FOR OFFICIAL USE

National Qualifications 2024

Mark

X807/77/01

Biology
Section 1 — Answer grid and Section 2

WEDNESDAY, 15 MAY
9:00 AM – 12:00 NOON

X8077701

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day | Month | Year

Scottish candidate number

Total marks — 100

SECTION 1 — 20 marks
Attempt ALL questions.
Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 80 marks
Attempt ALL questions.
A supplementary sheet for question 1 is enclosed inside the front cover of this question paper.
Question 13 contains a choice.
Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.
Use **blue** or **black** ink.
Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

X807770101

SECTION 1 — 20 marks

The questions for Section 1 are contained in the question paper X807/77/02.

Read these and record your answers on the answer grid on *page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

The thigh bone is called the

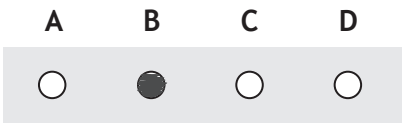
A humerus

B femur

C tibia

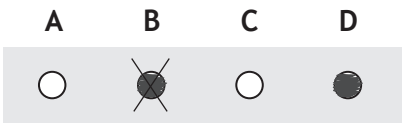
D fibula.

The correct answer is **B** — femur. The answer **B** bubble has been clearly filled in (see below).

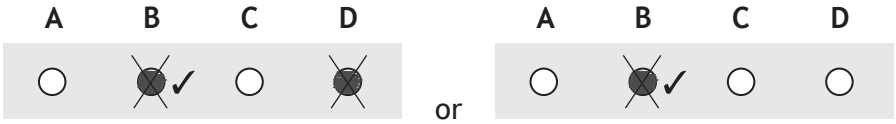


Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



SECTION 1 — Answer grid

OBJ20AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○

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SECTION 2 — 80 marks

Attempt ALL questions

Question 13 contains a choice

1. Read through the supplementary sheet for question 1 before attempting this question.

(a) In this research, *Drosophila melanogaster* serves as a model organism.

Explain what is meant by a model organism. **1**

(b) Refer to **Table 1**.

Using the formula given, calculate the mean preference index (PI) for this experiment. **1**

Space for calculation

_____ %

(c) (i) Refer to **Figure 2A**.

Describe how concentration affects the attraction of *Drosophila melanogaster* to ammonia. **1**

(ii) Refer to **Figure 2B**.

What general conclusion can be drawn about the attraction of *Drosophila melanogaster* to ammonia and amines? **1**

1. (continued)

(d) Refer to **Figure 1** and **Figure 2B**.

What does the negative preference index (PI) indicate about the behaviour of the flies in the T-maze containing carbon dioxide? **1**

(e) (i) Refer to **Figure 3**.

Explain how binding of odour molecules to ligand-gated ion channels would allow signals from odour molecules to be transduced. **1**

(ii) Refer to **Figure 5A** and **Figure 5B**.

Active calmodulin binds to Orco and is thought to regulate OR function in *Drosophila melanogaster.*

Explain how the data support the hypothesis that OR function in *Drosophila melanogaster* is regulated by the binding of calmodulin to Orco. **2**

[Turn over

2. Yeast cells can be cultured in a broth with suitable nutrients.

(a) When culturing yeast cells, aseptic technique is used.

(i) Give one way the equipment can be sterilised as part of aseptic technique. **1**

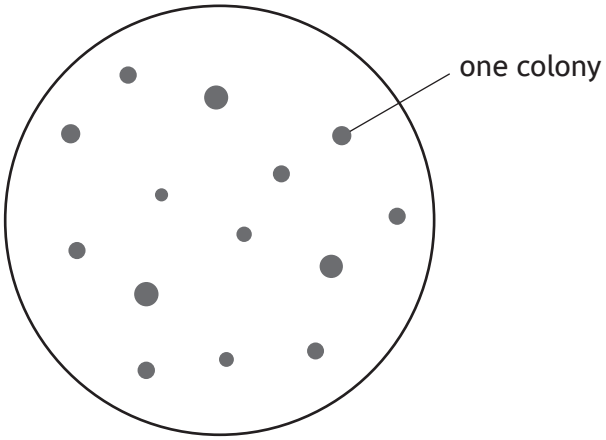
_____

(ii) Explain the benefit of aseptic technique when culturing yeast cells. **1**

_____

(b) Plating out of a liquid microbial culture on solid media allows the number of colony-forming units to be counted.

The diagram represents colonies on a solid culture medium following plating out of a diluted yeast culture. The original sample was diluted by a factor of 10^5 and a 0.2 cm^3 sample of this diluted culture was placed on the solid medium plate.



(i) Calculate the number of yeast cells in 1 cm^3 of the original undiluted yeast culture. **1**

Space for calculation

_____ cells per cm^3

2. (b) (continued)

(ii) Plating out allows the number of **viable** cells in a liquid culture to be estimated.

Describe another method that can be used to estimate the number of **viable** cells in a liquid culture. **1**

_____

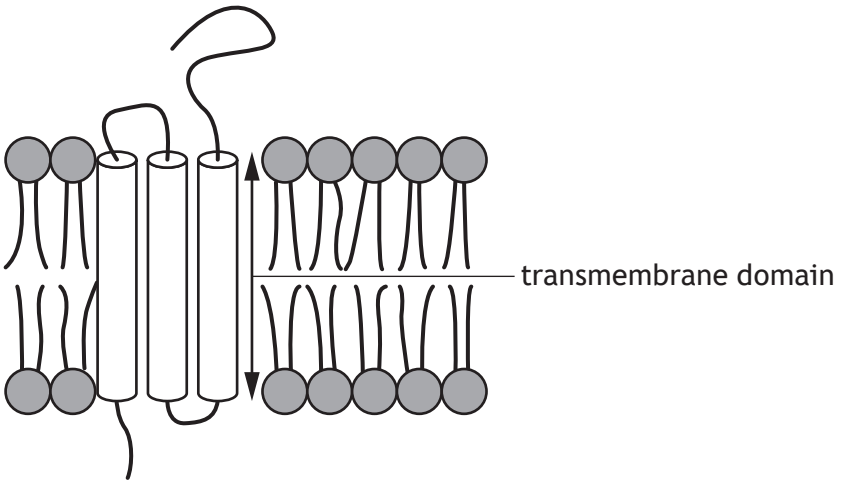
_____

[Turn over

3. Plasma membranes contain a range of different proteins.

The diagram shows an example of an integral protein within a membrane.

Transmembrane domains are regions of integral proteins that span the membrane.

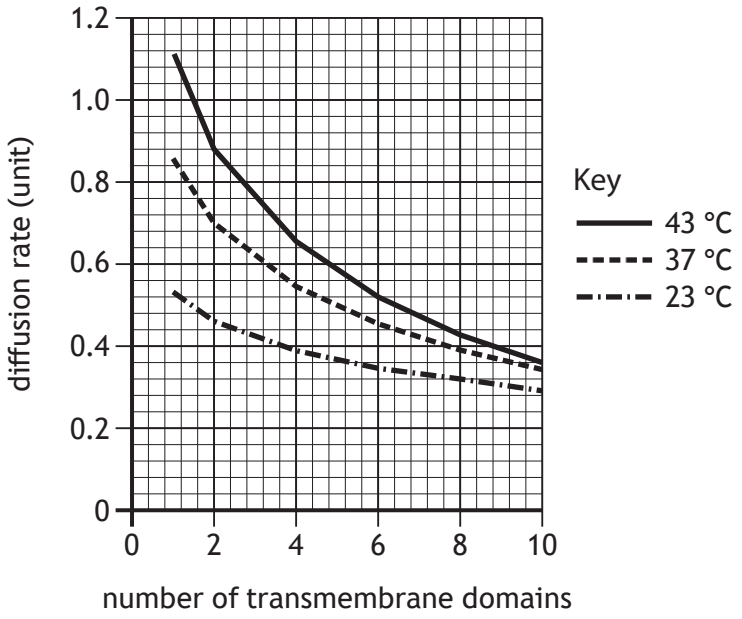


(a) Describe the interactions that hold an integral transmembrane protein within the phospholipid bilayer. **1**

3. (continued)

(b) Transmembrane proteins can diffuse sideways within the phospholipid bilayer. The diffusion rate of several proteins, each having a different number of transmembrane domains, was measured at different temperatures.

The results are shown in the figure.



(i) Describe two trends shown in the figure in relation to **temperature**. **2**

1. _____

_____

2. _____

_____

(ii) Suggest why having proteins with a higher number of transmembrane domains might be an advantage to cells. **1**

_____

_____

[Turn over

4. The popularity of organic vegetables has led to increased use of traditional organic fertilisers instead of inorganic fertilisers in modern farming.

One such fertiliser is nettle slurry, which is made from decomposing stinging nettle leaves. These slurries have been used for centuries but, due to a lack of controlled studies, there is little scientific evidence for their effectiveness.

A recent study examined the growth and yield of potato plants when treated with nettle slurry. A field plot was divided into four zones and each zone divided further into four sub-zones. Four different treatments were used in each zone as shown in **Figure 1**.

The four treatments were:

A: nettle slurry diluted to give the recommended dosage

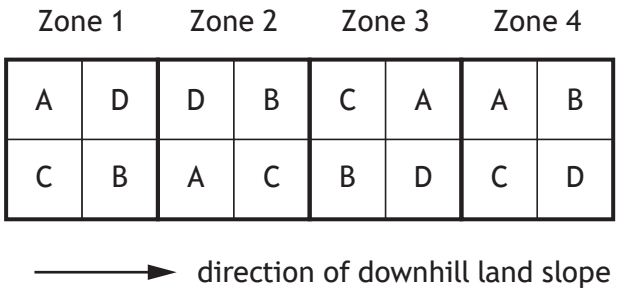
B: nettle slurry diluted to give half the recommended dosage

C: nettle slurry diluted to give double the recommended dosage

D: water without added nettle slurry.

Treatments were applied three times, at 30-day intervals.

Figure 1



(a) This type of experimental design is called a randomised block.

Give one advantage of this type of experimental design. **1**

(b) In this study, water without nettle slurry was used as a negative control. A positive control was not included.

Suggest a suitable positive control for this experiment. **1**

4. (continued)

(c) Nettle slurry is made by adding chopped young nettles to water and leaving the mixture to decompose for 14 days. The volume of each batch produced is limited by the size of the containers used. In this experiment, three batches of nettle slurry were required for each of the three separate applications.

(i) Suggest how the three batches of slurry should be applied to ensure that the experiment is valid. **1**

_____

_____

(ii) The recommended dilution for the nettle slurry was 1 in 10.

A single treatment of one sub-zone, at the recommended dose, required 15 litres of diluted slurry.

Calculate the total volume of **undiluted** nettle slurry required for all three applications. **1**

Space for calculation

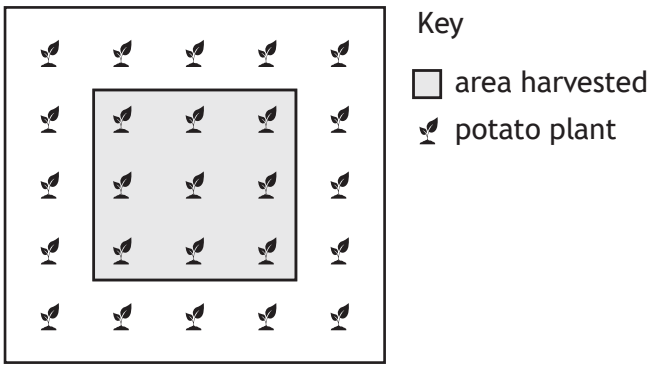
_____ litres

[Turn over

4. (continued)

(d) Each sub-zone was planted with five rows of five plants. Measurements were taken from nine plants in the central area, as shown in **Figure 2**. After 100 days, the authors assessed the yield of potatoes in kg per plant. They also measured the height of each plant and the number and length of the leaves on each plant.

Figure 2



(i) Suggest a null hypothesis for this study. **1**

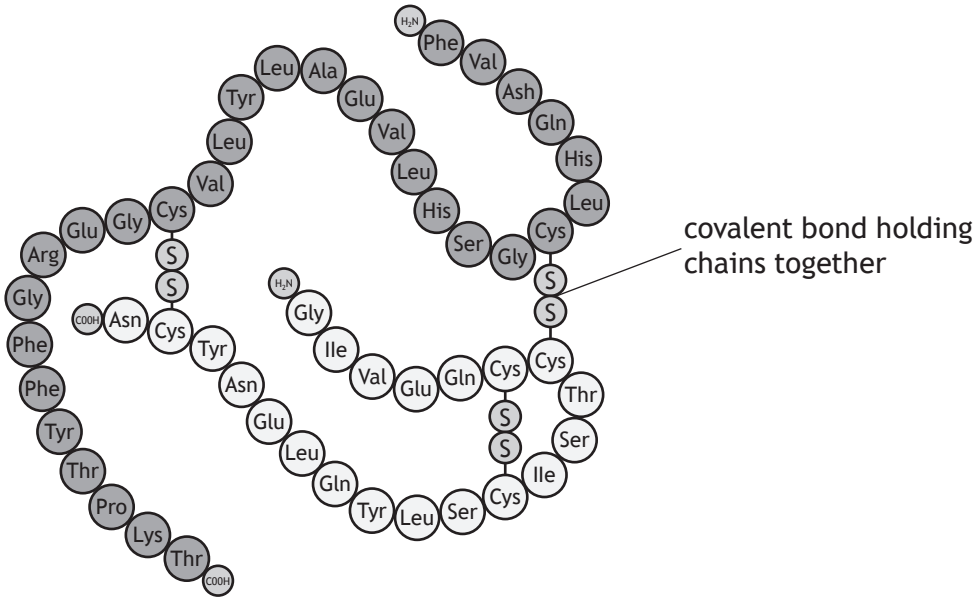
(ii) Suggest why plants only in the central region of each sub-zone were measured. **1**

(e) Compared to the control, small but significant increases in the height and leaf length of all plants treated with nettle slurry were found. However, no significant difference in potato yield was observed between the treatments and the control.

It was concluded that nettle slurry was not a beneficial fertiliser in any type of organic agriculture.

Suggest why this conclusion might **not** be valid. **1**

5. Insulin is a hormone that is involved in the regulation of blood glucose concentration. It is a small protein composed of two chains held together by covalent bonds as shown in the figure.



(a) Name the type of covalent bond that holds the two chains of insulin together. **1**

(b) Insulin signalling via its receptor involves a phosphorylation cascade.
Describe what happens in a phosphorylation cascade. **1**

(c) Diabetes is a condition in which blood glucose concentration is raised.
Describe how failure of insulin signalling leads to diabetes. **3**

6. Night blindness is a condition that results in reduced ability to see in low light intensities. It may be genetic, caused by injury, or by malnutrition. In the UK, the most common cause of this condition is a group of hereditary genetic disorders called *retinitis pigmentosa*. These disorders lead to a progressive degeneration of the retina, which begins with the loss of rod cells.

(a) (i) Rod cells contain the protein complex rhodopsin. When struck by a photon of light, rhodopsin becomes photoexcited.

Describe how photoexcited rhodopsin results in amplification of this signal to enable vision in low light intensities. **2**

(ii) As retinitis pigmentosa progresses, cone cells are also lost.

Predict what effect this would have on an individual's vision. **1**

(b) The most common cause of night blindness in developing countries is vitamin A deficiency (VAD). VAD results from a lack of dietary vitamin A but is also made worse by infections, which reduce both intake and absorption of vitamin A.

(i) The main circulating form of vitamin A in the blood is retinol, which is required to produce retinal.

Suggest how VAD may lead to night blindness. **1**

(ii) Vitamin A is also required for certain white blood cells to proliferate correctly.

Explain how this would contribute to progressive worsening of VAD in affected individuals. **2**

7. Discuss methods of sharing, and the importance of both sharing and reviewing, scientific findings. **4**

[Turn over

DO NOT WRITE IN THIS MARGIN

8. The dhole (*Cuon alpinus*) is an elusive, pack-hunting, social carnivore that is classified as endangered.

Scientists wanted to produce a time budget for the dhole to allow them to draw conclusions about how best to conserve the species. Their first step was to develop a checklist of behaviours for the dhole.

Part of the checklist of behaviours is shown in **Figure 1**.

Figure 1

Behaviour	Description
Resting	Lying down with eyes open or closed.
Sphinx rest	Lying on the belly with forelegs extended to the front. Head may or may not be lowered to rest on the forelegs or the ground.
Sit	Resting on folded hind legs.
Stand	Assuming an upright position with the weight of the body on all 4 legs.
Observation stand	Standing upright on the hind legs with front legs folded to observe an object of interest above eye level.

8. (continued)

(a) (i) State the term for a checklist of animal behaviours. **1**

_____

(ii) Suggest why producing a checklist of animal behaviours increased the validity of the study. **1**

_____

_____

(iii) When producing the checklist of animal behaviours, the scientists were careful to avoid anthropomorphism.

What is meant by the term anthropomorphism? **1**

_____

_____

(b) When studying the dhole behaviour, scientists used video recordings of the pack to analyse using the checklist.

When planning the study, it was decided that:

1. each individual in a pack was analysed separately
2. the same video footage was analysed separately by two scientists.

Explain why each of these aspects of experimental design would reduce error in the results. **2**

1. _____

_____

2. _____

_____

[Turn over

8. (continued)

(c) In order to prepare a time budget, the scientists recorded the frequency and duration of each behaviour.

Choose either frequency or duration by ticking (✓) **one** box and describe what your chosen term means in animal behaviour studies. **1**

Frequency ☐ Duration ☐

Description _____

_____

(d) The results of the investigation are shown in the table.

Behavioural category	Total time (minutes)	Time spent on behaviours (%)		
		Adult males	Adult females	Subadults
Movement	177.28	39.42	48.78	47.27
Resting	158.05	45.66	37.21	41.43
Social behaviour	24.62	6.02	8.37	7.35
Feeding	18.83	3.46	0.91	2.44
Scent marking	10.44	5.32	1.21	1.33
Other	5.73	0.10	3.51	0.18
Total	394.95	100	100	100

Give a general conclusion about movement and resting compared to all the other behaviours. **1**

_____

_____

9. Cauliflower coral (*Pocillopora damicornis*) is a species of reef-building, stony coral native to tropical and subtropical parts of the Indian and Pacific Oceans.

Corals are colony-forming organisms. Each colony is formed from hundreds of thousands of individual animals called polyps. The polyps secrete calcium carbonate, which forms coral reefs.

This species of coral has a mixed reproductive strategy; it can reproduce both asexually by parthenogenesis, and sexually.

(a) When these corals reproduce sexually, each individual polyp releases both eggs and sperm into the surrounding water. During a spawning event, all the colonies in a reef release their gametes at the same time.

(i) State the term used to describe organisms, such as a coral polyp, in which individuals can produce both male and female gametes. **1**

_____

(ii) Suggest an advantage to coral colonies of male and female gametes being released at the same time. **1**

_____

(iii) State two costs of sexual reproduction. **2**

1. _____

_____

2. _____

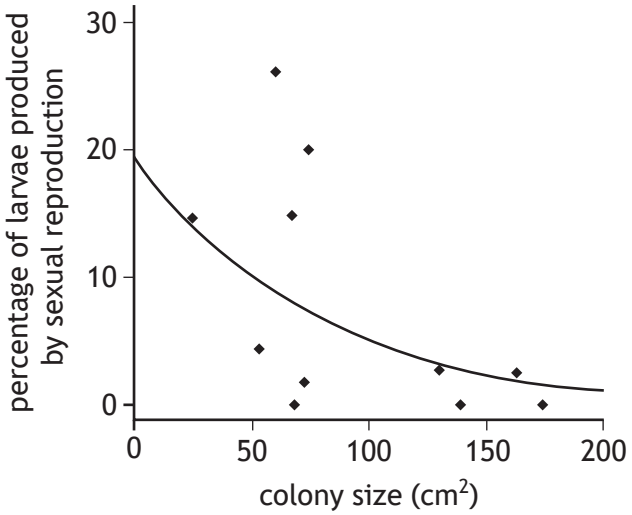
_____

9. (continued)

(b) Cauliflower coral larvae can be produced by both sexual and asexual reproduction.

An investigation was carried out to determine whether the size of colony had an effect on the reproductive strategy used by the corals.

Two different size classes were used in the study. Small colonies have a surface area less than 75 cm^2 and large colonies have a surface area greater than 130 cm^2. The results are shown in the figure.



(i) Compare the reproductive strategy used by small and large colonies. **1**

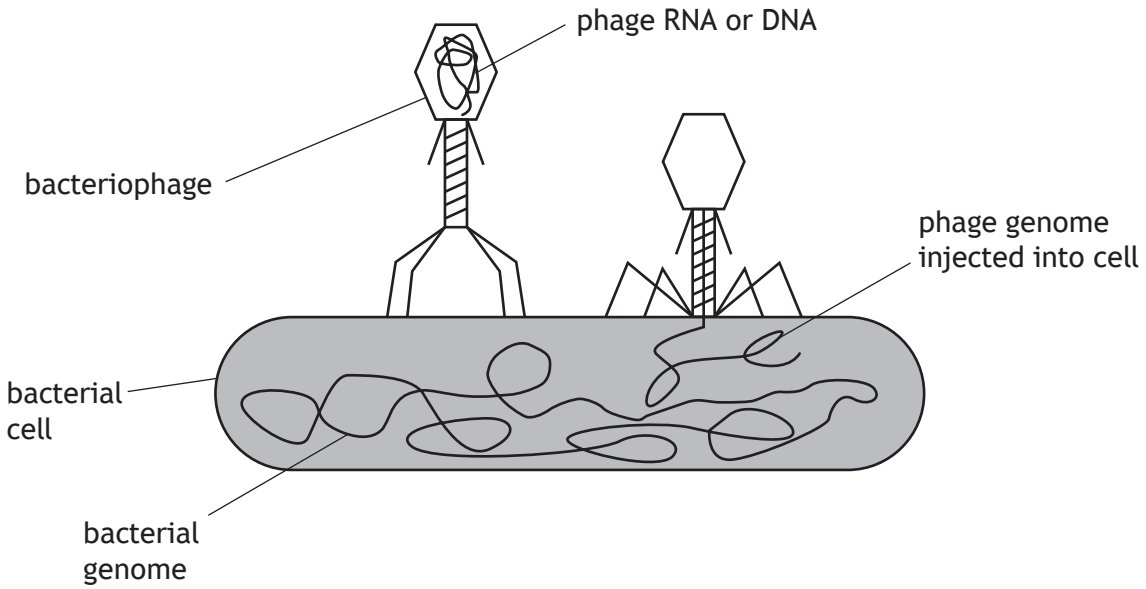
(ii) Suggest a reason for the trend shown in the graph. **1**

(iii) State whether the data are more reliable for small or large colonies.
Justify your answer. **1**

10. Bacteriophages (phages) are viruses that infect and kill bacteria. In the 1920s, they were used to treat bacterial diseases such as cholera. The use of phage therapy reduced as antibiotics were discovered and became widely available.

However, as many infections are now caused by bacteria that are resistant to antibiotics, interest in the use of phage therapy is increasing again.

Figure: Bacteriophage infecting a bacterium



(a) (i) Describe the next stage in the phage life cycle following the injection of phage genome into the bacterial cell. **1**

(ii) Phages are parasites.

State the meaning of the term parasite. **1**

[Turn over

10. (continued)

(b) In terms of the Red Queen hypothesis, predict an evolutionary response of bacteria to infection by bacteriophages. **1**

(c) Many health issues in developing countries are caused by parasitic infections. Describe challenges involved in the treatment and control of these diseases. **3**

11. The collared flycatcher (*Ficedula albicollis*) is a small, black and white songbird that breeds in southeast Europe. Adult males have a white forehead patch as shown.

(a) Female collared flycatchers choose their mate based on the size of the male's forehead patch. Males that express a large white forehead patch have a competitive advantage over rival males.

(i) Explain what is meant by sexual selection. **1**

(ii) Sexual dimorphism exists in this species, with the female being brown in colour.

Explain why female choice would result in sexual dimorphism in collared flycatchers. **2**

(iii) State the term used for traits that indicate the reproductive fitness of an individual. **1**

[Turn over

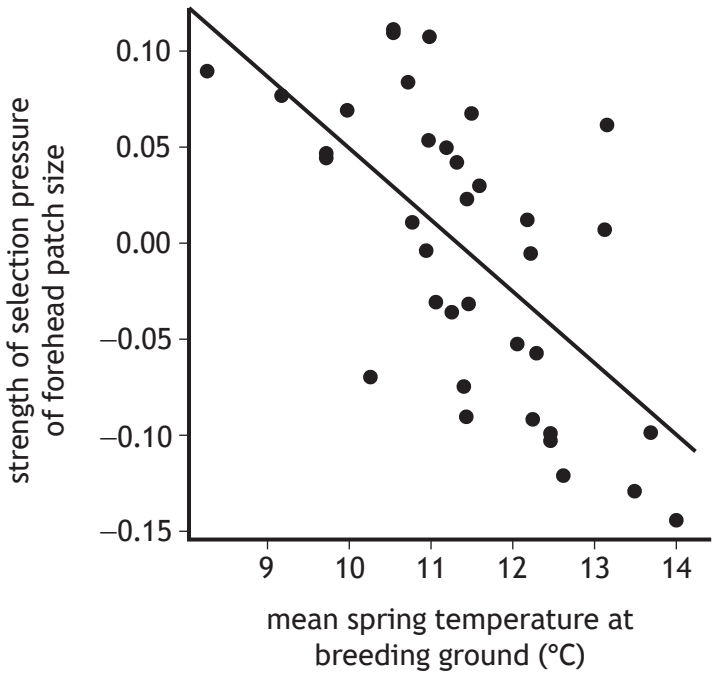
MARKS

DO NOT WRITE IN THIS MARGIN

(b) Selection trade-offs between investment in sexually selected traits and investment in survival can drive changes in the phenotype of a species.

The white forehead patch in the collared flycatcher is one characteristic thought to be involved in a selection trade-off; males with larger forehead patches are more attractive to females, but in high-risk environments there is a survival cost associated with large forehead patches.

An investigation was carried out to determine the impact of climate change on sexually selected traits in the collared flycatcher. The figure shows the effect of increasing mean spring temperature on the strength of the selection pressure on white forehead patch size. A positive number indicates the strength of selection for the forehead patch and a negative number indicates the strength of selection against the forehead patch.



(i) The 'selection trade-off' hypothesis proposes that males evolve conspicuous ornamentation, such as the forehead patch, in low-risk environments.

Use the information provided to support the suggestion that the temperature distribution of head patch size in the collared flycatcher is an example of selection trade-off. **2**

(ii) Predict **one** effect of climate change on this species. **1**

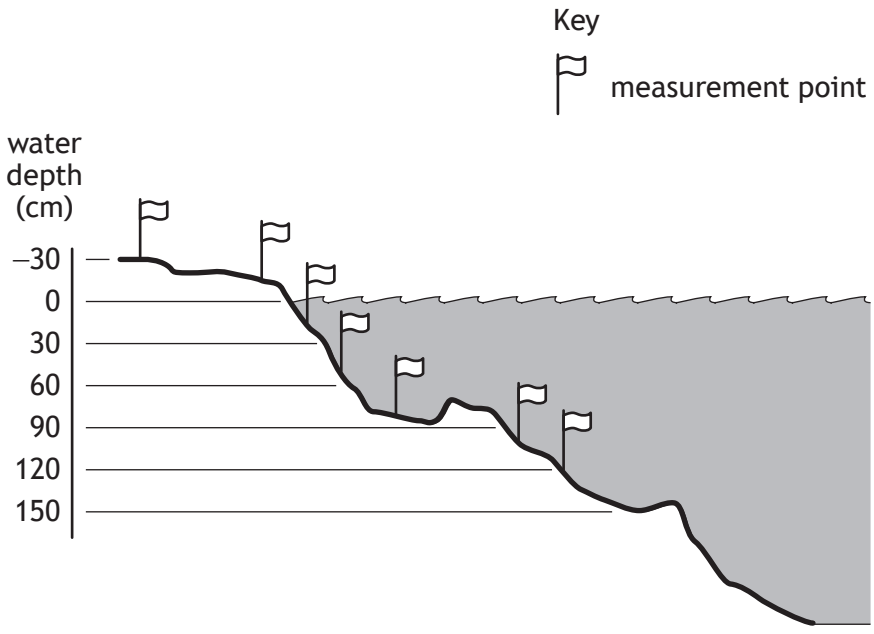
DO NOT WRITE IN THIS MARGIN

12. *Typha angustifolia* and *Typha latifolia* are two species of bulrushes found growing extensively in wetlands such as marshes and ponds in the Northern Hemisphere. They are commonly found growing together.

In a study, the distributions of these two species were compared along a transect from above the water line into a small pond, as shown in **Figure 1a**.

Together, the two species comprised up to 95% of the plant biomass found in the pond.

Figure 1a



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MARKS

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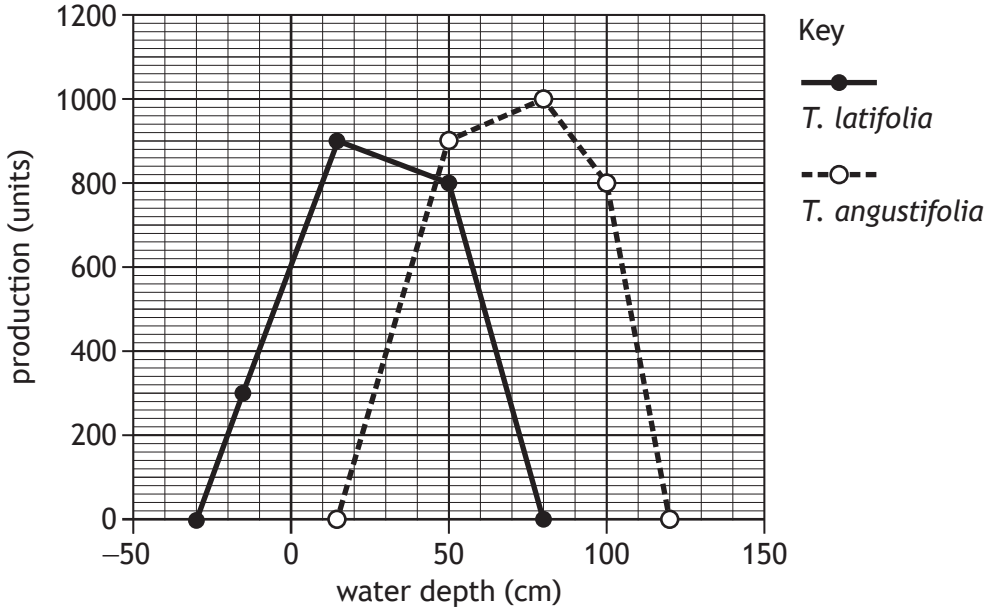
Figure 1b shows the distribution and production (accumulated mass) of both species growing together along the transect.

Figure 1b

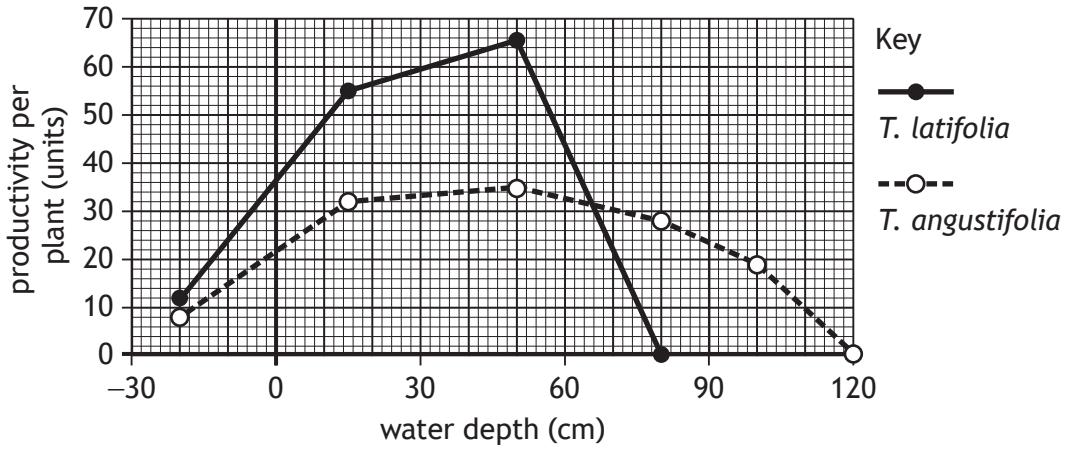


(a) Use the data to describe the distributions shown by both species in relation to water depth. **1**

(b) Name the type of competition shown between *T. latifolia* and *T. angustifolia*. **1**

Figure 1c shows the productivity of the two species when transplanted and grown **alone** in a range of water depths.

Figure 1c



12. (continued)

(c) Refer to **Figure 1b** and **Figure 1c**.

(i) Which figure shows the fundamental niche of *T. angustifolia*?

Justify your choice. **1**

Figure _____

Justification _____

_____

(ii) Researchers have called the competition 'asymmetric' because the two species are affected differently by the competition.

Explain how the figures can be used to justify this description. **1**

_____

_____

_____

(d) In the USA, a third species, *Typha domingensis* is found in southern states in contrast to *T. angustifolia*, which is generally found in more northern states. *T. angustifolia* shows several features typical of an r-selected species whilst *T. domingensis* is more likely to be classified as a K-selected species.

Give two differences that would be expected between these r-selected and K-selected species. **2**

1. _____

_____

2. _____

_____

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

13. Attempt **either A or B**. Write your answer in the space below and on *page 31*.

A Discuss the synthesis and post-translational modification of membrane proteins. **9**

OR

B Discuss the role of proteins in controlling progression through the cell cycle checkpoints. **9**

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ADDITIONAL SPACE FOR ANSWER to question 13

[END OF QUESTION PAPER]

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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