



National  
Qualifications  
2024

**X807/77/02**

**Biology**  
**Section 1 — Questions**

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

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Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X807/77/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



**SECTION 1 — 20 marks**

**Attempt ALL questions**

1. Which technique could be used to quantify the concentration of a pigmented compound extracted from plant tissue?

A Centrifugation  
B Colorimetry  
C Electrophoresis  
D Immunoassay

2. Following digestion, the sugar fructose is absorbed from inside the intestine into the cells that line the intestine. Fructose moves from a high concentration to a low concentration into the intestinal cells via a transmembrane protein. Fructose binds directly to the protein causing a conformational change that moves the fructose molecule through the membrane and releases it inside the cell.

Which of the following matches the mechanism of fructose transport described?

A Facilitated diffusion via a channel  
B Active transport via a transporter  
C Facilitated diffusion via a transporter  
D Facilitated diffusion via a symporter

3. The statements refer to steps in signalling pathways.

1. The hormone binds to a receptor protein in the cell membrane.
2. The hormone binds to a receptor protein in the nucleus or cytoplasm of the cell.
3. The hormone-receptor complex binds to DNA.
4. The activated receptor results in a G-protein relaying the signal to a target protein.

Which of these statements would refer to a signalling pathway for a steroid hormone?

A 1 and 3 only  
B 2 and 3 only  
C 1 and 4 only  
D 2 and 4 only

4. An investigation was carried out into the effect of changing light intensity on the growth of tomato plants. Plants were placed under different intensities of light, and their growth was determined by measuring the length and dry mass of the plants.

Which row in the table describes features of this investigation?

	Independent variable	Investigation is multi-factorial
A	discrete	yes
B	continuous	no
C	discrete	no
D	continuous	yes

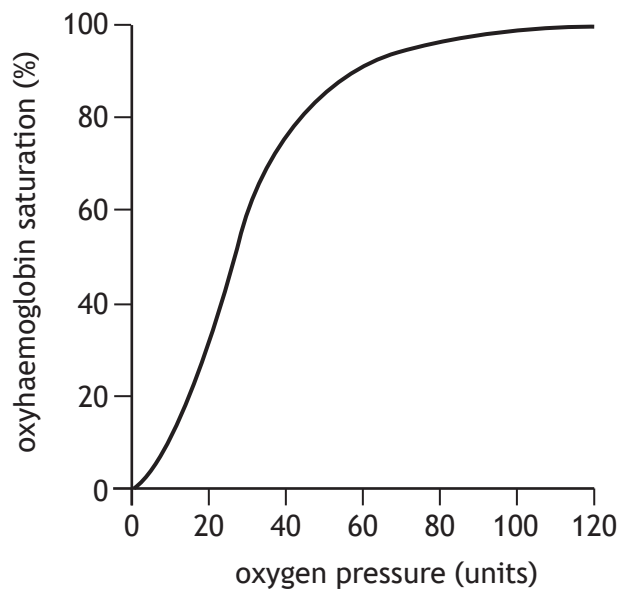
5. A researcher studying a protein with an isoelectric point of pH 8.2 wanted to separate it from a mixture of proteins and determine its molecular mass (size). A solution containing the mixture of proteins was adjusted to pH 8.2 then centrifuged.

The most appropriate next steps would be to

- A collect the protein from the pellet and carry out SDS-polyacrylamide electrophoresis (SDS-PAGE)
- B collect the protein from the supernatant and carry out SDS-polyacrylamide electrophoresis (SDS-PAGE)
- C collect the protein from the pellet and carry out native gel electrophoresis
- D collect the protein from the supernatant and carry out native gel electrophoresis.

[Turn over

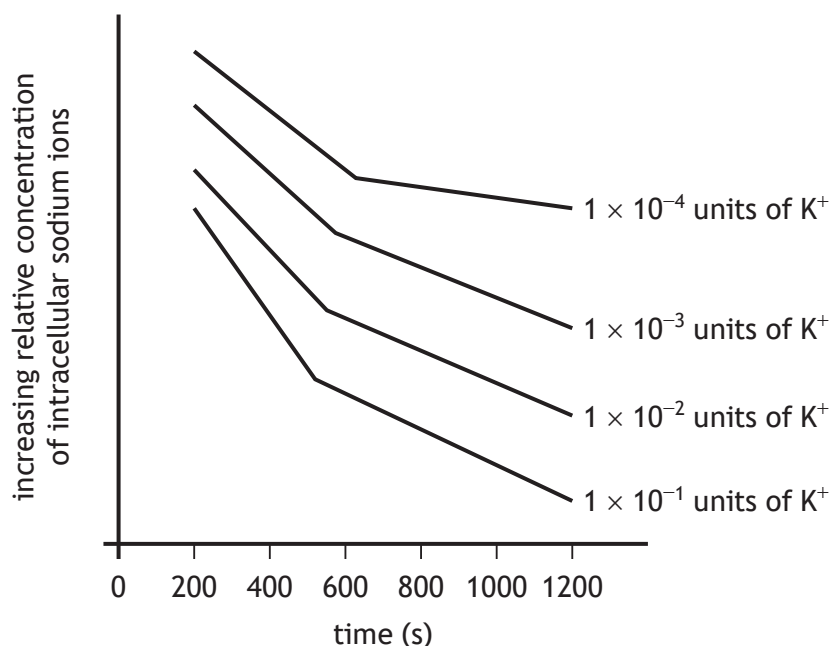
6. The figure shows the normal oxygen dissociation curve for haemoglobin.



Which row in the table shows the direction of shift in the oxygen dissociation curve as a result of changes in pH and temperature?

	Shift of curve	Change in pH	Change in temperature
A	left	decrease	increase
B	right	increase	increase
C	left	increase	decrease
D	right	decrease	decrease

7. The figure shows how the concentration of potassium ions ( $K^+$ ) in the extracellular environment affects the relative concentration of sodium ions inside a mammalian cell over time.



The following statements refer to the data in the figure.

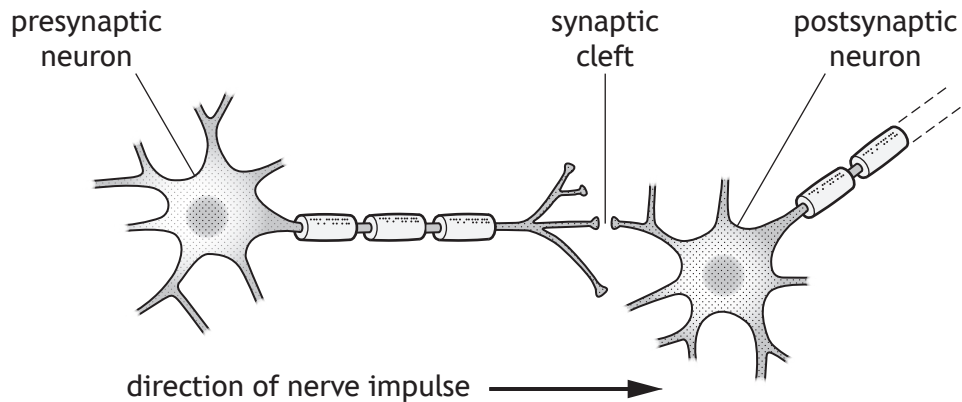
1. As the concentration of extracellular potassium ions decreases the relative concentration of intracellular sodium ions decreases.
2. The effect of changing the concentration of extracellular potassium ions decreases with time.
3. As the time in extracellular potassium ions increases the relative concentration of intracellular sodium ions decreases.
4. The relative concentration of intracellular sodium ions decreases more at higher concentrations of extracellular potassium ions.

Which of these statements are valid conclusions supported by the data shown?

- A 1 and 3 only  
B 2 and 3 only  
C 2 and 4 only  
D 3 and 4 only

[Turn over

8. The diagram shows two neurons and a synapse.



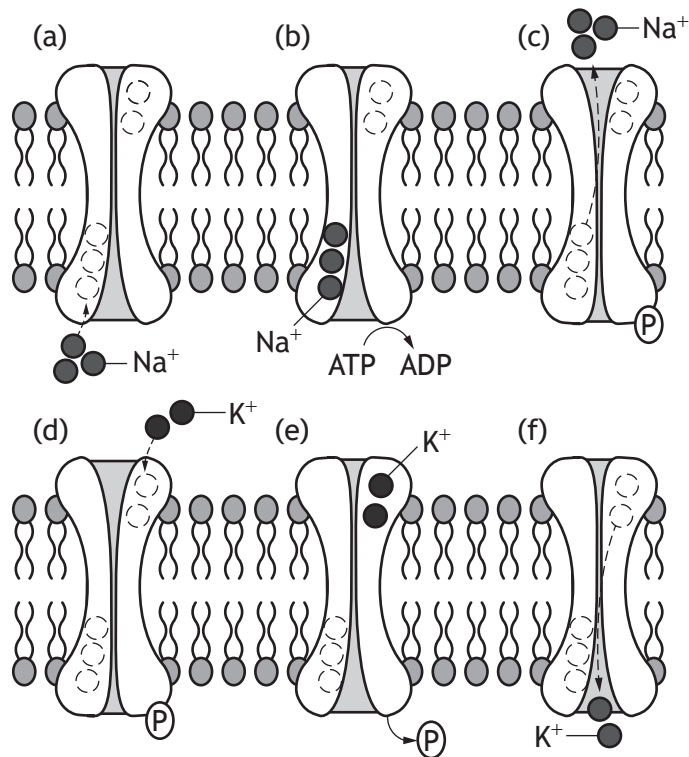
The following events occur during the transmission of a nerve impulse from one neuron to the next:

1. The neurotransmitter binds to its receptor.
2. Voltage-gated sodium channels open and sodium ions diffuse into the cell causing local depolarisation.
3. Vesicles containing the neurotransmitter fuse with the membrane.
4. Ligand-gated ion channels open.
5. The neurotransmitter diffuses across the synaptic cleft.

The correct order of events is

- A 5, 3, 4, 1, 2
- B 3, 5, 1, 4, 2
- C 3, 5, 1, 2, 4
- D 5, 3, 1, 4, 2

9. The diagram represents the stages in the operation of the sodium potassium pump.



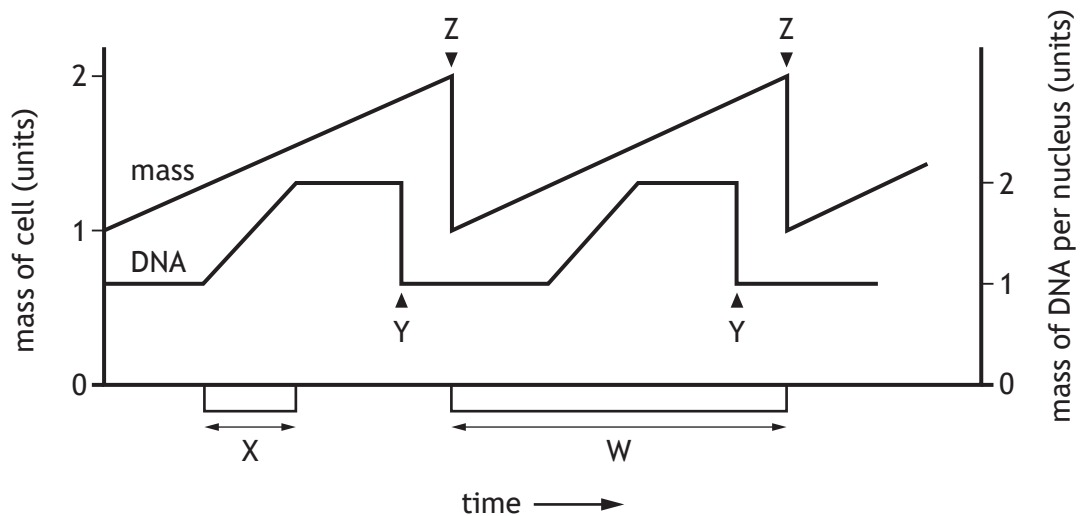
The pump is able to complete 150 cycles per second and each human red blood cell has around 200 sodium potassium pump proteins in its cell membrane.

Calculate the number of sodium ions that a red blood cell would be able to transport across the membrane in one minute.

- A  $2.7 \times 10^4$
- B  $9.0 \times 10^4$
- C  $1.8 \times 10^6$
- D  $5.4 \times 10^6$

[Turn over

10. The diagram shows the changes in cell mass and DNA content in a cell during two mitotic cell divisions.



Which row in the table identifies the cellular events labelled W, X, Y or Z in the diagram?

	Telophase	Cytokinesis	DNA replication
A	X	Y	W
B	Y	Z	W
C	Y	Z	X
D	Z	W	X

11. The ship rat (*Rattus rattus*) is an invasive species in New Zealand and threatens critically endangered bird life.

An elimination programme has been developed to reduce the size of the ship rat population on the islands. Scientists estimated the population size of the rats throughout the programme by using mark and recapture techniques.

Which of the following is **not** an assumption of the mark and recapture technique?

- A The ship rat population will increase due to their rapid reproduction rate.
- B The marked and released rats can mix fully with the total ship rat population.
- C None of the ship rats have left the survey area.
- D Every ship rat in the population has an equal chance of being captured during the sample.



12. Some stages of Meiosis I are described in the statements:

1. Sections of DNA are exchanged between non-sister chromatids.
2. Homologous chromosomes pair.
3. Chiasmata formation occurs.
4. Independent assortment of chromosomes occurs.
5. The chromosomes of each homologous pair separate.

The correct sequence of these stages in Meiosis I is

- A 2, 3, 1, 4, 5
- B 2, 5, 1, 3, 4
- C 3, 1, 2, 4, 5
- D 3, 1, 2, 5, 4

13. Which of the following is a correct statement about X chromosome inactivation?

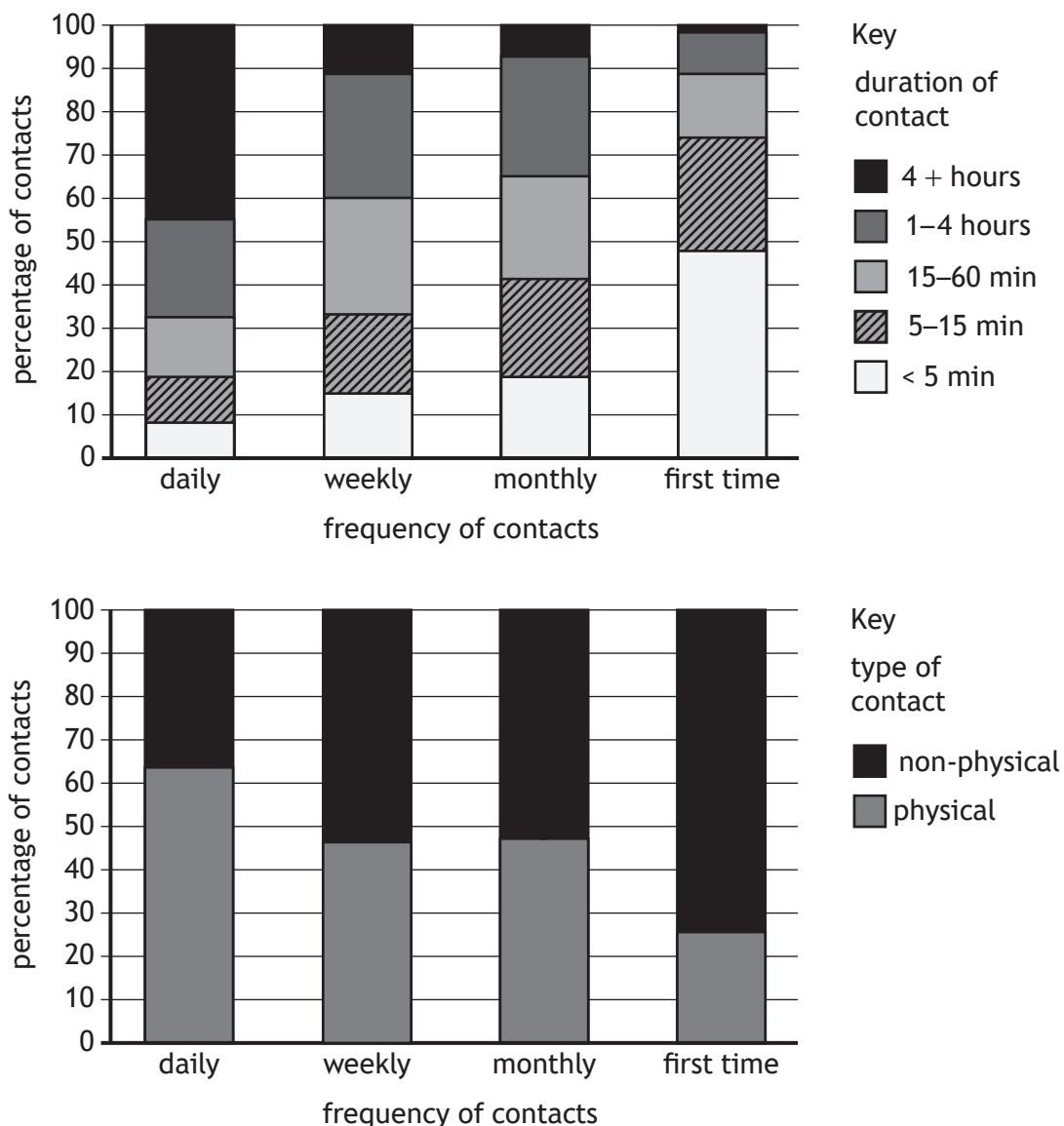
- A It is the cause of the Y chromosome being genetically inactive.
- B In females, it prevents the expression of harmful alleles present on the X chromosome.
- C The X chromosome inherited from the mother is active in all female cells.
- D It ensures the amount of protein encoded by X chromosomes in females is approximately equal to that of males.

[Turn over

14. A survey was conducted to predict the susceptibility of people to airborne infectious diseases during a pandemic. The survey examined the daily patterns of social contacts between 7000 individuals.

The frequency and duration of the interactions between an individual and each of their contacts, and whether it involved a physical or non-physical interaction, were recorded.

The results are shown in the graphs.



Which of the following observations is supported by these data?

- A Daily contacts are likely to be the longest but least likely to be physical.
- B First time contacts are the least likely to be physical and also likely to be the briefest.
- C Daily contacts are likely to be the shortest but more likely to be physical than less frequent contacts.
- D Weekly contacts are more likely to be physical than monthly contacts and likely to last longer.

15. A population of beetles was sampled by four different researchers. Each calculated the mean and variation in length of 85% of the sample. The whole population contained 362 beetles, with a combined body length of 6.878 m and a range in length of 1.1 cm for 85% of the population.

Which researcher has the most representative sample?

Researcher	Sample size	Mean body length (cm)	Variation in length of 85% of sample (cm)
A	105	1.9	1.6–2.0
B	84	1.7	1.2–2.3
C	128	1.8	1.4–2.5
D	273	1.9	1.3–2.4

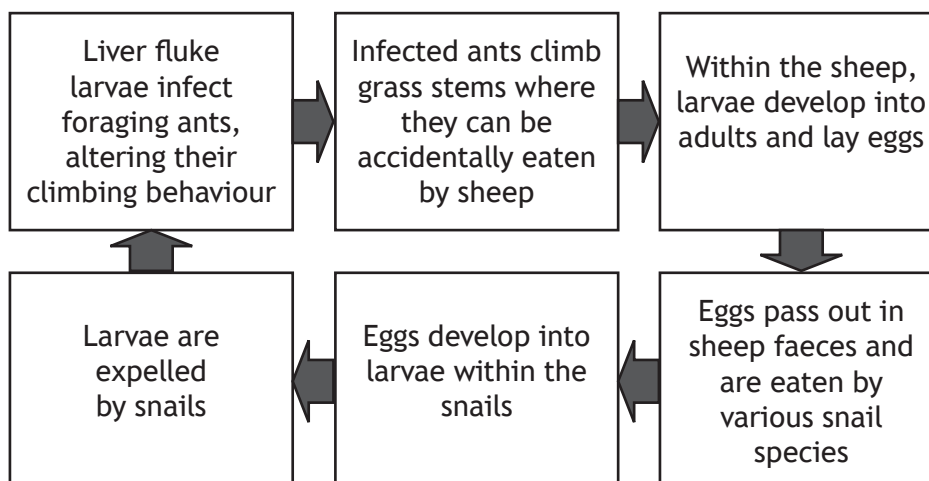
16. The table shows monthly samples of four species of copepods (small crustaceans) found in the surface layers of the North Atlantic Ocean.

Which species shows the lowest percentage change between March and July?

Species	Number caught per sample				
	March	April	May	June	July
A	95	100	110	20	100
B	95	70	80	30	80
C	120	140	180	150	110
D	105	100	110	100	120

[Turn over

17. The chart outlines the life cycle of a parasitic liver fluke.



Which of the following statements is correct for this life cycle?

- A Larvae are vectors
  - B Sheep are intermediate hosts
  - C Ants are intermediate hosts
  - D Snails are definitive hosts
18. A drug, used for the emergency treatment of a life-threatening condition, moderately increased survival in the short term but could also cause severe and life changing side effects.

To determine if the use of the drug should be discontinued, a study was proposed in which healthcare staff responding to medical emergencies for this condition would administer either an injection of the drug or a placebo. Healthcare staff would be unaware which injection had been administered, and patients would be assigned numbers designated on the injections given. After recovery from the immediate medical emergency, patients would be told about the study and its purpose and would be given the option to withdraw their data.

Why might this study be considered unethical?

- A The study had not been justified in terms of the benefits of its outcomes.
- B Informed consent was not obtained.
- C The drug causes severe and life changing side effects.
- D Confidentiality was not maintained.

19. Which of the following is the same for a **secondary** immune response?

- A Speed of antibody production
- B Antibody concentration in blood
- C Antigen triggering response
- D Duration of response

20. *Bent-tail* is an inherited condition in mice that causes them to have short, crooked tails. The gene responsible is sex-linked, and the allele for bent-tail ( $X^B$ ) is dominant to the allele for normal tail ( $X^b$ ).

If a male mouse with bent-tail is crossed with a heterozygous female mouse, the expected proportion of female mice with normal tails would be

- A 0.0
- B 0.25
- C 0.5
- D 0.75

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2  
OF YOUR QUESTION AND ANSWER BOOKLET.]

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FOR OFFICIAL USE



National  
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2024

Mark

**X807/77/01**

**Biology**  
**Section 1 — Answer grid**  
**and Section 2**

WEDNESDAY, 15 MAY

9:00 AM – 12:00 NOON



\* X 8 0 7 7 7 0 1 \*

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.



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## 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).

A	B	C	D
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

### 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**.

A	B	C	D
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

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:

A	B	C	D
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

 or 

A	B	C	D
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>



# SECTION 1 — Answer grid



	A	B	C	D
1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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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

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- (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

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

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

1

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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

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(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

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(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

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[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.

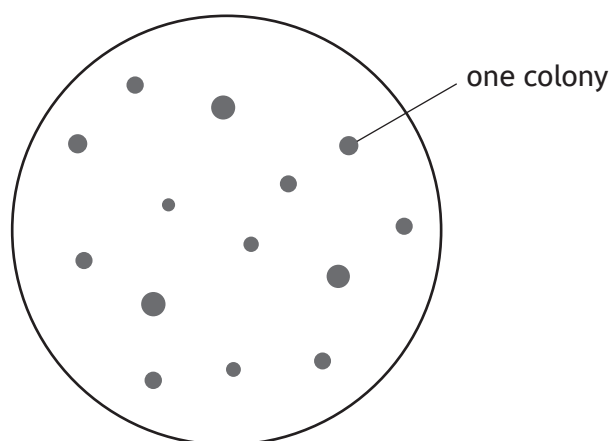
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(ii) Explain the benefit of aseptic technique when culturing yeast cells.

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  $0.2 \text{ cm}^3$  sample of this diluted culture was placed on the solid medium plate.



(i) Calculate the number of yeast cells in  $1 \text{ cm}^3$  of the original undiluted yeast culture.

1

*Space for calculation*

\_\_\_\_\_ cells per  $\text{cm}^3$





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

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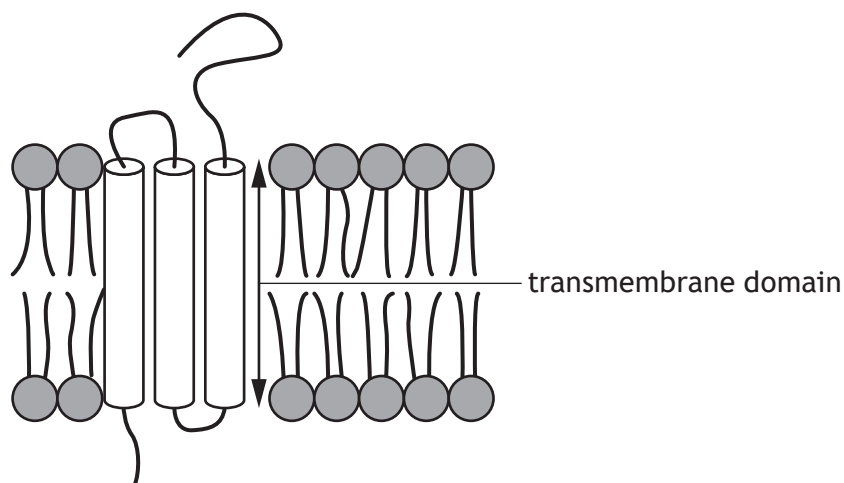
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3. Plasma membranes contain a range of different proteins.

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

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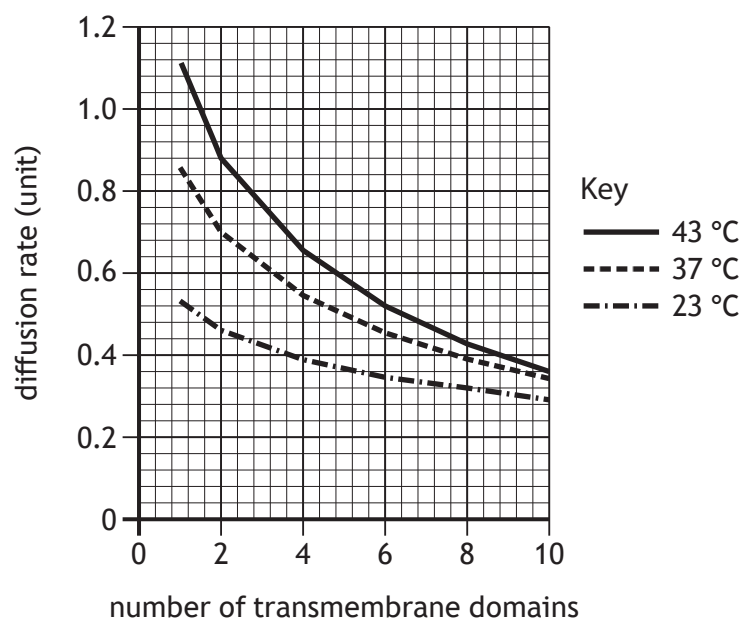
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3. (continued)

- (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. \_\_\_\_\_

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2. \_\_\_\_\_

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

1

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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

Zone 1		Zone 2		Zone 3		Zone 4	
A	D	D	B	C	A	A	B
C	B	A	C	B	D	C	D

—————▶ direction of downhill land slope

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

Give one advantage of this type of experimental design.

1

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- (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

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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

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- (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

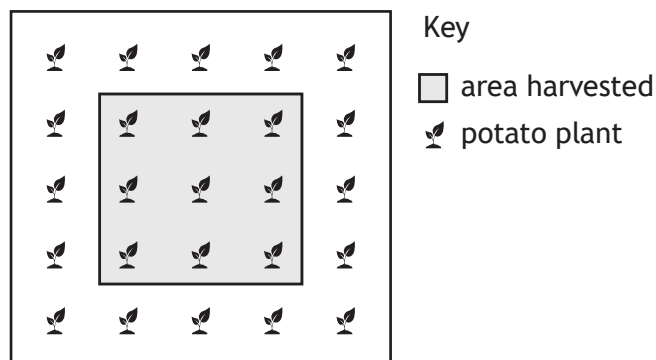
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4. (continued)

- (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

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

1

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- (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

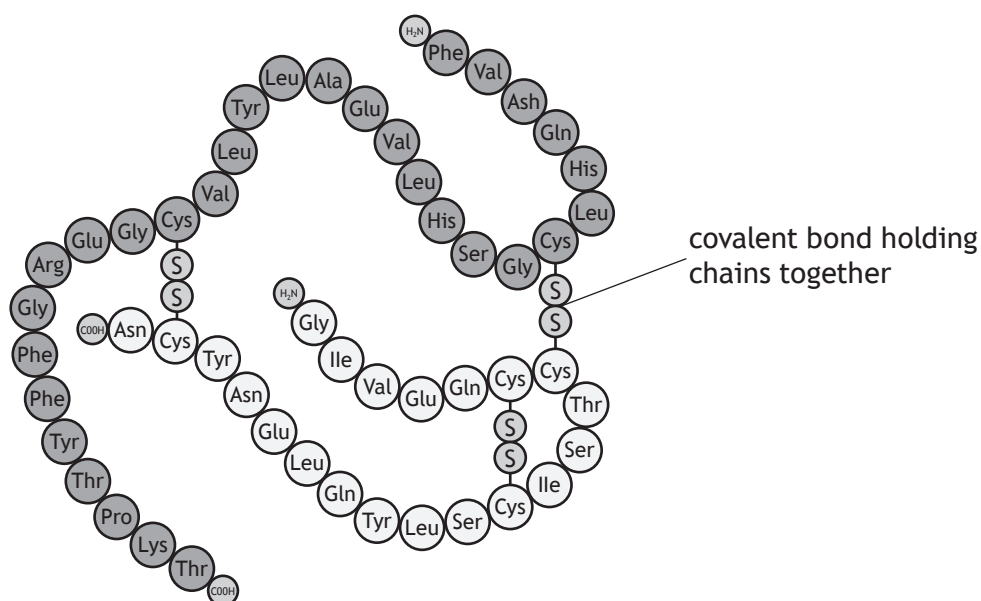
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5. Insulin is a hormone that is involved in the regulation of blood glucose concentration. It is a small protein composed of two chains held together by covalent bonds as shown in the figure.



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

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- (b) Insulin signalling via its receptor involves a phosphorylation cascade. 1

Describe what happens in a phosphorylation cascade.

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- (c) Diabetes is a condition in which blood glucose concentration is raised. 3

Describe how failure of insulin signalling leads to diabetes.

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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

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

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

1

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- (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

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- (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

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4

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

[illegible]

[Turn over



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

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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

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

1

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- (iii) State two costs of sexual reproduction.

2

1. \_\_\_\_\_

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2. \_\_\_\_\_

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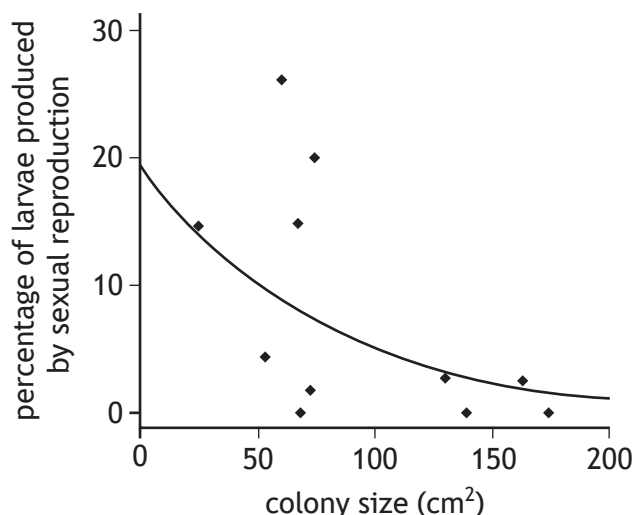


9. (continued)

- (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<sup>2</sup> and large colonies have a surface area greater than 130 cm<sup>2</sup>. The results are shown in the figure.



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

1

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

1

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

1

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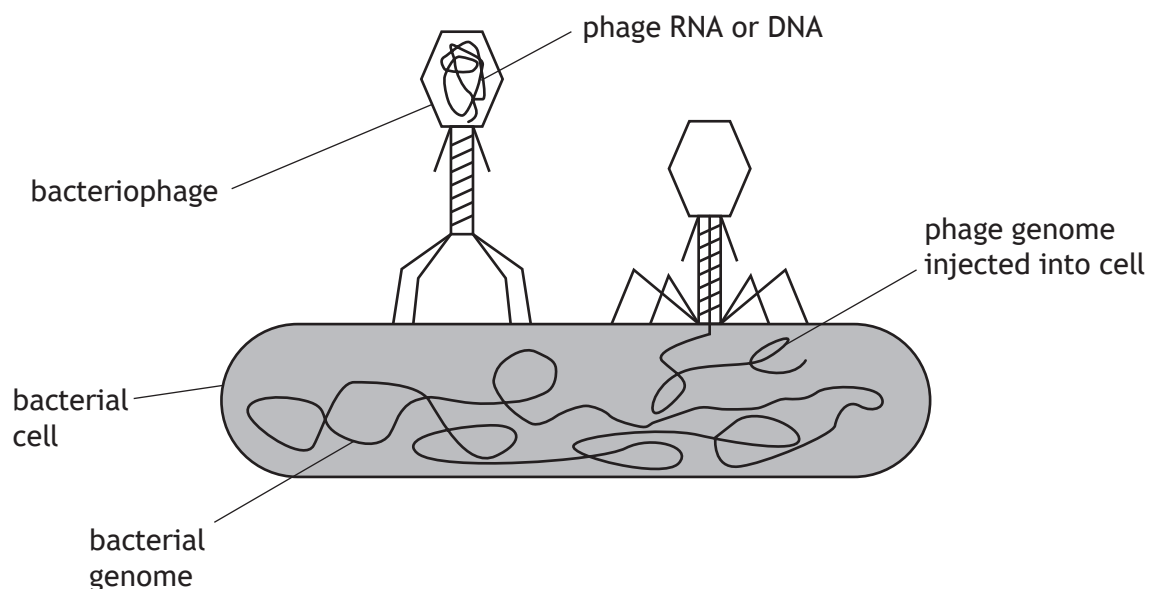
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10. Bacteriophages (phages) are viruses that infect and kill bacteria. In the 1920s, they were used to treat bacterial diseases such as cholera. The use of phage therapy reduced as antibiotics were discovered and became widely available.

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

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- (ii) Phages are parasites.  
State the meaning of the term parasite.

1

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[Turn over



10. (continued)

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

1

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

3

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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

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- (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

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

1

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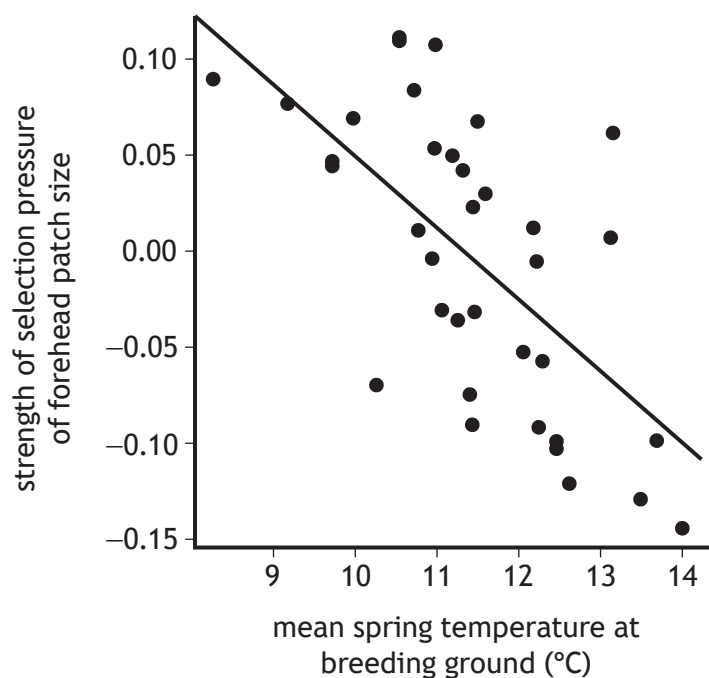
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- (b) Selection trade-offs between investment in sexually selected traits and investment in survival can drive changes in the phenotype of a species.

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

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

1

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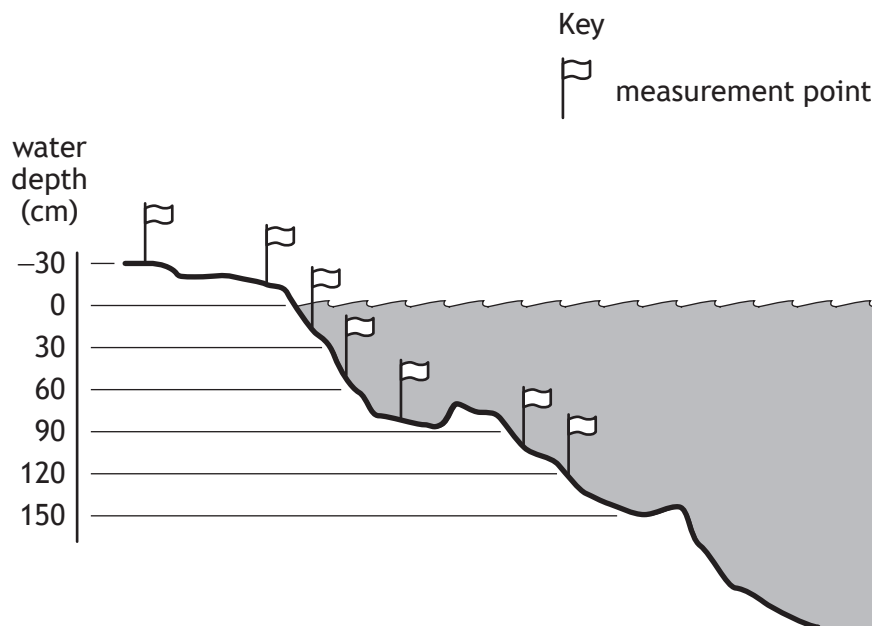
12. *Typha angustifolia* and *Typha latifolia* are two species of bulrushes found growing extensively in wetlands such as marshes and ponds in the Northern Hemisphere. They are commonly found growing together.



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**



[Turn over



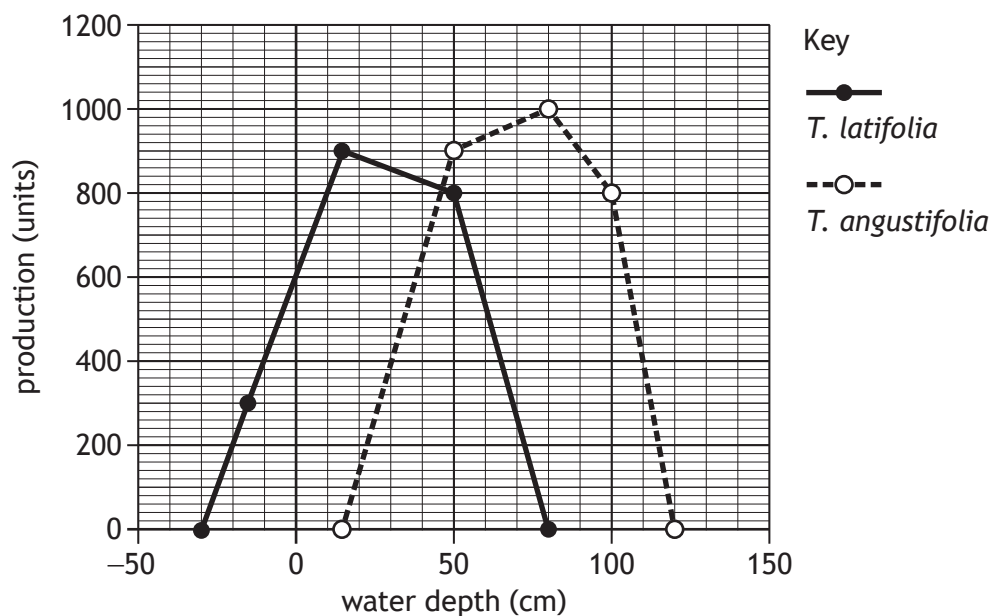
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12. (continued)

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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.

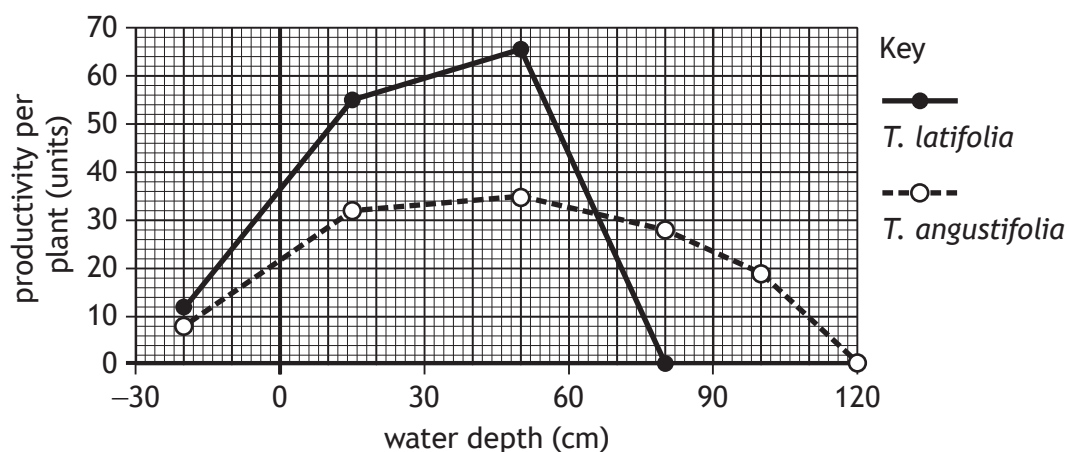
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- (b) Name the type of competition shown between  $T. latifolia$  and  $T. angustifolia$ .

1

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

Figure 1c



\* X 8 0 7 7 7 0 1 2 8 \*

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

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(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. \_\_\_\_\_

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2. \_\_\_\_\_

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[Turn over



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



ADDITIONAL SPACE FOR ANSWER to question 13

[END OF QUESTION PAPER]



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK





ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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Question 12	David Dennis/shutterstock.com



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