Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level BIOLOGY

Paper 1

Thursday 7 June 2018 Morning Time allowed: 2 hours

Materials

For this paper you must have:
- a ruler with millimetre measurements
- a scientific calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the space provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 91.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

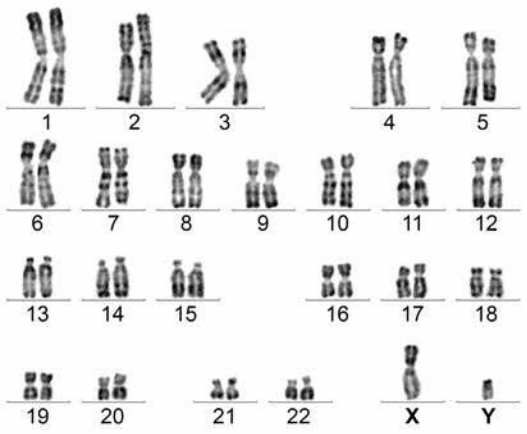
Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 **Figure 1** shows all the chromosomes present in one human cell during mitosis. A scientist stained and photographed the chromosomes. In **Figure 2**, the scientist has arranged the images of these chromosomes in homologous pairs.

Figure 1

Figure 2



0 1 . 1 Give **two** pieces of evidence from **Figure 1** that this cell was undergoing mitosis. Explain your answers.

[2 marks]

1. _____

_____

_____

_____

_____

_____

2. _____

_____

_____

_____

_____

_____

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0 1 . 2 Tick (✓) **one** box that gives the name of the stage of mitosis shown in **Figure 1**.

[1 mark]

Anaphase ☐

Interphase ☐

Prophase ☐

Telophase ☐

0 1 . 3 When preparing the cells for observation the scientist placed them in a solution that had a slightly higher (less negative) water potential than the cytoplasm. This did not cause the cells to burst but moved the chromosomes further apart in order to reduce the overlapping of the chromosomes when observed with an optical microscope.

Suggest how this procedure moved the chromosomes apart.

[2 marks]

Question 1 continues on the next page

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0 1 . 4 The dark stain used on the chromosomes binds more to some areas of the chromosomes than others, giving the chromosomes a striped appearance.

Suggest **one** way the structure of the chromosome could differ along its length to result in the stain binding more in some areas.

[1 mark]

0 1 . 5 In **Figure 2** the chromosomes are arranged in homologous pairs.
What is a homologous pair of chromosomes?

[1 mark]

0 1 . 6 Give **two** ways in which the arrangement of prokaryotic DNA is different from the arrangement of the human DNA in **Figure 1.**

[2 marks]

1.

2.

9

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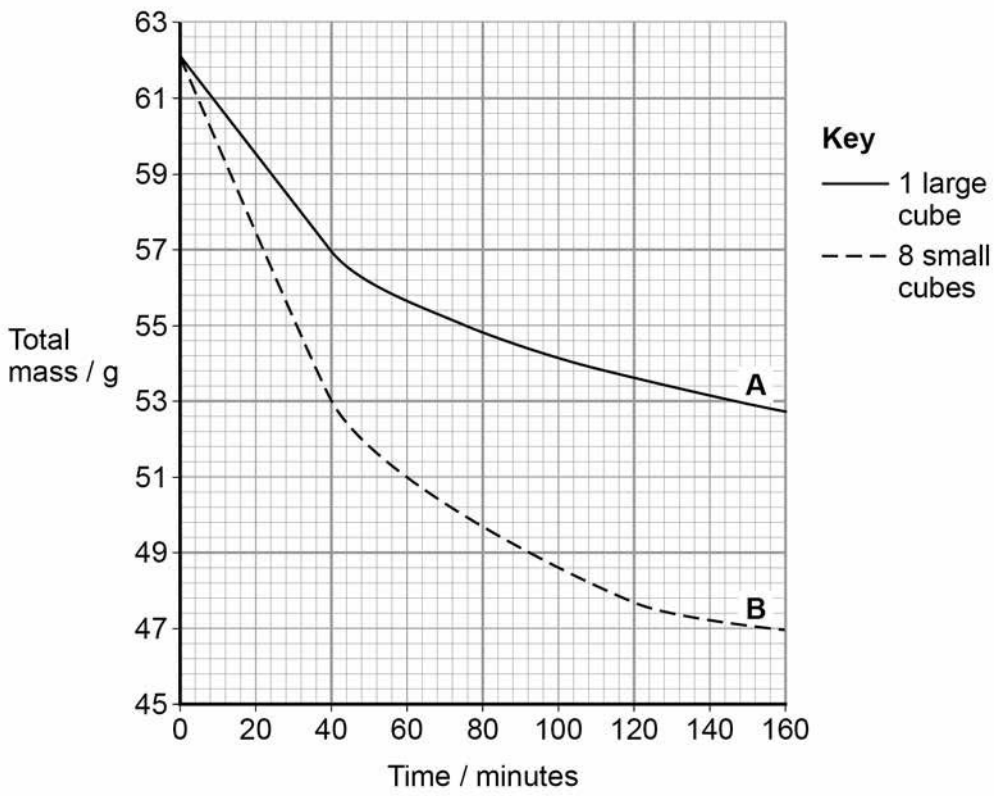
ANSWER IN THE SPACES PROVIDED

0 2 A student investigated the effect of surface area on osmosis in cubes of potato.

- He cut two cubes of potato tissue, each with sides of 35 mm in length.
- He put one cube into a concentrated sucrose solution.
- He cut the other cube into eight equal-sized smaller cubes and put them into a sucrose solution of the same concentration as the solution used for the large cube.
- He recorded the masses of the cubes at intervals.

His results are shown in **Figure 3**.

Figure 3



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0 2 . 1 Describe the method the student would have used to obtain the results in **Figure 3.** Start after all of the cubes of potato have been cut. Also consider variables he should have controlled.

[3 marks]

[Extra space]

Question 2 continues on the next page

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0 2 . 2 The loss in mass shown in **Figure 3** is due to osmosis. The rate of osmosis between 0 and 40 minutes is faster in **B** (the eight small cubes) than in **A** (single large cube).

Is the rate of osmosis per mm^2 per minute different between **A** and **B** during this time? Use appropriate calculations to support your answer.

[3 marks]

[Extra space]

6

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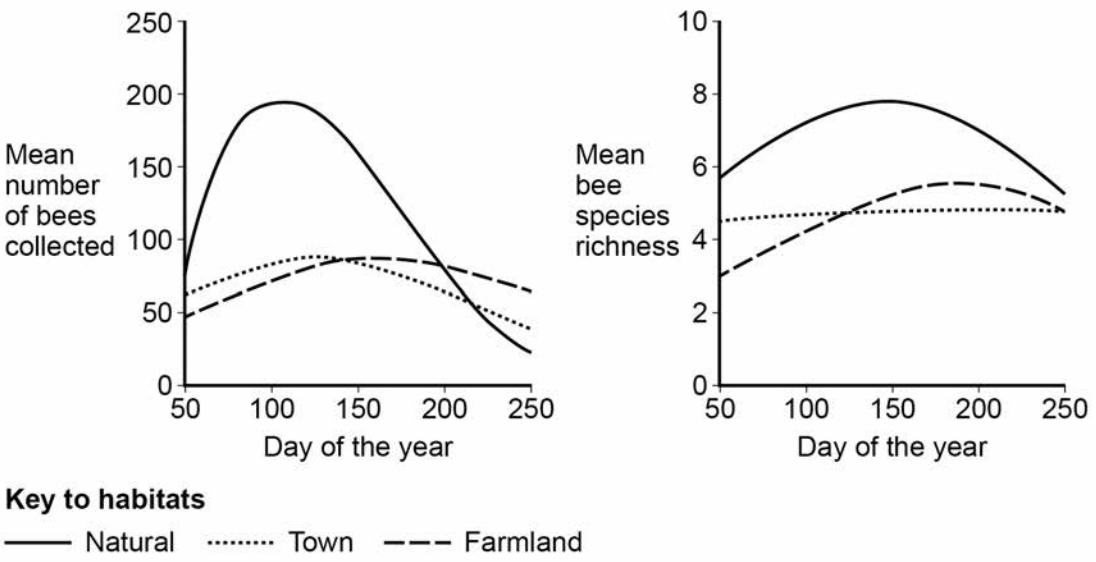
0 3 Bees are flying insects that feed on nectar made in flowers. There are many different species of bee.

Scientists investigated how biodiversity of bees varied in three different habitats during a year. They collected bees from eight sites of each habitat four times per year for three years.

The scientists' results are shown in **Figure 4** in the form they presented them.

Figure 4



0 3 . 1 What is meant by 'species richness'?

[1 mark]

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0 3 . 2 From the data in **Figure 4**, a student made the following conclusions.

1. The natural habitat is most favourable for bees.
2. The town is the least favourable for bees.

Do the data in **Figure 4** support these conclusions? Explain your answer.

[4 marks]

1. The natural habitat is most favourable for bees.

2. The town is the least favourable for bees.

Do not write outside the box

0 3 . 3 The scientists collected bees using a method that was ethical and allowed them to identify accurately the species to which each belonged.

In each case, suggest **one** consideration the scientists had taken into account to make sure their method

[2 marks]

1. was ethical.

2. allowed them to identify accurately the species to which each belonged.

Do not write outside the box

0 3 . 4 Suggest and explain **two** ways in which the scientists could have improved the method used for data collection in this investigation.

[2 marks]

1. _____

2. _____

Question 3 continues on the next page

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0 3 . 5 Three of the bee species collected in the farmland areas were *Peponapis pruinosa, Andrena chlorogaster* and *Andrena piperi*.

What do these names suggest about the evolutionary relationships between these bee species? Explain your answer.

[2 marks]

11

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0 4 . 1 Formation of an enzyme-substrate complex increases the rate of reaction.

Explain how.

[2 marks]

0 4 . 2 A scientist measured the rate of removal of amino acids from a polypeptide with and without an enzyme present. With the enzyme present, 578 amino acids were released per second. Without the enzyme, 3.0×10^{-9} amino acids were released per second.

Calculate by how many times the rate of reaction is greater with the enzyme present. Give your answer in standard form.

[2 marks]

Answer = _____ times faster

Turn over ►

Another scientist investigated an enzyme that catalyses the following reaction.

$$ATP \rightarrow ADP + Pi$$

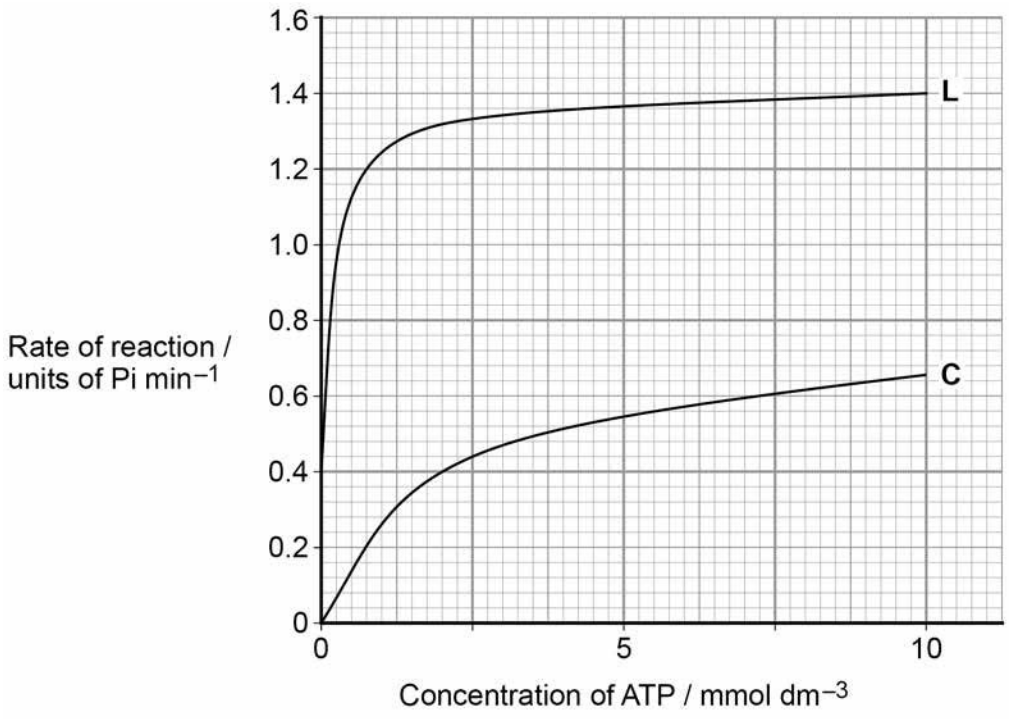
The scientists set up two experiments, **C** and **L**.

Experiment **C** used
- the enzyme
- different concentrations of ATP.

Experiment **L** used
- the enzyme
- different concentrations of ATP
- a sugar called lyxose.

The scientists measured the rate of reaction in each experiment. Their results are shown in **Figure 5**.

Figure 5



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0 4 . 3 Calculate the rate of reaction of the enzyme activity with no lyxose at 2.5 mmol dm^{-3} of ATP as a percentage of the maximum rate shown with lyxose.

[2 marks]

Answer = _____ %

Question 4 continues on the next page

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0 4 . 4 Lyxose binds to the enzyme.

Suggest a reason for the difference in the results shown in **Figure 5** with and without lyxose.

[3 marks]

[Extra space]

9

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0 5 . 1 Draw the general structure of an amino acid.

[1 mark]

Table 1 shows mRNA codons and the amino acids coded for by each codon. It also shows some properties of the R group of each amino acid.

Table 1

1st base	2nd base				3rd base
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		Stop	Stop	A
				Trp	G
C	Leu	Pro	His	Arg	U
					C
			Gln		A
					G
A	Ile	Thr	Asn	Ser	U
					C
	Met		Lys	Arg	A
					G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

Key to the properties of the R group of each amino acid

No overall charge Positively charged Negatively charged

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0 5 . 2 The genetic code is described as degenerate.

What is meant by this? Use an example from **Table 1** to illustrate your answer.

[2 marks]

Question 5 continues on the next page

A scientist investigated changes in the amino acid sequence of a human enzyme resulting from mutations. All these amino acid changes result from single base substitution mutations.
This enzyme is a polypeptide 465 amino acids long.

Table 2 shows the result of three of the base substitutions.

Table 2

Amino acid number	Correct amino acid	Amino acid inserted as a result of mutation
203	Val	Ala
279	Glu	Lys
300	Glu	Lys

0 5 . 3 What is the minimum number of bases in the gene coding for this polypeptide?

[1 mark]

Answer = _____

Do not write outside the box

0 5 . 4 Use information from **Table 1** to tick (✓) **one** box that shows a single base substitution mutation in **DNA** that would result in a change from **Val** to **Ala** at amino acid number 203

[1 mark]

CAA ⟶ CGA ☐

GUU ⟶ GCA ☐

GUU ⟶ GUC ☐

CAC ⟶ CGG ☐

0 5 . 5 A change from Glu to Lys at amino acid 300 had no effect on the rate of reaction catalysed by the enzyme. The same change at amino acid 279 significantly reduced the rate of reaction catalysed by the enzyme.

Use all the information and your knowledge of protein structure to suggest reasons for the differences between the effects of these two changes.

[3 marks]

[Extra space]

8

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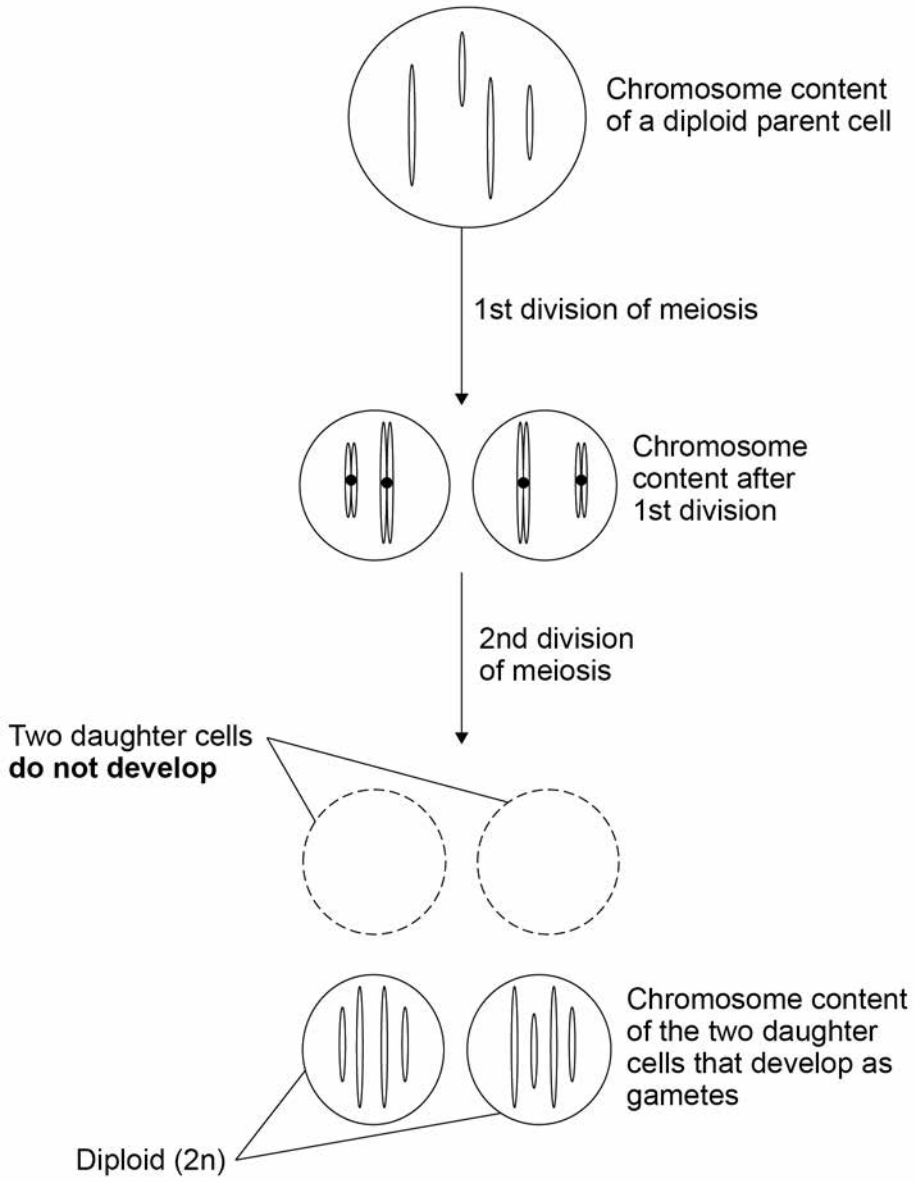
0 6 **Figure 6** shows a faulty form of meiosis that can occur in some plants.

Figure 6



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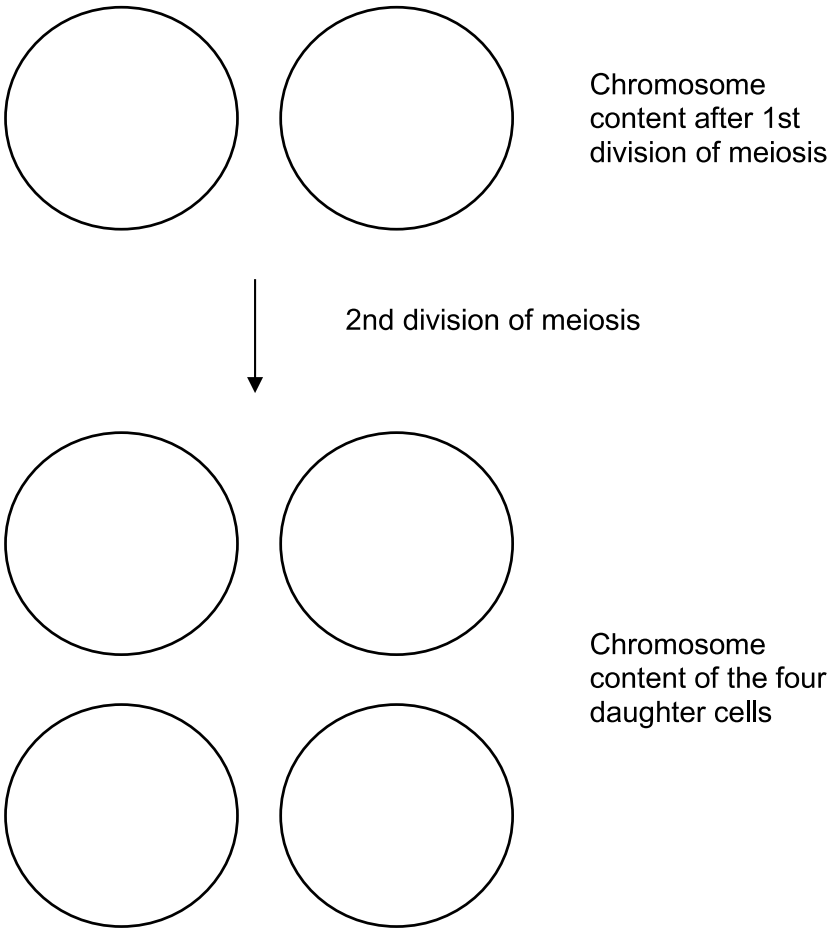
0 6 . 1 Complete **Figure 7** to show the chromosome content of the cells that would result from a normal meiotic division of the diploid parent cell shown in **Figure 6.**

[2 marks]

Figure 7



Question 6 continues on the next page

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

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

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

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

Table 3

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

The scientists used the following null hypothesis.

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

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

[2 marks]

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0 6 . 3 The scientists tested their null hypothesis using the chi-squared statistical test.
After 1 cycle their calculated chi-squared value was 350
The critical value at P=0.05 is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

[2 marks]

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

[3 marks]

[Extra space]

9

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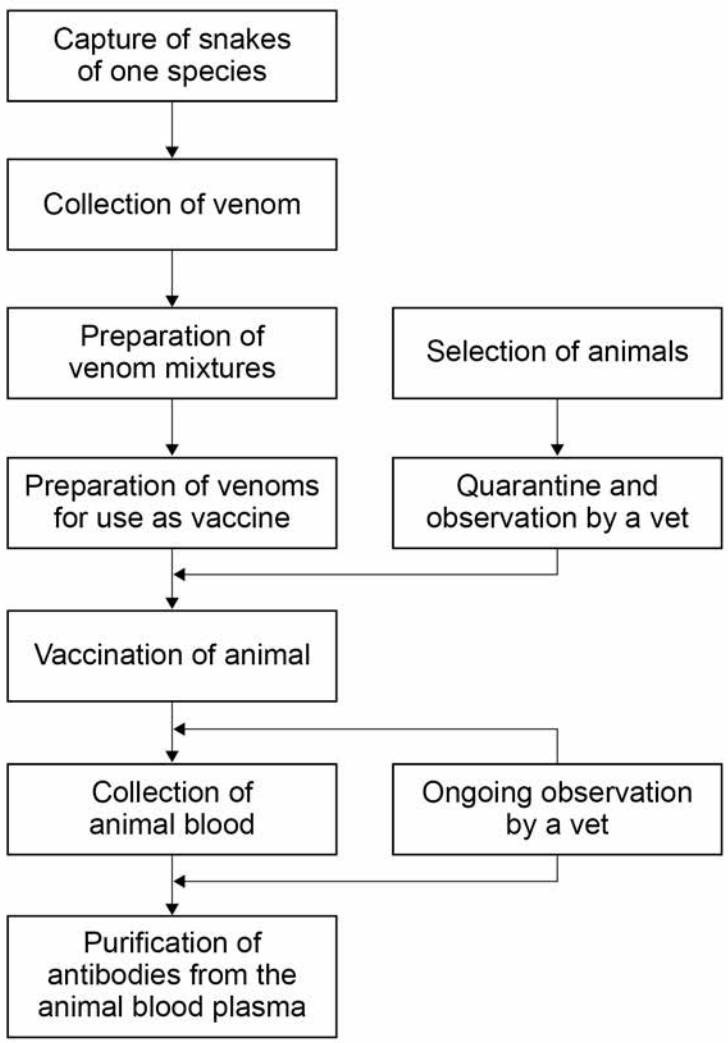
0 7 . 1 When a person is bitten by a venomous snake, the snake injects a toxin into the person. Antivenom is injected as treatment. Antivenom contains antibodies against the snake toxin. This treatment is an example of passive immunity.

Explain how the treatment with antivenom works and why it is essential to use passive immunity, rather than active immunity.

[2 marks]

Figure 8 shows a procedure used to produce antivenom.

Figure 8



0 7 . 2 A mixture of venoms from several snakes of the same species is used.

Suggest why.

[2 marks]

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0 7 . 3 Horses or rabbits can be used to produce antivenoms.
When taking blood to extract antibody, 13 cm^3 of blood is collected per kg of the animal's body mass.
The mean mass of the horses used is 350 kg and the mean mass of the rabbits used is 2 kg

Using only this information, suggest which animal would be better for the production of antivenoms.
Use a calculation to support your answer.

[2 marks]

0 7 . 4 During the procedure shown in **Figure 8** the animals are under ongoing observation by a vet.

Suggest **one** reason why.

[1 mark]

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0 7 . 5 During vaccination, each animal is initially injected with a small volume of venom. Two weeks later, it is injected with a larger volume of venom.

Use your knowledge of the humoral immune response to explain this vaccination programme.

[3 marks]

[Extra space]

10

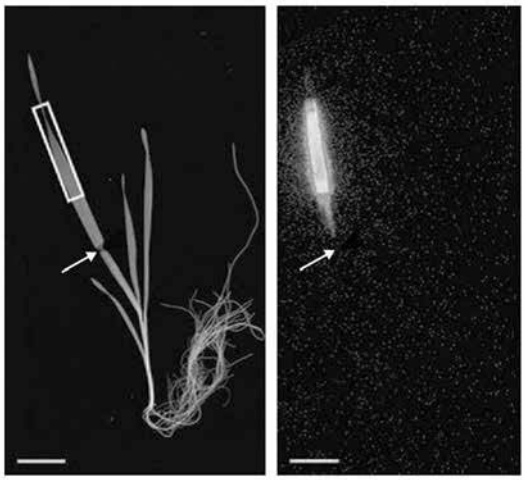
Turn over for the next question

0 8 Scientists investigated the effect of a heat treatment on mass transport in barley plants.

- They applied steam to one short section of a leaf of the heat-treated plants. This area is shown by the arrows in **Figure 9**.
- They did not apply steam to the leaves of control plants.
- They then supplied carbon dioxide containing radioactively-labelled carbon to each plant in the area shown by the rectangular boxes in **Figure 9**.
- After 4 hours, they:
  - found the position of the radioactively-labelled carbon in each plant. These results are shown in **Figure 9**.
  - recorded the water content of the parts of the leaf that were supplied with radioactively-labelled carbon dioxide. These results are shown in **Table 4**.

Figure 9

A – Heat-treated Plant



B – Control Plant, not heat treated

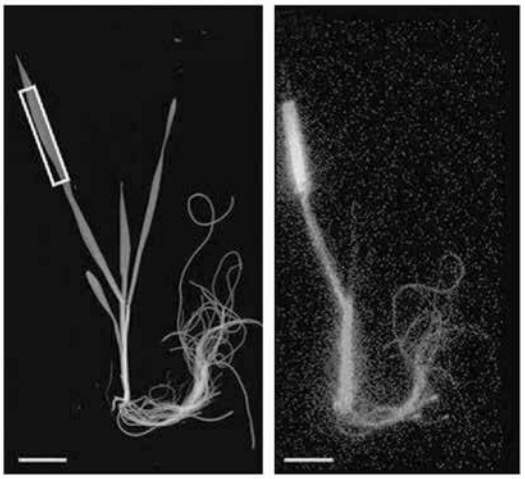


Table 4

Plant from which the leaf was taken	Water content of leaf / % of maximum (± 2 standard deviations)
Heat-treated Plant A	84.6 (±11.3)
Control Plant, not heat treated B	92.8 (±8.6)

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0 8 . 1 The scientists concluded that this heat treatment damaged the phloem.

Explain how the results in **Figure 9** support this conclusion.

[2 marks]

0 8 . 2 The scientists also concluded that this heat treatment did not affect the xylem.

Explain how the results in **Table 4** support this conclusion.

[2 marks]

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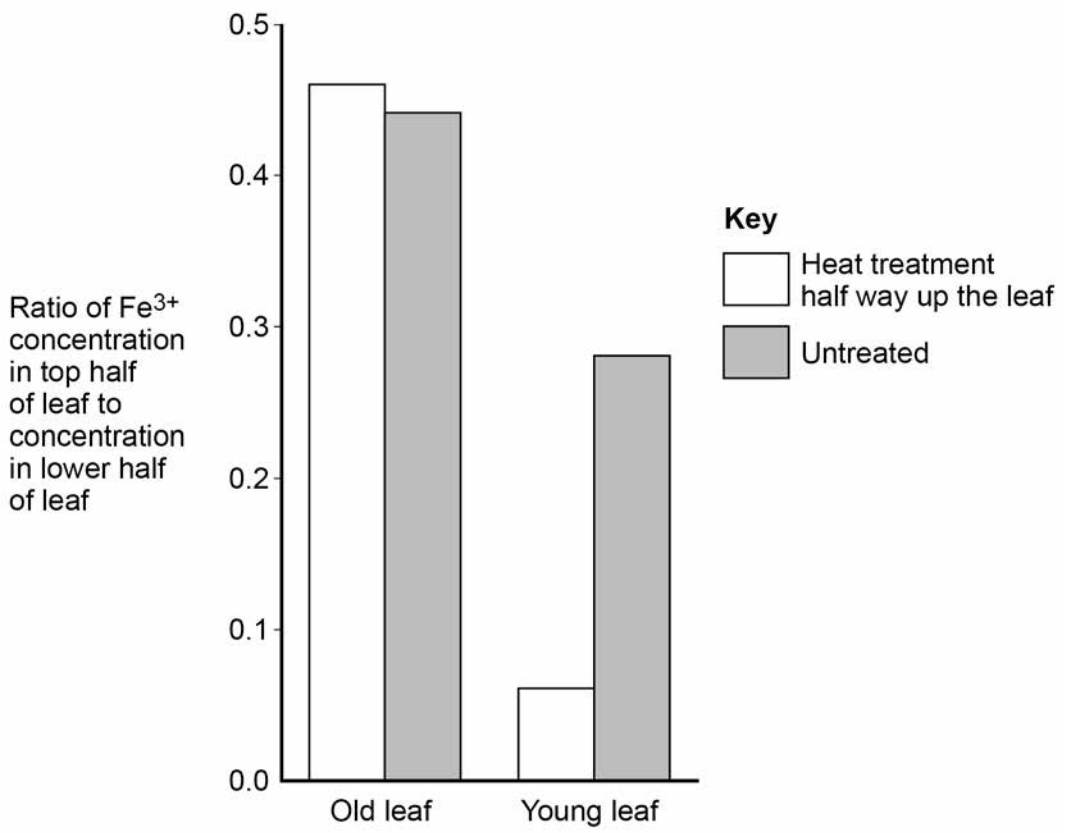
0 8 . 3 The scientists then investigated the movement of iron ions (Fe^{3+}) from the soil to old and young leaves of heat-treated barley plants and to leaves of plants that were not heat treated. Heat treatment was applied half way up the leaves. The scientists determined the concentration of Fe^{3+} in the top and lower halves of the leaves of each plant.

Their results are shown in **Figure 10.**

Figure 10



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What can you conclude about the movement of Fe^{3+} in barley plants?
Use all the information provided.

[4 marks]

8

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0 9 . 1 Describe the role of **two** named enzymes in the process of semi-conservative replication of DNA.

[3 marks]

[Extra space]

Question 9 continues on the next page

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0 9 . 2 Scientists investigated the function of a eukaryotic cell protein called cyclin A. This protein is thought to be involved with the binding of one of the enzymes required at the start of DNA replication.

The scientists treated cultures of cells in the following ways.
C – Control cells, untreated
D – Added antibody that binds specifically to cyclin A
E – Added RNA that prevents translation of cyclin A
F – Added RNA that prevents translation of cyclin A **and** added cyclin A protein

They then determined the percentage of cells in each culture in which DNA was replicating.

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

Table 5

Cell treatment	**Percentage of cells where DNA was replicating**
C Control	91
D Antibody that binds specifically to cyclin A	11
E RNA that prevents translation of cyclin A	10
F RNA that prevents translation of cyclin A **and** added cyclin A protein	92

Do not write outside the box

Suggest explanations for the results in **Table 5.**

[3 marks]

[Extra space]

6

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1 0 . 1 Describe the gross structure of the human gas exchange system and how we breathe in and out.

[6 marks]

Do not write outside the box

1 0 . 2 Mucus produced by epithelial cells in the human gas exchange system contains triglycerides and phospholipids.

Compare and contrast the structure **and** properties of triglycerides and phospholipids.
[5 marks]

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1 0 . 3 Mucus also contains glycoproteins. One of these glycoproteins is a polypeptide with the sugar, lactose, attached.

Describe how lactose is formed and where in the cell it would be attached to a polypeptide to form a glycoprotein.

[4 marks]

END OF QUESTIONS

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