Genetic Diversity and Adaptation: AQA A Level Biology Exam Questions

18 questions · 52 marks · about 68 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · AS Paper 2 · June 2023 · Q06.3 · 4 marks

0 6 . 3 Mammals feed their young on milk. CEL digests the triglycerides in milk. The ability to produce CEL occurred due to a gene mutation.

Describe how natural selection may have led to all mammals in a population producing CEL.

[4 marks]

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Question 2 · A level Paper 2 · June 2018 · Q09.1 · 4 marks

0 9 Lactose is the main sugar in milk and is hydrolysed by the enzyme lactase. Lactase is essential to newborn mammals as milk is their only source of food. Most mammals stop producing lactase when they start feeding on other food sources. Humans are an exception to this because some continue to produce lactase as adults. The ability to continue producing lactase is known as lactase persistence (LP) and is controlled by a dominant allele. A number of hypotheses based on different selection pressures have been put forward to explain LP in humans.

0 9 . 1 One hypothesis for LP in humans suggests that the selective pressure was related to some human populations farming cattle as a source of milk.

Describe how farming cattle as a source of milk could have led to an increase in LP.

[4 marks]

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Question 3 · AS Paper 2 · June 2017 · Q03.3 · 3 marks

0 3 . 3 Multiple copies of the *AMY1* gene is an adaptation to a high-starch diet.

Suggest how this evolved through natural selection.

[3 marks]

[Extra space]

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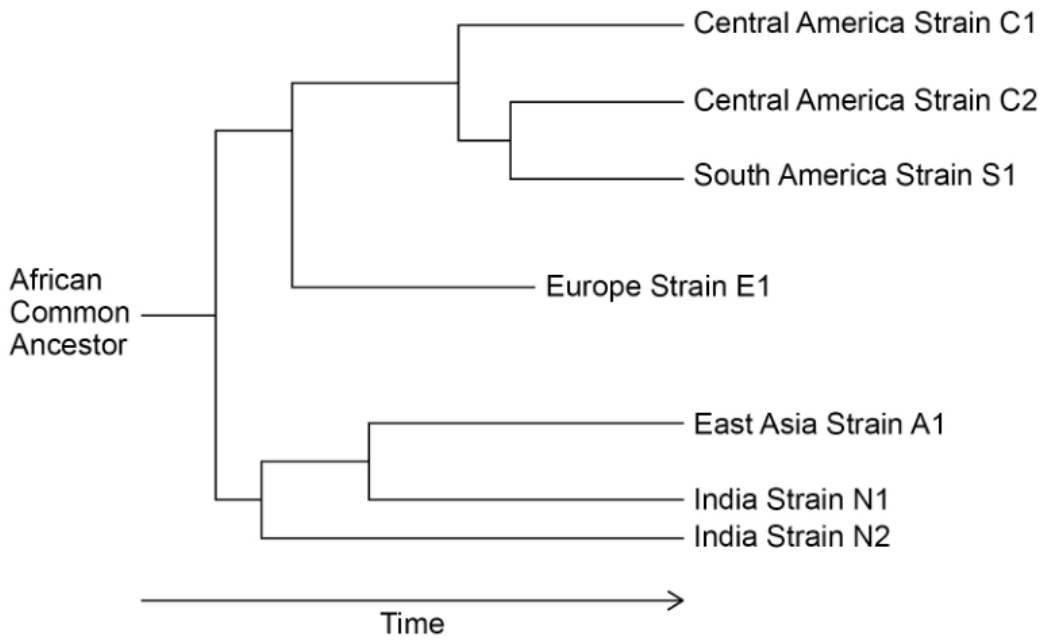
Question 4 · information from earlier in the question

P. vivax evolved from a common ancestor in Africa. As humans migrated around the world, new strains of *P. vivax* evolved.

P. vivax is now extremely rare in Africa but there are several different strains of *P. vivax* in other parts of the world.

Figure 3 shows a phylogenetic diagram of the evolution of these different strains.

Figure 3



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Question 4 · A level Paper 1 · June 2023 · Q03.5 · 4 marks

0 3 . 5 In Africa today, most of the human population are resistant to malaria caused by *P. vivax*.

Use your knowledge of natural selection to explain why this resistance is so common in Africa.

[4 marks]

Question 5 · information from earlier in the question

0 6 The fruit fly is a species of small insect.

The fruit fly has a gene that codes for an enzyme called alcohol dehydrogenase (AD). AD catalyses the breakdown of alcohol when alcohol is in the insects' food.

The gene coding for AD has two alleles, $\mathbf{AD^F}$ and $\mathbf{AD^S}$.

A scientist took a random sample of adult fruit flies from a population. He measured the frequency of the $\mathbf{AD^F}$ allele in this sample (generation 0). He then:

- selected 100 of these insects at random and kept them in a container
- fed the insects food containing alcohol
- let the insects reproduce
- repeated these steps for 45 generations of fruit fly reproduction.

The scientist measured the frequency of the $\mathbf{AD^F}$ allele in the 45th generation.

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Table 2 shows the scientist's results.

Table 2

Generation of fruit fly reproduction	Frequency of AD^F
0	0.20
45	0.74

0 6 . 3 Alcohol is toxic to fruit flies. Suggest and explain why the frequency of the **AD^F** allele changed during the 45 generations.

[4 marks]

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Question 6 · AS Paper 1 · June 2025 · Q09.1 · 1 mark

0 9 Read the following passage.

Penicillin-resistant *Staphylococcus aureus* (PRSA) bacteria have evolved by natural selection. From 1941, penicillin was used extensively to treat *S. aureus* infections. The first case of PRSA was reported in 1942. By the late 1960s, more than 80% of *S. aureus* bacteria were resistant to penicillin.

Many antibiotics have a beta-lactam ring in their chemical structure, which inhibits the synthesis of bacterial cell walls. PRSA have an allele of a gene *blaZ* that codes for an enzyme called beta lactamase. This enzyme hydrolyses beta-lactam rings in antibiotics such as penicillin.

The evolution of PRSA resulted in the development of new antibiotics, such as methicillin in 1960. However, by 1961, methicillin-resistant *S. aureus* (MRSA) were identified. In 2022, 675 cases of MRSA were reported in England. However, in 2023, the number of cases of MRSA rose to 787. Patients in hospitals are at greater risk of MRSA infections than the general population.

Use the information in the passage and your own knowledge to answer the following questions.

0 9 . 1 Penicillin-resistant *Staphylococcus aureus* (PRSA) have evolved by natural selection (lines 1–2).

Name the type of natural selection.

[1 mark]

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Question 7 · AS Paper 1 · June 2025 · Q09.2 · 3 marks

0 9 . 2 By the late 1960s, more than 80% of *S. aureus* were resistant to penicillin (lines 3–4).

Explain why.

[3 marks]

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Question 8 · A level Paper 1 · June 2022 · Q02.1 · 3 marks

0 2 . 1 *Clostridium difficile* is a bacterial species that causes disease in humans.

Antibiotic-resistant strains of *C. difficile* have become a common cause of infection acquired when in hospital.

Explain how the use of antibiotics has led to antibiotic-resistant strains of bacteria becoming a common cause of infection acquired when in hospital.

[3 marks]

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0 8 . 4 On some farms, animals are routinely given antibiotics in their food.

Scientists investigated whether these farm animals had antibiotic-resistant bacteria in their intestines. They tested the bacteria for resistance to two antibiotics, tetracycline and streptomycin.

Their results are shown in **Table 5**.

Table 5

Antibiotic	Percentage of antibiotic-resistant bacteria
Tetracycline	29
Streptomycin	13

Suggest and explain **one** reason why bacteria resistant to tetracycline are more common than bacteria resistant to streptomycin in these farm animals.

[2 marks]

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Question 10 · AS Paper 2 · June 2018 · Q08.5 · 1 mark

0 8 . 5 In recent years, these farm animals have not been given tetracycline in their food. Despite this, the percentage of bacteria resistant to tetracycline has remained constant.

Suggest **one** reason why.

[1 mark]

Question 11 · information from earlier in the question

0 5 Scientists investigated treatment of a human bladder infection caused by a species of bacterium. This species of bacterium is often resistant to the antibiotics currently used for treatment.

They investigated the use of a new antibiotic to treat the bladder infection. The new antibiotic inhibits the bacterial ATP synthase enzyme.

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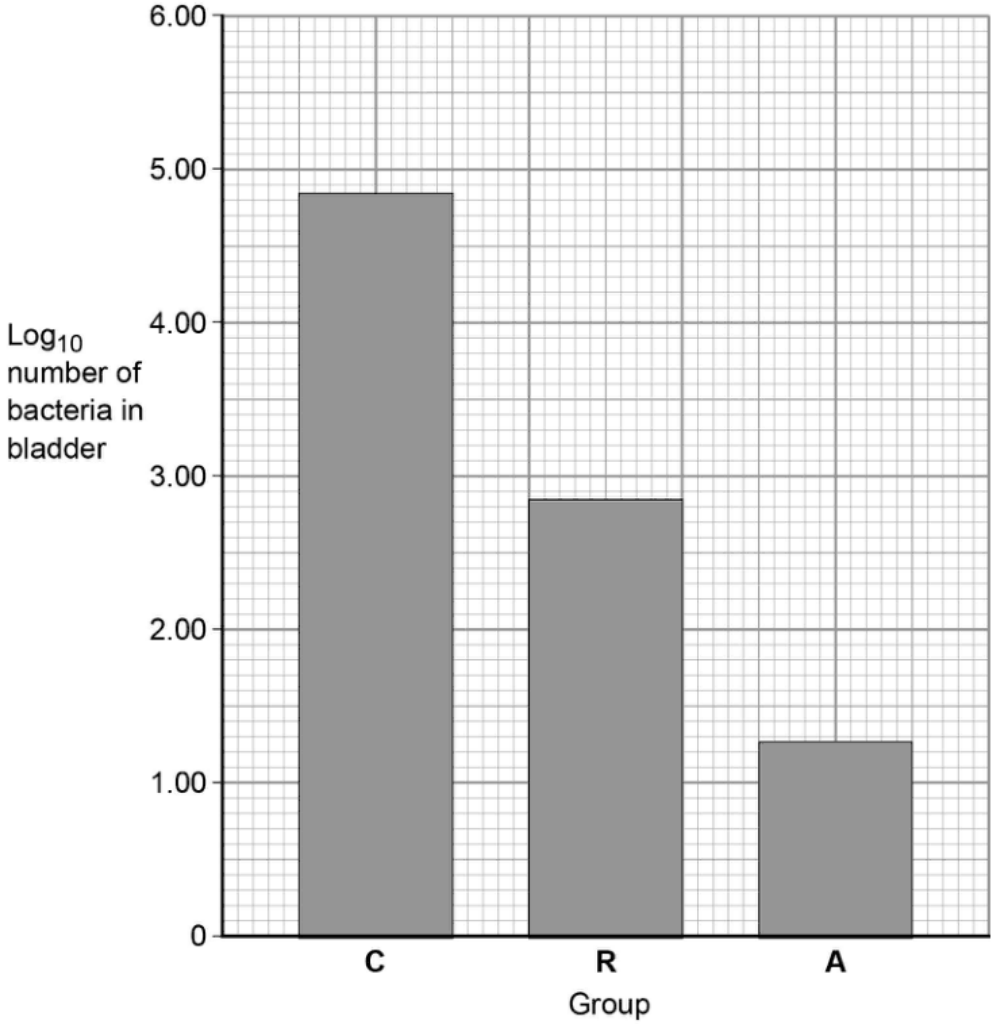
0 5 . 3 The scientists tested the new antibiotic on mice with the same bladder infection. They divided these mice into three groups, **C**, **R** and **A**.

- Group **C** was the control (untreated).
- Group **R** was treated with an antibiotic currently used against this bladder infection.
- Group **A** was treated with the new antibiotic.

They removed samples from the bladder of these mice after treatment and estimated the total number of bacteria in the bladder.

Their results are shown in **Figure 2**.

Figure 2



The antibiotics were given to the mice at a dose of 25 mg kg^{-1} per day.

Calculate how much antibiotic would be given to a 30 g mouse each day.

Show your working.

[2 marks]

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Question 11 · A level Paper 1 · June 2017 · Q05.5 · 3 marks

0 5 . 5 The scientists suggested that people newly diagnosed with this bladder infection should be treated with both the current antibiotic and the new antibiotic.

Explain why the scientists made this suggestion.

Use information from **Figure 2** and your knowledge of evolution of antibiotic resistance in bacteria in your answer.

[3 marks]

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0 7 Scientists investigated changes in the mass of fish from three populations of the same species. The fish they used had a life cycle of one year.

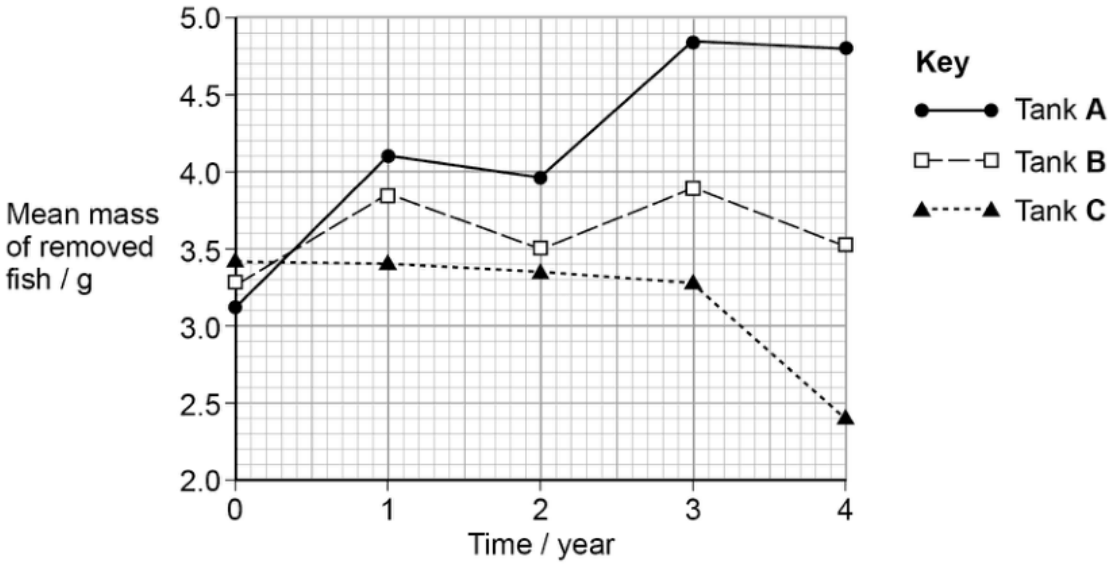
The scientists set up three fish tanks, each containing a separate population. Each year the scientists removed all the fish from each tank and determined the mean mass of the fish removed. They then put back 10% of each population in the following way.

Tank **A** – put back only the largest fish.
Tank **B** – put back fish at random.
Tank **C** – put back only the smallest fish.

During each year the fish were left to grow and reproduce.

The scientists' results are shown in **Figure 8**.

Figure 8



0 7 . 1 What type of selection were the scientists modelling in this investigation by putting back only the largest or only the smallest fish in Tank **A** and Tank **C**? Give a reason why.

[2 marks]

Type of selection _____

Reason _____

_____

_____

_____

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Question 13 · AS Paper 2 · June 2019 · Q07.4 · 3 marks

0 7 . 4 Sea fishing is regulated in law. The size of the mesh used in some fishing nets is controlled so that small fish can escape but large fish are captured. This regulation is designed to protect populations of wild fish.

Using all the information in this question, evaluate whether the scientists' investigation supports the use of these types of nets in sea fishing.

[3 marks]

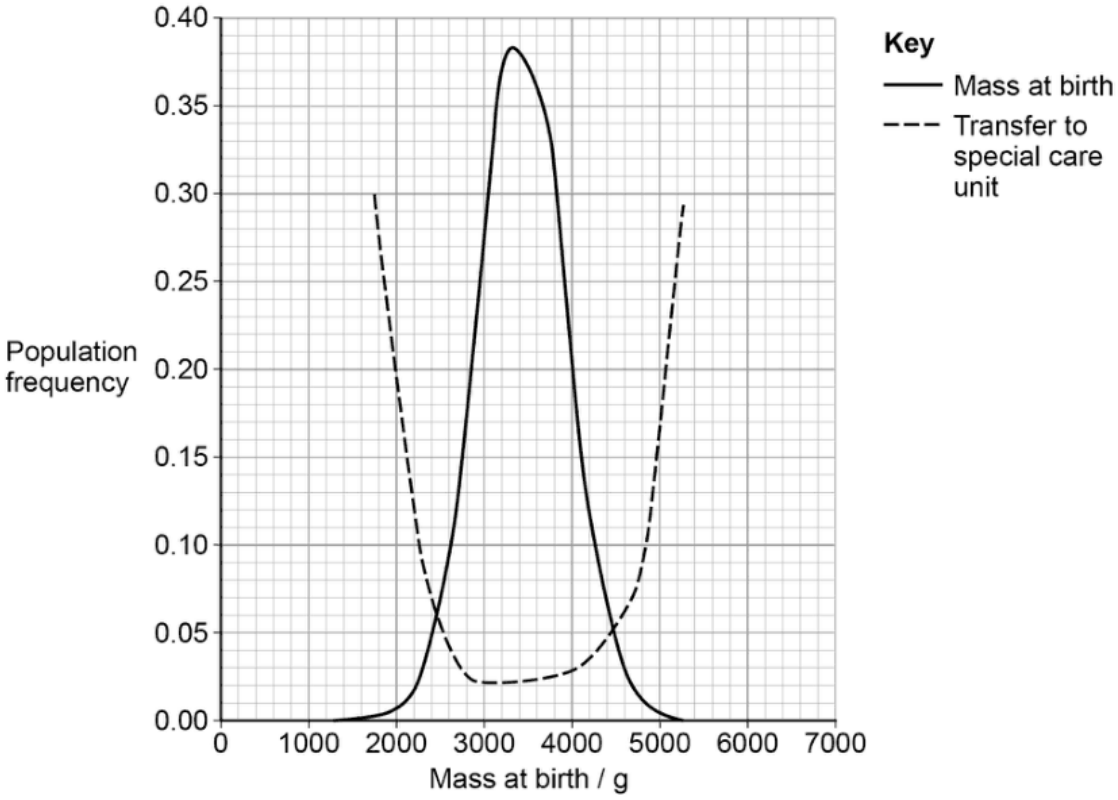
[Extra space]

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0 4 Scientists collected data on 800 000 human births. The data showed the mass of each baby at birth and whether the baby needed to be transferred to a special care unit for very ill babies.

Their results are shown in **Figure 5**.

Figure 5



0 4 . 1 Use **Figure 5** to explain how human mass at birth is affected by stabilising selection.

[3 marks]

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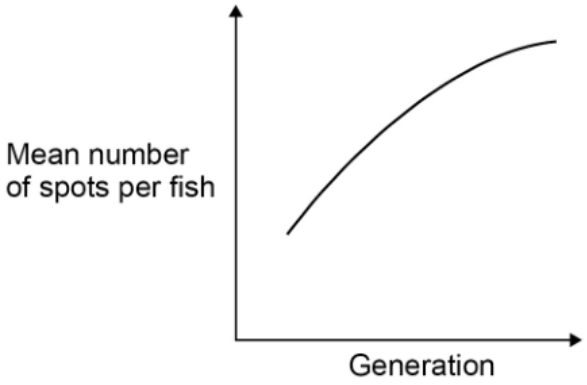
Question 15 · information from earlier in the question

0 8 Guppies are small fish with brightly coloured spots on their body.
The number of spots on a guppy is controlled by genes.

A scientist investigated guppy breeding in a large population of guppies in a fish tank.
The fish tank contained brightly coloured stones. After each generation of breeding, she counted the number of spots on every guppy.

Figure 9 shows her results.

Figure 9

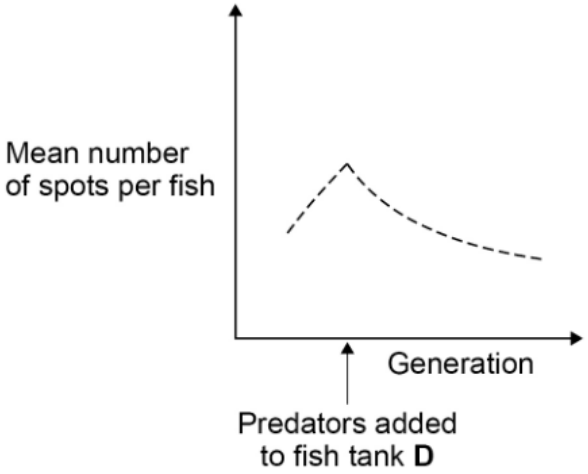


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0 8 . 3 The scientist repeated the investigation of guppy breeding in an identical fish tank, but added predators of the guppies into the fish tank at the fourth generation of breeding.

Figure 10 shows her results.

Figure 10



Name the type of selection the scientist investigated in this fish tank.

Explain why this selection affected the frequency of alleles in the population of guppies in this fish tank.

[4 marks]

Type of selection _____

_____

Explanation _____

_____

_____

_____

_____

_____

_____

_____

_____

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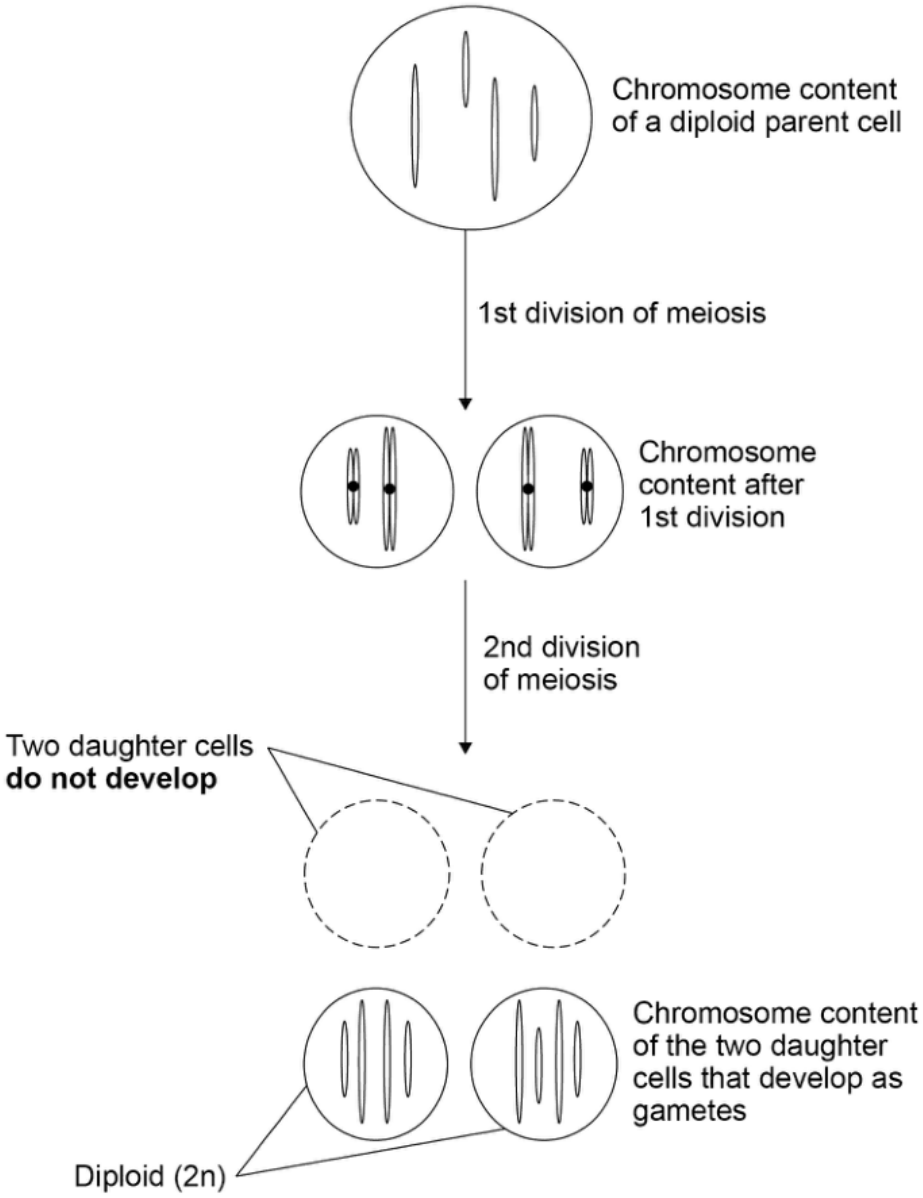
_____

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Question 16 · information from earlier in the question

0 6 **Figure 6** shows a faulty form of meiosis that can occur in some plants.

Figure 6



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0 6 . 2 If two diploid (2n) gametes fuse at fertilisation, it can result in the growth of a tetraploid plant which has 4 copies of each chromosome.
Red clover is a plant grown to produce cattle feed. Tetraploid red clover plants produce a higher yield than diploid red clover plants.
Whether a red clover plant produces 2n gametes is genetically controlled.

Scientists investigated the possibility of breeding red clover plants that only produced 2n gametes.

- In breeding cycle 0, they grew red clover plants and identified plants that produced 2n gametes.
- In breeding cycle 1, they used the plants producing 2n gametes to produce offspring.
- In breeding cycles 2 and 3, they identified plants producing 2n gametes and used these to produce offspring.

Their results are shown in **Table 3**.

Table 3

	Observed		**Expected**	
Breeding cycle	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes
0	50	4	50	4
1	14	42	……..	……..
2	2	44		
3	0	56		

The scientists used the following null hypothesis.

'The proportion of plants that produce 2n gametes will not change from one breeding cycle to the next.'

Complete **Table 3** to show the **expected number** of plants that **did not** produce 2n gametes and the expected number of plants that **did** produce 2n gametes after 1 cycle.
Give each answer to the nearest whole number.

[2 marks]

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Question 16 · A level Paper 1 · June 2018 · Q06.4 · 3 marks

0 6 . 4 Use your knowledge of directional selection to explain the results shown in **Table 3**.

[3 marks]

[Extra space]

Question 17 · AS Paper 2 · June 2016 · Q07.3 · 2 marks

0 7 . 3 The frequency of the *CCR5* mutation is highest in Europe. Scientists have collected data on the history and number of HIV infections in Europe. Using these data, scientists have concluded that the high frequency of the *CCR5* mutation is not due to natural selection in response to HIV.

Suggest **two** reasons why scientists reached this conclusion.

[2 marks]

1

2

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Question 18 · information from earlier in the question

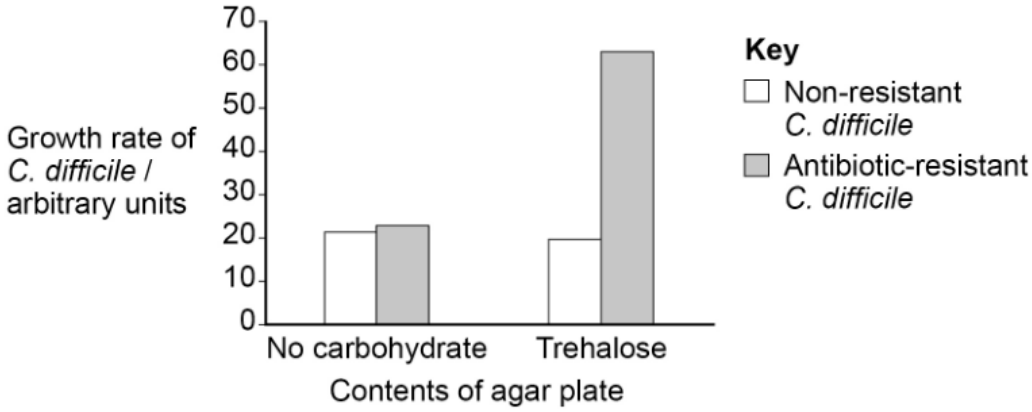
Scientists investigated the effect of trehalose on the growth rate of *C. difficile*. They grew populations of non-resistant and antibiotic-resistant *C. difficile* on separate agar plates with:

- no carbohydrate added
- trehalose added.

They measured the growth rate of the *C. difficile*.

Figure 2 shows the scientists' results.

Figure 2



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Question 18 · A level Paper 1 · June 2022 · Q02.4 · 3 marks

0 2 . 4 Use **Figure 2** to evaluate whether more trehalose in the diet could be a factor in the increased number of antibiotic-resistant *C. difficile* infections.

[3 marks]

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Mark schemes

Question 1 · AS Paper 2 · June 2023 · Q06.3 · 4 marks

06.3	1. Mutation results in (a new) allele; 2. Those with the (new) allele able to digest milk/triglycerides; 3. Individuals with CEL/allele more likely to (survive and) reproduce; 4. Directional selection; 5. Increase in frequency of (this) allele in population;	4 max (4 x AO2)

Allow ECF for use of gene rather than allele after not awarding mark in the first instance but **max 3** overall.

3. Accept 'pass on allele/characteristic' for reproduce

5. Accept description of increasing frequency, eg 'more common', 'higher proportion' but ignore increase in number of allele

2. 3. 5. Accept 'mutation' for allele

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09.1	1. LP due to mutation **OR** Allele due to mutation; 2. Milk provides named nutrient; 3. Individuals with LP more likely to survive **and** reproduce **OR** Individuals with advantageous allele more likely to survive **and** reproduce; 4. Directional selection; 5. Frequency of allele increases (in the offspring/next generation);	4 max

1. Reject mutation caused by drinking milk.

2. Accept any correct named nutrient e.g. glucose, galactose, protein

2. Ignore 'sugar' 'lactose' as named nutrient

1. and 3. Reject (LP) gene

3. Accept 'individuals who produce lactase' for 'LP individuals'

3. Accept 'pass on allele/LP/characteristic' for reproduce.

5. Accept description of increasing frequency of allele e.g.

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03.3	1. Mutation(s) produce extra copies of (*AMY1*) gene; 2. Those with more copies / this adaptation/mutation reproduce / survive better on high starch diet; 3. And pass on multiple copies / this adaptation/mutation (to offspring);	3	3. Ignore ref. to single allele/gene

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03.5	1. Mutation produced <u>allele</u>; 2. Those with allele/resistance less likely to/do not get malaria/*P vivax* **OR** Those with allele/resistance survive malaria/*P vivax*; 3. (So more likely to) reproduce and pass on the allele; 4. (Over generations) allele frequency increases;

4 (2 x AO1, 2 x AO2)	Reject gene for allele only once 1. Reject 'mutation caused by infection/exposure to *P. vivax'*. 2. Accept converse; eg 'people lacking the allele die from malaria' 4. Accept description of increasing frequency of allele eg 'higher proportion', 'more common' but 'ignore increase in **number** of allele'

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Question 5 · AS Paper 2 · November 2021 · Q06.3 · 4 marks

06.3	1. Flies with AD^F/allele have selective advantage (in presence of alcohol); 2. So insects (with AD^F more likely to) reproduce; 3. Pass on AD^F (allele/gene); 4. (So) allele frequency increases;	4	Accept converse for AD^S 1. Accept description of selective advantage

Question 6 · AS Paper 1 · June 2025 · Q09.1 · 1 mark

09.1	Directional;	1 (1 x AO1)

Question 7 · AS Paper 1 · June 2025 · Q09.2 · 3 marks

09.2	1. (Use of) penicillin/antibiotic creates selection pressure **OR** Penicillin/antibiotic kills susceptible/non-resistant *S. aureus*/bacteria; 2. (Resistant *S. aureus*/bacteria) are more likely to survive **and** reproduce to pass on *blaZ*/penicillin-resistance/beta lactamase allele; 3. Increased frequency of (*blaZ)* allele (in s offspring/next generation);	3 (1 x AO1, 2 x AO2)

2 and 3. Reject '*gene*' for '*allele*' once

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Question 8 · A level Paper 1 · June 2022 · Q02.1 · 3 marks

02.1	1. (Some bacteria have) alleles for resistance; 2. (Exposure to) antibiotics is the selection pressure **OR** Non-resistant bacteria die **OR** Resistant bacteria survive/reproduce; 3. More antibiotics used in hospital (compared with elsewhere) **OR** Patients have weakened immune systems **OR** (So) high frequency of resistance allele (in bacterial population);	3 (3 x AO1)

1 and 2 Reject reference to immunity only once

1. and 3. Accept gene for allele

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08.4	1. Tetracycline used more often / in higher doses; 2. Resistant bacteria more likely to (survive and reproduce and) pass on allele/gene for (tetracycline) resistance; OR 3. More / higher frequency of mutations (for tetracycline resistance); 4. (so) gene passed on to more bacteria; OR 5. Tetracycline used over longer time period; 6. More time for (chance) mutation to occur / for selection to occur;

2	Ignore reference to resistant animals Ignore reference to immunity 3. Reject reference to mutation being caused by use of antibiotic

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Question 10 · AS Paper 2 · June 2018 · Q08.5 · 1 mark

08.5	No selection against resistant bacteria / resistance gene/allele; OR Bacteria pass on (resistance) gene / allele when they reproduce; OR Bacteria resistant to tetracycline are passed on from one generation of farm animals to the next (probably via faeces); OR Environment does not change, so stabilising selection occurs;	1	Accept no selection to get rid of it Reject reference to mitosis or immunity

Question 11 · A level Paper 1 · June 2017 · Q05.5 · 3 marks

5.5	1. (From Fig 2) New/old antibiotic does not kill all bacteria; **OR** (From Fig 2) Some bacteria are resistant to the new/old antibiotic; 2. Resistant bacteria will reproduce to produce (more) resistant bacteria; 3. (Use of both) one antibiotic will kill bacteria resistant to the other antibiotic; **OR** Unlikely that bacteria are resistant to both the new and the old antibiotic; **OR** Use of both antibiotics (likely to) kill all/most bacteria;	3	Accept use of '**A**' for 'new antibiotic' and '**R**' for 'old antibiotic'. 1. Must relate to the bacteria that are still present – 'some bacteria are killed' or 'the bacteria number is reduced' is insufficient. 2. Accept 'resistant bacteria reproduce to pass on resistance gene/allele' 3. 'Use of both antibiotics will be more effective' is insufficient.

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Question 12 · AS Paper 2 · June 2019 · Q07.1 · 2 marks

07.1	**Type of selection** 1. Directional; **Reason:** 2. One extreme selected/removed/favoured/ chosen **OR** One extreme allowed to breed;	2	2. Ignore references to adaptations/ natural selection 2. Accept large fish/small fish for 'extreme'

Question 13 · AS Paper 2 · June 2019 · Q07.4 · 3 marks

07.4	**Not supported because** 1. (Sea) fishing reduces (mean) mass of fish; 2. Because large fish removed **OR** Because small fish escape/put back **OR** Because fishing (model) like Tank C; **But** 3. Information from (only) one species **OR** Sea fishing catches other/different (types of) species; 4. No statistical test; 5. Size of tank may affect fish growth; 6. Fish in tanks are all same age/sea fish not all the same age; 7. No measure of number of fish (removed)/ only measured mean mass **OR** No measure of (total) yield of fish **OR** No measure of reproductive success of fish; 8. Removal of 90% of population is unlikely to be replicated in the sea fishing; 9. Sea fish do not have life cycle of one year **OR** Sea fish do not reproduce all at the same time;	3 max	2 max for "But"
TOTAL		**9**	

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Question 14 · A level Paper 1 · June 2019 · Q04.1 · 3 marks

4.1	1. (Most likely to be) transferred to a special care unit are those under 2800 g **OR** (Most likely to be) transferred to a special care unit are those over 4200 g; 2. Extreme mass babies least likely to survive (to reproduce) **and** so less likely to pass on their <u>alleles</u> (for extreme mass at birth); 3. Extreme mass at birth decreases in frequency (in the population) **OR** <u>Alleles</u> (for extreme mass at birth) decrease in frequency (in the population); If neither 1 or 2 awarded allow correct stated mass less/more likely to survive for 1 mark	3	Accept converse answers linked to those with mass at birth at any value between 2800 and 4200 g. 1. For '2800 g' accept any value between 1400 g and 2800 g. 1. For '4200 g' accept any value between 4200 g and 5200 g. 1. If values for both extremes are given, both must be correct. 1. Reject data quoted below 1400 g or above 5200 g. 3. Accept 'proportion/percentage' for 'frequency'. 3. Do not accept 'number' for 'frequency'.

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Question 15 · AS Paper 2 · June 2022 · Q08.3 · 4 marks

08.3	1. Directional; 2. Fish with more spots are more likely to be predated; 3. Alleles for (more) spots not passed on; 4. (So) frequency of (more) spots alleles decreases;	4 (4 x AO2)

2. 3. and 4. Accept converse

2. Accept killed/eaten for 'predated'

2. Accept more of them killed/eaten, for 'more likely'

3. and 4. Reject 'gene' once

4. Accept 'proportion' for frequency

Ignore 'number of alleles decreases'

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1. The scientists selected/used for breeding plants that produced 2n gametes;
2. (So these plants) passed on their alleles (for production of 2n gametes to the next generation);
3. The frequency of alleles for production of 2n gametes increased (in the population).

06.4

3	For 'production of 2n gametes' accept 'abnormal meiosis'. 1. Answer must be in context of the scientists selecting plants to breed. Accept 'artificial selection' or 'selectively bred'. 2 and 3. Both mark points can be awarded if one correct reference is made to alleles (in either context). 3. Do not accept 'number' for frequency. Accept converse answers linked to plants that produce n gametes.

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07.3	1. Low/lower exposure to HIV (in Europe) **OR** Low/lower number of HIV/AIDS (infections/cases); 2. (HIV) has only been present for a short time period **OR** (HIV relatively) recently evolved; 3. Mutation/CCR5 has been around for many years; 4. Mutation/CCR5 is advantageous (for something else);	2 max	1. Accept: converse. 3. Accept: frequency of mutation has always been high.

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02.4	**For** 1. Resistant bacteria grow faster with trehalose; 2. (So) resistant bacteria (likely to) increase in frequency in the population/people; 3. Resistant bacteria (likely to) outcompete non-resistant bacteria; **Against** 4. In laboratory not in people; 5. Other disaccharides (in the diet) might affect bacteria; 6. Other bacterial species (in the body) might affect bacteria; 7. No stats test to see if difference/increase is significant; 8. No data for both resistant and non-resistant bacteria growing together; 9. No data for different concentrations of trehalose;	3 max (3 x AO3)

Max 2 if only 'For' or only 'Against' marks

1, 2, 3 ,4 and 5 Accept *C. difficile*/strain for bacteria

2. Accept 'percentage/ proportion' for 'frequency'

5. Accept carbohydrate OR

polysaccharide OR

sugar, for disaccharide

7. Accept 'is not due

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