OXFORD AQA
INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

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I declare this is my own work.

INTERNATIONAL A-LEVEL
BIOLOGY (9610)

Unit 4 Control

Tuesday 4 June 2024 07:00 GMT Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

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 spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

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

Do not write outside the box

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

0 1 Stem cells are used increasingly in research to treat a variety of human disorders.

Some stem cells are described as totipotent, other stem cells are described as pluripotent.

0 1 . 1 Define **totipotent** and **pluripotent**.

[2 marks]

Totipotent _____

_____

Pluripotent _____

_____

0 1 . 2 Suggest **two** human disorders that could be treated using stem cells.

[2 marks]

1 _____

2 _____

Induced pluripotent stem cells (iPSCs) can be made using cells from a patient. Growth factors are added to these cells, causing them to become pluripotent. These stem cells could then be used for treating a disorder. Stem cells can also be found in embryos.

0 1 . 3 Give **two** advantages of using iPSCs to treat a disorder instead of using embryonic stem cells.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

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Stem cells are also used to produce 'organoids'. An organoid is a cell culture system that is 3-dimensional. Organoids can be called 'mini organs' as they have **some** of the key functional characteristics of real organs.

0 1 . 4 Suggest how scientists could make use of these mini organs in medical research.

Give **two** examples.

[2 marks]

1 _____

2 _____

8

Turn over for the next question

Do not write outside the box

0 2 In recombinant DNA technology, scientists often use restriction enzymes.

'Flanking regions' are sequences of DNA bases found on either side of a gene that has been cut from a chromosome using a restriction enzyme.

The length of the flanking region will be determined by the restriction enzyme used to cut the DNA.

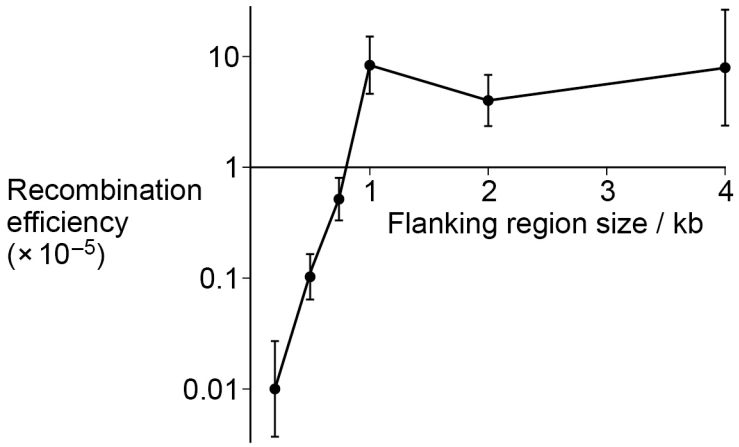
0 2 . 1 Explain why the use of different restriction enzymes generates flanking regions of different lengths.

[2 marks]

Figure 1 shows the recombination efficiency (number of successful recombinant cells per total number of cells present) for a gene with different sized flanking regions.

The error bars show ± standard error.

Figure 1



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0 2 . 2 Describe how the length of the flanking region affects recombination efficiency.

Use **Figure 1**.

[2 marks]

0 2 . 3 What do the error bars show about the significance of the data in **Figure 1**?

[1 mark]

5

Turn over for the next question

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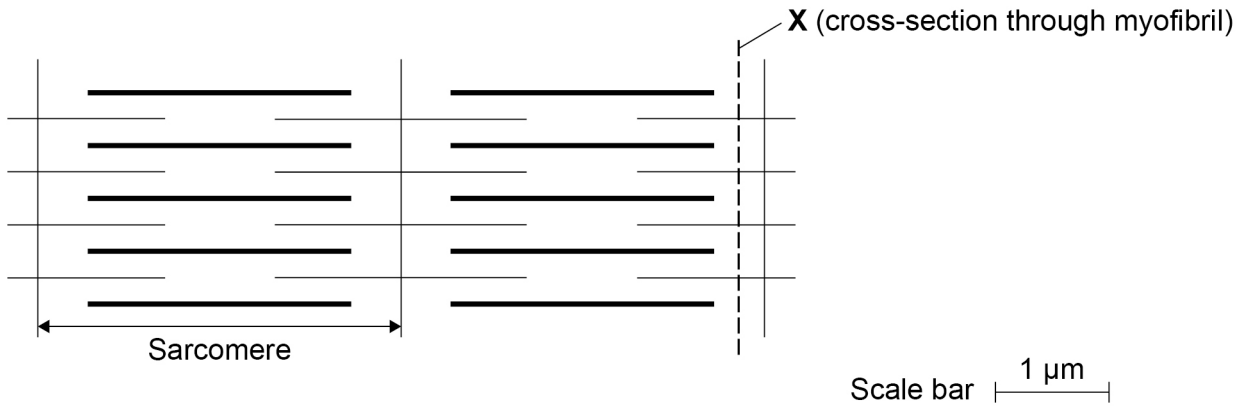
0 3 Muscle fibres contain myofibrils.

Figure 2 shows the arrangement of the two main protein filaments in one section of a relaxed myofibril.

Figure 2



0 3 . 1 Label **Figure 2** to show:

- one location where the enzyme ATPase would be found
- one location where the protein tropomyosin would be found.

[2 marks]

0 3 . 2 The full length of the muscle fibre is 35 mm when relaxed.

When the muscle fibre is contracted each sarcomere is 2.15 µm in length.

Calculate the full length of the muscle fibre when it is contracted.

Use the information provided and **Figure 2**.

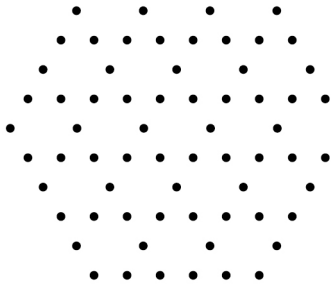
[3 marks]

Full length of muscle fibre when contracted _____ mm

Do not write outside the box

The myofibril in **Figure 2** was cut at position **X** to show a cross-section.
Figure 3 shows the appearance of the protein filaments in the cross-section when the myofibril is relaxed.

Figure 3



The appearance of **Figure 3** would be different if the myofibril were contracted.

0 3 . 3 Explain the difference in **Figure 3** when the myofibril is contracted.

[2 marks]

Question 3 continues on the next page

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Scientists investigate the activity of the enzyme ATPase during muscle contraction.

The scientists make three preparations, **A**, **B** and **C**:

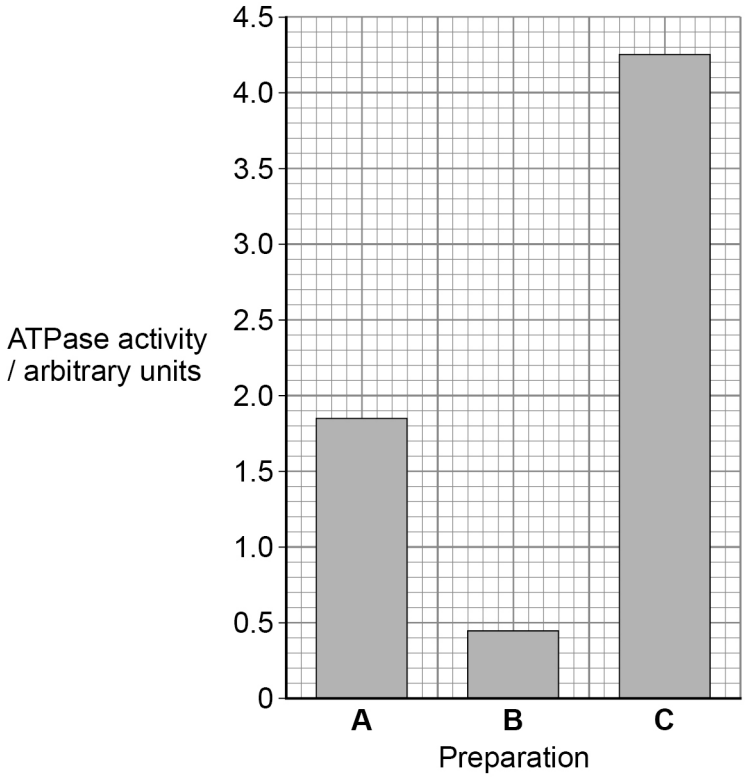
- **A** contains actin and myosin
- **B** contains actin, myosin and tropomyosin
- **C** contains actin, myosin, tropomyosin and calcium ions.

Each preparation also contains ATP.

The scientists measure the level of ATPase activity for each preparation.

Figure 4 shows the results.

Figure 4



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0 3 . 4 Explain the difference in the results for preparations **B** and **C** shown in **Figure 4**.

Include the roles of ATP and ATPase in your answer.

[6 marks]

13

Turn over for the next question

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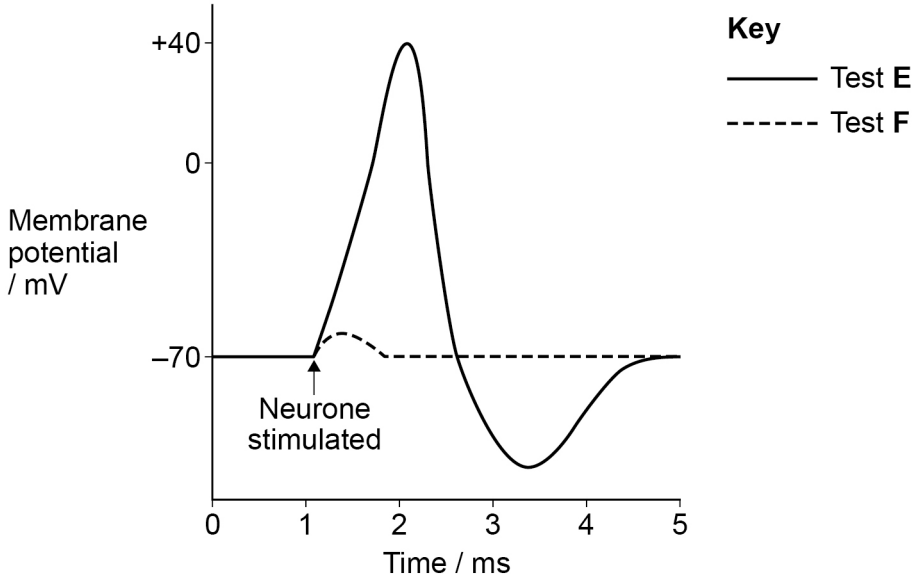
0 4 Scientists investigate the generation of impulses in a neurone.

The scientists:

- stimulate the neurone with an electrode
- measure changes in the neurone's membrane potential.

Figure 5 shows the results when the neurone is stimulated in two different tests, **E** and **F**.

Figure 5



0 4 . 1 Explain the difference between the response in Test **E** and the response in Test **F**.

[2 marks]

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Question 4 continues on the next page

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0 4 . 2 Explain why a neurone with a myelinated axon conducts a nerve impulse faster than a neurone with a non-myelinated axon.

[2 marks]

Scientists investigate the effect of a mutation in a gene called Cyfip1 on myelin thickness of neurones.

The scientists:

- collect tissue samples from the brains of mice with and without the Cyfip1 mutation
- analyse the axons of a large number of neurones from these tissue samples
- measure the axon diameter (*d*) and the neurone diameter (*D*)
- calculate a g-ratio (*d*/*D*) for each neurone.

Figure 6 shows how the scientists calculate the g-ratio.

Figure 6

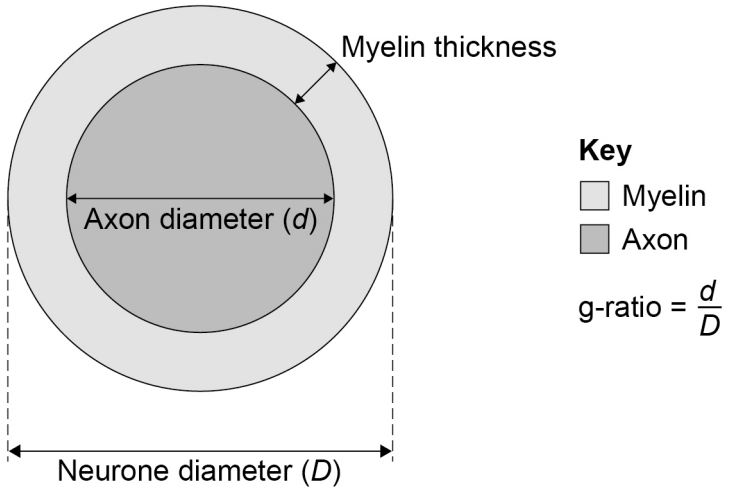

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Table 1 shows data from two neurones.

Table 1

Neurone	Axon diameter (*d*) / µm	g-ratio
J	0.4	0.62
K	0.4	0.47

0 4 . 3 Calculate the difference in the myelin thickness between neurone **J** and neurone **K**.

Use the information shown in **Table 1** and **Figure 6**.

[3 marks]

Difference in myelin thickness_____ µm

Question 4 continues on the next page

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Figure 7 shows the scientists' results.

Figure 7

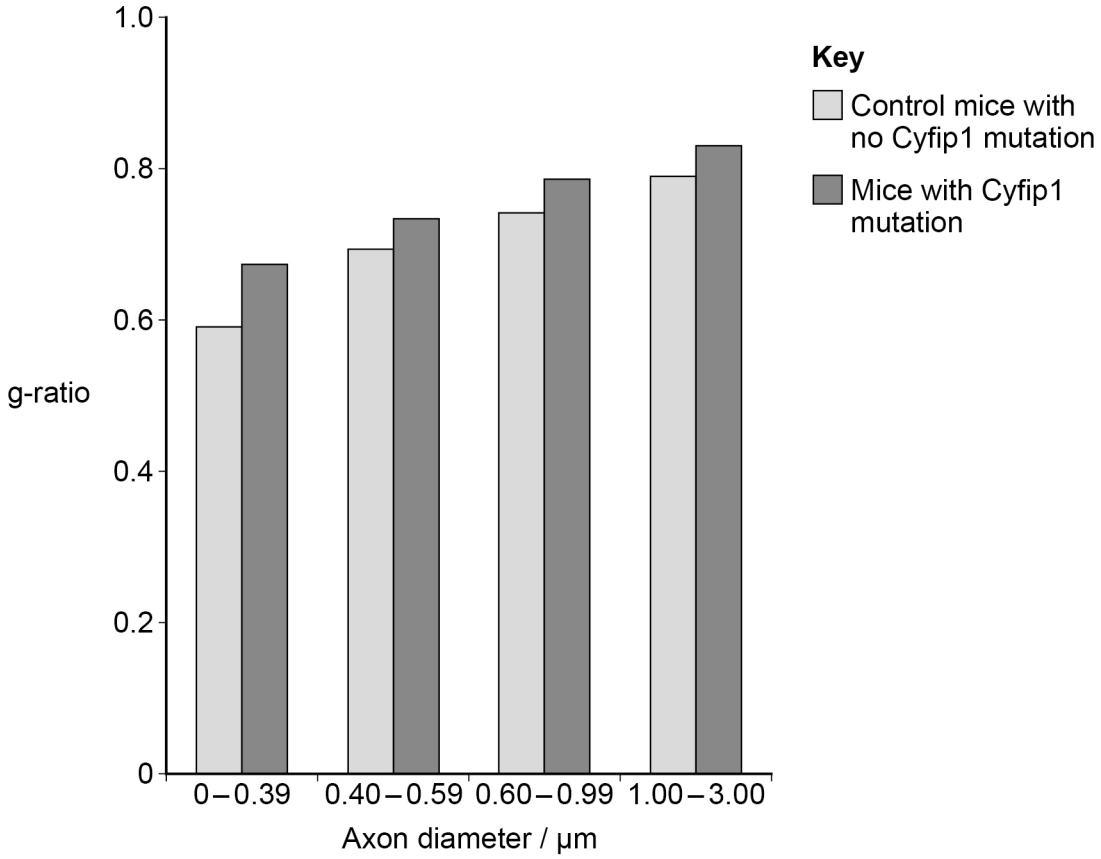
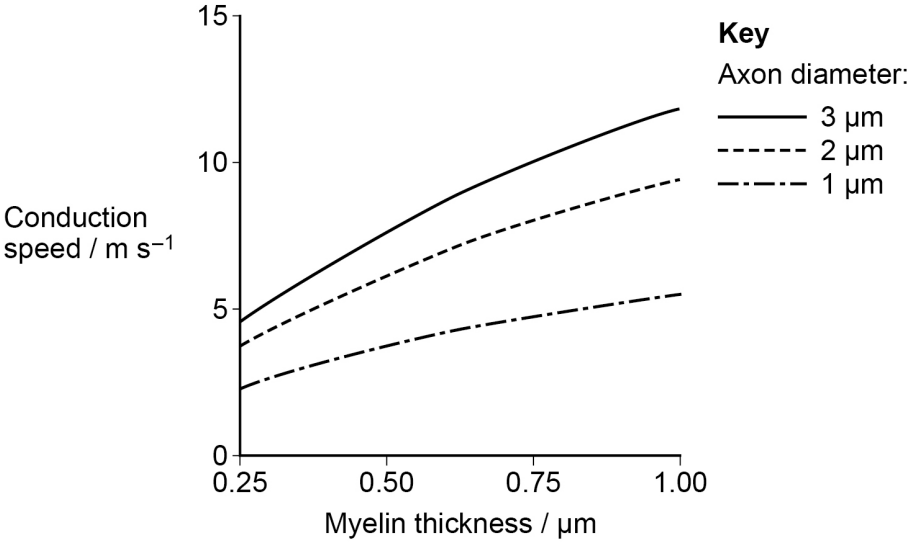


Figure 8 shows the relationship between myelin thickness and the speed of impulse conduction.

Figure 8



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0 4 . 4 Explain the effect that the Cyfip1 mutation will have on the speed of impulse conduction.

Use information from **Figure 7** and **Figure 8**.

[3 marks]

10

Turn over for the next question

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0 5 Homeostasis involves the process of negative feedback.

0 5 . 1 Define **negative feedback**.

[1 mark]

0 5 . 2 Explain why **positive** feedback is rare in biological control systems.

[2 marks]

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Question 5 continues on the next page

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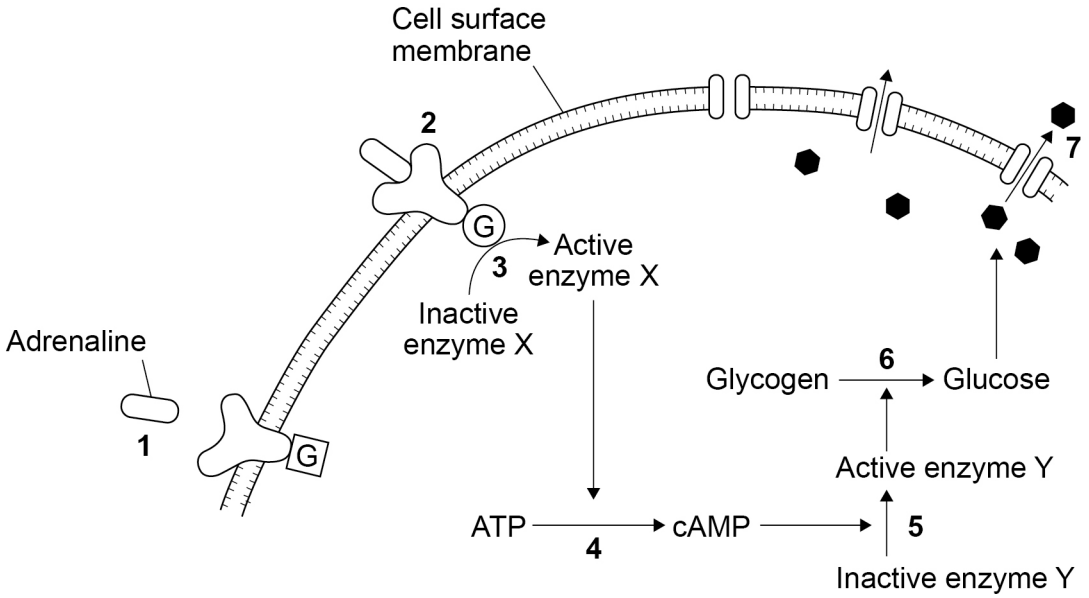
Adrenaline is a hormone involved in the control of blood glucose concentration. Adrenaline has an indirect effect on target cells. This is known as the second messenger model.

Figure 9 shows the mechanism of adrenaline action.

Figure 9



0 5 . 3 Use **Figure 9** and your own knowledge to describe how adrenaline increases blood glucose concentration.

[5 marks]

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0 5 . 4 Suggest why cells that use a second messenger to respond to a hormone have large numbers of mitochondria.

[2 marks]

Insulin and glucagon are protein hormones.

They bind to specific receptors on the cell surface membrane of target cells.

0 5 . 5 Oestrogen is a lipid-based hormone.

Suggest why oestrogen receptors are found in the cytoplasm and **not** on the cell surface membrane of target cells.

[2 marks]

12

Turn over for the next question

Do not write outside the box

0 6 Recombinant DNA technology involves the transfer of fragments of DNA from one organism to another. As an example, bacteria can be used to produce human insulin.

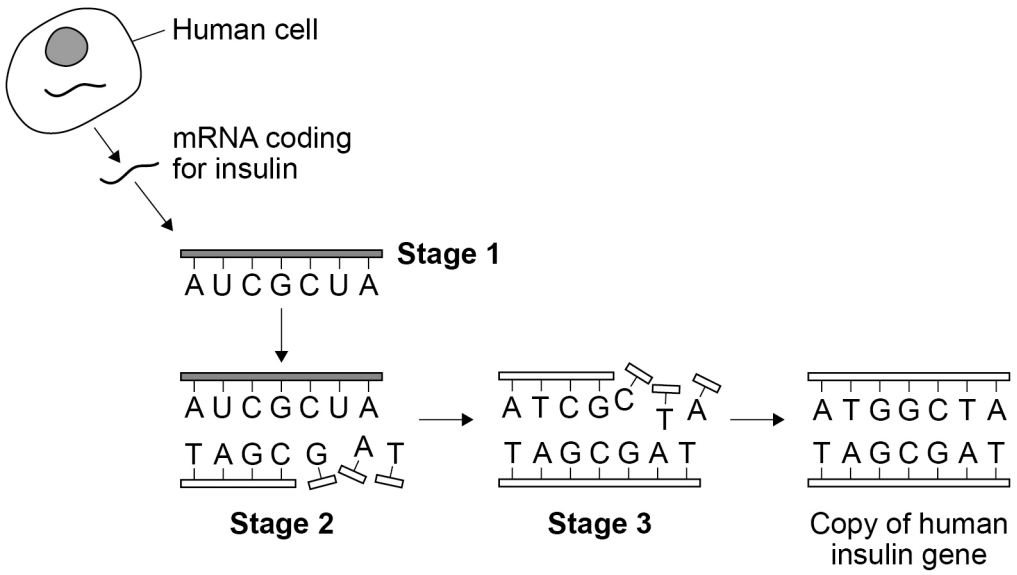
0 6 . 1 Explain why bacteria are able to make human proteins from human genes inserted into their DNA.

[2 marks]

Fragments of DNA can be obtained by several methods. One method involves the use of mRNA.

Figure 10 shows the steps involved in the production of DNA fragments containing the insulin gene from mRNA.

Figure 10



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0 6 . 2 Describe what happens in **Stage 2** and **Stage 3** in **Figure 10**. Include the names of the enzyme used in each stage.

[4 marks]

Stage 2 _____

_____

Name of enzyme needed _____

Stage 3 _____

_____

Name of enzyme needed _____

DNA fragments can also be obtained by using restriction enzymes to cut the desired gene from the DNA. This DNA can then be inserted into bacterial plasmids using the same restriction enzyme.

0 6 . 3 The **same** restriction enzyme is used to cut the DNA and the bacterial plasmid.

Explain why.

[2 marks]

_____

_____

_____

_____

_____

_____

Question 6 continues on the next page

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Using bacteria to make copies of human genes is called *in vivo* gene amplification.

Gene markers are used to identify which bacteria have successfully taken up the plasmids and which contain the human gene.

Examples of gene markers are antibiotic resistance genes found on bacterial plasmids. The plasmids are shown in **Figure 11**.

Figure 11

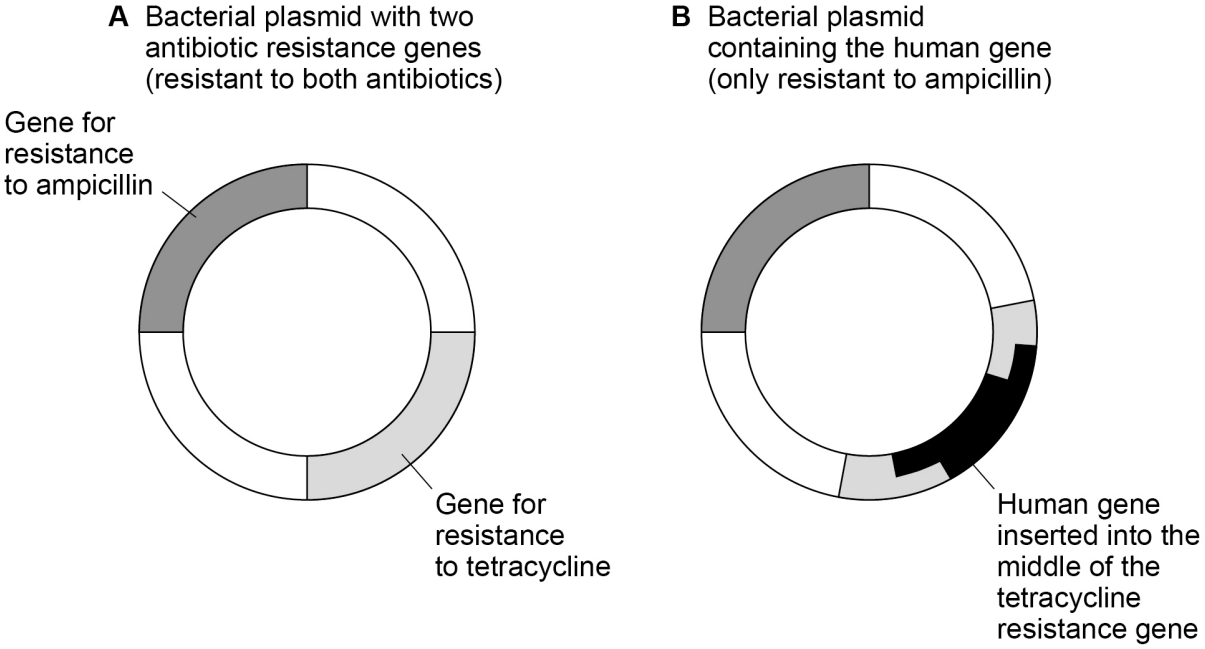
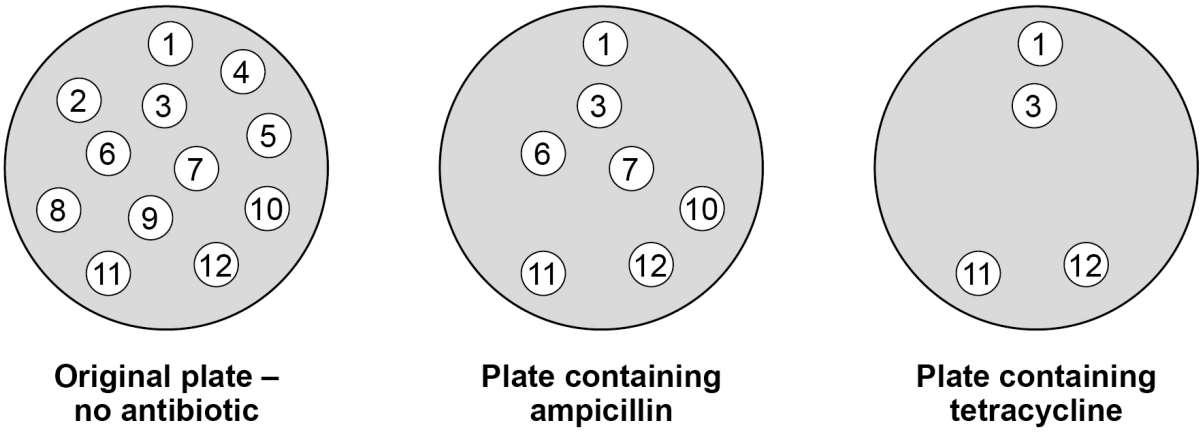


Figure 12 shows the results after growing the bacteria on agar plates. The circles on each plate represent bacterial colonies.

Figure 12



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0 6 . 4 Use **Figure 12** to identify the numbers of all the colonies containing bacteria that have:

- no plasmids with the antibiotic resistance genes
- plasmids with the human gene.

[2 marks]

No plasmids with the antibiotic resistance genes _____

Plasmids with the human gene _____

0 6 . 5 Give **one** disadvantage of using antibiotic resistance genes as marker genes.

[1 mark]

_____

_____

_____

0 6 . 6 Give **one** example of a gene marker other than antibiotic resistance.

[1 mark]

_____

_____

_____

12

Turn over for the next question

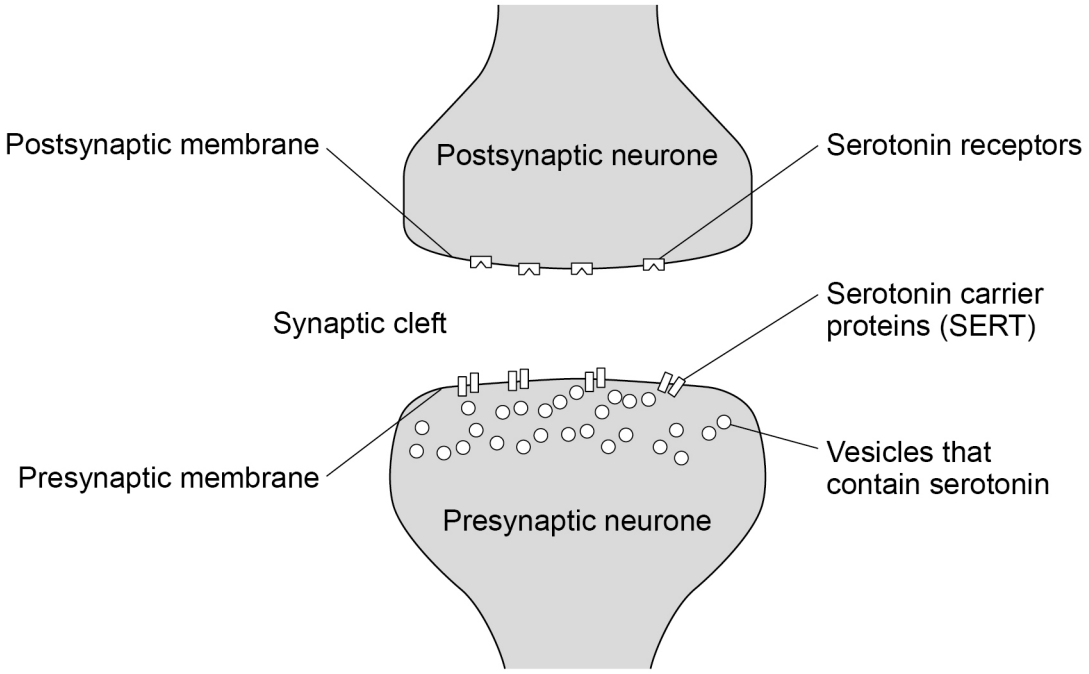
Do not write outside the box

0 7 A neurotransmitter is a chemical that diffuses across a synapse and causes an action potential in the next neurone.

Serotonin is a neurotransmitter produced by some neurones in the brain.

Figure 13 shows a synapse that uses serotonin as the neurotransmitter.

Figure 13



0 7 . 1 Describe the process that causes the release of a neurotransmitter such as serotonin by the presynaptic neurone.

[2 marks]

Do not write outside the box

0 7 . 2 The presynaptic membrane has serotonin carrier proteins (SERT) to reabsorb serotonin quickly from the synaptic cleft.

Explain why it is important for neurotransmitters such as serotonin to be reabsorbed quickly.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

Drugs can affect the functioning of synapses.

Scientists investigate the effect of the drug MDMA on the serotonin concentration and brain tissue of rats.

The scientists:

- put 24 adult male rats randomly into four groups (**Q**–**T**), each containing six rats
- prepare different concentrations of MDMA using saline solution
- inject the rats twice each day as shown in **Table 2**.

Table 2

Group	Concentration of MDMA / mg kg^{-1} body mass	Level of dosage
Q	0	–
R	5	Low
S	10	Medium
T	15	High

- keep all the rats under controlled conditions for 1 week
- collect samples of brain fluid from each rat
- measure the concentration of serotonin in the samples of brain fluid
- prepare and analyse samples of brain tissue to find the number of intact neurones.

0 7 . 3 Explain the purpose of group **Q** in this investigation.

[2 marks]

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Question 7 continues on the next page

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ANSWER IN THE SPACES PROVIDED

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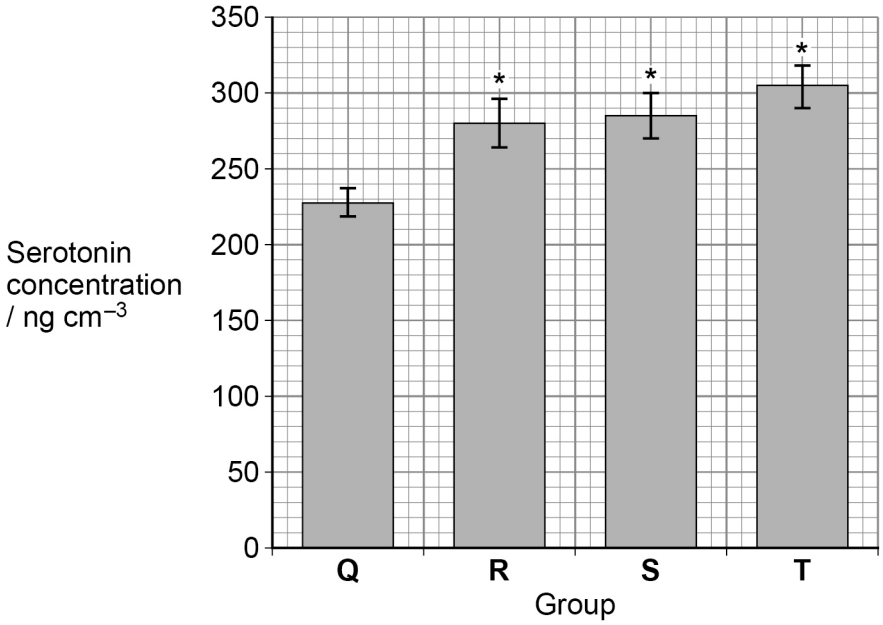
Figure 14 shows the mean serotonin concentration in brain fluid for each group of rats.

Error bars show ± 2 standard deviations.

* Shows significant difference compared to group **Q** at P<0.005

Figure 14



0 7 . 4 Describe what **Figure 14** shows about the effect of MDMA on the serotonin concentration of rats.

[2 marks]

Do not write outside the box

0 7 . 5 Suggest how MDMA causes the results shown in **Figure 14**.

Use information from **Figure 13** (on page 24) in your answer.

[2 marks]

Question 7 continues on the next page

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Table 3 shows the mean number of intact neurones in brain tissue samples from each group of rats.

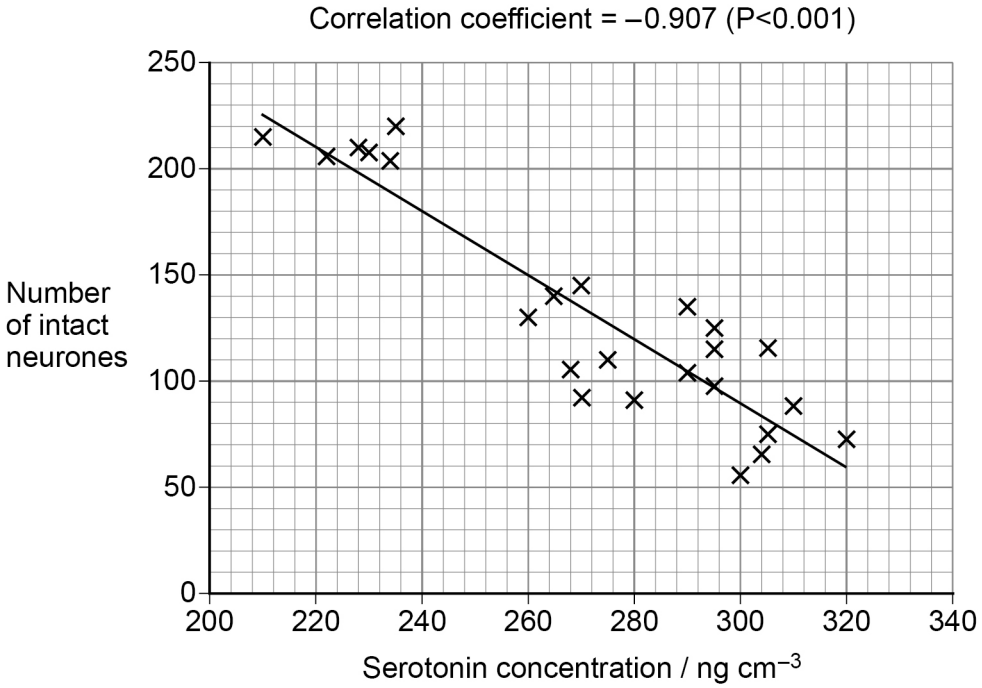
* Shows significant difference compared to group **Q** at P<0.001

Table 3

Group	Mean number of intact neurones ± 2 standard deviations
Q	210.5 ± 6.0
R	131.7 ± 10.8 *
S	104.2 ± 8.5 *
T	74.7 ± 13.2 *

Figure 15 shows the relationship between the number of intact neurones and the serotonin concentration for each rat.

Figure 15



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0 7 . 6 The scientists concluded that MDMA damages the neurones in the brain due to high serotonin concentrations.

Evaluate the scientists' conclusion.

Use the information provided and the data in **Table 3** and **Figure 15**.

[5 marks]

15

END OF QUESTIONS

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