

FOR OFFICIAL USE



National  
Qualifications  
2022

Mark

**X807/77/01**

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

THURSDAY, 19 MAY

1:00 PM – 4:00 PM



\* 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 14 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	or	A	B	C	D
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>		<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"/>
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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"/>
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SECTION 2 — 80 marks  
 Attempt ALL questions  
 Question 14 contains a choice

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

(a) Mammals have both specific and non-specific defences against parasites. Antibody production is a specific immune response.

Describe how **one** non-specific defence protects against parasites.

1

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

There is a positive correlation between total blood antibody concentration before and total blood antibody concentration after measles infection.

What conclusion can be drawn about the effect of measles on the total antibody concentration in the blood?

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

Give a conclusion about the effect of infection with the measles virus on antibody diversity.

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1. (c) (continued)

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

The mean age of the control group and the measles infected groups was around eight years old, but the mean age of the group vaccinated against measles was less than two years old, as this is the normal age for measles vaccination.

Suggest why the antibody diversity might be expected to increase more in younger children compared to the control children.

1

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(d) Refer to **Figure 3**.

(i) Calculate the percentage decrease in the proportion of antibodies still present between the medians of the control group and the severely affected measles group.

1

*Space for calculation*

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(ii) Other than the differences in the median values, use the data to compare the effect of the severity of measles infections on the proportion of antibodies still present.

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(iii) Previous studies have suggested that loss of memory cells may contribute to the immune suppression observed after measles virus infection.

Explain how the data support this hypothesis.

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2. Many species of bacteria can be grown in liquid culture.

(a) State the importance of aseptic technique when culturing micro-organisms.

1

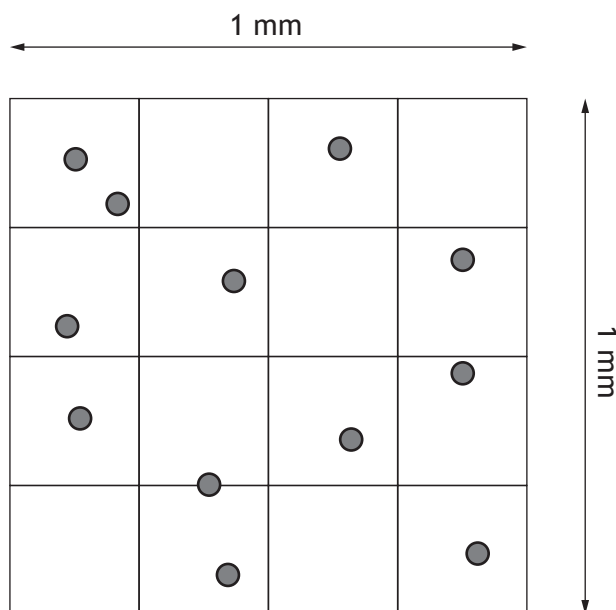
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(b) A haemocytometer can be used to estimate the number of bacterial cells in a liquid culture.

The figure represents bacterial cells from a culture, placed in a haemocytometer that has a depth of 0.1 mm.



Calculate the number of cells per  $\text{cm}^3$  of the liquid culture.

1

*Space for calculation*

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



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2. (continued)

- (c) An experiment was carried out to compare the effects of two novel antimicrobial substances, compounds A and B, on the growth of the bacterium *E. coli*. Cultures of *E. coli* were grown in the presence of the compounds. Cell counts were carried out following vital staining with a dye that is only retained by non-viable cells.

Results from the experiment are shown in the table.

Antimicrobial compound in culture	Mean number of cells	
	Stained by vital stain	Not stained by vital stain
A	380	40
B	385	127

- (i) State which of the antimicrobial compounds is more effective at killing bacterial cells and use the data to explain your choice.

1

Most effective antimicrobial \_\_\_\_\_

Explanation \_\_\_\_\_

- (ii) What method, other than vital staining, can be used to determine the number of viable bacterial cells in a liquid culture?

1

- (iii) Benzalkonium chloride is an antimicrobial compound found in products such as handwashes. It works by disrupting the interactions between the phospholipids of the cell membrane.

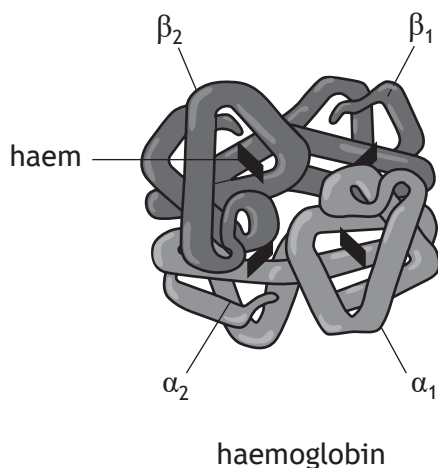
Suggest how this disruption could lead to cell death.

1

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3. Haemoglobin, the oxygen-carrying protein in the blood of vertebrates, consists of four subunits: two alpha ( $\alpha$ ) subunits and two beta ( $\beta$ ) subunits. The  $\alpha$  and  $\beta$  subunits have similar tertiary structure. Each subunit contains a haem group, which binds to oxygen to produce oxyhaemoglobin.



- (a) Within each haemoglobin subunit, a high proportion of the amino acids in the polypeptide form  $\alpha$ -helices.

State the main force stabilising these regions.

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- (b) Explain why haem is described as a prosthetic group.

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- (c) Haemoglobin is affected by a number of allosteric interactions.

Allosteric interactions between the oxygen-binding sites result in co-operativity.

Explain what is meant by co-operativity in haemoglobin.

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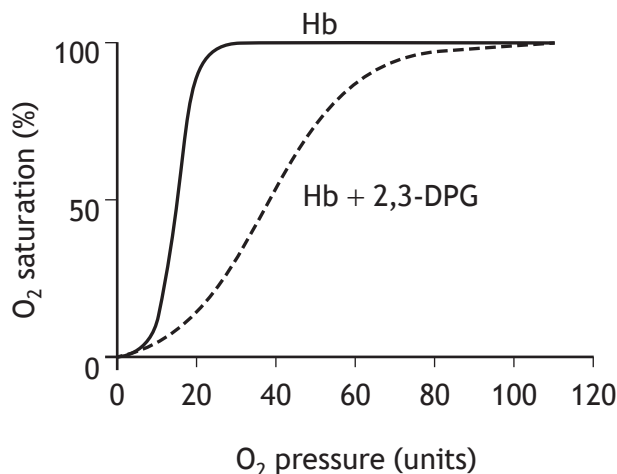


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3. (continued)

- (d) The compound 2,3-diphosphoglycerate (2,3-DPG) is an allosteric modulator that binds haemoglobin (Hb).

The graph shows the effect of 2,3-DPG on the binding of oxygen.



- (i) Explain how the data show that 2,3-DPG is acting as a negative modulator.

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- (ii) The concentration of 2,3-DPG in the blood is normally 5 mmol per litre, but this rises to approximately 8 mmol per litre in individuals living at high altitude.

Explain how this increase in 2,3-DPG concentration at high altitude would help oxygen delivery to tissue.

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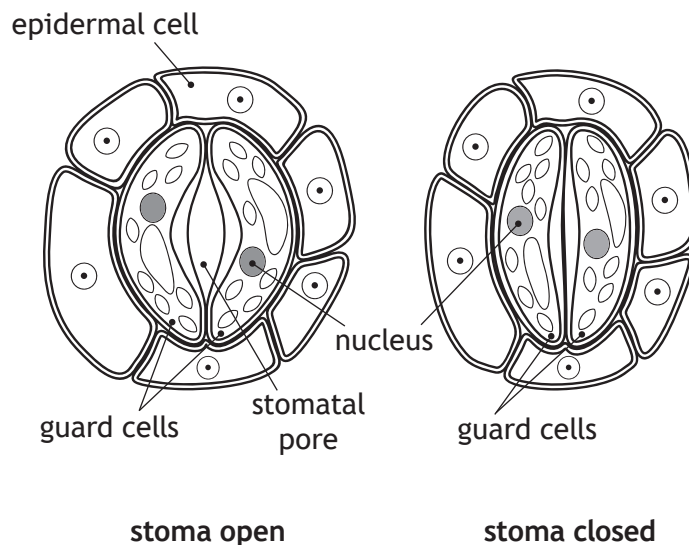


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4. Stomata are pores in the underside of the leaves of plants that allow gas exchange. Each pore (stoma) opens in response to high light intensity and humidity.



The opening mechanism begins with the active transport of positively charged hydrogen ions out of the guard cells via an ion pump.

- (a) The hydrogen ion pump is known to be an ATPase.  
Describe the chemical reaction that ATPases catalyse.

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- (b) What name is given to ion channels that open or close in response to changes in ion concentration?

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4. (continued)

(c) (i) Explain the meaning of the term electrochemical gradient.

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(ii) The movement of hydrogen ions out of the guard cells causes the inside of the cell to become more negatively charged, which in turn results in the opening of potassium ion channels. The final event in the process is the movement of water molecules into the guard cells by osmosis, which results in opening of the stoma.

Explain why, after the potassium channels open, positive potassium ions move into the cell **against** the concentration gradient.

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6. The black mamba, *Dendroaspis polylepis*, is a large African snake whose bite is extremely venomous and usually fatal to humans. Its venom consists of a mixture of toxins that primarily affect the nervous system.

- (a) One of these toxins binds to neurotransmitter receptors at synapses, preventing their activation.

Describe the process by which neurotransmitters released into a synapse initiate an action potential in a connecting cell.

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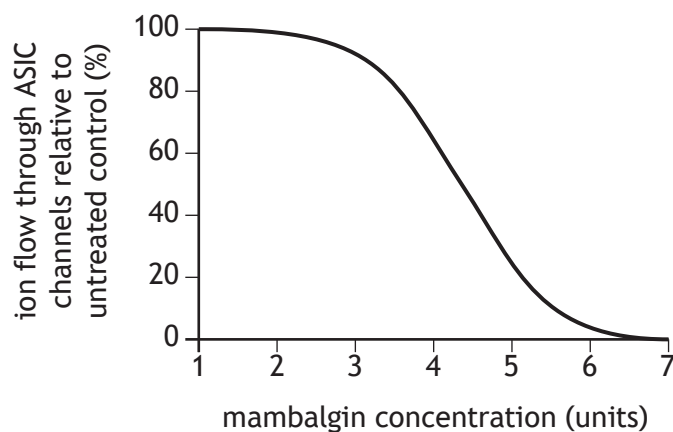


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6. (continued)

(b) *Acid sensing ion channels* (ASICs) are involved in the perception of pain and are activated by small changes in the pH of the surrounding cellular environment. *Mambalgin* is another toxin found in black mamba venom, which is known to be able to bind to ASICs.

The graph shows the effect of increasing the dose of mambalgin on the activity of ASIC ion channels.



(i) Describe the effect of mambalgin concentration on the activity of the ASIC channels.

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(ii) Laboratory experiments on mice show that mambalgin has a similar effect to that of a strong painkiller.

Suggest the mechanism by which mambalgin might work as a painkiller by preventing the generation of a nerve impulse.

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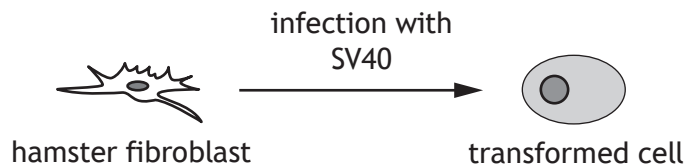
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7. Some viruses can deregulate cell division in cells and cause tumours. Simian virus 40 (SV40) is a virus that naturally infects some species of monkeys. SV40 infection rarely causes disease in its natural host, but it has been shown to be able to induce tumours in laboratory animals and transform rodent cells in culture by causing them to divide in an unregulated way.



(a) (i) Cells transformed with SV40 have features of tumour cells in culture.  
State one way in which tumour cell lines differ from primary cell lines in culture. 1

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(ii) Suggest one advantage of studying SV40 in laboratory animals rather than in cell culture. 1

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(b) Large T antigen (Tag) is a protein encoded by the SV40 genome. This protein is essential for SV40's tumour-forming capabilities. Tag has been shown to bind to and inactivate the tumour suppressor p53.

(i) Give one outcome of p53 activation in a normal cell. 1

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(ii) Tag has also been shown to bind to and inactivate the retinoblastoma protein (Rb).  
Explain how the interaction of Tag with Rb would disrupt the normal control of cell division. 2

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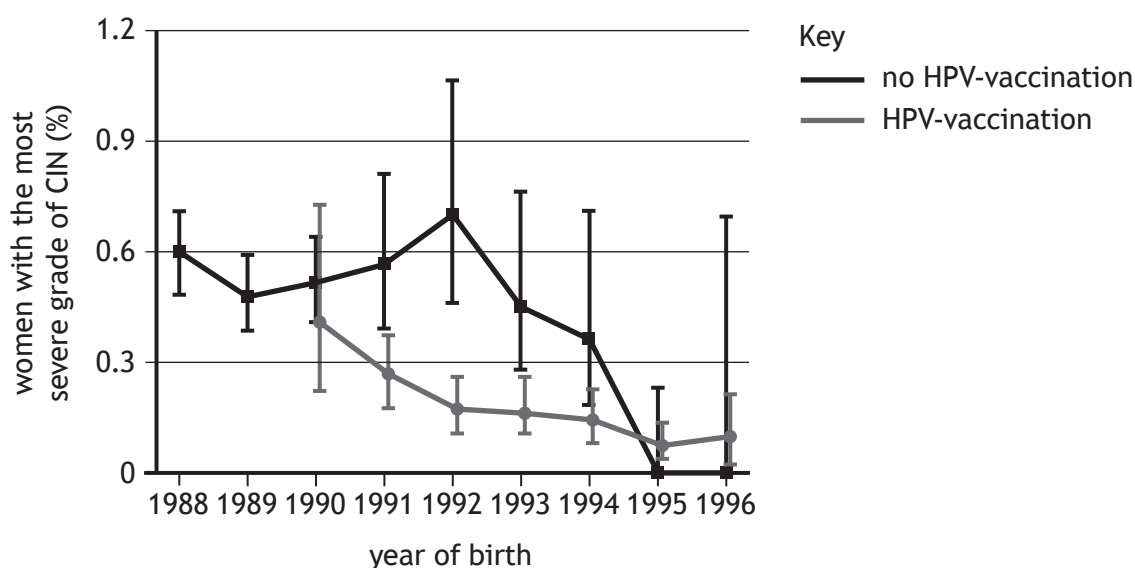
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7. (continued)

- (c) Human papillomavirus (HPV) is another virus that has also been found to inhibit p53 and Rb. HPV can cause the development of cervical intraepithelial neoplasia (CIN), the abnormal growth of cells that line the cervix that can lead to the development of cervical cancer.

A recent study in Scotland assessed the impact of routine vaccination against HPV on the development of CIN in the first year of screening. The graph shows the effect of HPV-vaccination on the percentage of women found to have the most severe grade of CIN by cervical screening.



- (i) What is the effect of HPV-vaccination on the incidence of CIN? 1

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- (ii) Explain how the data support the suggestion that vaccination against HPV could lead to herd immunity. 1

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[Turn over



8. As bananas ripen, the insoluble starch in the cells is converted to soluble sugars giving a sweet taste.

A student wanted to estimate the changes in soluble carbohydrate content of bananas using colorimetry. They crushed peeled banana segments in distilled water and centrifuged the resulting extract. The supernatant was pipetted off into vials and tested with Anthrone reagent. Anthrone turns a blue-green colour with carbohydrates. This coloured solution was then tested in a colorimeter measuring absorbance at 620 nm. Five bananas attached together in a bunch were used. One banana from the bunch was taken and tested each day for 5 days.

The student prepared a range of concentrations of glucose solutions and tested these in the same way as the banana extract solutions.

- (a) The student used information from a peer reviewed article to develop their method using Anthrone reagent.

Describe what happens during the peer review process.

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- (b) (i) Identify a positive control for this experiment.

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- (ii) Suggest why it was important to use bananas originally attached in a single bunch rather than separate bananas.

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- (c) The student used data from the known glucose concentrations to construct a standard curve.

Describe the purpose of this standard curve.

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8. (continued)

(d) Anthrone reacts with both soluble and insoluble carbohydrates.

In the pilot study, the student did not use the centrifuge.

Explain why using the centrifuge is an improvement to this experimental procedure.

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(e) Describe a method that the student could have used when preparing the banana extract to ensure the concentration was controlled.

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(f) The student did not carry out an independent replicate of this experiment.

State one feature of an independent replicate for this experiment.

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(g) Give one reason, other than the lack of independent replication, and the extract concentration, why any results achieved might be considered invalid.

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9. Taxonomy is an essential tool for studies of biodiversity. It involves both the identification and classification of organisms, often based on their morphology.

(a) (i) State one method that can be used to identify organisms in a sample during fieldwork.

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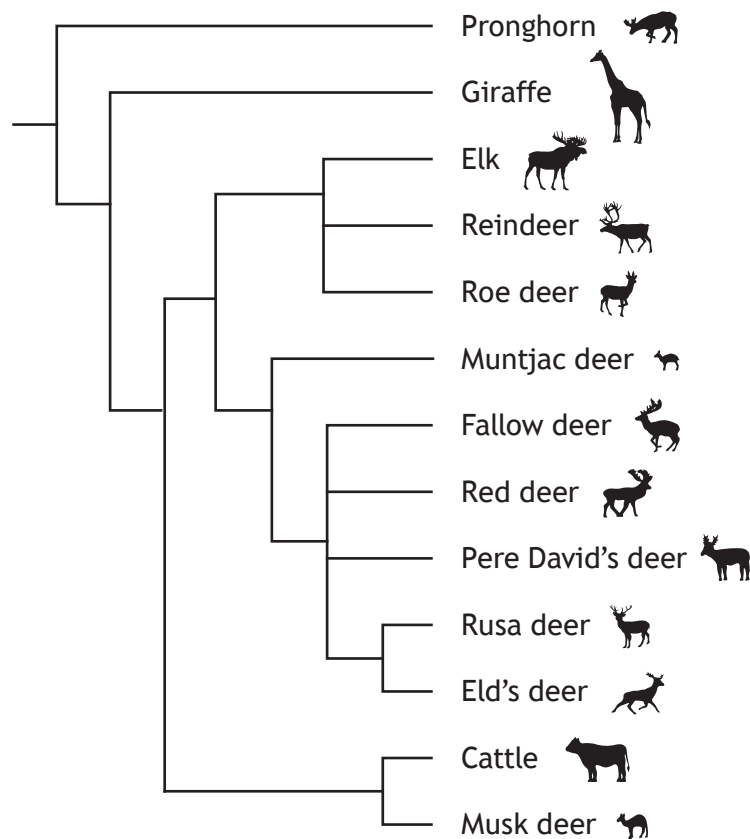
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(ii) What is meant by 'morphology'?

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(b) The figure is a phylogenetic tree showing the evolutionary history and relationships of a number of mammalian species.



(i) Other than morphology, give an example of heritable evidence that may be used to construct a phylogenetic tree.

1

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## 9. (b) (continued)

- (ii) Tick (✓) the box to indicate which of the following statements is correct from the evidence shown.

1

Red deer are more closely related to reindeer than elk	
Cattle are closer relatives of fallow deer than giraffes	
Pere David's deer and red deer have evolved at the same rate	

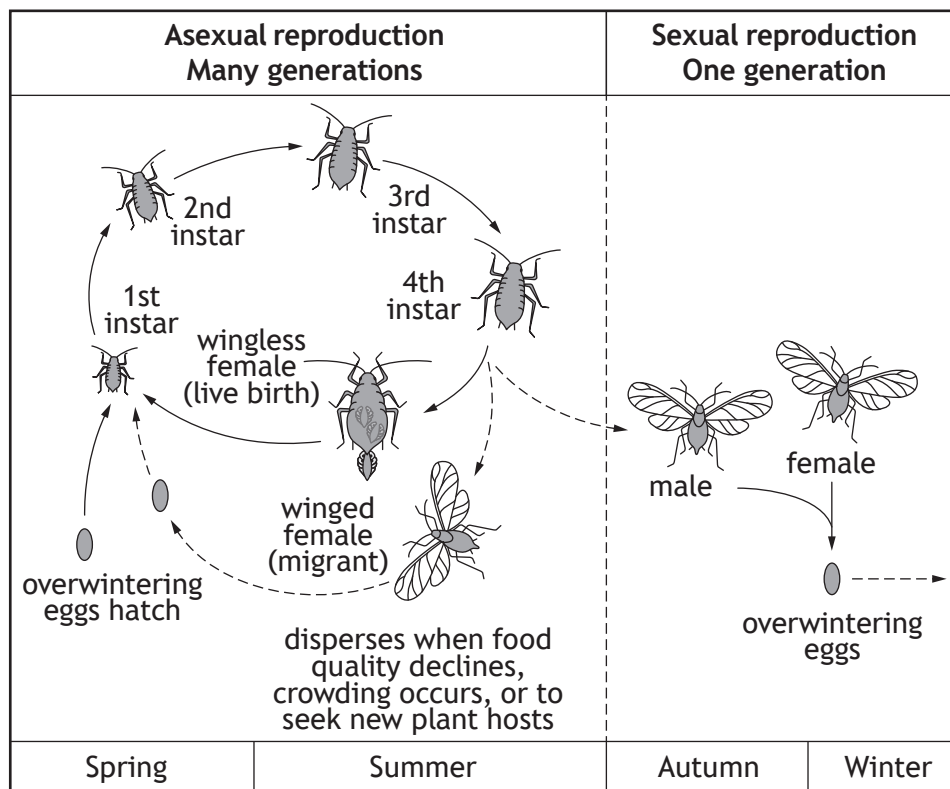
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10. Aphids are small insects adapted to feed on plants by piercing and sucking sap from them. Many crop species are hosts of aphid species and the rapid reproduction rate of aphids represents a significant challenge to food crop production.

Aphids have complex life cycles as shown in the figure.



(a) The form of asexual reproduction carried out by aphids is called parthenogenesis.

State the meaning of the term parthenogenesis.

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(b) Many invertebrates act as vectors for plant viruses.

Use the figure to explain how aphids may act as vectors for plant viruses.

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10. (continued)

The importance of aphids in food security has prompted research into how they are affected by climate change.

(c) In a study of 55 aphid species, it was found that over a period of many years all produced winged forms earlier in the year. Most species showed an increased duration of the flight season. These aphid flight trends follow trends in climate change associated with rising global temperatures.

(i) Predict with justification the effect of these trends on crop production. 1

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(ii) Suggest one evolutionary benefit to aphid populations from increased sexual reproduction made possible by climate change. 1

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[Turn over



11. Several hypotheses regarding the adaptive significance of zebra stripes have been proposed. One study investigated the effect that stripes might have on biting insects. Biting flies are serious pests of many animals, affecting behaviour and productivity.

In this study, an experiment was carried out that involved painting striped patterns on Japanese Black cows. Changes in fly-repelling behaviours and the number of biting flies landing on the cows were observed.

Three cows were each subjected to three different treatments:

- Treatment 1 (BW) — painted stripes using white lacquer (4–5 cm wide)
- Treatment 2 (BB) — painted stripes using black lacquer (4–5 cm wide)
- Treatment 3 (CONT) — no painted stripes (control)

The figure shows a Japanese Black cow with white painted stripes (BW).



The researchers used a grid called a Latin Square to organise the treatments given to each cow. Each experiment lasted for 9 days and was made up of three periods, each lasting for 3 days.

Each cow experienced all three treatments over the course of the three periods. Only one cow was assigned to each treatment in one period.

- (a) Use the codes **BW/BB/CONT** to complete the grid to show one way in which the treatments could have been organised as a Latin Square.

1

	Period 1	Period 2	Period 3
Cow 1			
Cow 2			
Cow 3			



11. (continued)

- (b) Explain how the experimental design contributed to minimising any ethical concerns about the study.

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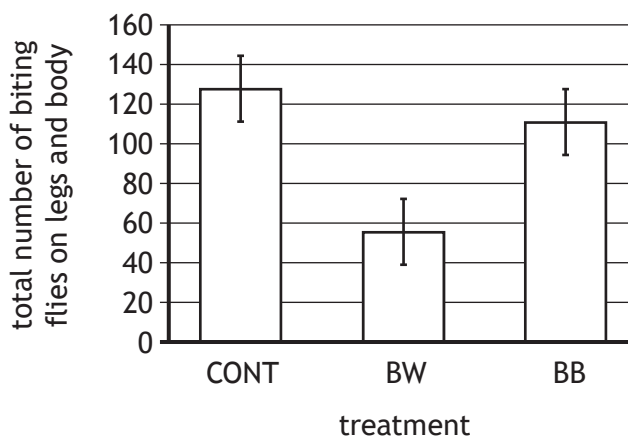
- (c) Each cow was observed twice a day (am/pm) for 30 minutes. Photo images were used to count the number of biting flies on the body and legs.

- (i) Suggest one confounding variable, other than those mentioned, that would need to be controlled in this experiment.

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Results from the experiment are shown in the graph.



- (ii) Give one conclusion about the effects of the treatments.

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- (d) Assuming that colonies of biting flies can be safely maintained in a laboratory, briefly describe a simple experiment (not using live cows) that could be carried out to check the findings of this research.

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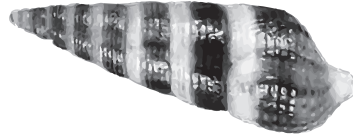
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12. *Batillaria cumingi* is a mudsnail species abundant in saltmarshes and mudflats in north-east Asia. This snail is frequently infected with trematode (flatworm) parasites such as *Cercaria batillariae*. A study was carried out to see the effect of these parasites on the growth and behaviour of the snail hosts.



*Batillaria cumingi*

At the principal study sites infected snails were 20–30% longer than uninfected snails, and their reproductive ability was either blocked or ended.

- (a) Suggest one benefit to the parasites of the changes induced in the snails.

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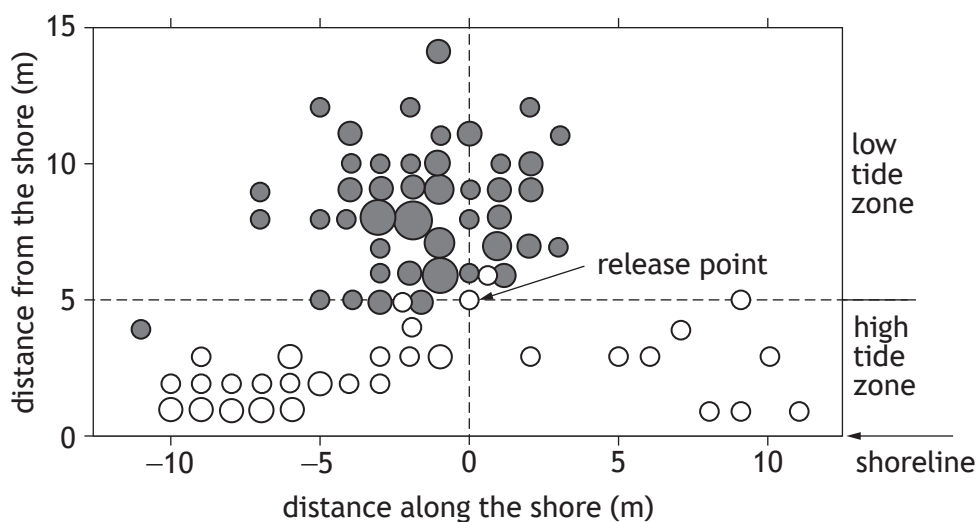
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12. (continued)

A transplant experiment was carried out in which 200 snails, collected from both the upper and lower shores, were moved to the boundary between the upper and lower tidal zones and released. After two weeks the vertical and horizontal distances from the release point were recorded for the snails that were recaptured. All snails were examined for parasites.

Results are shown in the figure.



Key

- uninfected snails
- snails infected by *C. batillariae*

The area of each circle is proportional to the number of snails found at each location

(b) Use the figure to describe the effect of parasite infection on the snails' behaviour.

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(c) Suggest how a new ecological niche for these snails may be created by the changes in their growth and behaviour caused by this parasite.

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12. (continued)

- (d) The mark and recapture technique was involved in some stages of this research.

Describe how the mark and recapture technique could be used to estimate the size of a population.

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13. Cooke and Ryder (1971) studied the genetics of Ross's goose (*Anser rossii*). As goslings (baby geese), they have either yellow or grey feathers. Once the geese mature to adulthood, they all become white.



adult Ross's goose

In a population of geese, observers counted 274 yellow goslings and 423 grey goslings.

- (a) (i) Grey is dominant (G) and yellow is recessive (g).

Use the Hardy-Weinberg principle to calculate the frequency of the homozygous dominant genotype to 2 decimal places.

1

*Space for calculation*

- (ii) Not all goslings survive to adulthood. The Arctic skua preys upon yellow goslings more than grey goslings. It was observed that 312 grey goslings survived to adulthood, but only 121 yellow goslings survived.

An absolute fitness value of 0.8 was calculated for yellow goslings.

What does this value indicate about the frequency of this genotype?

1

[Turn over



13. (continued)

- (b) Ross's geese form a symbiotic relationship with a nematode parasite, *Amidostomum spatulatum*.

What is meant by a symbiotic relationship?

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- (c) For many nematode parasites, definitive hosts are infected through direct uptake of eggs or larvae passed from faeces of infected definitive hosts.

What is meant by a definitive host?

1

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14. Attempt either A or B. Write your answer in the space below and on *page 34*.

A Discuss animal reproduction strategies under the following headings:

- (i) mating systems in animals 3
- (ii) courtship and female choice. 6

OR

B Discuss changes in allele frequency under the following headings:

- (i) natural selection 4
- (ii) genetic drift. 5



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ADDITIONAL SPACE FOR ANSWER to question 14

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MARKS DO NOT  
WRITE IN  
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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

*Acknowledgement of copyright*

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Question 13 Image of goose is taken from Wikipedia. Creative Commons Attribution 2.0 Generic license.



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