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Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 4 Control

Wednesday 10 January 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	
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TOTAL	



J A N 2 4 B L O 4 0 1

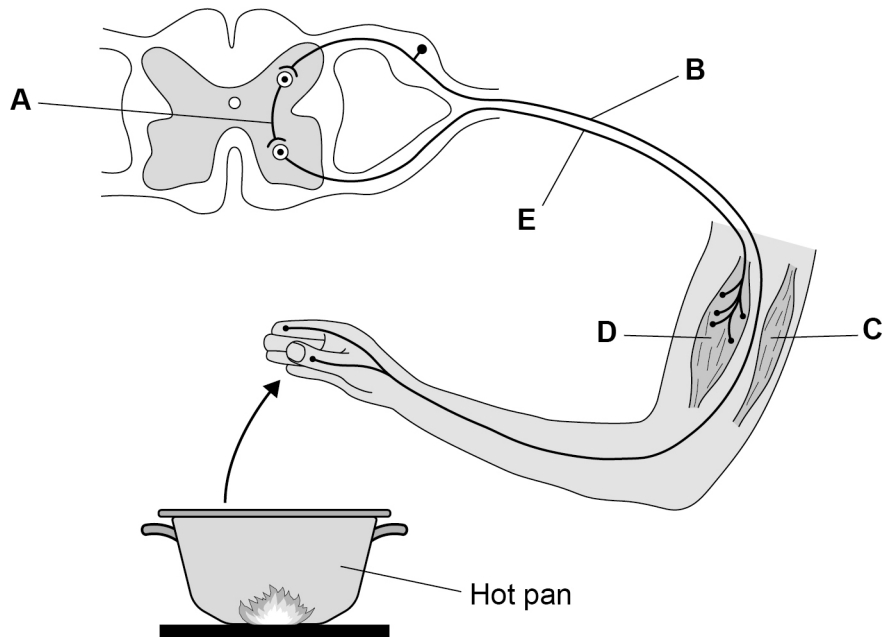
Answer **all** questions in the spaces provided.

0 1

A reflex is an automatic response to a stimulus.

Figure 1 shows the reflex arc when a person puts a hand on a hot pan.

Figure 1



0 1 . 1

Identify the structures **A**, **B** and **E**.

[2 marks]

A *relay neurone*

B *sensory neurone*

E *motor neurone*

0 1 . 2

State the importance of the reflex in **Figure 1**.

[1 mark]

It is a rapid, automatic response that removes the hand from the hot pan to avoid (further) damage to the tissue.



The reflex shown in **Figure 1** causes the arm to bend at the elbow.

0 1 . 3

After bending the arm, **both** muscles in the upper arm are involved in straightening the arm again.

Explain why.

Use information from **Figure 1**.

[2 marks]

The two muscles, C and D, are antagonistic: they work as a pair and pull in opposite directions, because muscles can only pull, not push.

To straighten the arm, muscle C (the triceps) contracts and muscle D (the biceps) relaxes.

0 1 . 4

In the reflex arc shown in **Figure 1**, the effector is a muscle.

Name a different type of effector.

[1 mark]

Gland

6

Turn over for the next question

Turn over ►



0 2

LEMS is an autoimmune condition that affects neuromuscular junctions.

One of the symptoms of LEMS is reduced muscle contraction.

0 2 . 1

In people with LEMS, antibodies block many of the calcium ion channels on the pre-synaptic neurones at neuromuscular junctions.

Explain how the antibodies can prevent an action potential starting in muscle fibres.

[4 marks]

When an action potential arrives at the presynaptic knob, fewer (or no)

calcium ions can diffuse into the presynaptic neurone, as the calcium ion channels are blocked.

So fewer (or no) vesicles move to and fuse with the presynaptic membrane.

Less (or no) acetylcholine is released by exocytosis into the synaptic cleft.

Less (or no) acetylcholine diffuses across and binds with the receptors on the postsynaptic membrane of the muscle fibre, so fewer sodium ion channels open and the membrane does not reach threshold, so no action potential starts.

If patients with LEMS continue trying to move, their muscles will eventually contract.

This information has encouraged doctors to use an inhibitor of the enzyme acetylcholinesterase as a treatment for LEMS.

Acetylcholinesterase is an enzyme that breaks down acetylcholine.



0 2 . 2

Suggest why an inhibitor of acetylcholinesterase can be used to treat LEMS.

[2 marks]

Acetylcholine is not broken down, so it stays in the synaptic cleft for longer, builds up and keeps binding to the receptors.

So there is more chance of depolarising the postsynaptic membrane past threshold, so an action potential is passed on and the muscle fibre contracts.

Amifampridine (AFP) is a new drug used for treating LEMS.
Doctors monitor the use of AFP with further clinical trials.

Doctors select 26 patients with LEMS who are all the same age, race and sex.

At the start of the trial, all the patients are:

- already taking AFP
- assessed by the doctors on their ability to do exercises (= doctor score)
- asked how they feel (= patient score).

The patients are then put into two groups at random:

- AFP group – continue to take the AFP tablets
- placebo group – take tablets that do **not** contain AFP.

After 4 days, the doctor score and patient score are collected again.
The patients and the doctors do not know which group the patients are in.

0 2 . 3

This type of trial is called a withdrawal trial as patients in the placebo group stop taking the AFP.

The trial only lasts for 4 days.

Suggest why.

[1 mark]

Patients in the placebo group will suffer worse symptoms of LEMS, so it is not safe or ethical to withhold a known treatment from them for a longer time.

Turn over ►



Both the doctor score and the patient score use 7-point scales.

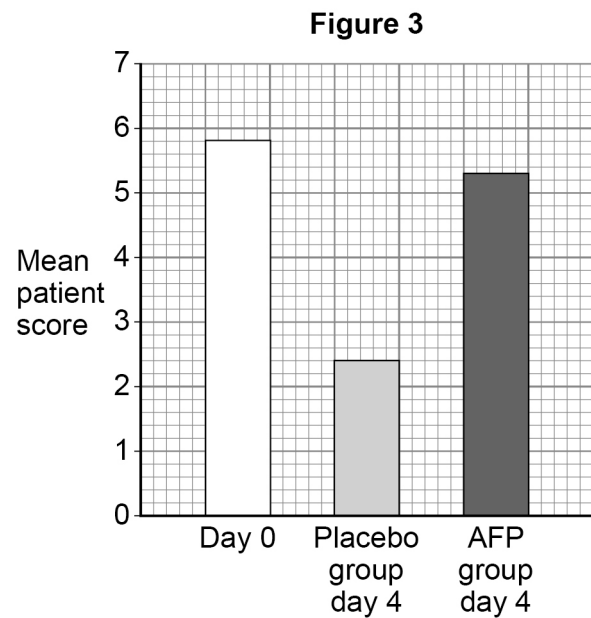
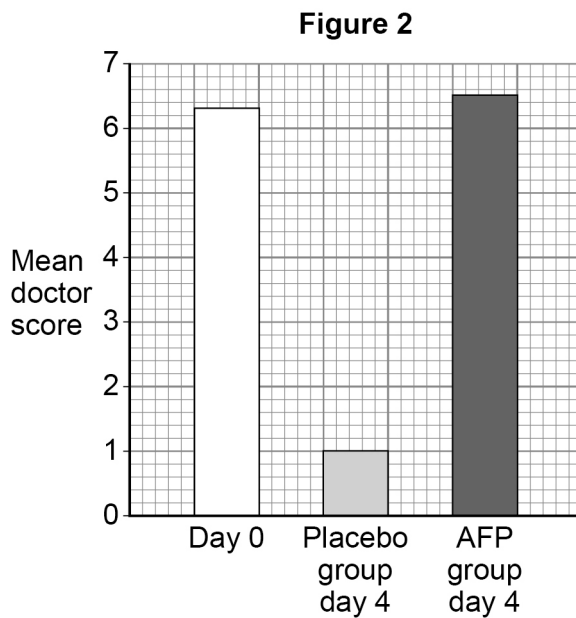
Table 1 shows the meanings of the highest and lowest scores.

Table 1

	Highest score (7)	Lowest score (1)
Doctor score	Able to complete all of the exercises	Unable to complete any of the exercises
Patient score	Feels very well	Feels very unwell

Figure 2 shows the mean doctor score.

Figure 3 shows the mean patient score.



0 2 . 4

As LEMS is a rare condition, the number of patients in any trial will always be small.

However, even with this limitation, the doctors conclude that this trial shows that AFP is a suitable treatment for LEMS.

Evaluate this conclusion.

Use all the information provided in Question 02 to answer this question.

[4 marks]

For: without AFP the placebo group performed worse (doctor score fell from 6.3 to 1) and felt worse (patient score 5.8 to 2.4).

It was double-blind, patients were matched for age, race and sex, removing these variables, and assigned to groups at random.

Against: scoring is subjective, especially the patient score; AFP patients might think they are in the placebo group and score more harshly.

No information on side effects of AFP, and no statistics, so unknown if differences are significant.

All patients were the same age, sex and race, so we do not know if AFP would work for other groups.

11

Turn over for the next question

Turn over ►



0 3

Tomatoes are climacteric fruit. This means that tomatoes can be picked unripe (when they are green) and they will ripen (turn red) off the plant.

A plant growth substance, **X**, ripens the tomatoes.

0 3 . 1

Name plant growth substance **X**, that ripens the tomatoes.

[1 mark]

Ethene (ethylene)

Growers can use plant growth substance **X** to artificially ripen tomatoes.

Peppers are another fruit that change colour from green to red when fully ripe.

A student investigates if plant growth substance **X** can be used to ripen peppers.

The student has:

- green tomatoes
- green peppers
- suitable containers
- plant growth substance **X**.

0 3 . 2

Describe an investigation to test if plant growth substance **X** can ripen peppers as quickly as it ripens tomatoes.

[3 marks]

Use the tomatoes as a standard: put 3 green tomatoes in a container with substance X (ethene) and 3 green tomatoes in a container with air only.

Do the same with 3 green peppers with ethene and 3 green peppers with air only (without substance X).

Observe at set intervals, e.g. every day for 1 week, until the tomatoes in ethene turn red, and compare with when (or if) the peppers turn red.

Control variables: same concentration of ethene, same temperature, same size of container and same size and maturity of fruit.



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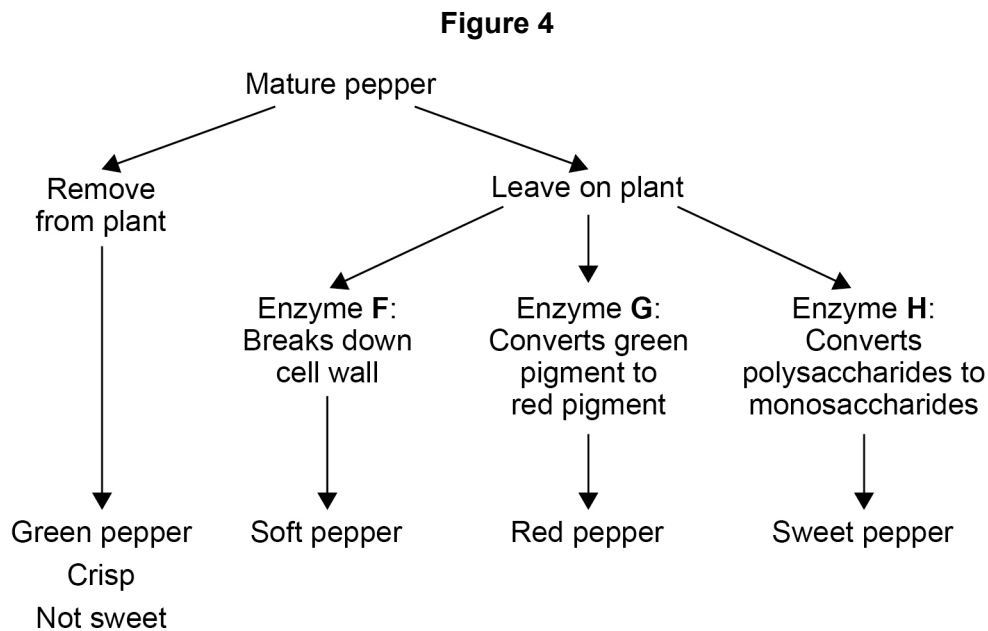
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Peppers can be eaten when green or when red. Ripe red peppers are softer and sweeter than green peppers.

Figure 4 shows the different enzyme pathways involved in ripening peppers from green to red.



0 3 . 3 Epigenetic changes can produce **sweeter** red peppers.

Suggest how.

Use information from **Figure 4**.

[3 marks]

Methyl groups are removed from (the DNA of) the gene that codes for enzyme H, or acetyl groups are added to the histone proteins associated with the gene for enzyme H.

This makes the gene accessible, so RNA polymerase can bind and the gene is transcribed, producing mRNA.

The mRNA is translated into more enzyme H, so there is more (faster) conversion of polysaccharides to monosaccharides and the pepper tastes sweeter.



Growers would like to produce green peppers that are as soft and sweet as red peppers.

Scientists plan to help the growers do this using RNA interference techniques.

0 3 . 4 Explain how RNA interference could produce soft, sweet, green peppers.

Use information from **Figure 4**.

[4 marks]

To keep the peppers green, production of enzyme G must be stopped (the gene for enzyme G silenced), so the green pigment is not converted to red pigment.

To make them soft and sweet, the peppers must continue to produce enzymes F and H, so the gene for F and the gene for H are not targeted.

siRNA is made that is complementary to the mRNA for enzyme G, and it binds to this mRNA by complementary base pairing.

The mRNA for enzyme G is then broken up into fragments, so it cannot be translated and enzyme G is not made.

11

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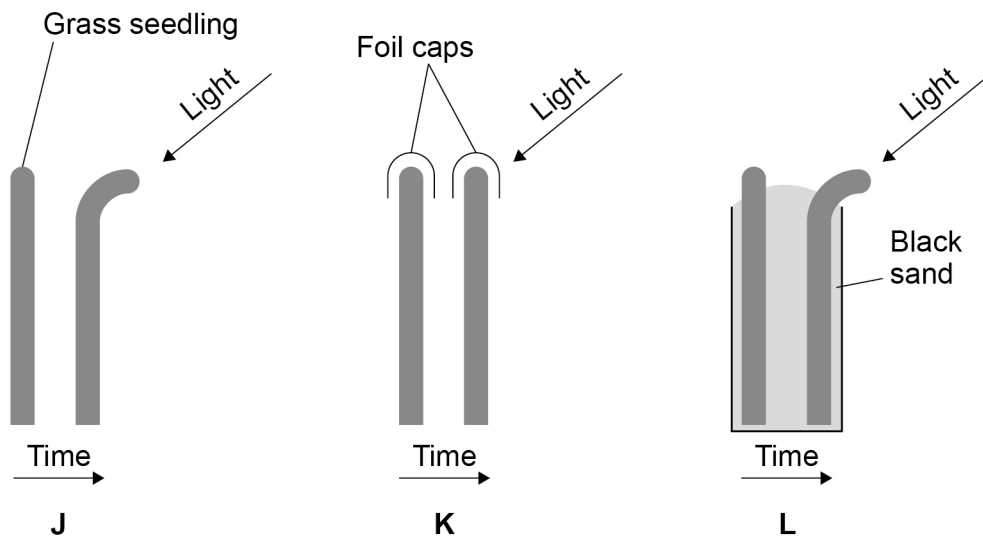
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0 4

Charles Darwin investigated the effect of light on the growth of grass seedlings. The results from some of his investigations are shown in **Figure 5**.

Figure 5



0 4 . 1

Describe how the diagrams demonstrate that seedlings show positive phototropism and that the stimulus for this is detected by the tip.

[2 marks]

In J (the control) the seedling grows (bends) towards the light, a positive response to light.

Covering the tip (K) stops the response, but covering the base (L) does not, so the tip is responsible for detecting the light.

0 4 . 2

Explain how positive phototropism helps a plant to grow.

[2 marks]

The shoot grows towards the light, into an area of higher light intensity.

So the leaves absorb more light for more photosynthesis, producing more sugars for more growth.



Experiments show that the tropism is a result of IAA causing cell elongation. However, it is not clear how the light is detected by the plant.

Some students think that a light-absorbing pigment is involved.

The students investigate three pigments found in plants. These pigments are:

- cryptochrome
- phototropin
- phytochrome.

Question 4 continues on the next page

Turn over ►



The students measure:

- the wavelengths of light absorbed by these pigments (**Figure 6**)
- the wavelengths of light that cause the plant to show phototropism (**Figure 7**).

Figure 6 shows the wavelengths of light absorbed by the three pigments.

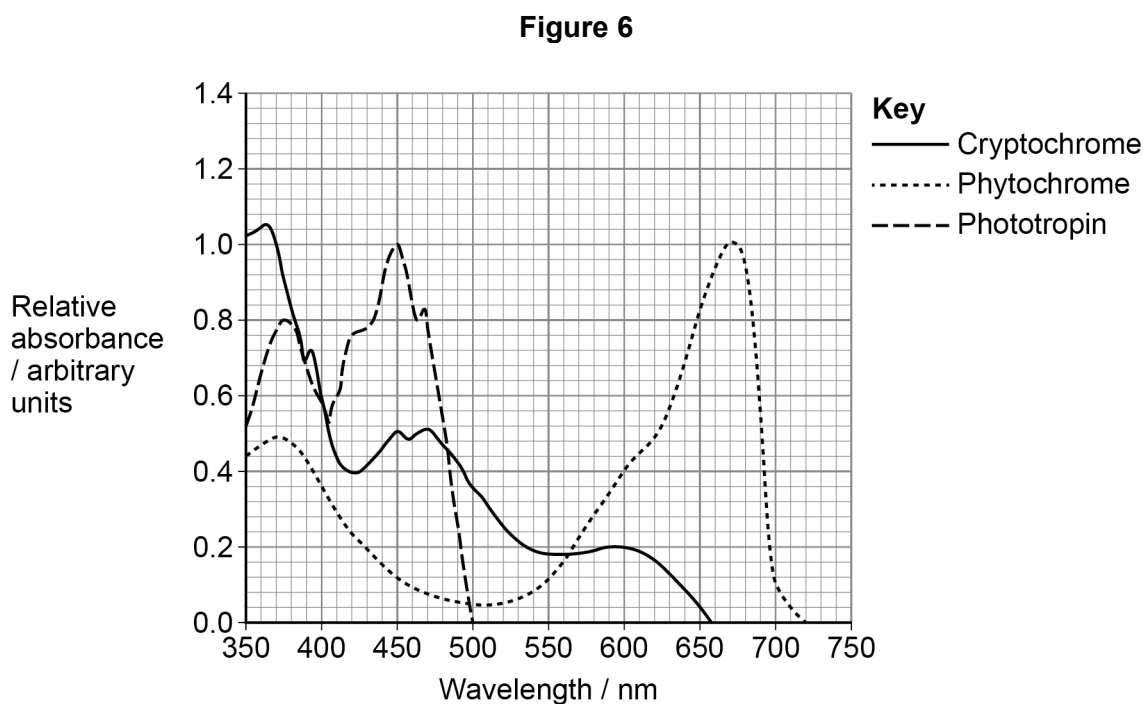
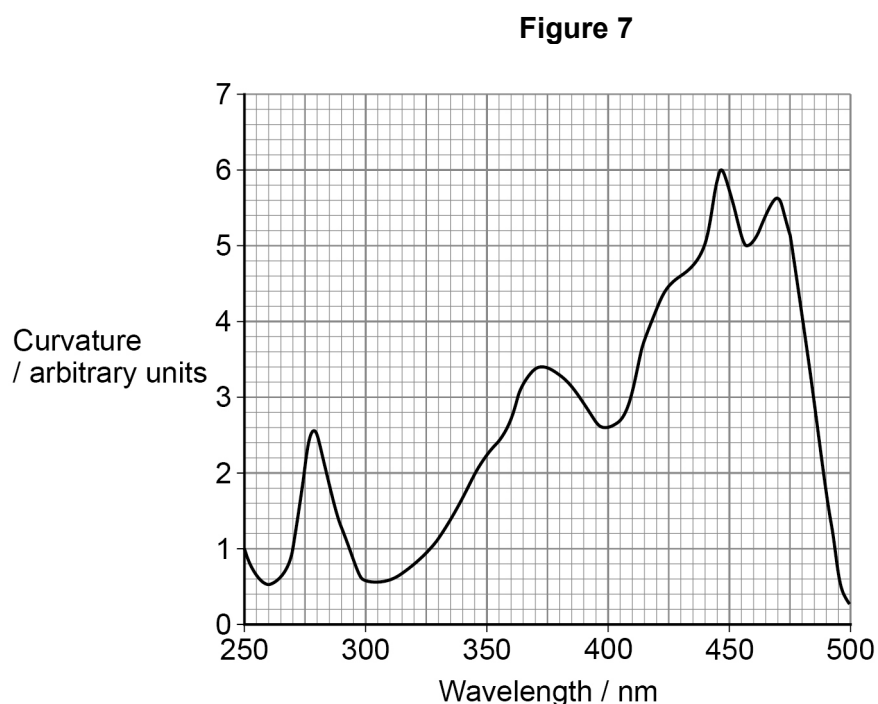


Figure 7 shows the wavelengths of light that cause the plant to show phototropism by curving towards the light.



0 4 . 3

The students use the information from **Figure 6** and **Figure 7** to identify the pigment most likely to detect light.

Describe how they use the information to identify the pigment.

[2 marks]

Use Figure 7 to find the wavelengths that cause the most phototropism (curvature), around 450 nm.

Then match this with Figure 6 to identify the pigment that absorbs most light at those wavelengths.

0 4 . 4

Using only **Figure 6** and **Figure 7**, the students identify the pigment most likely to detect light.

Give the pigment the students identify.

[1 mark]

Phototropin

0 4 . 5

The students' teacher is **not** confident with the identification of the pigment.

Give **one** reason why.

[1 mark]

Figure 7 does not cover the whole range of wavelengths that are absorbed in Figure 6 (above 500 nm), so there could be a peak at around 675 nm, i.e. it could be phytochrome.

8

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0 5

Mammals maintain their core body temperature within a set range.

0 5 . 1

Describe why it is important to maintain a stable core body temperature.

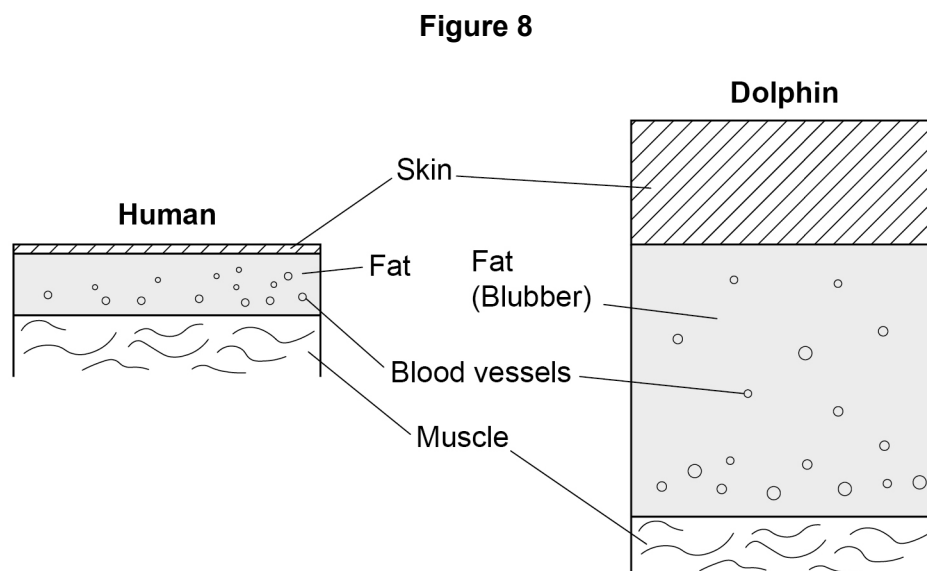
[1 mark]

So enzymes work at their optimum temperature: too high and they denature, too low and the reactions are too slow.

Dolphins are marine mammals with a core body temperature of 37 °C

Dolphins are often found in seas with water temperatures as low as 10 °C

Figure 8 shows the relative thickness of the different layers covering a human and a dolphin.



0 5 . 2

Suggest why dolphins can stay in cold water for longer than humans.

Use information from **Figure 8**.

[3 marks]

The fat (blubber) layer in dolphins is much thicker than the fat layer in humans, and the dolphin also has a thicker skin layer.

Fat (blubber) is an insulator, so it reduces (prevents) heat loss to the cold water.

The dolphin has fewer blood vessels near the skin surface, which reduces heat loss, so dolphins need less heat from metabolism to maintain body temperature than humans.

Although dolphins are commonly found in colder waters, they have also been observed in tropical waters with temperatures up to 38 °C

At 38 °C, humans sweat to cool their bodies.

0 5 . 3

Describe how sweating helps to cool a human.

[2 marks]

Sweat glands release sweat (water) onto the skin surface.

The water in the sweat evaporates, taking heat energy away from the body (latent heat of vaporisation).

Question 5 continues on the next page

Turn over ►



Dolphins are not able to sweat to cool their body temperature.

Scientists investigate if dolphins can cool themselves.

The scientists:

- use a captive bottlenose dolphin
- put the dolphin in a tank of water at 15 °C
- slowly heat the water to 38 °C
- leave the dolphin in the tank of warmed water for 20 minutes
- measure the dolphin's core body temperature throughout
- return the dolphin to its pool.

0 5 . 4

Give **three** disadvantages to the method.

[3 marks]

1 *Small sample size: only one dolphin of only one species was used.*

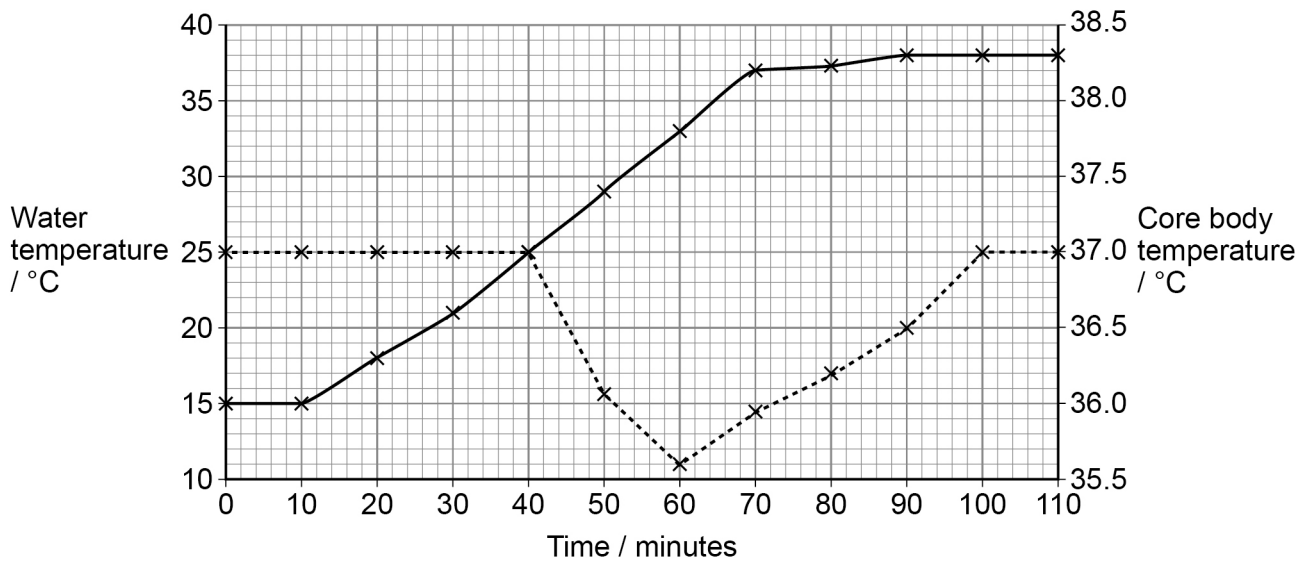
2 *A captive dolphin was used, not a wild one, and it is in a tank so not moving as much as in the wild.*

3 *The dolphin was only in the warm water for a brief time (20 minutes).*



Figure 9 shows the change in core body temperature for the dolphin over time.

Figure 9



Key

- x— Water temperature
 ---x--- Core body temperature

While the dolphin is in the tank of water, the scientists predict that its core body temperature will rise if the dolphin cannot cool itself.

This rise in temperature is due to metabolic activity and would start when the water temperature exceeds 25 °C

Metabolic activity would raise core body temperature by $0.03\text{ }^{\circ}\text{C min}^{-1}$

0 5 . 5

Calculate the dolphin's predicted core body temperature at the end of the investigation if no cooling happens.

Give your answer to 2 significant figures.

[3 marks]

Starting core temperature = 37 °C

Water exceeds 25 °C at 40 min, so time = 110 - 40 = 70 min

Rise = $0.03 \times 70 = 2.1\text{ }^{\circ}\text{C}$; $37 + 2.1 = 39.1\text{ }^{\circ}\text{C}$

Temperature at end = 39 °C

Question 5 continues on the next page

Turn over ►



0 5 . 6

The scientists were surprised by the decrease in core body temperature between 40 and 60 minutes.

The scientists think that the dolphins are using the fat (blubber) layer to keep themselves cool.

Suggest how. Use information from **Figure 8** (on page 16).

[1 mark]

Blood is diverted through the blubber, so heat is transferred from the blood into the blubber and lost to the water, and blubber is an insulator so heat does not move back into the core.

13



0 6

Regular exercise helps to keep the heart healthy. During exercise, the heart rate increases.

Scientists have calculated the safe maximum heart rate and target heart rate ranges for moderate and intense exercise. These values vary for people of different ages.

Table 2 shows the safe maximum heart rate and the target heart rates for moderate and intense exercise.

Table 2

Age	Safe maximum heart rate	Target heart rate range during moderate exercise	Target heart rate range during intense exercise
20	194	124–147	149–180
30	187	120–142	144–174
40	180	115–137	139–167
50	173	111–132	133–161

The safe maximum heart rate can be calculated using the formula:

$$\text{Safe maximum heart rate} = 206.9 - (0.67 \times \text{age})$$

Moderate exercise should raise the heart rate to 64–76% of the maximum.

Intense exercise should raise the heart rate to 77–93% of the maximum.

0 6**1**

Complete **Table 2** for a person who is 20 years old.

[2 marks]

Question 6 continues on the next page

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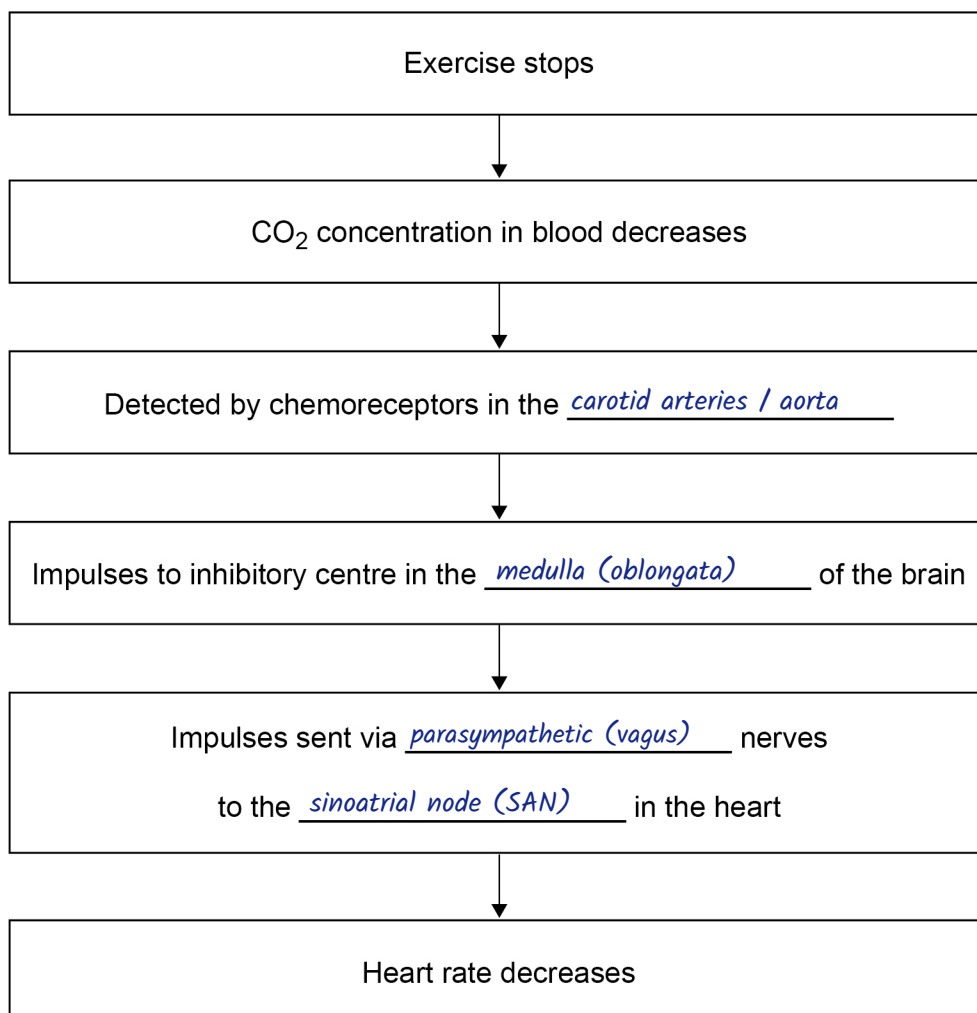


0 6 . 2 Heart rate increases during exercise but starts to decrease when the exercise stops.

Complete **Figure 10** with the most appropriate word or words to explain how this decrease is controlled.

[4 marks]

Figure 10

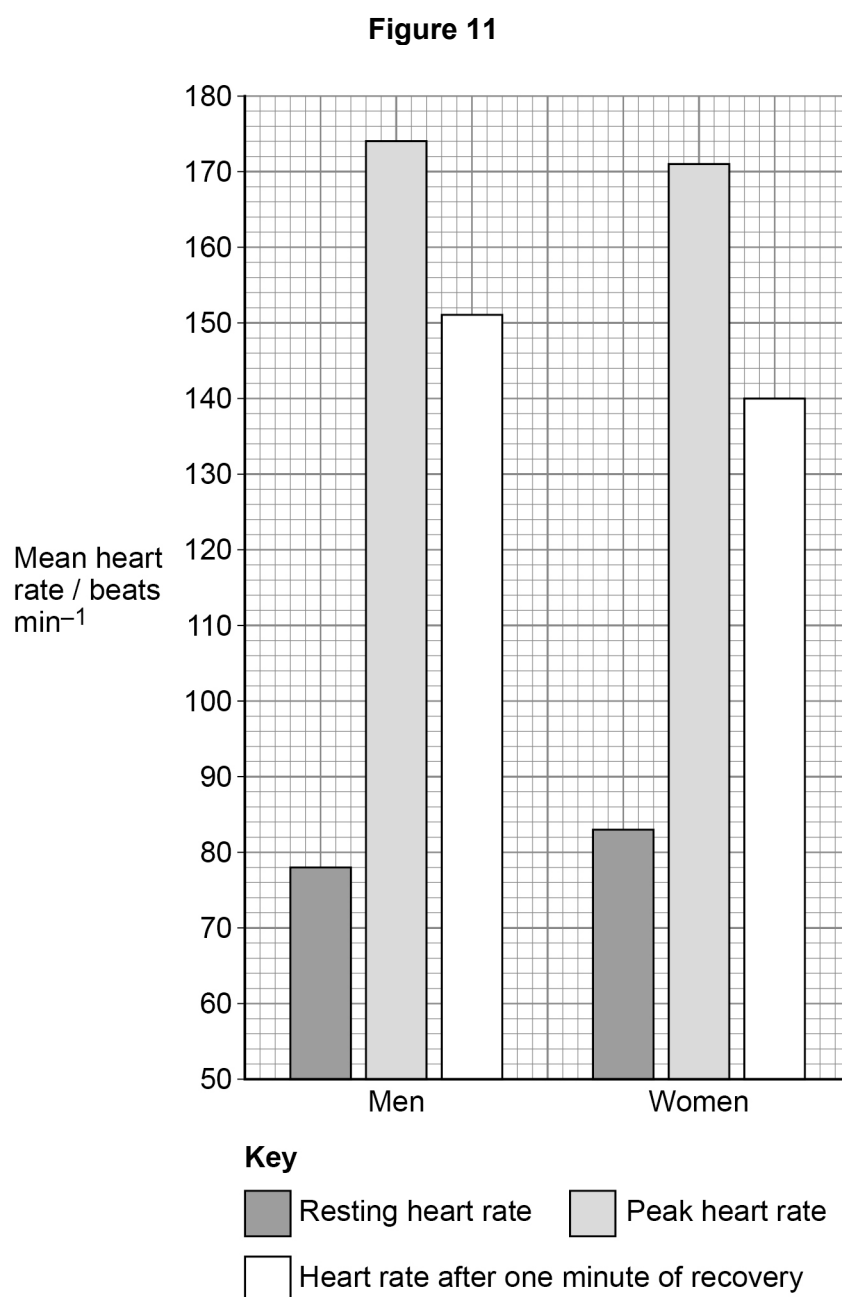


Some students investigate heart rate before, during and after exercise.

They measure the heart rates of 10 men and 10 women:

- before exercise
- during exercise
- after 1 minute of recovery from the exercise.

Figure 11 shows the mean heart rates.



Question 6 continues on the next page

Turn over ►



0 6 . 3 Compare the resting heart rate of the men with the resting heart rate of the women.

Use data from **Figure 11** (on page 23).

[1 mark]

The men's mean resting heart rate is 78 bpm and the women's is 83 bpm, so the men's is 5 bpm lower than the women's.

One student claims that the resting heart rates prove that the men must be fitter than the women.

Another student suggests that they should consider heart rate recovery (HRR).

HRR measures how quickly the heart rate decreases per second in the first minute after exercise stops. HRR is used to classify fitness level.

Table 3 shows the mean HRR for people with poor, good and excellent fitness levels.

Table 3

	Fitness level		
	Poor	Good	Excellent
Mean HRR / beats s ⁻¹	0.2	0.3	0.5



06.4

Compare the fitness level of the men with the fitness level of the women using HRR.

Use **Figure 11** (on page 23) and **Table 3**.

[3 marks]

Men: $174 - 151 = 23$ beats decrease in 1 minute; women: $171 - 140 = 31$ beats decrease in 1 minute.

HRR: men = $23 \div 60 = 0.38 \text{ beats s}^{-1}$; women = $31 \div 60 = 0.52 \text{ beats s}^{-1}$.

So the women show excellent fitness (HRR above 0.5) and the men show good fitness (between 0.3 and 0.5), so the women are fitter than the men.

06.5

HRR may also indicate heart health. The fitness level, age and sex of a person can affect HRR.

Suggest **one** other factor that could affect HRR.

[1 mark]

Smoking

11

Turn over for the next question

Turn over ►



0 7

Type 2 diabetes is becoming more common.

One way to control Type 2 diabetes is by making changes to a person's diet.

Some common foods have medicinal properties.

Scientists investigate if including onions in the diet could help to control Type 2 diabetes.

Investigation 1

The scientists:

- put 21 people with Type 2 diabetes into 3 groups of 7
- measure blood glucose concentration of each person at the start
- give water to the first group
- give glibenclamide (a common drug treatment for Type 2 diabetes) to the second group
- give onion (100 g raw) to the third group
- measure blood glucose concentrations again after 2 hours and 4 hours.

Table 4 shows the scientists' results.

Values are means $\pm$ standard deviations (SD).

Table 4

Group	Mean blood glucose concentration / mg 100 cm ⁻³		
	At start	After 2 hours	After 4 hours
Water	164 $\pm$ 18.5	162 $\pm$ 19.1	149 $\pm$ 8.7
Glibenclamide	171 $\pm$ 11.7	131 $\pm$ 7.5	100 $\pm$ 6.4
Onion	160 $\pm$ 25.3	150 $\pm$ 17.7	115 $\pm$ 15.5



0 7 . 1

Table 4 shows standard deviations.

Describe how standard deviations can be used when comparing mean values.

[1 mark]

If the standard deviations overlap, the means are not (unlikely to be) significantly different; if the SDs do not overlap, the means are likely to be significantly different.

0 7 . 2

Doctors aim to keep blood glucose concentration within the range 80–120 mg 100 cm⁻³ for all patients.After **Investigation 1**, the scientists suggest that glibenclamide is a more appropriate treatment for Type 2 diabetes than water or onion.

Explain why.

[3 marks]

With water, the blood glucose concentration stays high, decreasing only slightly, so it is still above the 80–120 range after 4 hours (149).

With glibenclamide (100) and onion (115), the mean blood glucose concentration is within the range by 4 hours.

But only for glibenclamide is the mean + SD still within the range at 4 hours (106.4); for onion the mean + SD (130.5) is above 120 mg 100 cm⁻³, outside the range.

Question 7 continues on the next page**Turn over ►**

Drug treatments can be expensive. The use of onions could be more cost-effective but not everyone likes eating raw onions.

The scientists investigate if quercetin is the active compound in onion that affects blood glucose concentration. Quercetin is also found in other vegetables.

The scientists plan to repeat **Investigation 1** with different vegetables. To make it comparable, they must use the same amount of quercetin as in the 100 g of raw onion.

The scientists:

- measure the concentration of quercetin in some other vegetables
- calculate the mass of the vegetable needed to provide the same dose of quercetin as 100 g of raw onion.

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

Table 5

Vegetable	Concentration of quercetin / mg g ⁻¹	Mass of vegetable to be eaten / g
Onion	0.226	100
Broccoli	0.028	807
Celery	0.035	646
Kale	0.051	Y

0 7 . 3 Calculate the value of Y in **Table 5**.

[2 marks]

$$\text{Mass of quercetin in 100 g onion} = 0.226 \times 100 = 22.6 \text{ mg}$$

$$Y = 22.6 \div 0.051 = 443.1 \text{ g}$$

$$Y = \underline{443} \text{ g}$$



Based on **Table 5**, the scientists decide it is not realistic to rely on only one type of vegetable to get the required amount of quercetin each day.

However, drying onions would allow the amount of quercetin to be concentrated in powder form.

The scientists investigate if the method used for drying the onion changes its effectiveness.

Investigation 2

The scientists investigate two different methods of drying the onions:

1. Dried by freezing.
2. Dried by heating.

The scientists put adult rats into 4 groups.

The rats:

- in group **P** are controls and do not have diabetes
- in groups **Q**, **R** and **S** have diabetes
- in all the groups are kept in the same standard conditions for 8 weeks
- are fed standard rat food with or without added onion.

Table 6 shows the food each group is given.

Table 6

Group	Standard rat food	Freeze-dried onion added	Heat-dried onion added
P (control)	✓	x	x
Q	✓	x	x
R	✓	✓	x
S	✓	x	✓

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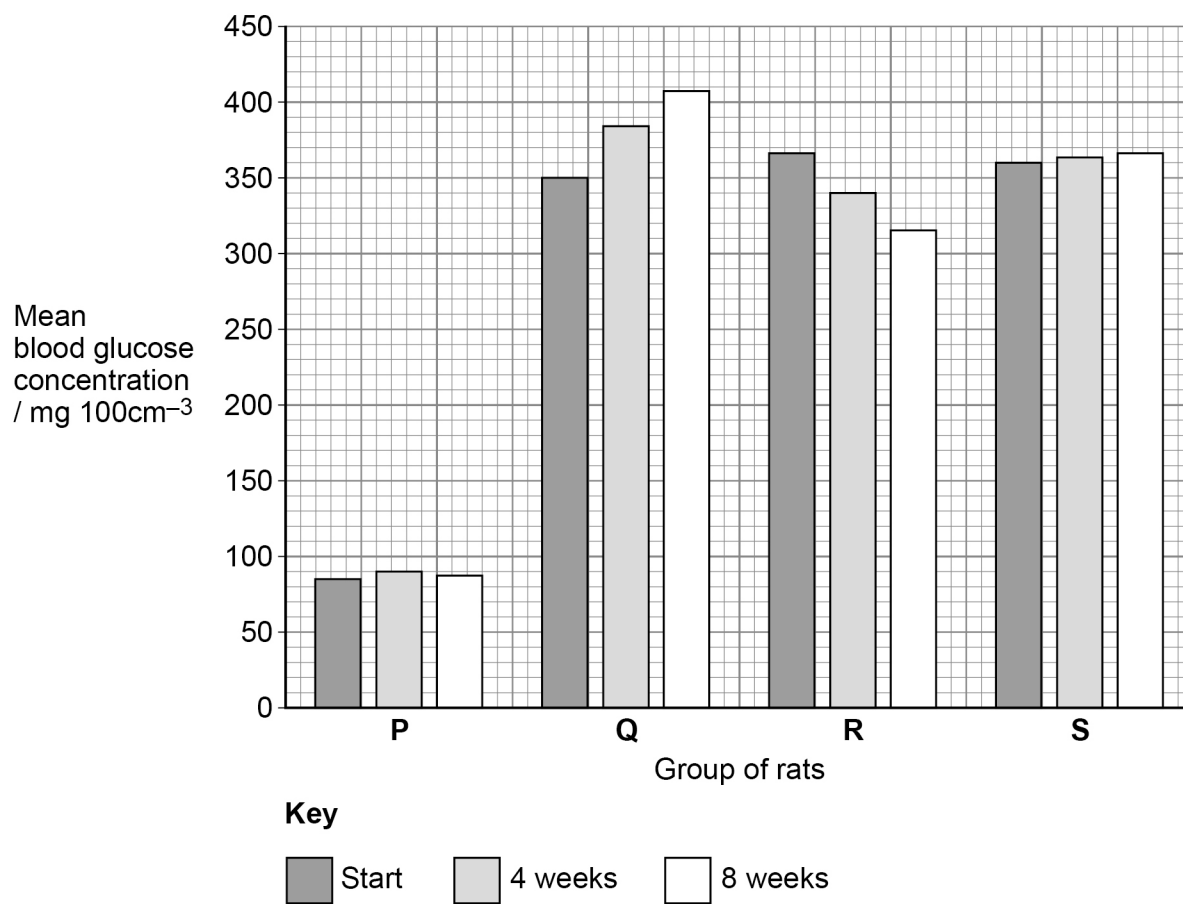
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The blood glucose concentration of the rats in each group is measured at the start, after 4 weeks, and after 8 weeks.

Figure 12 shows the mean blood glucose concentration for each group of rats.

Figure 12



0 7 . 4

Describe and compare how the mean blood glucose concentration changes over time for group **P** and group **Q**.

Use data from **Figure 12**.

[3 marks]

Group **P** *Mean blood glucose concentration remains stable, at about 85 to 90 mg 100 cm⁻³, throughout.*

Group **Q** *Mean blood glucose concentration increases during the test, from 350 to 410 mg 100 cm⁻³.*

Comparison *Group Q mean blood glucose concentration is much higher than group P at all times, and Q increases while P stays the same.*

A journalist sees the data from both **Investigation 1** (**Table 4**, on page 26) and **Investigation 2** (**Figure 12**). He writes an article with the headline:

“Everyone with diabetes should add onions to their diet.”

0 7 . 5

Evaluate the journalist's headline.

Use information from **Table 4** (on page 26) and **Figure 12**.

[3 marks]

Yes: raw onion lowers blood glucose (160 to 115, Table 4); freeze-dried onion (R) lowers it and heat-dried onion (S) prevents the increase seen in Q.

No: dried onion only tested on rats; raw onion only tested on Type 2, and the rats' diabetes type is unknown.

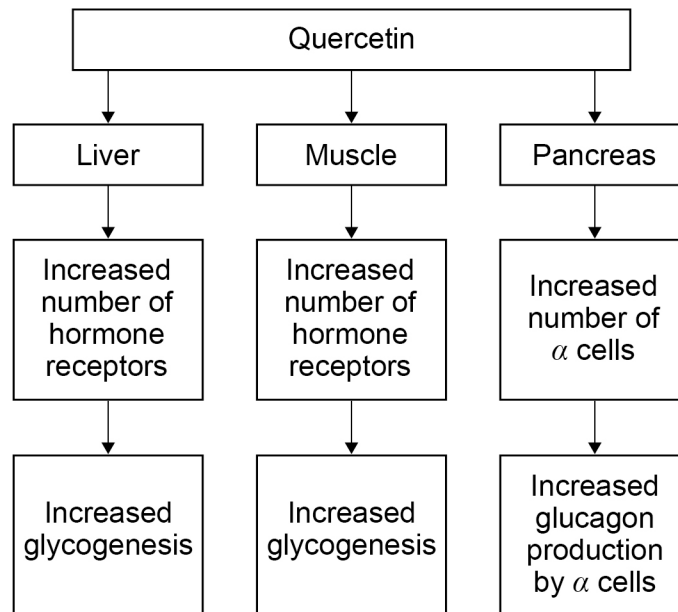
Small sample (7 people); no error bars or statistics for rats, so may not be significant; unknown how much onion was added to rat food or how often to eat it; onion + SD is above the 80–120 range.

Turn over ►



The scientists produce a diagram to show the effects quercetin has on different organs in the body.

Figure 13



0 7 . 6

Explain why quercetin is more useful in preventing high blood glucose concentration in people with **Type 2** diabetes than in people with **Type 1** diabetes.

[3 marks]

Type 1 diabetes: the pancreas does not produce enough insulin; Type 2

diabetes: insulin is produced but the cells are unresponsive to insulin.

In the pancreas quercetin increases the number of α cells, so more

glucagon is produced, not insulin, so quercetin won't help Type 1

diabetes.

In the liver and muscle quercetin increases the number of hormone

(insulin) receptors and increases glycogenesis, so the cells of people with

Type 2 diabetes respond to insulin and blood glucose concentration is

reduced.

15

END OF QUESTIONS



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