Paper 3 · June 2024 · Q06.1 · 2 marks

06.1	1. A group (of organisms) of the same species in a (particular) space at a (particular) time; 2. That can (potentially) interbreed;

2 (2 x AO1)	1. Accept descriptions of 'space' eg area, part of the world, habitat, ecosystem 2. Accept that can produce fertile offspring

Question 2 · A level Paper 2 · June 2017 · Q09.1 · 1 mark

09.1	All the <u>alleles</u> in a population;	1	Accept: The number of alleles in a population. Note: All or number of <u>alleles</u> in a species on its own is not enough on its own.

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Question 3 · A level Paper 2 · June 2022 · Q06.4 · 1 mark

06.4	0.2 **OR** 0.20;	1 (AO2)

Question 4 · A level Paper 2 · June 2022 · Q06.6 · 2 marks

06.6	1. Selection (against/for a blood group/phenotype/allele); 2. (High rate of) mutation; 3. Immigration/emigration; 4. No random mating.	2 max (2 x AO2)	1 to 4. Reject converse statements as context would be incorrect' Ignore births/deaths. 3. Accept 'migration' or population is not isolated. 4. Ignore no 'random fertilisation'.

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06.6	**No – no mark** 1. Mice with autoimmune disease will be unlikely to reproduce/survive **OR** Mice with autoimmune disease will be selected against; 2. Will not pass on allele (for autoimmune disease) **OR** Allele frequency (for autoimmune disease) will reduce/change; **Yes – no mark** 3. As long as the autoimmune disease did not affect the mice's ability to reproduce/survive; 4. The allele frequency will remain constant/not change;	2 max (2 x AO2)

Award as mark points 1 and 2, **OR** 3 and 4

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Question 6 · A level Paper 3 · June 2025 · Q05.1 · 2 marks

05.1	1. Not caused by one gene; 2. (Hardy-Weinberg) cannot predict (the effect of) environmental factors **OR** Environmental factors involved; 3. (Various genetic factors suggests) mutations occur; 4. Human populations migrate/emigrate/ immigrate;	2 max (2 x AO2)

Ignore any references to random mating

1. Ignore ideas relating to not knowing about dominant/ recessive
2. Accept 'methylation/ epigenetic factors' for 'environmental factors'
4. Accept descriptions of human migration
4. Accept human populations are not isolated
4. Ignore population size changes due to births/deaths

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Question 7 · A level Paper 2 · June 2019 · Q06.5 · 2 marks

06.5	1. Correct answer of 48% = **2 marks**;; 2. Incorrect answer but shows understanding that 2pq = heterozygous/carriers = **1 mark** **OR** Incorrect answer but shows understanding that $1 - (p^2 + q^2)$ = heterozygous/carriers = **1 mark**;	2

1. Accept 0.48 for 1 mark. 2. Accept understanding of 2pq by using a calculation involving 2 x two different numbers.

Question 8 · A level Paper 2 · June 2017 · Q07.5 · 2 marks

07.5	1. Correct answer of 32% = **2 marks**;; 2. Incorrect answer but shows understanding that 2pq = heterozygous/carriers = 1 mark;

2	2. Accept: understanding of 2pq by using a calculation involving 2 x two different numbers.

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Question 9 · A level Paper 2 · June 2024 · Q04.3 · 2 marks

04.3	1. Correct answer of 18 (%) = **2 marks**;; 2. Incorrect answer but shows understanding that 2pq = heterozygous/carriers = **1 mark** **OR** Incorrect answer but shows understanding that $1 - (p^2 + q^2)$ = heterozygous/carriers = **1 mark**;	2 (2 x AO2)

1. Accept 0.18 for **one mark**.
2. Accept understanding of 2pq by using a calculation involving 2 x two different numbers.

Question 10 · A level Paper 2 · June 2023 · Q04.4 · 2 marks

04.4	Correct answer of 0.8 = **2 marks**;; Incorrect answer but shows ff/q^2 = 0.64 = **1 mark** **OR** Incorrect answer but shows ff/q^2 = 64% = **1 mark;**	2 (2 x AO2)	Accept answer of 80% for **2 marks.**

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Question 11 · A level Paper 2 · November 2020 · Q06.4 · 2 marks

06.4	1. Correct answer of 42% = **2 marks**;; 2. Incorrect answer but shows understanding that 2pq = pink/heterozygous/carriers = **1 mark** **OR** Answer = 0.42 = **1 mark** **OR** Answer = 16.38 / 16.4 = **1 mark**;	2	1. Accept: 0.42 for 1 mark. 2. Accept $1 - (p^2 + q^2)$ for 2pq or equivalent using numbers. 2. Accept: understanding of 2pq by using a calculation involving 2 × two different numbers.

Question 12 · A level Paper 3 · November 2021 · Q01.1 · 2 marks

01.1	1. Answer of 12/13 = **2 marks**;; 2. 0.36(48)/0.365/0.37 **= 1 mark** **OR** 36(.48)/36.5/37% = **1 mark** **OR** q^2= 0.06/0.059/0.0588 = **1 mark** **OR** or q = 0.2/0.24/0.243 = **1 mark;**	2	For 1 mark accept q^2 = 6%/5.9%/5.88%

Question 13 · A level Paper 3 · November 2021 · Q01.2 · 1 mark

01.2	0.71	1

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05.2	Correct answer of 3 (people) = **3 marks**;;; 3.462564706/3.48/3.45 (or any correct rounding down to 1dp) = **2 marks** (answer not to the nearest whole number) 23 = **2 marks** (number of Faroe Islanders with nuclear mutations) 4 = **2 marks** (not factored in that only 80% of mutations are in nuclear DNA) 29 = **1 mark** (number of Faroe Islanders with LS)	3 (3 x AO2)

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