Helicate

HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.4.4 Genetic diversity and adaptation

Topic question bank

Version 1 · 9 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
10	70	No time limit	/ 70

Contents

Subtopic	Questions	Marks
Genetic diversity and natural selection Specification 3.4.4	01–03	19
Directional and stabilising selection Specification 3.4.4	04–06	19
Adaptation Specification 3.4.4	07–08	11
Required practical 6: antimicrobial substances Specification 3.4.4	09	15
Extended response: selection and adaptation Specification 3.4.4	10	6
Total		**70**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA AS and A-level Biology (7401/7402), specification section 3.4.4. Not affiliated with or endorsed by AQA.

Do not write outside the box

Genetic diversity and natural selection 3.4.4

0 1 . 1 What is meant by the genetic diversity of a population?
Tick (✓) one box.

[1 mark]

- The number of different genes in the population ☐
- The number of different alleles of genes in the population ☐
- The number of individuals in the population that carry a mutation ☐
- The number of different species in the community that includes the population ☐

Question 1 continues on the next page

Do not write outside the box

Scientists compared a crop variety of a cereal plant with a population of its closest wild relative. They took samples from 80 plants of each type and found the number of different alleles of six genes.

Table 1 shows their results.

Table 1

Plants sampled	Number of different alleles found for each gene					
	Gene A	Gene B	Gene C	Gene D	Gene E	Gene F
Wild relative	6	4	9	3	7	5
Crop variety	2	1	3	1	2	1

0 1 . 2 The scientists concluded that the wild relative has a greater genetic diversity than the crop variety.
Evaluate this conclusion.

[2 marks]

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0 1 . 3 Calculate the percentage decrease in the mean number of alleles per gene in the crop variety compared with the wild relative.
Give your answer to **one** decimal place.

[2 marks]

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Answer ..... **%**

Question 1 continues on the next page

Do not write outside the box

A new fungal disease has started to spread through fields of the crop variety.

0 1 . 4 Use Table 1 to explain why the crop variety is more likely to be wiped out by the fungal disease than the wild relative.

[3 marks]

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8

0 2 . 1 Which statement about mutation and natural selection is correct?
Tick (✓) one box.

[1 mark]

An antibiotic causes the mutations that make bacteria resistant to it. ☐

Mutations occur randomly, and only some new alleles benefit an organism in a particular environment. ☐

Organisms mutate in order to become adapted to a change in their environment. ☐

Most mutations produce new alleles that increase reproductive success. ☐

Question 2 continues on the next page

Do not write outside the box

A student wrote this description of antibiotic resistance.

"When bacteria are treated with an antibiotic, each bacterium gradually becomes immune to it. This happens because the antibiotic causes a mutation in the bacteria."

0 2 . 2 The description contains **three** errors.
For each error, give the correct information.

[3 marks]

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4

Turn over for the next question

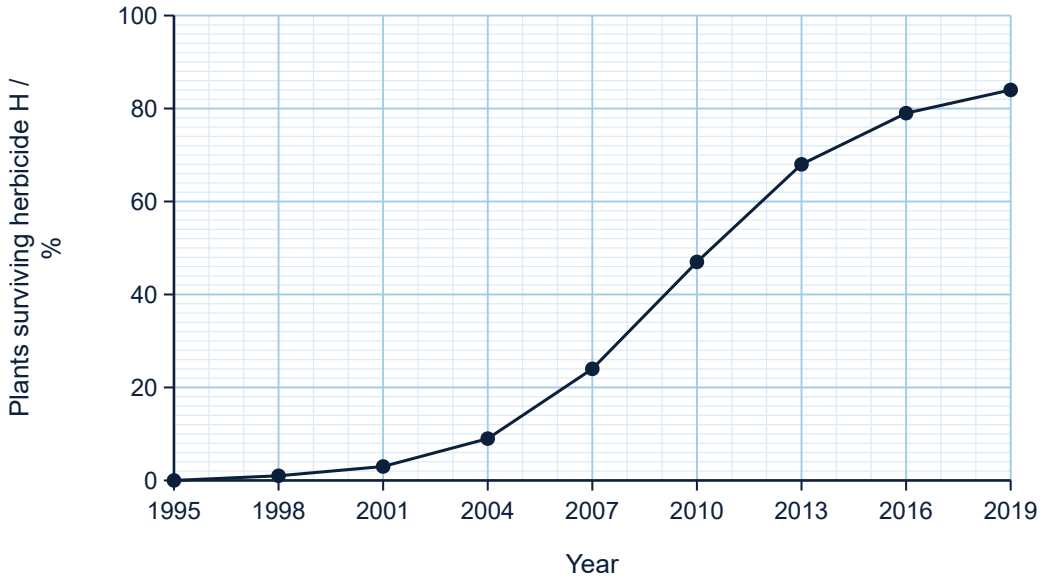
Do not write outside the box

Blackgrass is a weed that grows in wheat fields. Blackgrass plants complete their life cycle in one year.

From 1995, a farmer sprayed one field every year with herbicide H. Herbicide H kills plants by inhibiting enzyme **E**, an enzyme that is needed to make lipids. Some blackgrass plants now have an allele, $\mathbf{E^R}$, of the gene for enzyme **E**. The enzyme coded for by allele $\mathbf{E^R}$ is not inhibited by herbicide H.

Each year, scientists tested blackgrass plants grown from seeds collected in the field. Figure 1 shows the percentage of the plants that survived spraying with herbicide H.

Figure 1



0 3 . 1 In 2013, there were 3.5×10^4 blackgrass plants per hectare in the field.
Use Figure 1 to calculate the number of blackgrass plants per hectare that would survive spraying with herbicide H in 2013.
Give your answer in standard form.

[2 marks]

Answer ..... **plants per hectare**

Question 3 continues on the next page

Do not write outside the box

0 3 . 2 Before 1995, allele $\mathbf{E^R}$ was not present in the blackgrass population in this field. Explain the change shown in Figure 1. Use your knowledge of natural selection.

[4 marks]

0 3 . 3 Name the type of selection shown in Figure 1.

[1 mark]

7

Turn over for the next question

Do not write outside the box

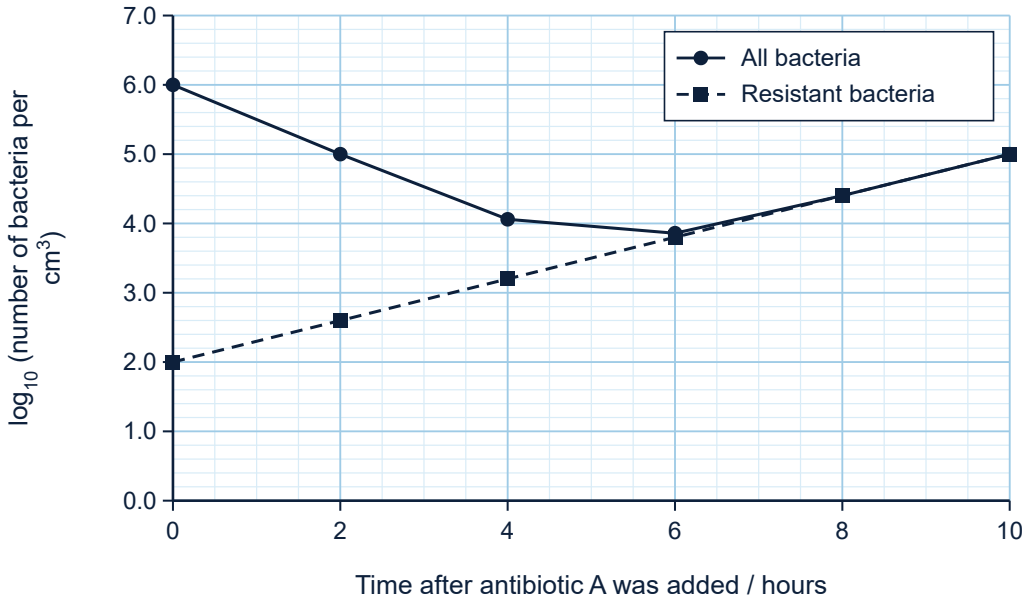
Directional and stabilising selection 3.4.4

Scientists added a culture of a bacterium to a flask of nutrient broth containing antibiotic A. Antibiotic A kills bacteria that are not resistant to it. At the start, a small number of the bacteria in the culture were already resistant to antibiotic A.

Every 2 hours, the scientists removed samples from the flask. They found the number of resistant bacteria per cm^3 and the total number of bacteria per cm^3.

Figure 2 shows their results. The numbers of bacteria are plotted as $\log_{10}$ values.

Figure 2



0 4 . 1 Use Figure 2 to calculate the percentage of the bacteria that were resistant to antibiotic A at the start.

[2 marks]

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Answer ..... **%**

Question 4 continues on the next page

Do not write outside the box

0 4 . 2 By how many times did the number of resistant bacteria per cm^3 increase between 0 and 10 hours?
Tick (✓) one box.

[1 mark]

2.5 ☐

3 ☐

1000 ☐

100 000 ☐

0 4 . 3 Explain the change in the proportion of resistant bacteria in the flask between 0 and 10 hours.

[3 marks]

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0 4 . 4 Suggest why the scientists plotted the numbers of bacteria as $\log_{10}$ values.

[1 mark]

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Question 4 continues on the next page

Do not write outside the box

To find the number of resistant bacteria at 6 hours, the scientists:

- added 1 cm^3 of the sample to 9 cm^3 of sterile water and mixed it
- spread 0.1 cm^3 of this diluted sample on agar containing antibiotic A
- incubated the plate and counted 63 colonies.

Each colony grew from a single resistant bacterium.

0 4 . 5 Calculate the number of resistant bacteria per cm^3 in the 6-hour sample.
Give your answer in standard form.

[2 marks]

Answer ..... **per cm^3**

9

Turn over for the next question

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Do not write outside the box

Tuberculosis is a disease caused by a bacterium. Patients with tuberculosis are treated with two different antibiotics, **P** and **Q**, at the same time. The two antibiotics act on different targets in the bacterial cell.

In a population of this bacterium, about 1 in every 1×10^8 bacteria has an allele that gives resistance to antibiotic **P**. About 1 in every 1×10^7 bacteria has an allele that gives resistance to antibiotic **Q**. These alleles arise by separate mutations of different genes, which happen independently of each other.

0 5 . 1 A patient is infected with 5×10^{10} of these bacteria.
Calculate the number of these bacteria that would be expected to be resistant to **both** antibiotic **P** and antibiotic **Q**.
Give your answer in standard form.

[2 marks]

Answer .....

0 5 . 2 Explain why treating the patient with antibiotics **P** and **Q** at the same time is less likely to result in a population of resistant bacteria than treating the patient with antibiotic **P** alone.

[3 marks]

5

Turn over for the next question

Do not write outside the box

Human birth mass is an example of a characteristic affected by stabilising selection.

Table 2 shows data on birth mass for all babies born in one country over a period of 5 years.

Table 2

Birth mass / kg	Percentage of all babies born	Number of deaths in the first 28 days per 1000 babies born
Less than 1.5	1.2	175
1.5 to 2.4	5.8	21
2.5 to 3.4	52.6	2.4
3.5 to 4.4	38.0	1.6
4.5 or more	2.4	4.8

0 6 . 1 Use Table 2 to calculate the percentage of all deaths in the first 28 days that were of babies with a birth mass of less than 1.5 kg.
Give your answer to **three** significant figures.

[2 marks]

Answer ..... **%**

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Explain how the data in Table 2 show that birth mass is affected by stabilising selection.

[2 marks]

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0 6 . 3 Which describes the effect of stabilising selection on birth mass in a population over many generations?
Tick (✓) one box.

[1 mark]

The mean birth mass increases and the range decreases. ☐

The mean birth mass stays about the same and the standard deviation decreases. ☐

The mean birth mass stays about the same and the standard deviation increases. ☐

The mean birth mass decreases and the standard deviation stays the same. ☐

5

Turn over for the next question

Do not write outside the box

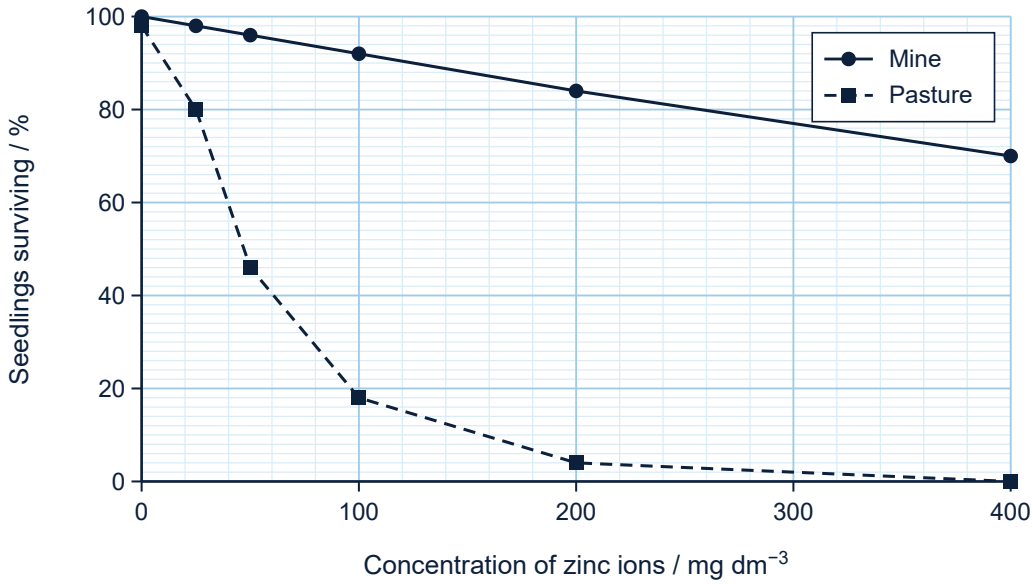
Adaptation 3.4.4

A species of grass grows on the waste tips of an old zinc mine and in a pasture 200 m away. The soil on the waste tips contains a high concentration of zinc ions, which are toxic to most plants. Zinc tolerance is a physiological adaptation.

Scientists collected seeds from plants at each site. They grew 50 seedlings from each site in each of six solutions containing different concentrations of zinc ions. After 4 weeks, they recorded the percentage of seedlings that survived.

Figure 3 shows their results.

Figure 3



0 7 . 1 Use Figure 3 to calculate how many times greater the percentage survival of mine seedlings was than that of pasture seedlings at a zinc ion concentration of 100 mg dm^{-3}.
Give your answer to **one** decimal place.

[1 mark]

Answer .....

Question 7 continues on the next page

Do not write outside the box

The scientists also grew 30 seedlings from each site in soil with no added zinc ions. After 4 weeks, they measured the dry mass of each seedling.

Table 3 shows their results.

Table 3

Site where seeds were collected	Number of seedlings	Mean dry mass / g	Standard deviation / g
Mine	30	0.43	0.06
Pasture	30	0.45	0.05

0 7 . 2 A student said that, without added zinc ions, pasture seedlings grow significantly better than mine seedlings.
Use mean ± 2 standard deviations to evaluate this statement.

[2 marks]

0 7 . 3 The scientists grew all the seedlings from seeds in the same conditions, instead of comparing adult plants growing at the two sites.
Suggest why.

[1 mark]

Question 7 continues on the next page

Do not write outside the box

When mine plants and pasture plants were grown together in soil with no added zinc ions, the mine plants produced 42% fewer seeds than the pasture plants.

0 7 . 4 Very few plants in the pasture are zinc tolerant.
Use all of the information to explain why.

[3 marks]

7

Turn over for the next question

Do not write outside the box

A species of lizard lives on two islands, **P** and **Q**. Predatory birds hunt the lizards on island **P**. There have been no predators of the lizards on island **Q** for at least 2000 years.

Running away from an approaching animal is a behavioural adaptation. Scientists measured the flight initiation distance of lizards. This is the distance between a lizard and an approaching person at the moment the lizard starts to run away.

The scientists measured the flight initiation distance of adult lizards caught on each island. They also collected eggs from each island and hatched them in a laboratory with no predators. They measured the flight initiation distance of these lizards when they were adults.

Table 4 shows their results.

Table 4

Group of lizards	Number of lizards	Mean flight initiation distance / m	Standard deviation / m
Adults caught on island **P**	40	4.1	0.8
Adults caught on island **Q**	40	1.2	0.5
Lizards hatched in the laboratory from eggs laid on island **P**	25	4.0	0.8
Lizards hatched in the laboratory from eggs laid on island **Q**	25	1.3	0.5

Question 8 continues on the next page

Do not write outside the box

0 8 The scientists concluded that the short flight initiation distance of lizards on island **Q** is the result of natural selection.
Evaluate this conclusion.

[4 marks]

4

Turn over for the next question

Do not write outside the box

Required practical 6: antimicrobial substances 3.4.4

A mouthwash contains an antiseptic. A student investigated how the time that a non-pathogenic bacterium is in contact with the mouthwash affects the number of bacteria that survive. She:

- added 1 cm^3 of a culture of the bacterium to 9 cm^3 of mouthwash in a test tube, and started a stop clock
- after 0.5, 1, 2 and 4 minutes, removed 0.1 cm^3 from the tube and added it immediately to 9.9 cm^3 of a solution that stops the antiseptic working
- spread 0.1 cm^3 of each of these solutions on each of three agar plates
- repeated the procedure with 9 cm^3 of sterile water instead of mouthwash, removing a sample after 4 minutes only
- incubated all the plates at 20 °C for 3 days, then counted the colonies.

0 9 . 1 Explain why the student included the tube containing sterile water.

[2 marks]

Question 9 continues on the next page

Do not write outside the box

Table 5 shows the student's results.

Table 5

Tube	Contact time / minutes	Number of colonies		
		Plate 1	Plate 2	Plate 3
Sterile water	4	236	251	233
Mouthwash	0.5	161	149	158
Mouthwash	1	102	91	101
Mouthwash	2	39	34	38
Mouthwash	4	6	3	6

0 9 . 2 Calculate the mean number of colonies after 1 minute in mouthwash as a percentage of the mean number of colonies for sterile water.
Give your answer to **three** significant figures.

[2 marks]

Answer ..... **%**

0 9 . 3 Suggest why the student added each 0.1 cm^3 sample to a solution that stops the antiseptic working.

[1 mark]

Question 9 continues on the next page

Do not write outside the box

0 9 . 4 Describe how the student should spread 0.1 cm^3 of a solution on an agar plate, using aseptic technique.

[3 marks]

When the student repeated the investigation, one of the plates for 2 minutes had colonies of two different colours and shapes.

0 9 . 5 Explain why the student should not use the number of colonies on this plate in her results.

[2 marks]

Question 9 continues on the next page

Do not write outside the box

The label on the mouthwash claims: *"Rinsing your mouth for 30 seconds kills 99% of bacteria."*

0 9 . 6 Use Table 5 and the information about the investigation to evaluate this claim.

[5 marks]

15

Turn over for the next question

Do not write outside the box

Extended response: selection and adaptation 3.4.4

A species of snail lives on rocky shores. Shell thickness is an anatomical adaptation that protects the snail. Shell thickness varies between snails in the population and is affected by several genes.

- On one shore, fossils show that the mean shell thickness of the snails stayed almost the same for thousands of years.
- In 1900, a species of crab that crushes snail shells arrived on this shore. Since then, the mean shell thickness of the snails has increased.

1 0 Use your knowledge of selection to explain **both** of these observations.

[6 marks]

6

END OF QUESTIONS

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