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Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 4 Control

Wednesday 19 June 2019 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	
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TOTAL	



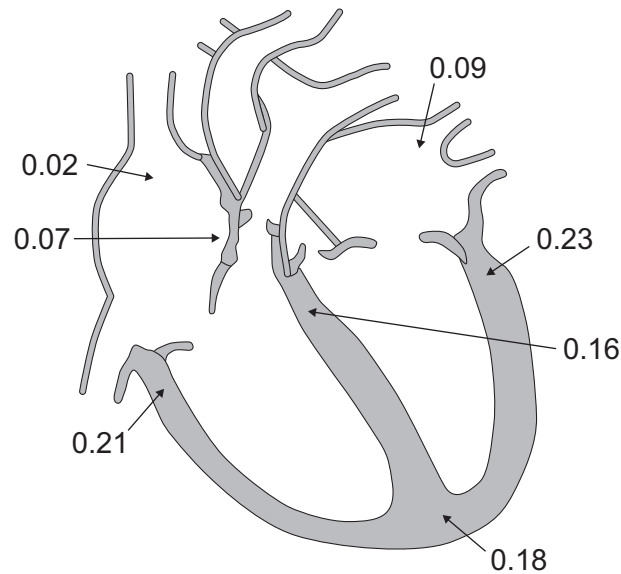
Answer **all** questions in the spaces provided.

0 1

Heart rate in humans can be controlled by myogenic stimulation. The sinoatrial node (SAN) is the heart's 'pacemaker'. The SAN sends electrical impulses through the walls of the heart.

Figure 1 shows a section through the human heart. The numbers show the time taken in seconds for an electrical impulse to travel from the SAN to seven different parts of the heart.

Figure 1



Key

0.02 = impulse takes 0.02 seconds
to travel from SAN to here

0.23 = impulse takes 0.23 seconds
to travel from SAN to here

Electrical impulses in the heart wall can only pass from the atria to the ventricles through the atrioventricular node (AVN).

0 1 . 1

Use data from **Figure 1** to show that the AVN causes a slight delay in the transmission of the electrical impulse from the atria to the ventricles.

[2 marks]

The impulse takes $0.07 - 0.02 = 0.05$ s to cross the right atrium

from the SAN to the AVN (it reaches the AVN at 0.07 s).

It appears beyond the AVN at 0.16 s, so it takes $0.16 - 0.07 = 0.09$

s to pass through the AVN, 0.04 s longer than crossing the atrium.



0 1 . 2

Explain how the delay in transmission of the impulse at the AVN helps the heart to function efficiently.

[2 marks]

The delay allows the atria to contract and empty, sending all the blood into the ventricles so that the ventricles fill, before the ventricles are stimulated to contract.

0 1 . 3

Use data from **Figure 1** to show that the ventricles contract from the base of the heart upwards.

[1 mark]

The impulse reaches the base of the ventricles at 0.18 s but the top at 0.21 s and 0.23 s, so the base is stimulated 0.03 to 0.05 s first.

0 1 . 4

Suggest why it is an advantage for the ventricles to contract from the base of the heart upwards.

[1 mark]

Blood is squeezed upwards towards the arteries, so all (the maximum amount) of the blood is pumped out of the ventricles.

0 1 . 5

During exercise, chemoreceptors detect a change in the composition of the blood.

The chemoreceptors cause an increase in the heart rate.

Which substance increases in concentration in the blood during exercise and stimulates an increase in heart rate?

[1 mark]

Tick (✓) **one** box.

ATP

☐

Carbon dioxide

☒

Glucose

☐

Oxygen

☐

7

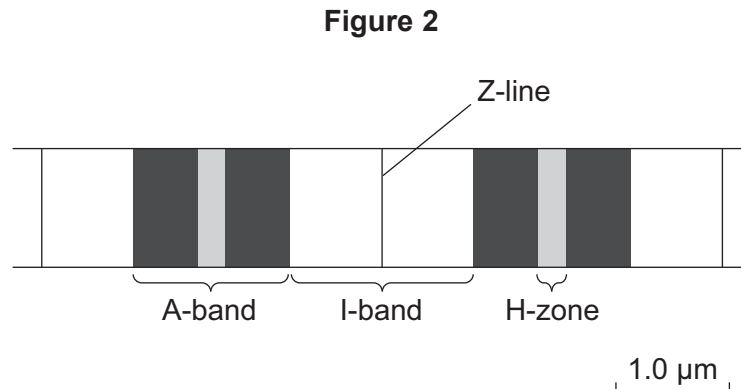
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0 2

A skeletal muscle fibre contains many units called myofibrils.

Figure 2 shows part of a relaxed myofibril.



0 2 . 1

Explain how the distribution of the muscle proteins **actin** and **myosin** causes the banding pattern shown in **Figure 2**.

[4 marks]

Actin is found in the thin filaments and myosin in the thick filaments.

The light band (I-band) is where there is only actin (only thin filaments), which do not overlap with myosin.

The dark band (A-band) is where there is both actin and myosin (thin and thick filaments overlap),

except the H-zone in the middle of the A-band, where there is only myosin (only thick filaments), so it is lighter.

0 2 . 2

Calculate the length of **one** sarcomere shown in **Figure 2**.

Give your answer in micrometres (μm).

[2 marks]

Sarcomere (Z-line to Z-line) measures 45 mm

Scale bar 1.0 μm measures 15 mm

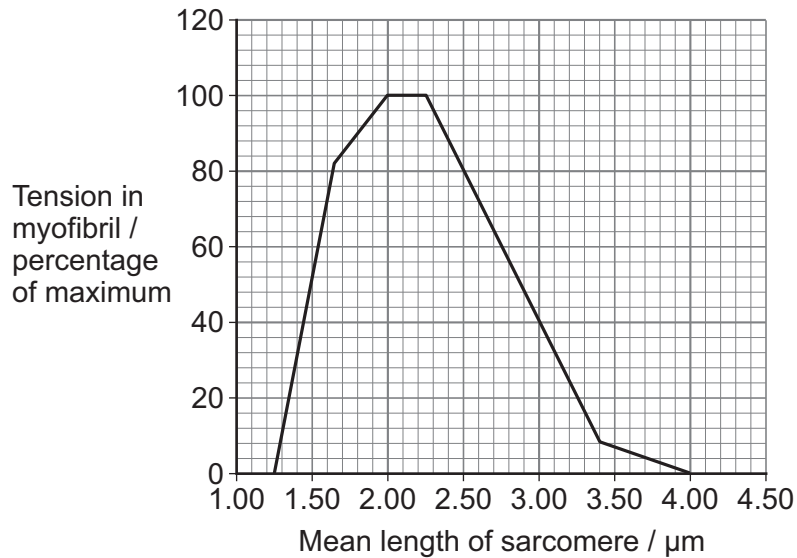
length = $45 \div 15 \times 1.0 \mu\text{m} = 3.0 \mu\text{m}$

Length of one sarcomere = 3.0 μm



Figure 3 shows the relationship between the mean length of a sarcomere and the amount of tension developed in the myofibril.

Figure 3



0 2 . 3

The myofibril in **Figure 2** contracts by 20%.

Calculate the tension developed in the myofibril.

Use your answer from question **02.2** and information from **Figure 3**.

[2 marks]

Tension = 88 % of maximum

Question 2 continues on the next page

After contracting by 20%: $3.0 \times 80 \div 100 = 2.4 \mu\text{m}$

From Figure 3, at a sarcomere length of $2.4 \mu\text{m}$, tension = 88%

Turn over ►



0 2 . 4

Describe the role of calcium ions in the contraction of a myofibril.

[4 marks]

An action potential causes release of Ca^{2+} from the sarcoplasmic reticulum, so there is a rise in Ca^{2+} in the sarcoplasm.

The Ca^{2+} binds to troponin, which causes the blocking molecule tropomyosin to move, exposing the (myosin) binding sites on the actin (thin filament).

This allows the myosin heads to bind to actin, forming cross-bridges.

The myosin heads change angle (power stroke), so the actin (thin filament) slides (is pulled) along the myosin (thick filament) towards the centre of the sarcomere.

Ca^{2+} also activates the ATP-ase on the myosin heads, which hydrolyses ATP to release energy.

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0 3

Regulation of the temperature of the human body is an example of a homeostatic process.

0 3 . 1

State the meaning of the term, 'homeostatic process'.

[2 marks]

*Maintenance of a (approximately) constant internal environment,
keeping a factor such as core temperature within restricted limits
around a set level (norm),
by physiological processes, involving negative feedback.*

Human core body temperature normally varies between 36.8 and 37.9 °C.

When a person is exposed to cold and wet environmental conditions for several hours, the core body temperature may drop by 4 or 5 °C and the person suffers from hypothermia. Severe hypothermia may cause cardiac arrest.

A person with hypothermia needs to be warmed up slowly.

One suggested method is:

- remove the person's wet clothing and replace with dry clothing
- wrap the person in a blanket
- give the person a warm drink to swallow slowly
- allow the person to breathe warm, moist air from a ventilator machine.

0 3 . 2

Suggest how removing wet clothing and replacing with dry clothing helps to warm the body of a person with hypothermia.

[3 marks]

*In wet clothing the water evaporates, and evaporation uses body heat
(latent heat of vaporisation), causing cooling of the body.
Dry clothing insulates the body and helps to retain heat: it traps a
layer of still air close to the skin, which reduces heat loss.*



0 3 . 3

Table 1 compares the effects of:

- wrapping a person in a blanket
- allowing a person to breathe warm, moist air from a ventilator machine.

Table 1

Time / min	Change in core body temperature / °C	
	Person A: Blanket	Person B: Breathing warm, moist air
0	0.0	0.0
5	-0.3	+0.3
10	-0.2	+0.6
15	+0.6	+0.8
20	+1.6	+1.0
25	+2.0	+1.1
30	+2.2	+1.2
35	+2.1	+1.3
40	+2.0	+1.3
45	+1.9	+1.4
50	+1.9	+1.4

Doctors think that breathing warm, moist air is a better treatment for hypothermia than wrapping the person in a blanket.

Evaluate this opinion.

[4 marks]

For: breathing warm, moist air causes no initial temperature drop (no delay in warming), whereas with the blanket core temperature falls by 0.3 °C at 5 min, so there is less risk of cardiac arrest.

It gives a steady, more gradual temperature rise (person should be warmed slowly), and there is no decrease after 30 min.

Against: the blanket raises core temperature to a higher level (+2.2 °C compared with +1.4 °C) and more rapidly after 20 min.

Data are for only 2 people, so they may not be representative (not valid) and there are insufficient data for a statistical test.

Turn over ►

0 4

A nerve impulse is generated by the movement of ions across the axon membrane of a neurone.

Figure 4 shows changes in the permeability of part of an axon membrane to two types of ion, **A** and **B**. The changes in permeability cause an action potential in the neurone.

Figure 5 shows changes in the membrane potential during the action potential.

Figure 4

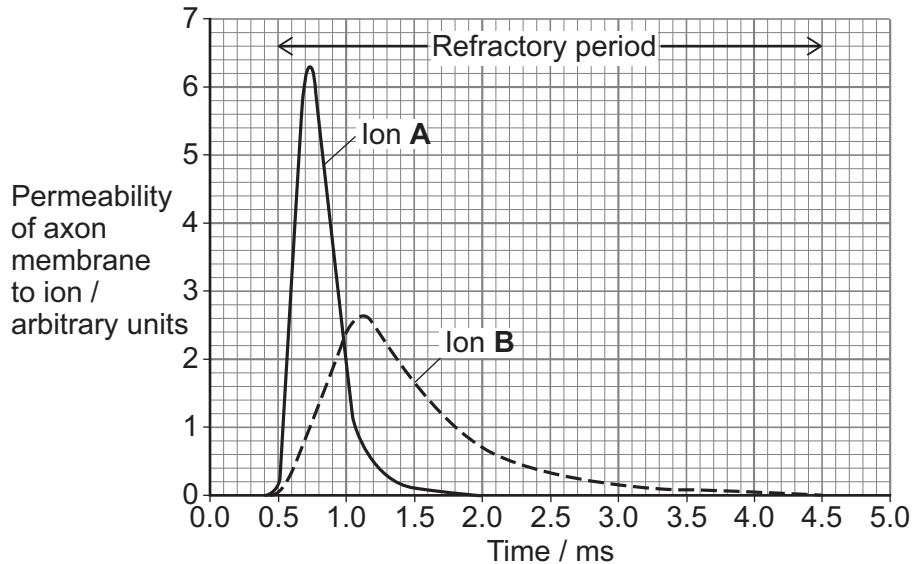
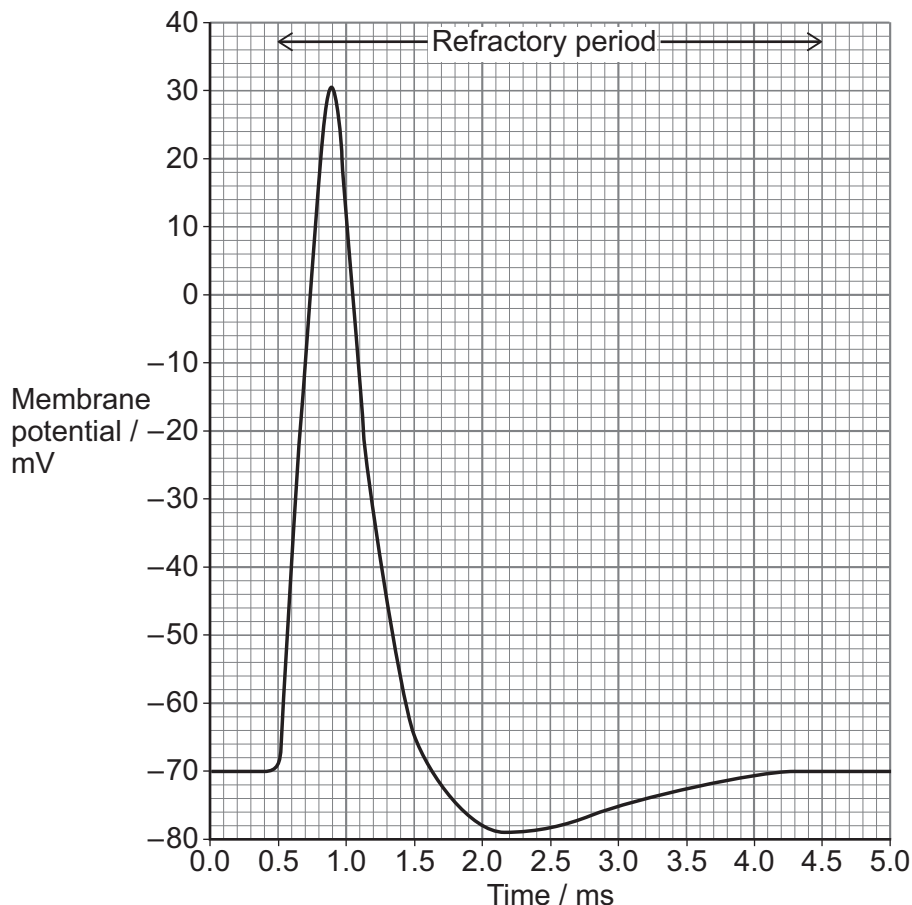


Figure 5



0 4 . 1 Name ion **A** and ion **B** in **Figure 4**.

[1 mark]

A Sodium ions (Na^+)

B Potassium ions (K^+)

0 4 . 2 Explain what causes the changes in membrane potential of the neurone between 0.5 milliseconds and 1.5 milliseconds.

Use information from **Figure 4** and **Figure 5**.

[6 marks]

At 0.5 ms the membrane potential is raised above threshold (positive feedback during Na^+ entry).

This causes Na^+ gates to open, so permeability to Na^+ (ion A) increases, peaking at 0.75 ms.

Na^+ enters the axon by diffusion down its concentration gradient, causing rising membrane potential (depolarisation) from -70 to $+30$ mV.

Then the Na^+ gates close and the K^+ gates open, so permeability to K^+ (ion B) increases to a peak at 1.1 ms.

K^+ leaves the axon by diffusion down its concentration gradient, causing lowering of membrane potential (repolarisation) to -65 mV at 1.5 ms.

0 4 . 3 Explain why the maximum frequency of action potentials along this neurone is 250 per second.

Use data from **Figure 5**.

[2 marks]

The refractory period lasts 4 ms (0.5 to 4.5 ms); no other action potential can be produced during it.

So the maximum frequency = $1000 \div 4 = 250$ action potentials per second.

Turn over ►



0 4 . 4

One of the proteins in the axon membrane is an ATP-ase enzyme.

Scientists added a chemical inhibitor of the ATP-ase to a nerve.

After some time the nerve lost the ability to conduct action potentials.

Explain why the inhibitor prevented the production of action potentials.

[4 marks]

The inhibitor prevents the ATP-ase from breaking down (hydrolysing)

ATP to release energy (it changes the shape of the active site of the ATP-ase).

So there is no energy for the active transport of the

sodium-potassium pump,

so Na^+ is no longer pumped out of the axon and K^+ is no longer pumped into the axon.

The resting potential (ion concentration gradients) cannot be restored,

so no further action potentials can be produced.

13



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0 5

Crop plants can be genetically modified to make them resistant to the herbicide glyphosate.

0 5 . 1

Explain the advantage of producing crops resistant to the herbicide glyphosate.

[3 marks]

*Glyphosate can be sprayed to kill the weeds growing with the crop
without killing (harming) the crop.*

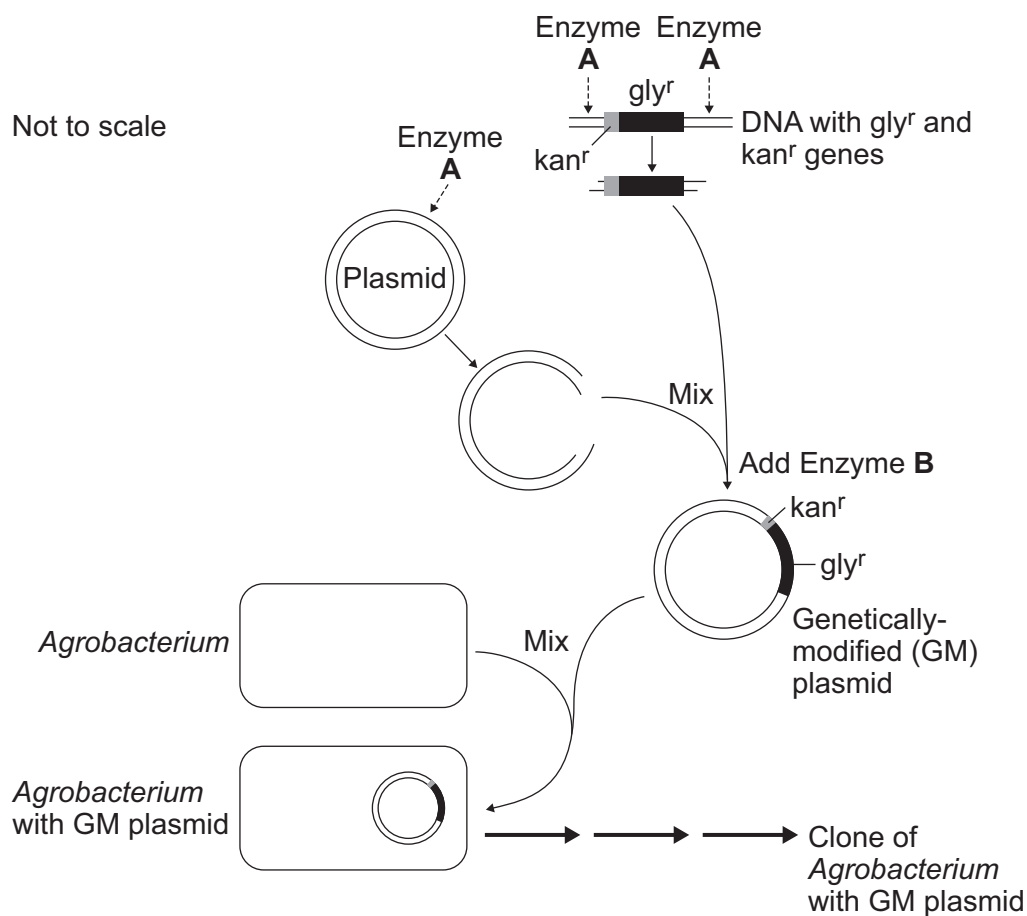
*Therefore there is reduced competition from weeds for light, water
and mineral ions,*

leading to an increased crop yield.

Scientists used a bacterium called *Agrobacterium* to put the glyphosate-resistance gene (gly^r) into maize plants and soya plants.

Figure 6 shows how the scientists put a plasmid into *Agrobacterium*. The plasmid contained the gly^r gene and a gene for resistance to a substance called kanamycin (kan^r).

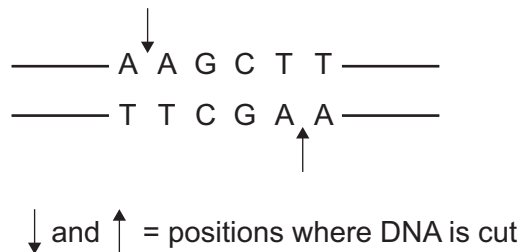
Figure 6



Enzyme **A** in **Figure 6** is a restriction endonuclease enzyme.

Enzyme **A** cuts DNA at the specific base sequence shown in **Figure 7**.

Figure 7



0 5 . 2

Explain why enzyme **A** only cuts DNA at the specific positions shown in **Figure 7**.
[1 mark]

*The base sequence has a specific shape that is complementary to
(fits) the active site of the enzyme.*

0 5 . 3

Figure 6 shows that enzyme **A** is used for cutting:

- plasmid DNA
- DNA with the gly^r and kan^r genes.

Explain why scientists use the **same** enzyme to cut both pieces of DNA.

[2 marks]

*Cutting both with the same enzyme produces complementary sticky
ends (short single-stranded base sequences) on both pieces of DNA,
hence the two pieces of DNA can hydrogen bond together by
complementary base pairing.*

0 5 . 4

Enzyme **B** in **Figure 6** joins the two pieces of DNA.

Give the name of enzyme **B**.

[1 mark]

DNA ligase

Question 5 continues on the next page

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0 5 . 5

Figure 6 on page 14 shows the GM plasmid entering an *Agrobacterium* cell to form GM *Agrobacterium*.

The GM *Agrobacterium* divides repeatedly to form a clone of GM *Agrobacterium* cells.

Name the type of cell division that produces the clone of GM *Agrobacterium* cells.

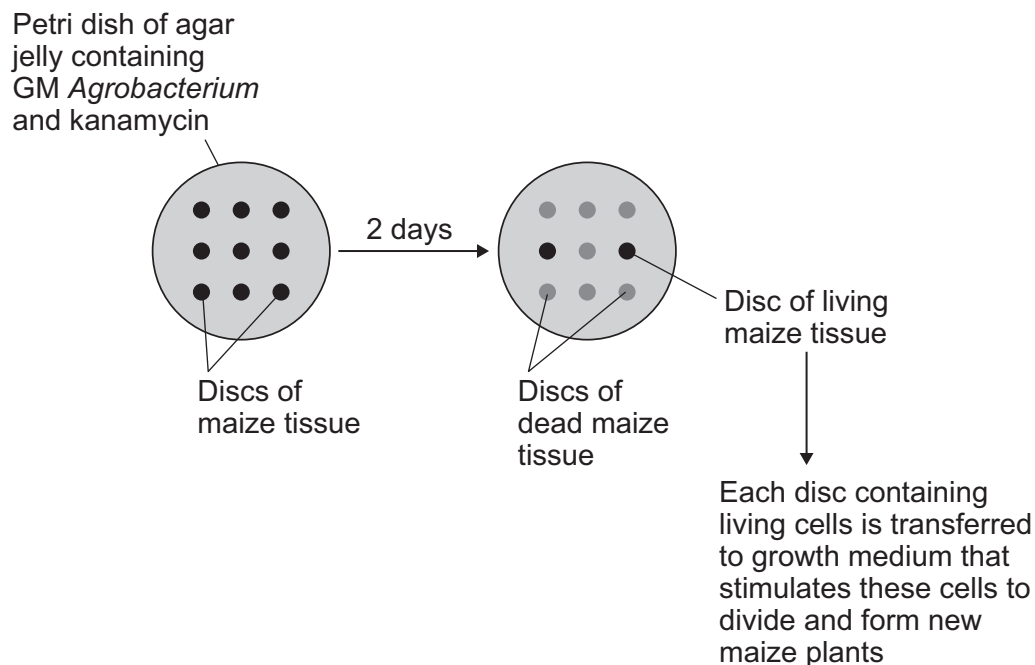
[1 mark]

Binary fission

0 5 . 6

Figure 8 shows how scientists can use the GM *Agrobacterium* to produce GM maize plants resistant to glyphosate.

Figure 8



Kanamycin will kill plant cells.

Explain why all of the cells of the maize plants produced as shown in **Figure 8** contain the *gly^r* gene.

[2 marks]

Only cells that took up the GM plasmid survived, so the living cells must have the *kan^r* gene since they were not killed by kanamycin.

The *gly^r* gene is joined to the *kan^r* gene in the same plasmid, so every surviving cell, and all cells produced from it, contains *gly^r*.



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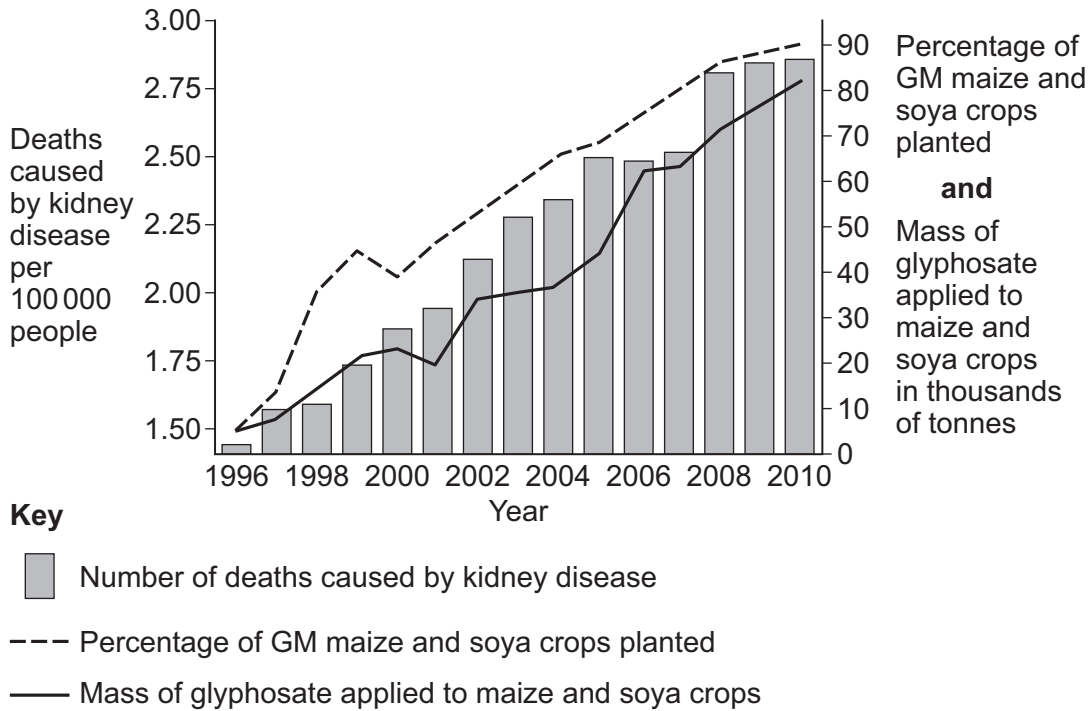
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Some people have concerns about the use of GM herbicide-resistant crop plants.

Figure 9 shows data about the use of glyphosate and glyphosate-resistant maize and soya crops in the USA and human deaths caused by kidney disease.

Figure 9



A newspaper printed the data in **Figure 9** under the headline:

‘Scientists show that herbicide-resistant GM crops cause kidney disease.’

0 5 . 7

Give evidence from **Figure 9** to support the newspaper’s headline.

[1 mark]

Deaths caused by kidney disease increase as the percentage of GM crops planted increases; deaths correlate with % GM crops.

0 5 . 8

Suggest **three** reasons why the headline may **not** be valid.

[3 marks]

1 *Correlation does not prove a causal link; another factor could be the cause, e.g. obesity, diet, infection or better diagnosis of kidney disease.*

2 *There is no evidence that the kidney patients actually ate GM crops (or how much), and no control group; it could be the effect of glyphosate rather than GM crops.*

3 *Death rates are very low and only increase slightly (1.4 to 2.8 per 100 000); no statistical test shows whether the correlation is significant.*

14

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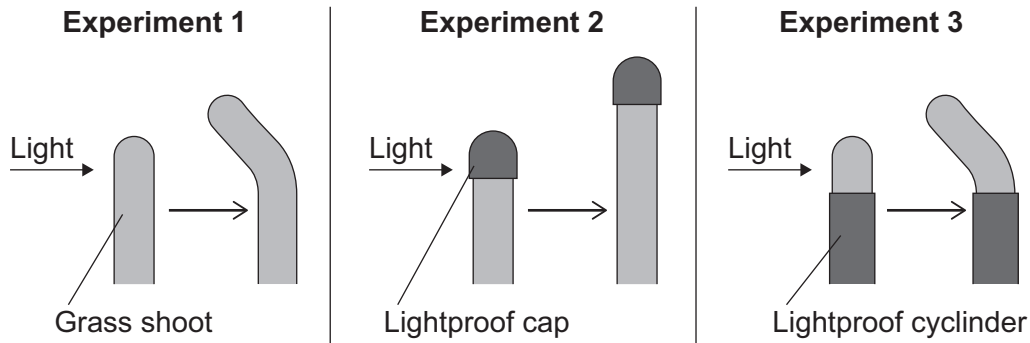


0 6

Charles Darwin investigated tropisms using grass shoots.

Figure 10 shows the results of three of Darwin's experiments.

Figure 10



0 6 . 1

Give **three** conclusions from the results of Darwin's investigation.

[3 marks]

- 1 *Grass shoots detect the direction of light and grow (bend) towards the light; they are positively phototropic.*
- 2 *The tip detects the direction of light: with a lightproof cap on the tip the shoot does not bend.*
- 3 *The region of response is just below the tip, and the response is a growth response.*

0 6 . 2

Suggest a suitable control for Darwin's investigation.

[1 mark]

A grass shoot with its tip removed in one-sided light, or an intact shoot in complete darkness (or with all-round light).



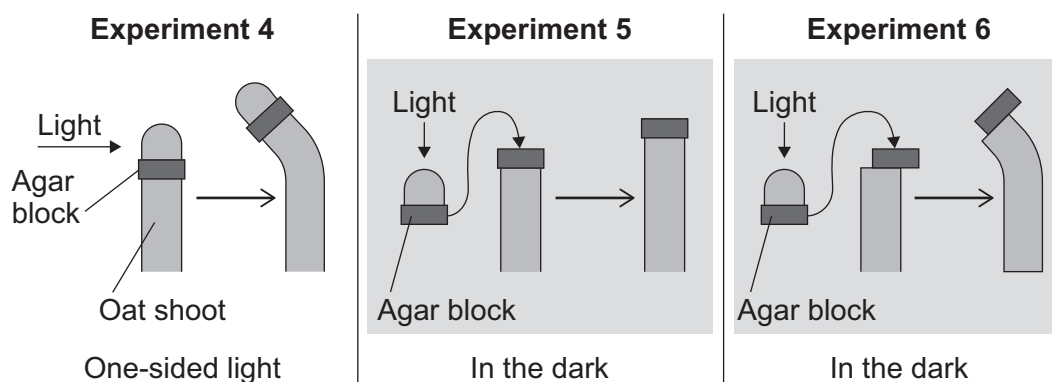
A different scientist investigated tropisms using oat shoots.

The scientist:

- cut the tips off some growing shoots
- placed each tip on a small block of agar jelly
- placed each agar block on top of a cut shoot in one of three different ways, as shown in **Figure 11**.

Figure 11 also shows the results of each experiment.

Figure 11



0 6 . 3

This scientist concluded:

‘A chemical substance diffuses from the shoot tip into the agar. This substance stimulates growth further down the shoot.’

Evaluate this conclusion.

You should refer to experiments 4, 5 and 6 in your answer.

[3 marks]

Valid: in Exp. 4 the shoot is still phototropic with agar between the tip and the shoot, so a chemical diffuses through the agar.

In Exp. 5 the agar block stimulated growth in the cut shoot.

In Exp. 6, with the agar placed asymmetrically, the side with agar grew more, so the shoot bent away from it.

Not valid: there is no control (a plain agar block never in contact with a tip), so the result may be due to the agar itself.

Turn over ►



A student thinks that the chemical substance is an auxin called indoleacetic acid (IAA). The student investigates the role of IAA in growth using pieces from the shoot of a single daffodil plant.

Table 2 shows the results of the student's investigation.

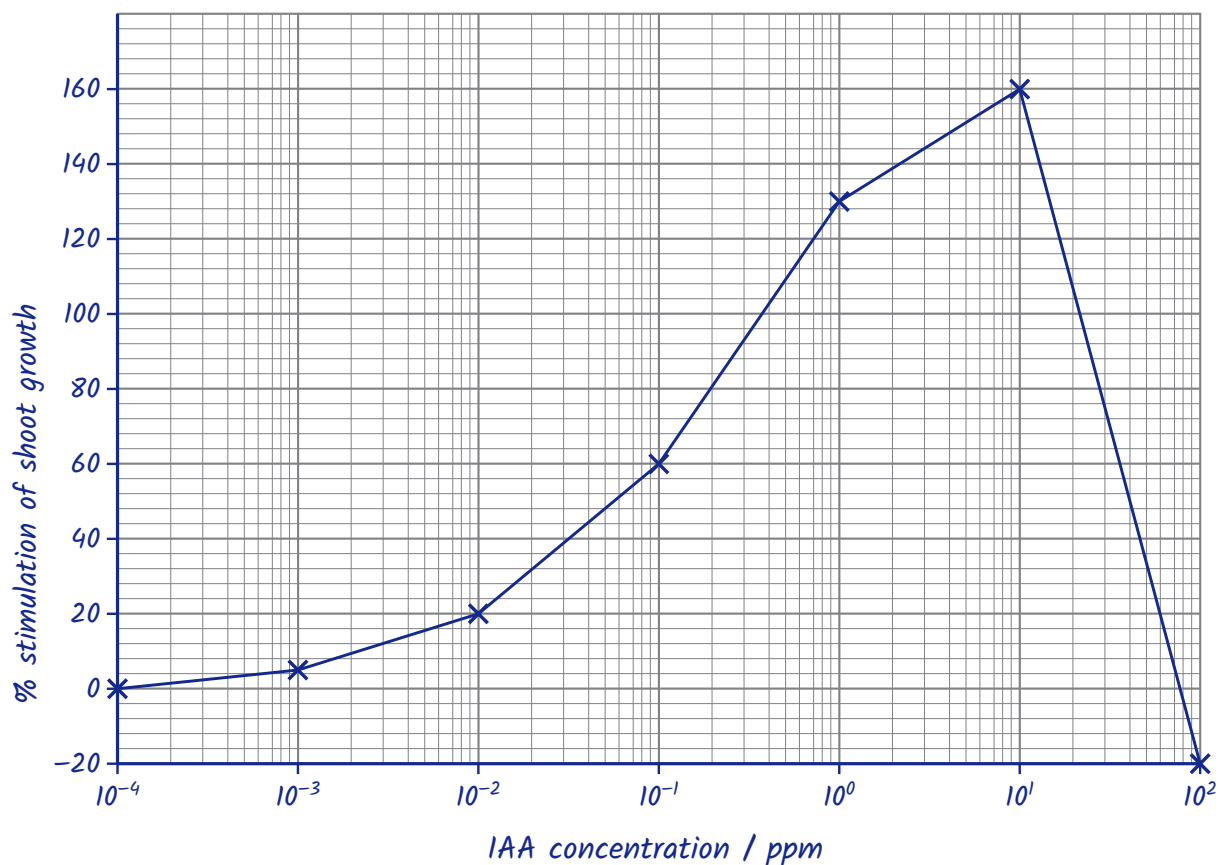
Table 2

IAA concentration / ppm	Percentage stimulation of shoot growth
10^{-4}	0
10^{-3}	5
10^{-2}	20
10^{-1}	60
10^0	130
10^1	160
10^2	-20

0 6 . 4

Plot the results from **Table 2** on the graph paper. Join the points with a suitable line.

[3 marks]



0 6 . 5

What conclusions can you make about the effect of IAA on shoot growth?

Use the student's results.

Include data from the graph in your answer.

[2 marks]

Increasing IAA concentrations up to 10 ppm (10') stimulate growth more, reaching a maximum stimulation of 160% at 10 ppm.

Concentrations higher than 10 ppm stimulate growth less, and above approximately 77 ppm IAA inhibits growth (-20% at 100 ppm).

0 6 . 6

Explain why using only one plant of one species in the investigation may invalidate your conclusions in question 06.5.

[3 marks]

Not all plant species may respond to different IAA concentrations in the same way, so the results cannot be applied to other species.

The individual plant could be atypical (anomalous), or different parts of one shoot may respond differently.

There are no repeats from other plants, which prevents the use of a statistical test (e.g. a t-test) to see whether the effects on growth are significant.

15

Turn over for the next question

Turn over ►



0 7

Scientists have found a correlation between prostate cancer and exposure to cadmium ions.

The scientists investigated the effect of cadmium ions on cells from a human prostate gland.

The scientists placed some prostate gland cells in a medium containing $10 \mu\text{mol dm}^{-3}$ cadmium ions for 10 weeks and some cells in a control medium.

At intervals, the scientists measured:

- how much DNA was methylated
- how much mRNA for the enzyme methyl transferase was produced
- how much p16 tumour-suppressor protein was produced.

The scientists also compared the amount of DNA methylation in cells from several different types of cancer with the amount of DNA methylation in normal, non-cancerous cells.

Figures 12, 13, 14 and 15 show the scientists' results.

Figure 12

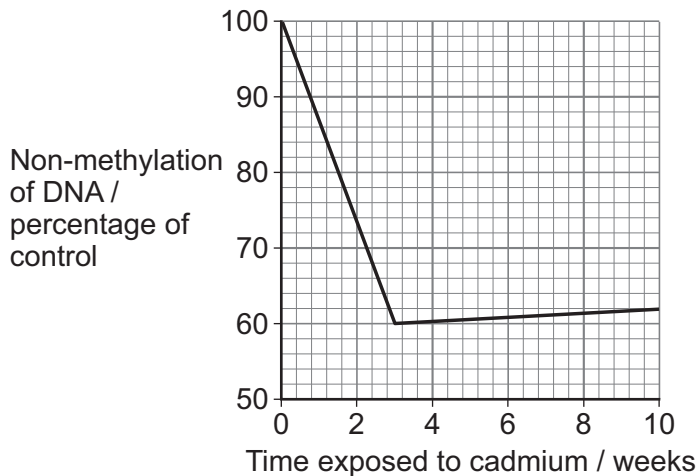


Figure 13

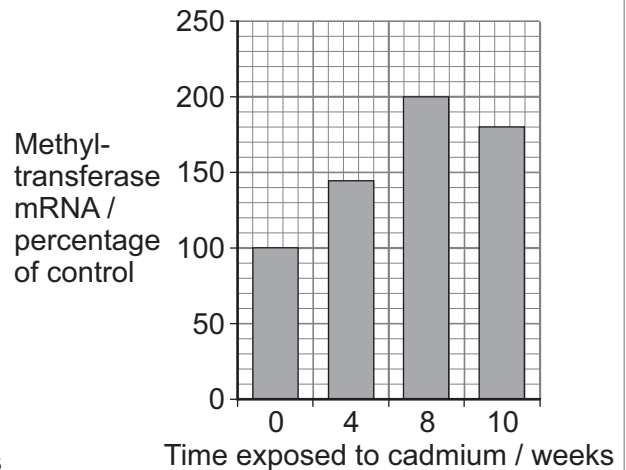


Figure 14

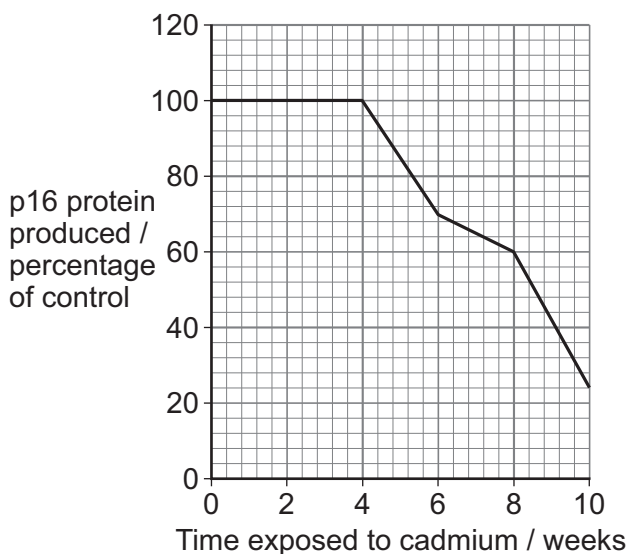
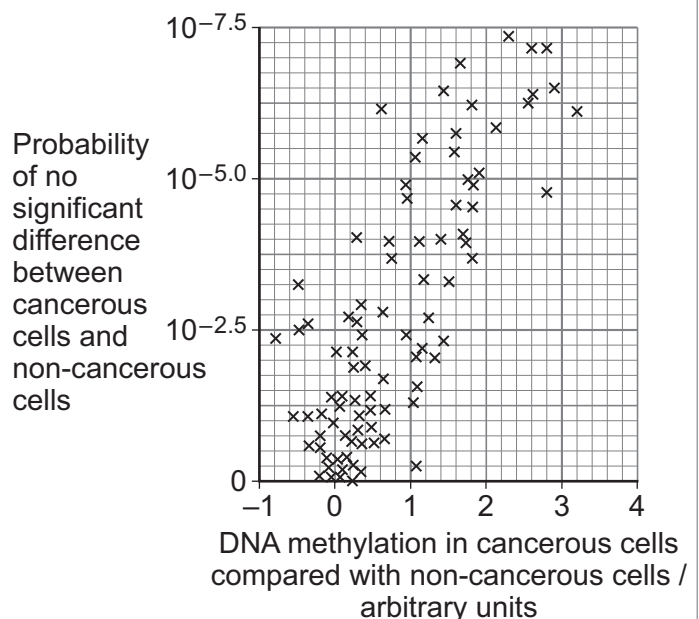


Figure 15



07.1

The scientists concluded that increased methylation of the promoter region of tumour suppressor genes is an important factor in stimulating the growth of tumours.

Use information from **Figures 12, 13, 14 and 15** to give evidence for this conclusion.

[5 marks]

Figure 15: methylation of DNA in cancer cells is generally significantly greater than in normal cells, because for most points $P < 10^{-2}$ ($P < 0.05$).

Figure 12: exposure to Cd^{2+} increases methylation of DNA (non-methylation falls to 60% of control by 3 weeks).

Figure 13: exposure to Cd^{2+} increases production of methyl transferase mRNA (to 200% at 8 weeks), and therefore increases production of methyl transferase,

which transfers methyl groups to the DNA, to the promoter of the p16 gene, so RNA polymerase cannot bind and p16 transcription (mRNA production) is inhibited.

Figure 14: exposure to Cd^{2+} decreases production of p16 protein (translation of the p16 gene) to 25% by 10 weeks, therefore decreasing suppression of tumour growth.

5

END OF QUESTIONS



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