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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Control Systems (9)

A Level Biology B Topic 9

38 questions · 366 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
9(a) HORMONES AND CHEMICAL CONTROL (ANIMALS AND PLANTS)		8 questions · 72 marks	4
1. Q1	<i>also Topic 1</i> A Level Paper 2 June 2017	5	5
2. Q5	A Level Paper 2 June 2025	6	7
3. Q5	A Level Paper 2 June 2019	7	10
4. Q2	<i>also Topic 1</i> A Level Paper 2 June 2022	8	12
5. Q4	A Level Paper 3 June 2023	9	14
6. Q9	A Level Paper 2 November 2021	10	16
7. Q5	<i>also Topic 1</i> A Level Paper 3 October 2020	13	19
8. Q7	<i>also Topic 8, 1</i> A Level Paper 2 June 2019	14	21
9(b) HOMEOSTASIS: THERMOREGULATION, KIDNEY AND BLOOD GLUCOSE		10 questions · 104 marks	24
9. Q2	A Level Paper 3 June 2019	6	25
10. Q3	<i>also Topic 4</i> A Level Paper 2 October 2020	6	27
11. Q6	<i>also Topic 4</i> A Level Paper 2 June 2022	8	29
12. Q2	A Level Paper 3 June 2024	9	31
13. Q8	A Level Paper 2 June 2018	10	34
14. Q7	A Level Paper 2 June 2024	11	37
15. Q7	<i>also Topic 4</i> A Level Paper 3 November 2021	12	41
16. Q7	<i>also Topic 1</i> A Level Paper 2 June 2025	12	43
17. Q7	<i>also Topic 10</i> A Level Paper 3 October 2020	13	47
18. Q4	A Level Paper 3 June 2017	17	50
9(c) THE NERVOUS SYSTEM, RECEPTORS AND THE BRAIN		20 questions · 190 marks	53
19. Q3	<i>also Topic 5</i> A Level Paper 2 June 2018	6	54
20. Q2	<i>also Topic 4</i> A Level Paper 2 June 2017	7	55
21. Q2	A Level Paper 3 November 2021	7	57
22. Q1	A Level Paper 3 June 2022	7	59
23. Q6	A Level Paper 2 June 2023	7	61
24. Q2	A Level Paper 3 June 2025	7	64
25. Q5	A Level Paper 2 June 2017	8	66
26. Q1	A Level Paper 3 June 2018	8	68
27. Q9	A Level Paper 2 October 2020	8	71
28. Q2	A Level Paper 2 October 2020	9	74
29. Q4	<i>also Topic 8</i> A Level Paper 2 June 2017	10	76
30. Q2	A Level Paper 2 June 2019	10	79
31. Q5	A Level Paper 2 June 2022	10	81
32. Q9	A Level Paper 2 June 2025	10	84



33.	Q6		A Level Paper 2	October 2020	11	87
34.	Q5	<i>also Topic 8</i>	A Level Paper 2	June 2023	11	91
35.	Q8	<i>also Topic 4</i>	A Level Paper 2	June 2023	13	94
36.	Q8		A Level Paper 2	June 2024	13	97
37.	Q10		A Level Paper 3	June 2019	14	101
38.	Q6		A Level Paper 2	November 2021	14	104



QUESTIONS

38 questions · 366 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC 9(a)

HORMONES AND CHEMICAL CONTROL (ANIMALS AND PLANTS)

8 questions in this sub-topic · 72 marks · lowest tariff first



- 1 Chemical control in plants is brought about by plant growth substances such as auxins.

Auxins cause elongation of cells.

Auxins weaken the bonds between molecules found in cell walls. Molecules found in cell walls include cellulose and hemicellulose.

- (a) (i) Which of the following statements about cellulose molecules is correct?

(1)

- ☐ A they are branched polymers
- ☐ B they contain α -glucose
- ☐ C they are bonded to each other by hydrogen bonds
- ☐ D they contain 1,6 glycosidic bonds

- (ii) The following statements relate to calcium pectate:

1. found in the middle lamella
2. holds cell walls together
3. prevents the movement of water

Which of the following is correct for calcium pectate?

(1)

- ☐ A statement 1 and statement 2
- ☐ B statement 1 and statement 3
- ☐ C statement 2 only
- ☐ D statement 3 only



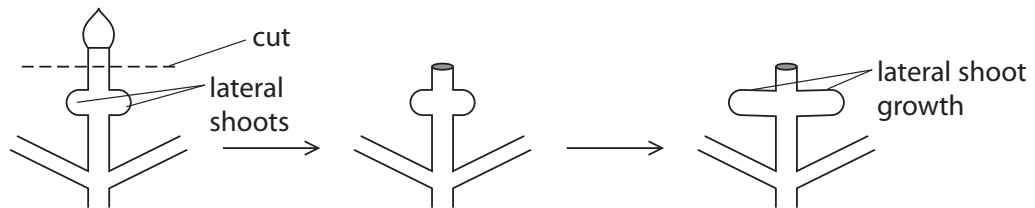
(b) A scientist investigated apical dominance in plants.

In experiment 1, the shoot tips were cut off and the growth of lateral shoots assessed.

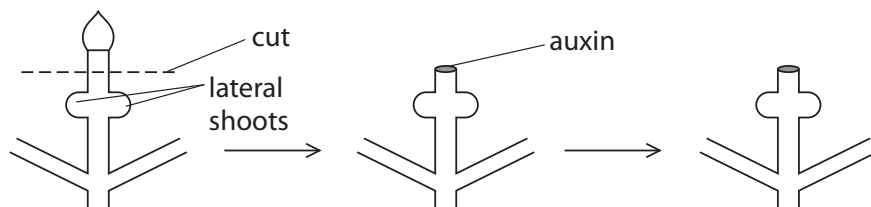
This was repeated in experiment 2, but auxin was placed over the cut end of the tips and the growth of lateral shoots was assessed.

The results are shown in the diagrams.

Experiment 1



Experiment 2



Explain how the interaction between auxins and cytokinins could have produced the results shown in the diagram.

(3)

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5 Auxin is a plant growth substance.

(a) Which of the following are functions of auxin?

1. inhibiting lateral shoot growth
2. stimulating the elongation of cells in plant stems
3. stimulating flowering

(1)

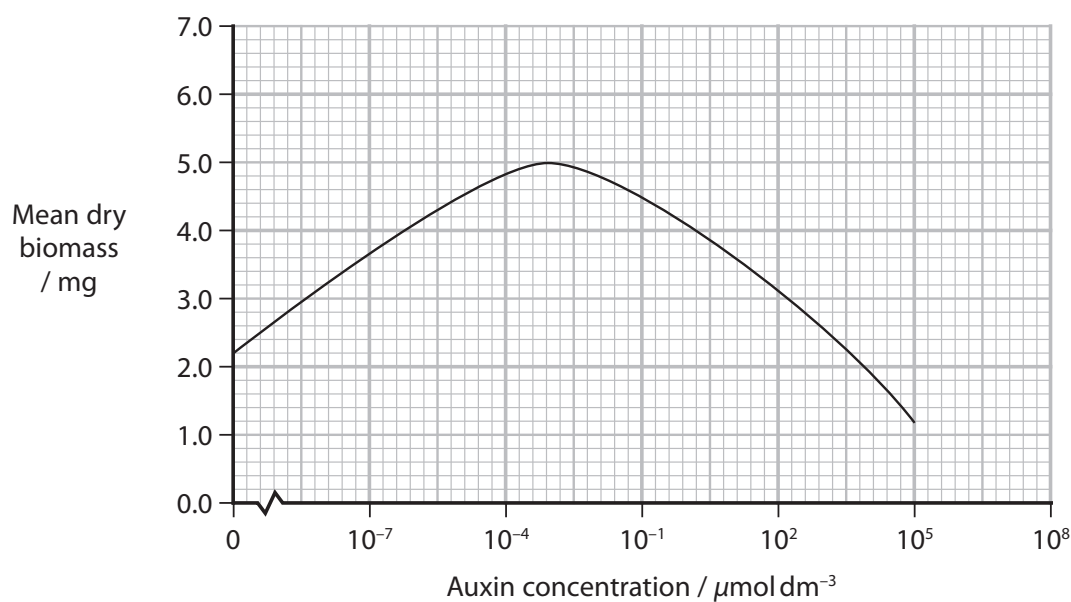
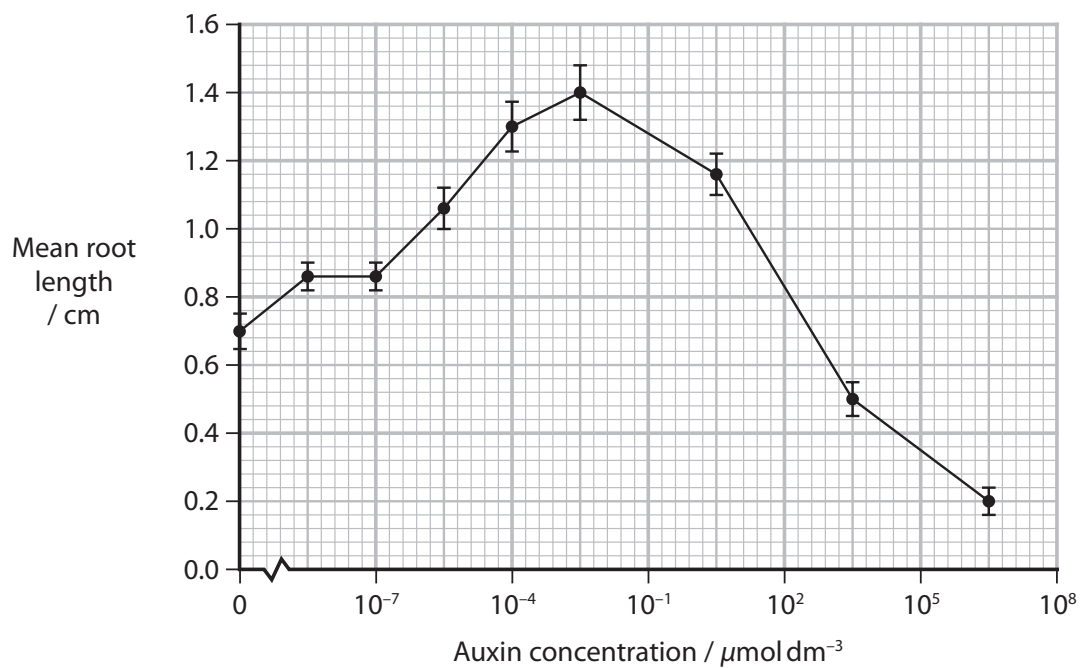
- ☐ **A** 1 and 2
- ☐ **B** 1, 2 and 3
- ☐ **C** 1 and 3
- ☐ **D** 2 and 3



- (b) In an investigation, wheat seedlings were exposed to different concentrations of auxin.

The mean lengths of the roots and the mean dry biomass of the seedlings were calculated.

The graphs show the results of this investigation.



- (i) Calculate the percentage increase in mean root length when given an auxin concentration of $10^{-4} \mu\text{mol dm}^{-3}$ compared with no auxin.

Give your answer to the **nearest whole number**.

(1)

Answer

- (ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4)

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5 Chemical control in plants involves plant growth substances.

(a) Which of the following effects are caused by auxin?

(1)

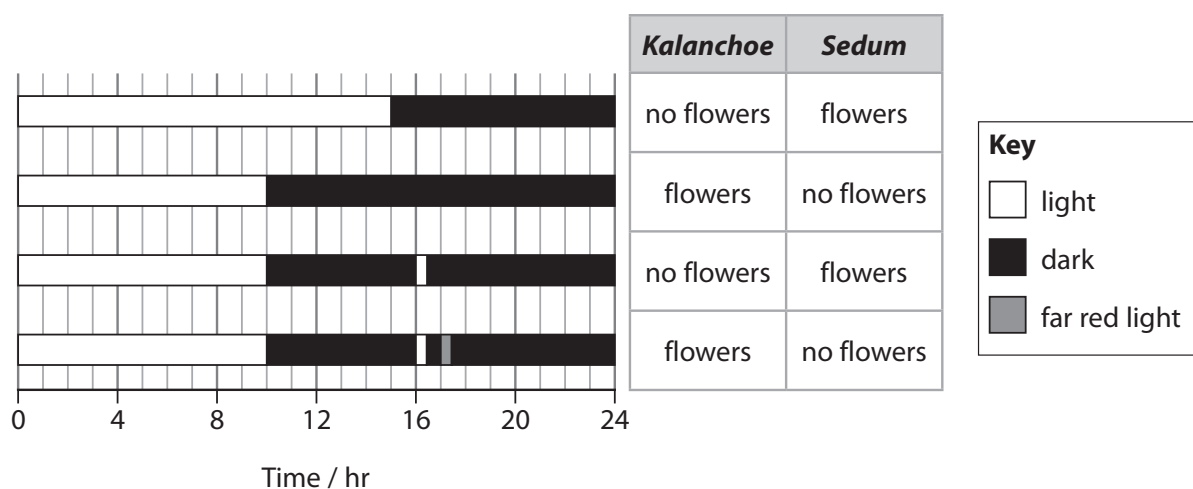
- 1 cell elongation
- 2 suppression of lateral bud growth
- 3 photomorphogenesis

- ☒ A 1 and 2
- ☒ B 1 and 3
- ☒ C 2 and 3
- ☒ D 1, 2 and 3

*(b) The effect of day length on flowering in two species of plants, *Kalanchoe* and *Sedum*, was investigated.

The effect of different periods of light and darkness and the effects of exposure to far red light were investigated.

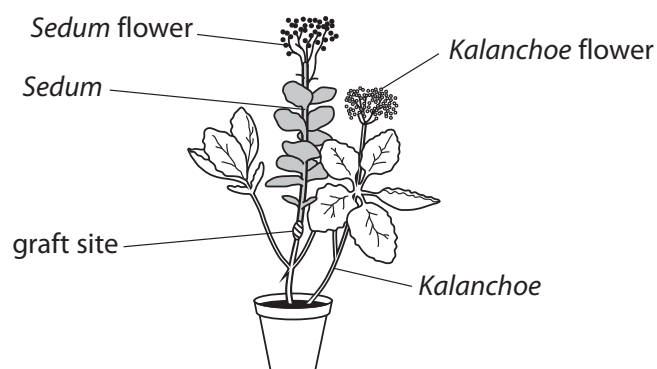
The diagram shows the results of this investigation.



In another investigation, a piece of *Sedum* was grafted onto the stem of a *Kalanchoe* plant.

This plant and graft were exposed to 10 hours of light followed by 14 hours of darkness.

The *Kalanchoe* and the *Sedum* graft both produced flowers, as shown in the diagram.



Analyse the data to explain the effects of different light periods and far red light on flowering in *Kalanchoe* and *Sedum*.

(6)

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2 Plant growth substances and phytochromes are chemicals that affect the growth of plants.

- (a) (i) Which row of the table shows the concentrations required for the fastest growth of lateral buds?

(1)

	Auxin concentration	Cytokinin concentration
☐ A	high	high
☐ B	high	low
☐ C	low	high
☐ D	low	low

- (ii) Some types of auxin affect the activity of cells in the same way as hormones such as oestrogen affect human cells.

These auxins pass through the cell membrane and affect the synthesis of enzymes.

Explain how these auxins affect the synthesis of enzymes.

(3)

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(b) Phytochrome is involved in the germination of seeds.

The effect of red (R) light and far-red (FR) light on the germination of lettuce seeds was investigated.

A scientist exposed five groups of 50 seeds to red light for one minute.

The seeds were planted and the mean number that germinated was calculated.

Another five groups each of 50 seeds were then exposed to red light for one minute, followed by far-red light for four minutes.

These seeds were planted and the mean number that germinated was calculated.

The experiment was repeated with different combinations of red light and far-red light.

The results are shown in the table.

Sequence of red (R) and far-red (FR) light	Mean number of seeds that germinated	Standard deviation (SD)
R	45	± 4
R, FR	5	± 2
R, FR, R	45	± 5
R, FR, R, FR	10	± 4
R, FR, R, FR, R	40	± 9

Analyse the data to comment on the effect of red (R) and far-red (FR) light on the germination of lettuce seeds.

(4)

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4 When cereal grains germinate, stored starch is broken down by amylase.

- (a) A student investigated the effect of gibberellin concentration on the production of amylase in cereal grains.

This method was used:

Step 1 Dilute a stock solution of gibberellin to give five different concentrations.

Step 2 Cut the cereal grains in half and discard the half containing the embryo.

Step 3 Soak the remaining halves of the grains in sodium hypochlorite solution for five minutes.

Step 4 Soak one grain in each of the gibberellin solutions for 24 hours.

- (i) The stock solution of gibberellin has a concentration of 1 g per dm^3 .

Describe how you would dilute this stock solution to give a test solution of $300 \mu\text{g per dm}^3$.

(2)

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- (ii) State **one** reason for each of the following steps in the method.

(2)

Step 2

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Step 3

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(b) The student completed the investigation using the following steps:

- the grains soaked in gibberellin solution were transferred to starch agar plates using forceps
- after 12 hours the surface of each plate was covered with iodine in potassium iodide solution, which was then poured away
- the diameter of the clear zone around each grain was measured.

(i) Describe how you would control **one** named abiotic variable and **one** named biotic variable.

(2)

Abiotic

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Biotic

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(ii) Describe **three** further improvements to the method outlined in parts (a) and (b) that would improve the validity of the results.

(3)

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- 9 Auxins and cytokinins are plant growth regulators that control apical dominance and cell elongation.

(a) Explain how auxins and cytokinins control the growth of lateral buds.

(3)

- (b) Auxin is an uncharged molecule when it diffuses through the cell surface membrane. When inside the cytoplasm, auxin develops a negative charge. Auxin leaves cells by facilitated diffusion.

Explain how the structure of the cell membrane affects the transport of auxin.

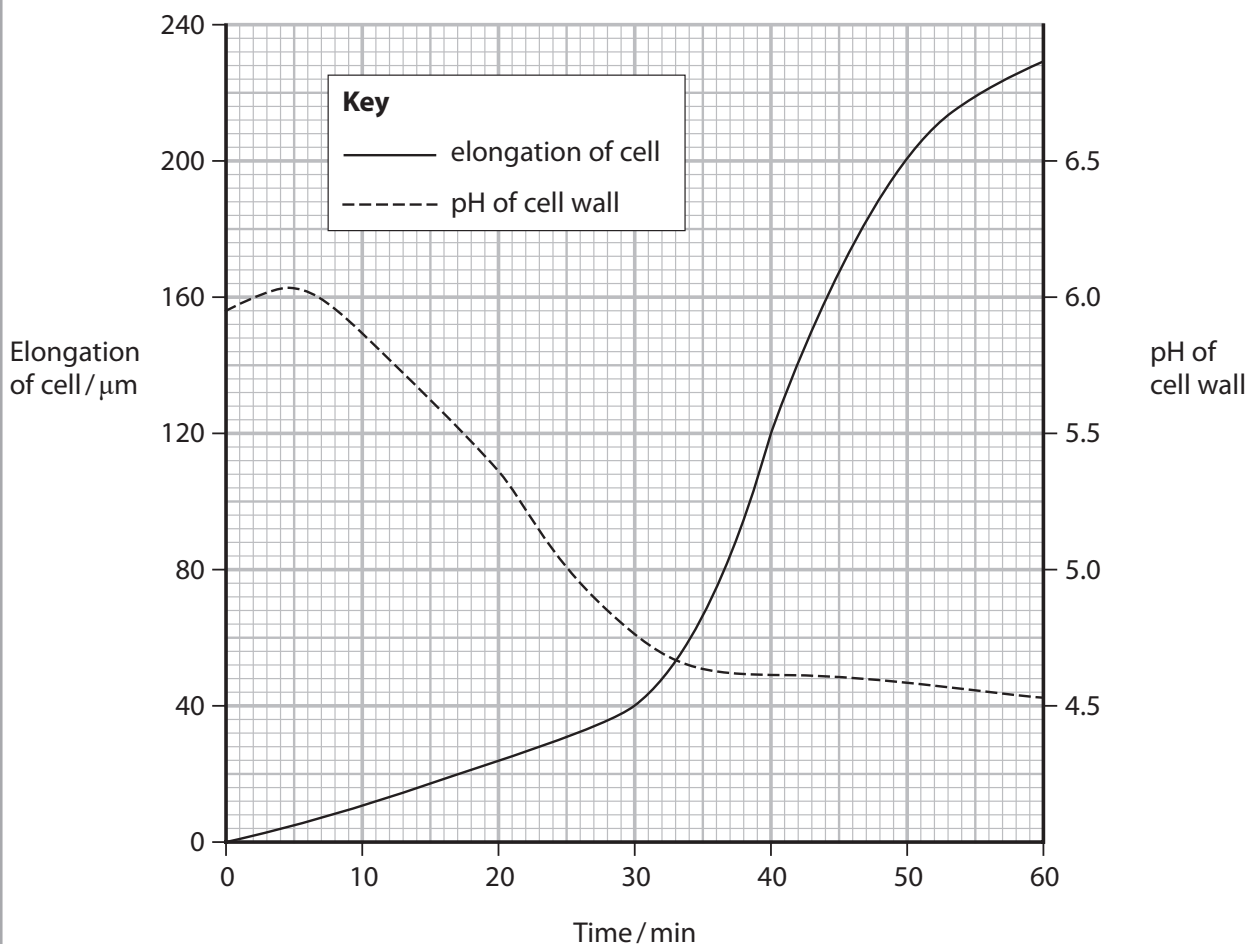
(2)



- (c) When auxin enters a cell, it causes hydrogen ions to be pumped out of the cell into the cell wall.

The effect of auxin on the pH of the cell wall and cell elongation was investigated. Auxin was added to plant cells. The pH of the cell wall and cell elongation were measured over a period of 60 minutes.

The results are shown in the graph.



- (i) Calculate the maximum rate of elongation of the cell.

(2)

Answer.....



(ii) Expansin is a protein located in cell walls.

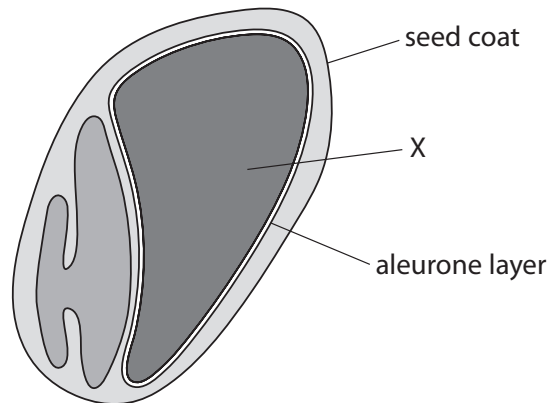
Expansin disrupts hydrogen bonds and ionic bonds of molecules in the cell wall.

Deduce a mechanism by which auxin and expansin cause cells to elongate.

(3)

- 5 Gibberellin stimulates cells in the aleurone layer of cereal grains, such as barley, to produce the enzyme amylase.

The diagram shows the location of the aleurone layer in a barley grain.

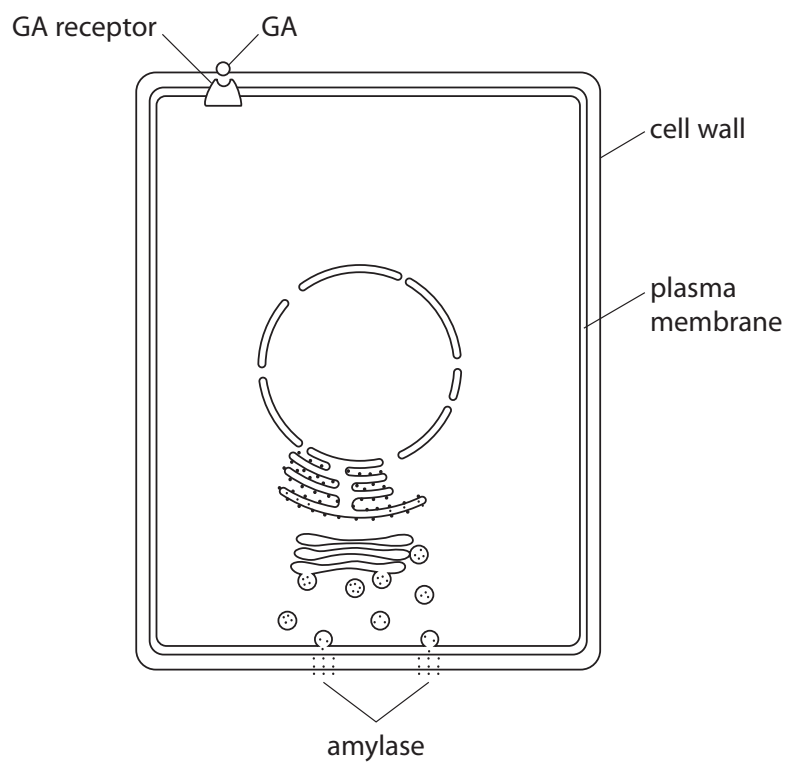


- (a) The part labelled X contains triploid cells.

Name the part labelled X.

(1)

- (b) The diagram shows a cell from the aleurone layer with some of the structures involved in the production of amylase.



Gibberellin binds to a protein receptor in the cell surface membrane and this stimulates transcription in the nucleus.

- (i) Describe the process of transcription in the nucleus of this cell.

(2)

- (ii) Describe the processes occurring after transcription that result in the release of amylase from the cell shown in the diagram.

(5)

- (c) Global warming may cause sea levels to rise and salty seawater to flood land used for growing crops.

A student read that salt (NaCl) inhibits gibberellin synthesis.

This could affect amylase production in cereal grains.

Devise an investigation to show the effect of salt concentration on amylase production in cereal grains.

(5)



7 Adrenaline is a hormone that stimulates the breakdown of glycogen into glucose.

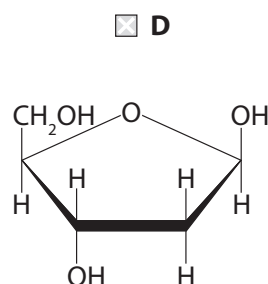
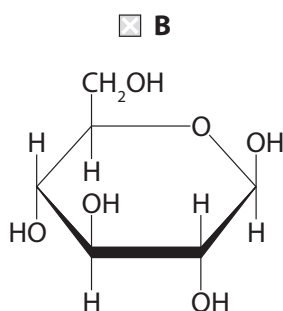
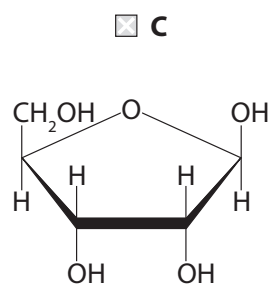
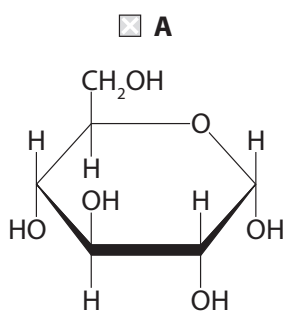
(a) (i) Which of the following describes this breakdown?

(1)

- ☐ **A** condensation reaction breaking glycosidic bonds
- ☐ **B** condensation reaction breaking phosphodiester bonds
- ☐ **C** hydrolysis reaction breaking glycosidic bonds
- ☐ **D** hydrolysis reaction breaking phosphodiester bonds

(ii) Which diagram shows the structure of the glucose produced?

(1)



(iii) Explain how the structure of glycogen is related to its function.

(3)

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- (b) The hormone adrenaline is unable to pass through cell membranes.

When liver and muscle cells are exposed to adrenaline, the enzyme glycogen phosphorylase breaks down glycogen in these cells.

Describe how adrenaline causes liver cells to increase the concentration of glucose in the blood.

(3)

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- (c) The genetic condition Hers disease is caused by a recessive allele of the glycogen phosphorylase gene.

In an isolated population of 1400 people in the USA, 15 people have Hers disease.

- (i) Calculate the number of heterozygous individuals in this population.

Use the Hardy-Weinberg equation

(4)

$$p^2 + 2pq + q^2 = 1$$

Answer



(ii) The frequency of Hers disease in most human populations is 1 in 40 000.

Explain why the frequency of Hers disease is higher in the isolated population.

(2)



SUB-TOPIC 9(b)

HOMEOSTASIS: THERMOREGULATION, KIDNEY AND BLOOD GLUCOSE

10 questions in this sub-topic · 104 marks · lowest tariff first

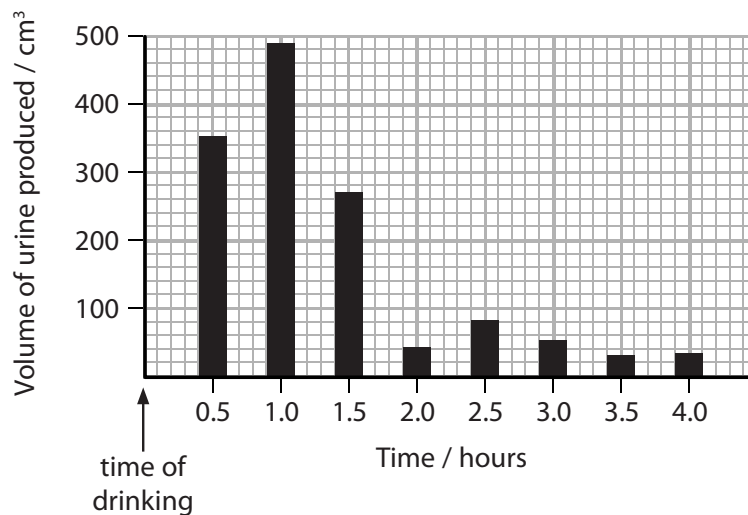


- 2 Negative feedback control of blood plasma concentration is an example of homeostasis.

A student investigated the effect of drinking water on the volume of urine produced.

The student drank one dm^3 of water and waited for half an hour. The student then collected the urine produced every 30 minutes for four hours.

The graph shows the results of this investigation.



- (a) (i) Determine the total volume of urine produced during the first two hours.

(1)

Answer cm^3

- (ii) Explain the role of negative feedback in the control of blood plasma concentration during the first hour after drinking water.

(4)

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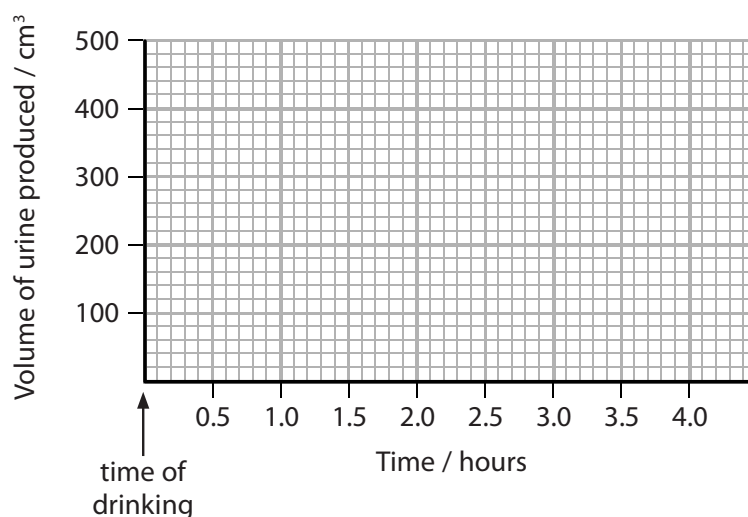
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- (b) The next day the student drank one dm^3 of dilute salt solution with the same water potential as blood plasma.

The student waited half an hour and collected the urine produced every 30 minutes for four hours.

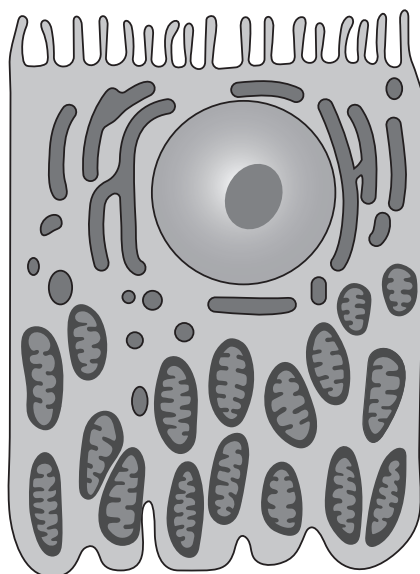
Sketch a graph to predict the results.

(1)



(Total for Question 2 = 6 marks)

- 3 (a) The diagram shows a cell from the proximal convoluted tubule of the nephron.



Explain how the features shown in the diagram enable this cell to carry out its function.

(4)

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(b) (i) Which of the following statements about facilitated diffusion are correct?

(1)

1. substances move through membrane proteins
2. substances move against a concentration gradient
3. substances move down a concentration gradient
4. substances move between phospholipids

- ☐ **A** 1 and 2
- ☐ **B** 1 and 3
- ☐ **C** 2 and 3
- ☐ **D** 2 and 4

(ii) The collecting duct is also part of the nephron.

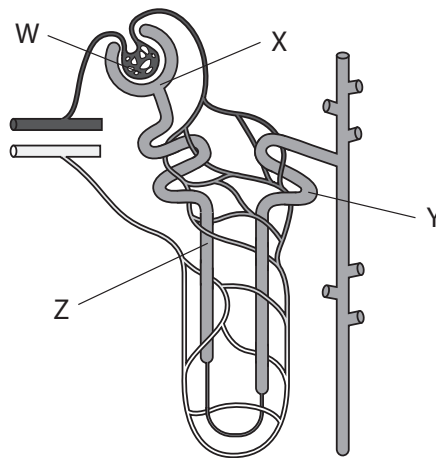
Which of the following are the effects of increased release of antidiuretic hormone (ADH)?

(1)

- ☐ **A** decreased permeability of the collecting duct to water, producing more concentrated urine
- ☐ **B** decreased permeability of the collecting duct to water, producing more dilute urine
- ☐ **C** increased permeability of the collecting duct to water, producing more concentrated urine
- ☐ **D** increased permeability of the collecting duct to water, producing more dilute urine

(Total for Question 3 = 6 marks)

6 The diagram shows a nephron.



(a) Which labelled parts of this nephron would normally contain glucose?

(1)

- ☐ A W only
- ☐ B W and X
- ☐ C W, X, and Y
- ☐ D W, X, Y, and Z

(b) Oedema is an accumulation of tissue fluid. This is due to less tissue fluid being returned to the blood capillaries.

(i) Explain how tissue fluid is returned to capillaries.

(3)

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- (ii) Furosemides are drugs that are used to reduce oedema. They are diuretics that increase urine production.

Furosemides reduce the active transport of sodium ions by the loop of Henle.

Explain how furosemides cause an increase in urine production.

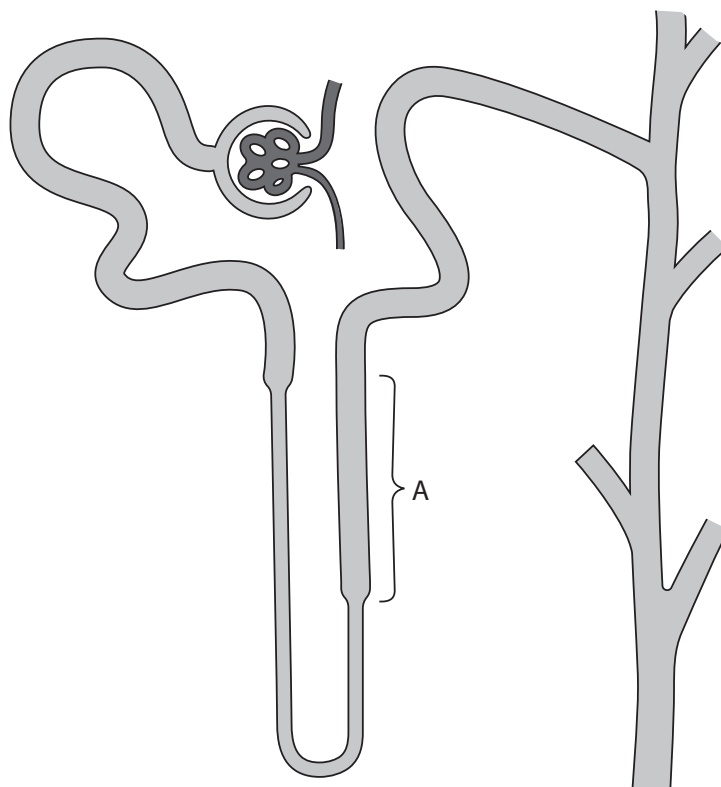
(4)



2 The mammalian kidney contains over one million nephrons.

One of their functions is to produce urine with a high concentration of urea.

(a) The diagram shows one nephron, collecting duct and some of the associated blood vessels.



(i) Explain how urea enters the nephron.

(2)

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- (ii) In the region labelled A, sodium ions are actively pumped out of the nephron into the surrounding fluid.

Explain how this movement of ions results in the formation of concentrated urine.

(3)

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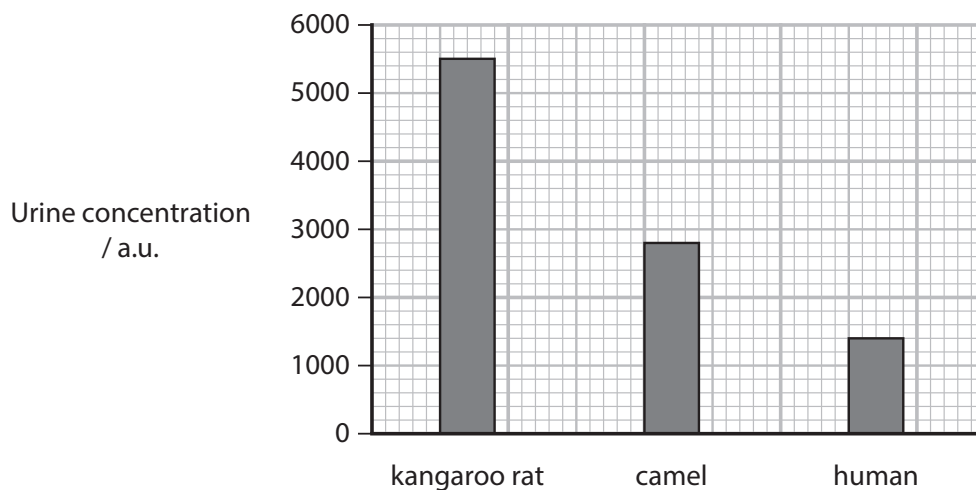
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- (b) The concentration of urine varies between species of mammals.

The graph shows the concentration of urine in kangaroo rats, camels and humans.



- (i) Determine the ratio of urine concentration for these three mammals.

(1)

Answer



(ii) Kangaroo rats live in a desert habitat.

Explain **one** adaptation in the structure of a kangaroo rat kidney that enables it to produce very concentrated urine.

(2)

(iii) Kangaroo rats are endotherms.

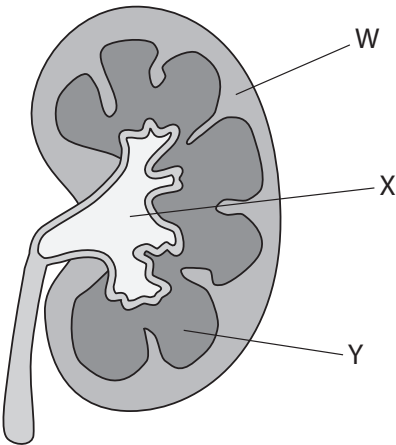
Give **one** behavioural adaptation that you would expect to see in kangaroo rats that helps them to conserve water in a hot desert.

(1)

(Total for Question 2 = 9 marks)



8 The diagram shows a section through a mammalian kidney.



(a) Which row of the table names the parts of the kidney labelled in the diagram?

(1)

	W	X	Y
☒ A	cortex	medulla	pelvis
☒ B	cortex	pelvis	medulla
☒ C	medulla	pelvis	cortex
☒ D	medulla	cortex	pelvis

(b) The table shows information about substances found in the blood and in the filtrate in the renal (Bowman's) capsule.

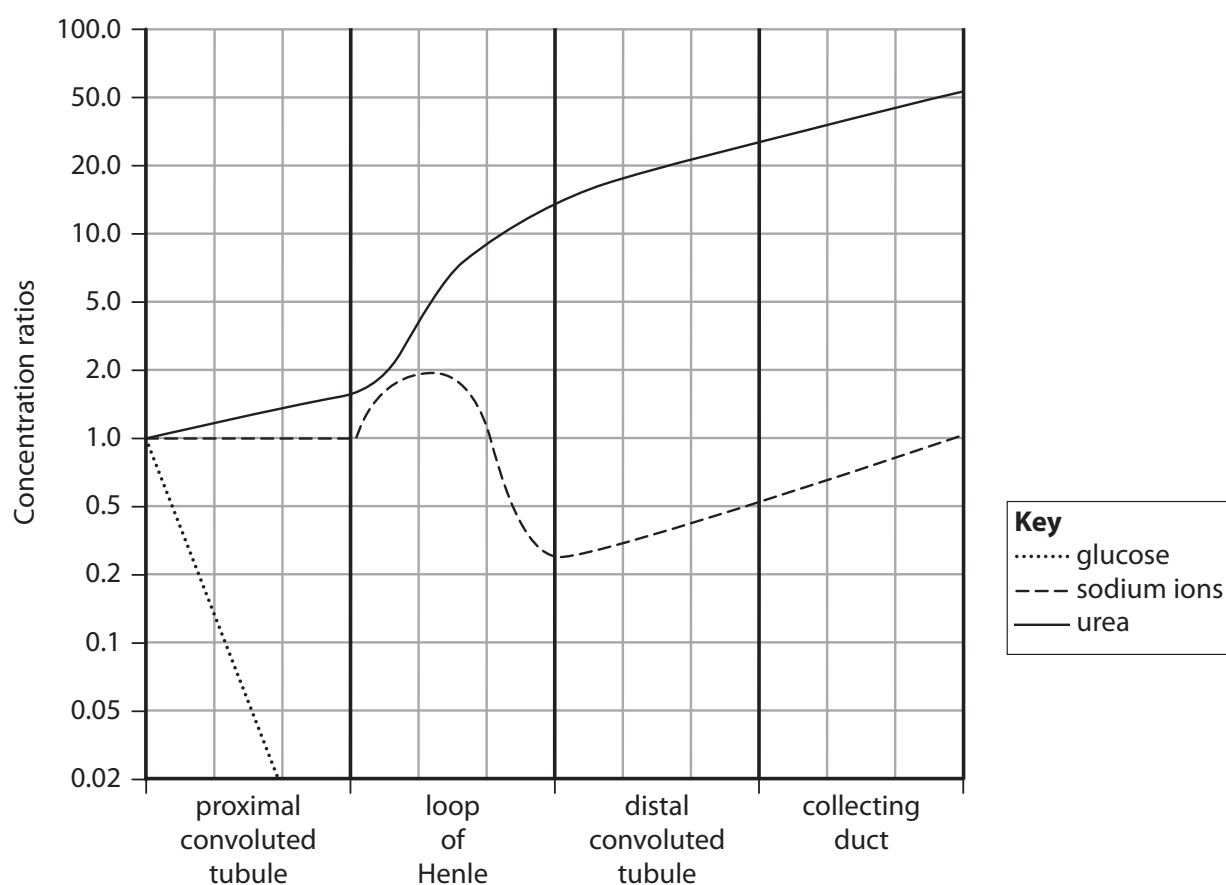
Substance	Relative molecular mass	Ratio of concentration in the filtrate in the renal (Bowman's) capsule : concentration in blood
sodium ions	23	1.00
water	18	1.00
urea	60	1.00
glucose	180	1.00
myoglobin	17 000	0.75
plasma proteins	69 000	<0.01

Analyse the data to explain the ratios of these substances.

(3)

*(c) The renal (Bowman's) capsule is part of each nephron found in the kidney.

The graph shows the concentration ratios of three solutes in different parts of the nephron compared with their concentrations in the renal capsule.



Explain the changes in the concentration ratios of these solutes in the different parts of the nephron.

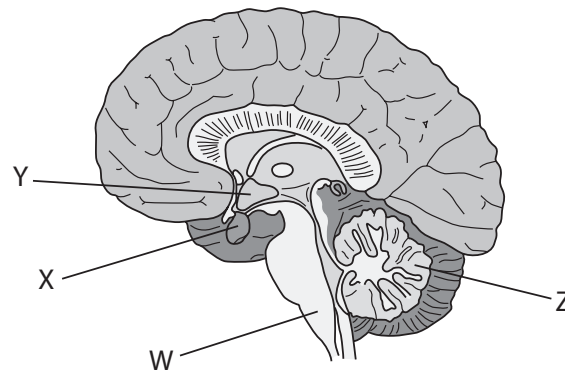
(6)



7 Thermoregulation and osmoregulation are examples of homeostasis.

(a) In mammals, the hypothalamus has a role in thermoregulation.

The diagram shows a cross section of a human brain.



Which structure is the hypothalamus?

(1)

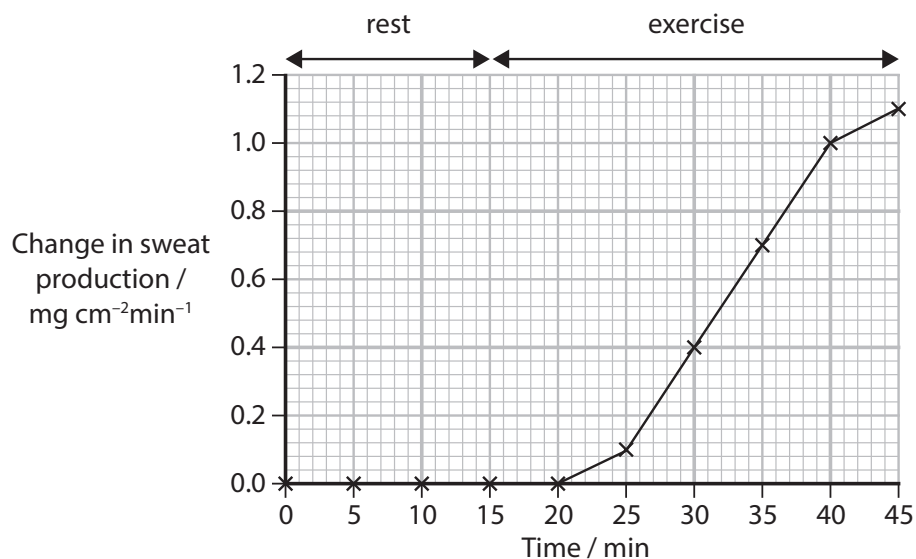
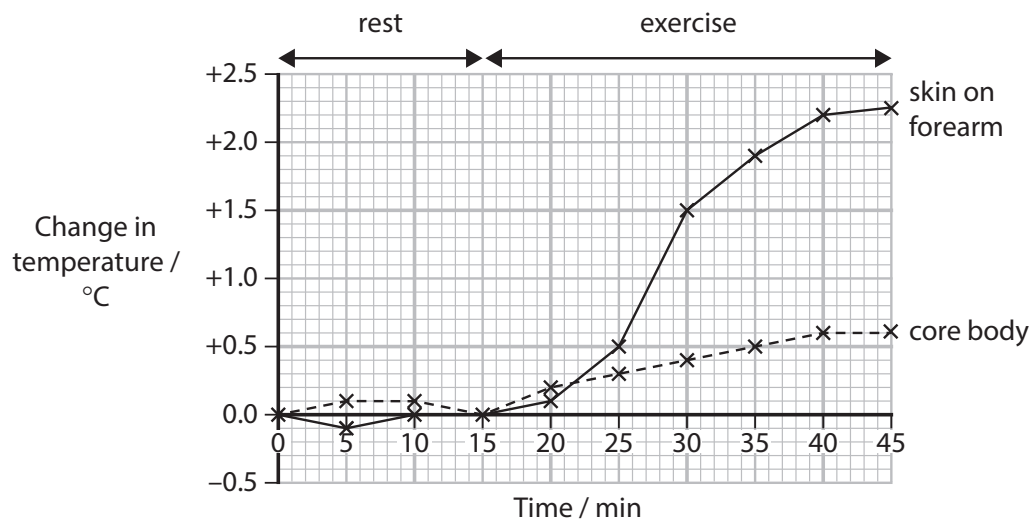
- ☐ A W
- ☐ B X
- ☐ C Y
- ☐ D Z

(b) A student investigated the effect of exercise on:

- the change in core body temperature
- the change in skin temperature (on the forearm)
- the change in production of sweat from skin on the chest.

The student monitored these factors every five minutes during 15 minutes of rest, followed by 30 minutes of exercise.

The graphs show the results.



(i) Explain the changes in core body temperature and skin temperature during exercise, using the information in the graphs.

(4)

(ii) Mammals are endotherms.

Give **one** method that **ectotherms**, such as reptiles, can use to thermoregulate.

(1)



- (iii) Hypothermia occurs when thermoregulation does not work and the body temperature of a mammal becomes too low.

If the body is unable to thermoregulate, core temperature decreases rapidly.

Explain how **positive feedback** results in a decrease in core body temperature.

(2)

- (c) The hypothalamus plays a role in osmoregulation.

Describe how stimulation of the hypothalamus leads to the production of concentrated urine.

(3)



- 7 A student investigated the effect of the concentration of sodium chloride solution on blood.

The student set up six test tubes, each with a different concentration of sodium chloride solution.

Five drops of blood were added to each test tube.

The appearance of the solutions was then recorded.

Samples of each solution were observed using a light microscope.

The table shows the results of this investigation.

Concentration of sodium chloride (%)	Appearance of solution after blood was added	Observation with light microscope
3.0	very cloudy	cells seen with shrunken edges
1.0	very cloudy	cells seen
0.9	very cloudy	cells seen
0.7	slightly cloudy	cells seen
0.5	cloudy at first, then went clear	no cells seen
0.3	clear	no cells seen

- (a) Analyse the data to comment on the effect of the concentration of sodium chloride solution on blood.

(4)

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- (b) The student then investigated the effect of using glucose solutions and sucrose solutions, instead of sodium chloride solutions.

The appearance of the solutions was recorded and samples were observed using a light microscope.

When the concentration of glucose solution was below 3%, the solution was clear and no blood cells could be seen. When the concentration of glucose solution was above 3%, the solution was cloudy and blood cells could be seen.

When the concentration of sucrose solution was below 6%, the solution was also clear and no blood cells could be seen. When the concentration of sucrose solution was above 6%, the solution was cloudy and blood cells could be seen.

Explain the differences in the effects of the solutions of glucose and sucrose.

(3)

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- (c) (i) State the part of the brain responsible for osmoregulation.

(1)

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- (ii) Explain how, on a very hot day, the brain ensures that the water potential of the blood remains constant.

(4)

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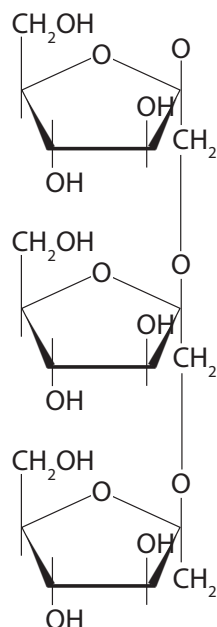
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- 7 Inulin is a polysaccharide made of fructose that is used as a storage molecule by some plant species.

The diagram shows part of a molecule of inulin.



- (a) (i) The inulin molecule in the diagram contains fructose.

Which of these carbohydrates also contain fructose?

(1)

- ☒ **A** lactose, maltose, and sucrose
- ☒ **B** lactose and sucrose
- ☒ **C** maltose and sucrose
- ☒ **D** sucrose

- (ii) Which is the name of the chemical bond that joins the monosaccharides in inulin?

(1)

- ☒ **A** ester
- ☒ **B** glycosidic
- ☒ **C** hydrogen
- ☒ **D** peptide

(iii) Fructose has the same molecular formula as glucose.

Which is the molecular formula of a molecule of inulin consisting of four fructose sugars?

(1)

- ☐ **A** $C_{24}H_{42}O_{21}$
- ☐ **B** $C_{24}H_{44}O_{22}$
- ☐ **C** $C_{24}H_{48}O_{21}$
- ☐ **D** $C_{24}H_{48}O_{24}$

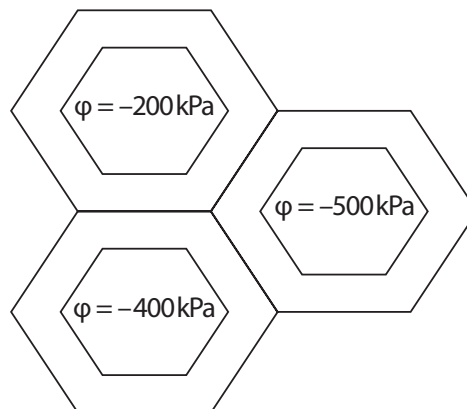
(b) The number of fructose molecules in inulin can vary from 10 to 70.

Inulin with high numbers of fructose molecules is less soluble in water.

(i) The diagram shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1)



(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2)

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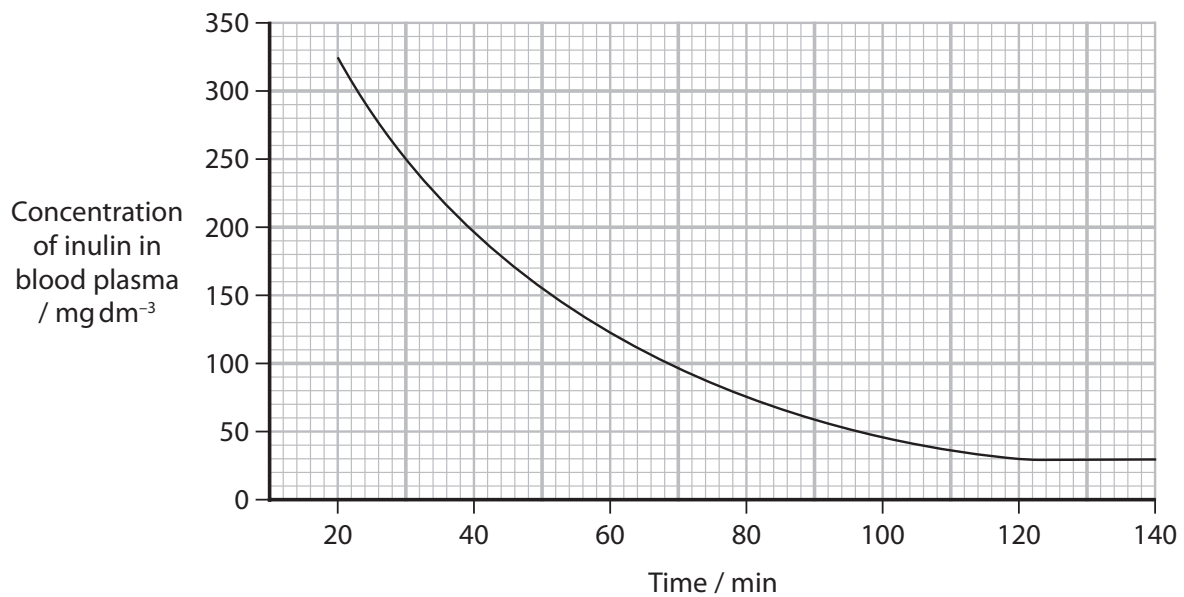
(c) Inulin is used to measure the rate of filtration by the kidneys.

A saline solution containing inulin is injected into the vein of a patient.

The concentration of inulin in the blood plasma is then measured over time.

The rate of filtration is a measure of the maximum rate that inulin is removed from the blood by the kidneys.

The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

Answer

(ii) Explain how inulin passes from the blood plasma into the proximal convoluted tubule of a nephron.

(2)

(iii) Explain why all the inulin is released into the urine.

(2)



7 The photograph shows a wood mouse, *Apodemus sylvaticus*.



(Source: © Eric Isselee/Shutterstock)

A scientist measured the population size of these mice living in a woodland habitat.

The scientist used the capture-mark-recapture method (CMR) to sample the population.

This is the CMR method used by the scientist:

- randomly place mammal traps in the woodland for one day
- put a coloured band on a leg of each captured mouse (S1)
- release these marked mice
- after one week place mammal traps in the woodland again for one day
- count the number of mice captured (S2)
- count the number of mice with leg bands in this second sample (L).

The table shows some of the results.

Number of mice captured	
S1	S2
200	250

- (a) The scientist calculated that the number of mice in the woodland was 1000, using the formula

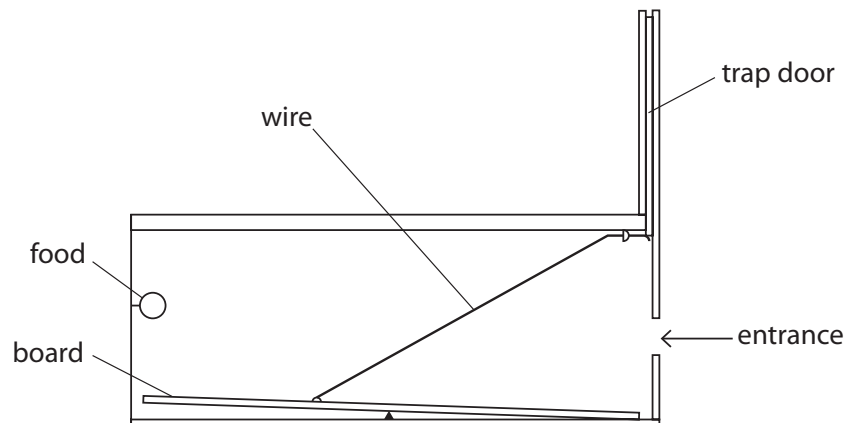
$$\text{number of mice} = \frac{S1 \times S2}{L}$$

Determine the number of mice that had leg bands (L) in the second sample.

(1)

Answer

- (b) The diagram shows a section of the trap used by the scientist.



Explain how the design of the trap is effective for capturing mice.

(3)

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(c) Wood mice are small mammals.

They cannot maintain their body temperature and will die if left in the trap for a long period of time.

Explain why wood mice cannot maintain their body temperature if left in the trap.

(4)

(d) Comment on the claim that the CMR method produces an accurate measure of the population size of mice in the woodland.

(5)

4 Mammals produce urea as a nitrogenous waste product.

(a) Describe how urea is produced in mammals.

(2)

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(b) Bowman's capsule (renal capsule) in the kidney is involved in the excretion of urea in mammals.

Name the cluster of blood capillaries enclosed by Bowman's capsule.

(1)

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(c) The table shows the concentrations of molecules and ions in the blood plasma of the kidney, in the filtrate produced in Bowman's capsule and in the bladder.

Molecule or ion	Blood plasma of kidney (%)	Filtrate produced in Bowman's capsule (%)	Urine in the bladder (%)
Water	90 to 93	94 to 96	96
Protein	7 to 9	0.0	0.0
Glucose	0.10	0.10	0.0
Urea	0.03	0.03	2.0
Sodium	0.32	0.32	0.30 to 0.35
Chloride	0.37	0.37	0.60

(i) Name the process by which this filtrate is produced in Bowman's capsule.

(1)

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- (ii) Analyse the data to explain the difference between the protein and the other molecules or ions in the filtrate in Bowman's capsule.

(3)

- (iii) Urea and chloride ions both become more concentrated as they pass from Bowman's capsule to the urine in the bladder.

Calculate how many more times urea becomes concentrated compared with chloride ions.

(3)

Answer

- (iv) Analyse the data to explain the glucose concentration in the bladder.

(2)



(v) Explain how the loop of Henlé is involved in the production of concentrated urine. (5)



SUB-TOPIC 9(c)

THE NERVOUS SYSTEM, RECEPTORS AND THE BRAIN

20 questions in this sub-topic · 190 marks · lowest tariff first



3 The retina contains rod cells and bipolar neurones.

Rod cells contain large numbers of mitochondria.

(a) Explain the role of mitochondria in the functioning of rod cells.

(2)

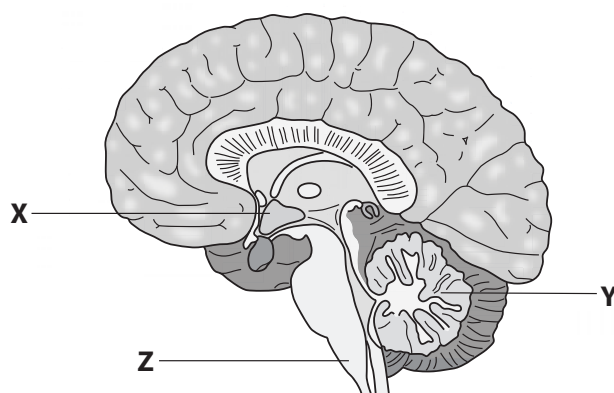
(b) Rod cells release glutamate, an inhibitory neurotransmitter.

Describe how light causes a change in the release of glutamate from rod cells.

(4)

2 The brain is involved in many homeostatic mechanisms.

(a) The diagram shows a vertical section through a human brain.



Which row of the table correctly matches the regions **X**, **Y** and **Z** with their functions?

(1)

	Control of breathing rate	Control of balance	Temperature regulation
☐ A	X	Y	Z
☐ B	Y	Z	X
☐ C	Z	X	Y
☐ D	Z	Y	X

(b) An action potential results from the depolarisation of the membrane of a neurone.

Which row of the table shows the correct state of the ion channels during this depolarisation?

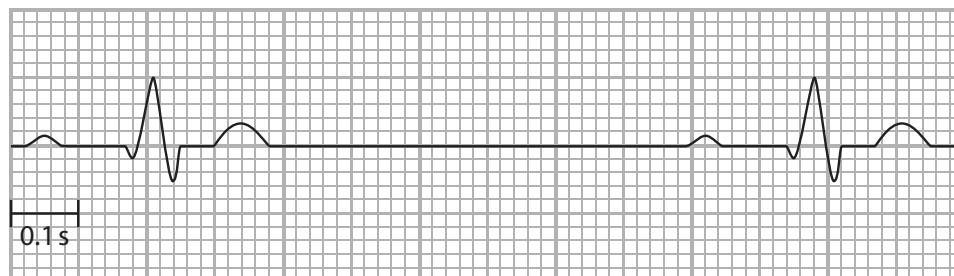
(1)

	Na ⁺ channels	K ⁺ channels
☐ A	closed	closed
☐ B	closed	open
☐ C	open	closed
☐ D	open	open

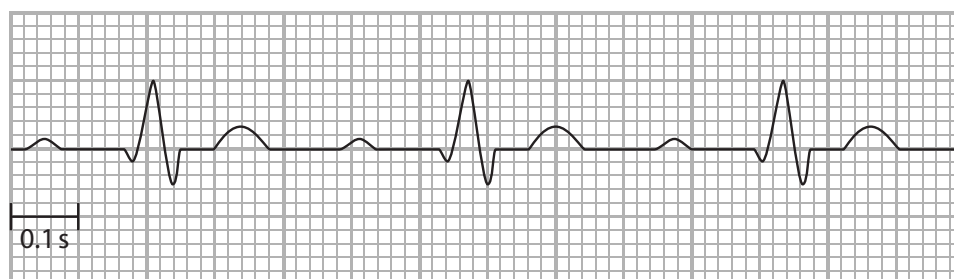
(c) The autonomic nervous system plays a role in regulating heart rate.

The diagram shows an ECG trace from a student before and during exercise.

before exercise



during exercise



(i) Calculate the heart rate of this student during exercise.

(1)

Answer

(ii) Describe how exercise results in an increased heart rate.

(4)

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- 2 (a) Compare and contrast the central nervous system and the peripheral nervous system. (3)

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- (b) During the First World War, some soldiers received head wounds that damaged one side of the cerebellum.

One soldier said

'The movements of my left hand are done subconsciously but I have to think out each movement of my right arm.'

- (i) State one function of the cerebellum.

(1)

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- (ii) State the part of the brain the soldier used to think about moving his right arm.

(1)

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(iii) Explain why this soldier had problems moving his right arm.

(2)



1 Nerve impulses are transmitted along neurones.

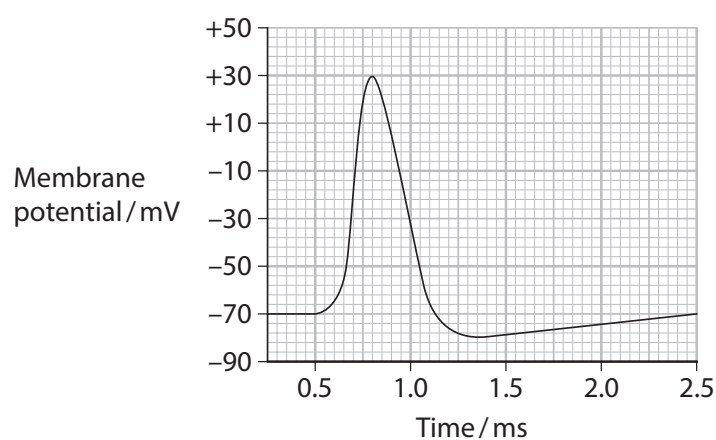
- (a) (i) In the time period between two nerve impulses, the potential difference across the membrane is -70 mV .

State the term given to this potential difference.

(1)

- (ii) When the neurone is stimulated, an action potential may occur in the axon, due to the change in permeability of the membrane to ions.

The graph shows an action potential.



Describe what happens in the axon membrane to cause the change in potential difference between 0.55 ms and 0.80 ms.

(4)

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- (b) Scientists investigated the effect of stimulating an axon with different voltages and measured the response.

The table shows the results of this investigation.

Stimulus voltage / mV	Response
25	No action potential
35	No action potential
45	No action potential
55	Action potential
65	Action potential
75	Action potential

Analyse the data to describe the conclusions which can be drawn.

(2)

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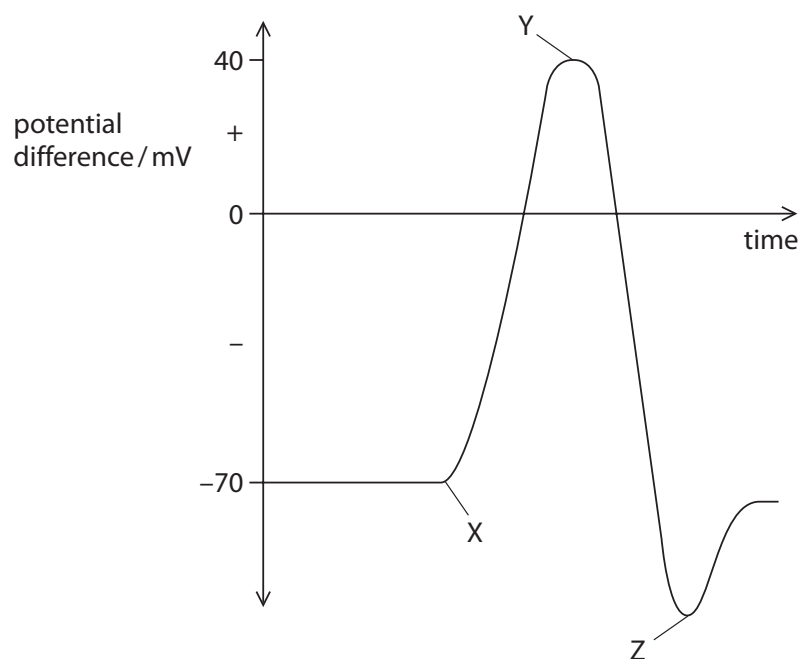
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6 The diagram shows an action potential in a neurone.



(a) (i) Which of the following causes the change in potential between X and Y?

(1)

- ☐ A movement of calcium ions out of the neurone
- ☐ B movement of potassium ions out of the neurone
- ☐ C movement of sodium ions into the neurone
- ☐ D movement of sodium ions out of the neurone

(ii) Explain how membrane proteins cause the change in potential between Y and Z.

(2)

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(b) The photograph shows an African crested rat.



(Source: © https://commons.wikimedia.org/wiki/File:Lophiomys_imhausi.jpg)

This rat has several adaptations to prevent it being eaten by predators.

These adaptations include:

- The rat chews the bark of a tree called the arrow tree. The bark of this tree contains a poison called ouabain.
- The rat rubs the poison onto its fur, which is hollow to absorb the poison.
- The rat produces proteins in its saliva that prevent the ouabain harming it.

(i) Which types of adaptation has the rat evolved?

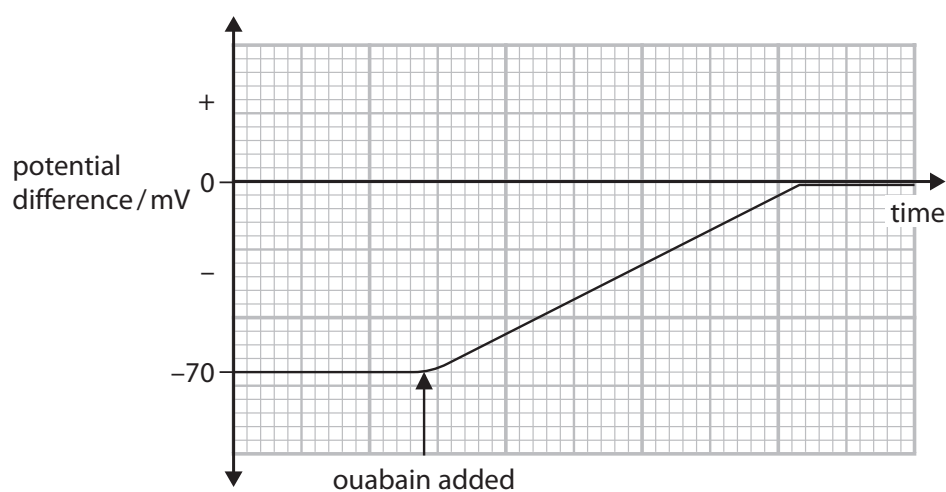
- 1 anatomical
- 2 behavioural
- 3 physiological

- ☐ **A** 1 and 2
- ☐ **B** 1, 2 and 3
- ☐ **C** 1 and 3
- ☐ **D** 2 and 3

(1)

(ii) Ouabain inhibits sodium–potassium exchange pumps.

The diagram shows the effect of ouabain on the potential difference across a motor neurone membrane.



Explain how ouabain prevents the transmission of nerve impulses.

(3)

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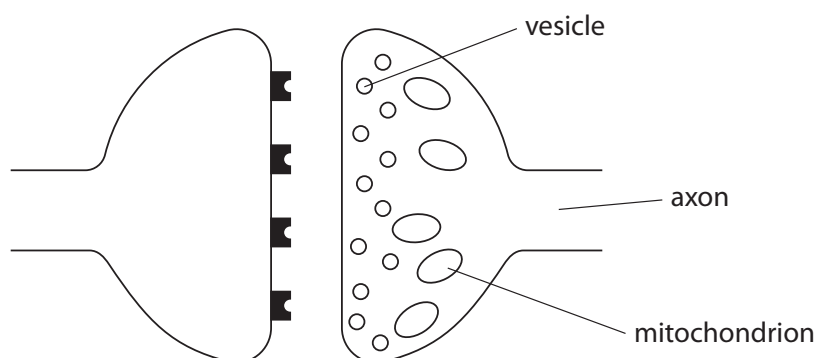
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2 Where two neurones meet they are linked by a synapse.

(a) The diagram shows the structure of a synapse.



(i) Draw an arrow on the diagram to show the direction in which the nerve impulse travels.

(1)

(ii) Describe the role of acetylcholine in synaptic transmission.

(3)

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(iii) State the role of the mitochondria in synaptic transmission.

(1)

(b) Some neurones have a myelin sheath around them.

Explain how the myelin sheath speeds up the transmission of nerve impulses.

(2)

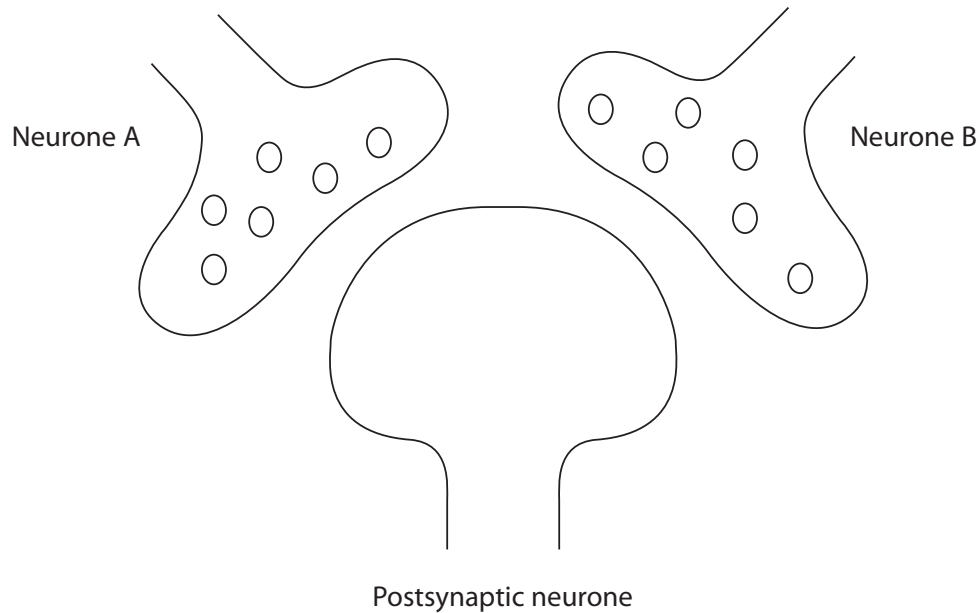


5 The diagram shows the structure of a synaptic junction between three neurones.

Neurone A releases the excitatory neurotransmitter acetylcholine.

Neurone B releases the inhibitory neurotransmitter glutamate.

Glutamate causes chloride ions to move into the postsynaptic neurone.



(a) (i) Describe the sequence of events that leads to an excitatory postsynaptic potential (EPSP) in the postsynaptic neurone after stimulation of neurone A.

(4)

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- (ii) Which of the following rows correctly describes the action of each substance on this postsynaptic neurone?

(1)

	Nicotine	Lidocaine	Cobra venom
☒ A	excitatory	excitatory	excitatory
☒ B	excitatory	inhibitory	inhibitory
☒ C	inhibitory	excitatory	excitatory
☒ D	inhibitory	inhibitory	inhibitory

- (b) A scientist investigated the effect of the intensity of stimulation of neurones A and B on the production of an action potential in the postsynaptic neurone.

High intensity stimulation of neurones A and B causes a high frequency of impulses to arrive at the presynaptic terminals.

The results are shown in the table.

Intensity of stimulation		Production of action potential in postsynaptic neurone
Neurone A	Neurone B	
low	low	no
low	high	no
high	low	yes
high	high	no

Explain the effect of the intensity of stimulation on the production of an action potential in the postsynaptic neurone.

(3)

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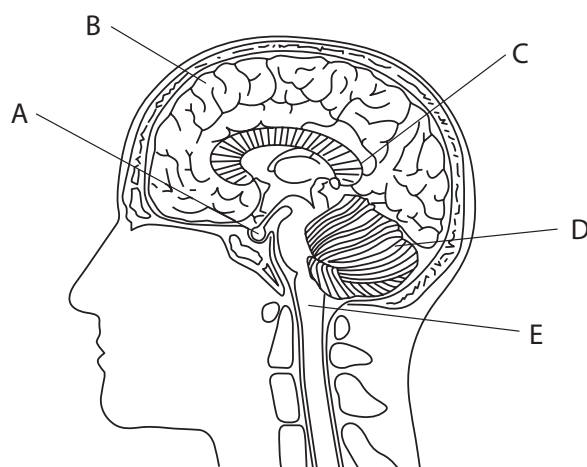
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- 1 The human brain controls many functions.

The diagram shows a section through a human brain with parts labelled A to E.



- (a) Which letter labels the part of the brain that controls heart rate?

(1)

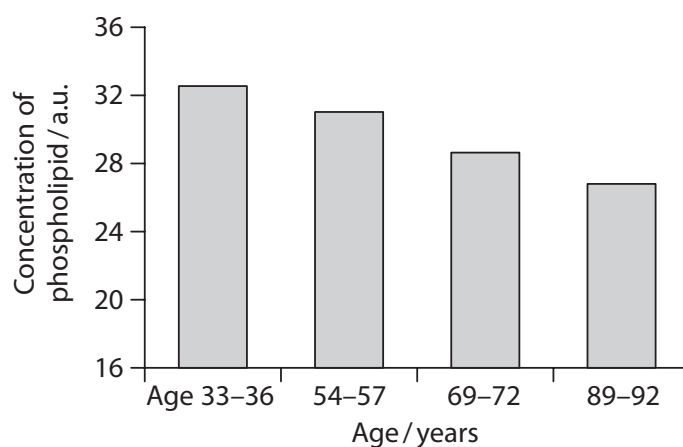
- (b) The human brain consists of 100 billion neurones.

The function of these neurones is affected by many factors.

The concentration of phospholipid in neurones from one part of the brain was measured.

This was carried out in people from different age ranges.

The graph shows the results.



Explain how age might affect the structure of a neurone and the speed of transmission of an impulse.

(3)



(c) Poisons can also affect the function of neurones in the brain.

The photograph shows a pufferfish, a traditional food delicacy in Japan.



Pufferfish have to be carefully prepared by a chef to remove a poison called tetrodotoxin. This poison causes muscle paralysis.

Neurones were placed in a solution containing tetrodotoxin and in a control solution.

The neurones were stimulated and the potential difference across the axon membrane was measured.

The table shows the results.

Solution	Potential difference after stimulation / mV
tetrodotoxin	-70
control	+40

Analyse the data to explain the effect of tetrodotoxin on the neurone.

(4)

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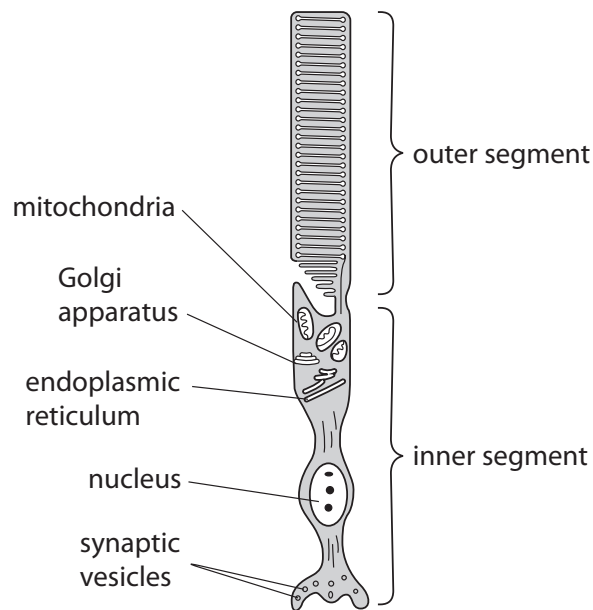
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9 The diagram shows the structure of a rod cell.



(a) (i) How many of the labelled organelles have a double membrane?

(1)

- ☐ **A** 0
- ☐ **B** 1
- ☐ **C** 2
- ☐ **D** 3

(ii) Which of the following statements about the effect of light on rod cells are correct?

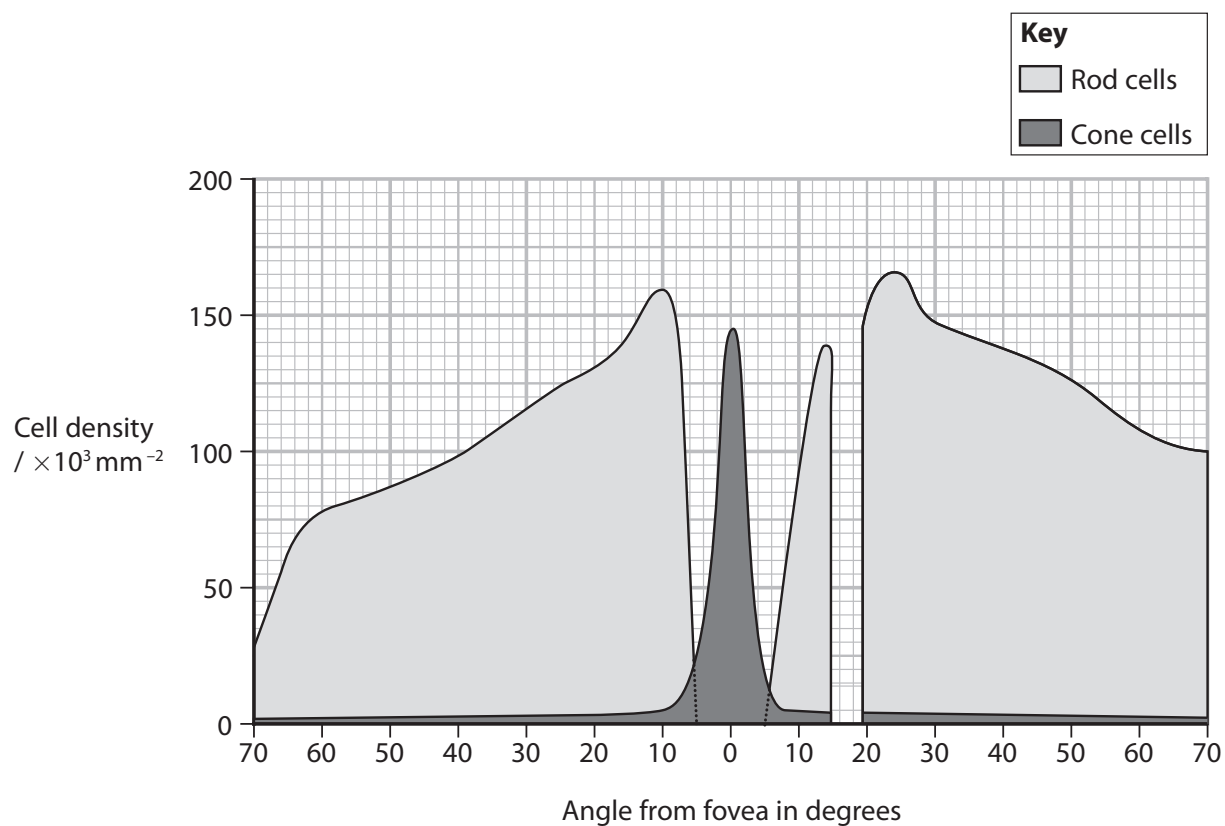
(1)

1. rhodopsin breaks down into opsin and trans-retinal
2. voltage-gated sodium channels open in the membrane
3. more neurotransmitter is released from the presynaptic terminal

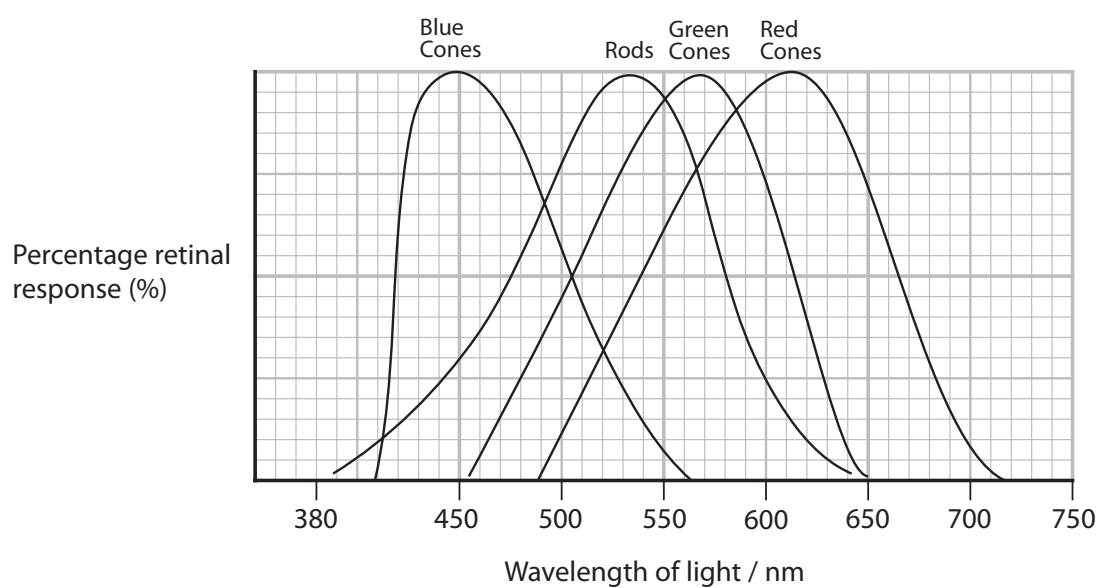
- ☐ **A** 1 only
- ☐ **B** 1 and 2
- ☐ **C** 1 and 3
- ☐ **D** 2 and 3

*(b) Graph 1 shows the distribution of photoreceptors across the retina.

Graph 2 shows the sensitivity of rod cells and cone cells to light of different wavelengths.



Graph 1



Graph 2

Students investigated the ability to detect beams of light of different colours and intensities.

A student covered one eye and a bright red light (wavelength 670 nm) was placed at different angles in the field of vision of the other eye. The student stated if they could detect the red light.

This was repeated with a dim red light.

This was then repeated with a bright green light and a dim green light (wavelength 525 nm).

The table shows the results of this investigation.

Angle from fovea in degrees	Light detected (Yes/No)			
	Bright light Red	Dim light Red	Bright light Green	Dim light Green
60	N	N	Y	Y
30	N	N	Y	Y
15	N	N	Y	Y
10	N	N	Y	Y
5	Y	N	Y	N
0	Y	N	Y	N
5	Y	N	Y	N
10	N	N	Y	Y
15	N	N	N	N
30	N	N	Y	Y
60	N	N	Y	Y

Analyse the data to explain the results of this investigation.

(6)

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2 Acetylcholine is a neurotransmitter produced by the parasympathetic nervous system.

(a) Describe the process by which acetylcholine is released from a synapse.

(4)

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(b) Some chemical pesticides, such as diisopropyl fluorophosphate (DFP), affect the activity of synapses.

This pesticide acts by binding irreversibly to the R group of an amino acid in the active site of acetylcholinesterase.

(i) Explain why DFP inhibits the activity of acetylcholinesterase.

(2)

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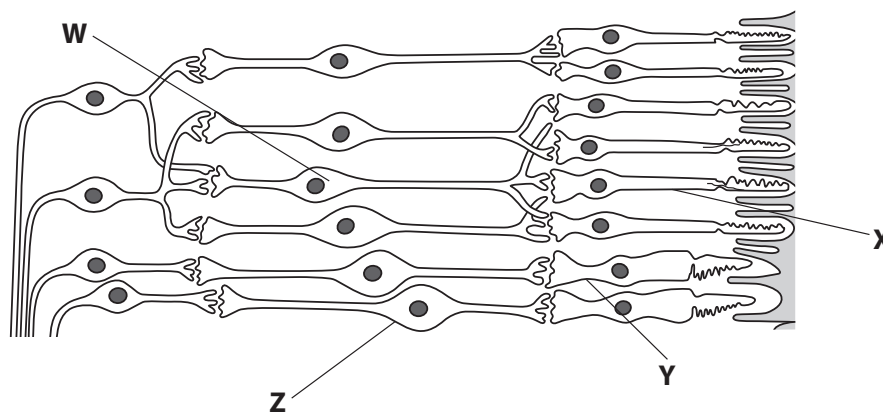
(ii) Explain why a person poisoned with DFP has a slower heart rate.

(3)



4 The retina is the light sensitive structure in the eye.

(a) The diagram shows some of the cells in a human retina.



(i) Which row in the table correctly identifies the cells **W**, **X** and **Y**?

(1)

	Cell W	Cell X	Cell Y
☐ A	bipolar cell	cone cell	rod cell
☐ B	bipolar cell	rod cell	cone cell
☐ C	ganglion cell	cone cell	rod cell
☐ D	ganglion cell	rod cell	cone cell

(ii) Draw an arrow on the diagram to show the direction of the light passing through the retina.

(1)

(iii) Explain why a higher light intensity is required to produce an action potential in cell **Z** than in cell **W**.

(3)

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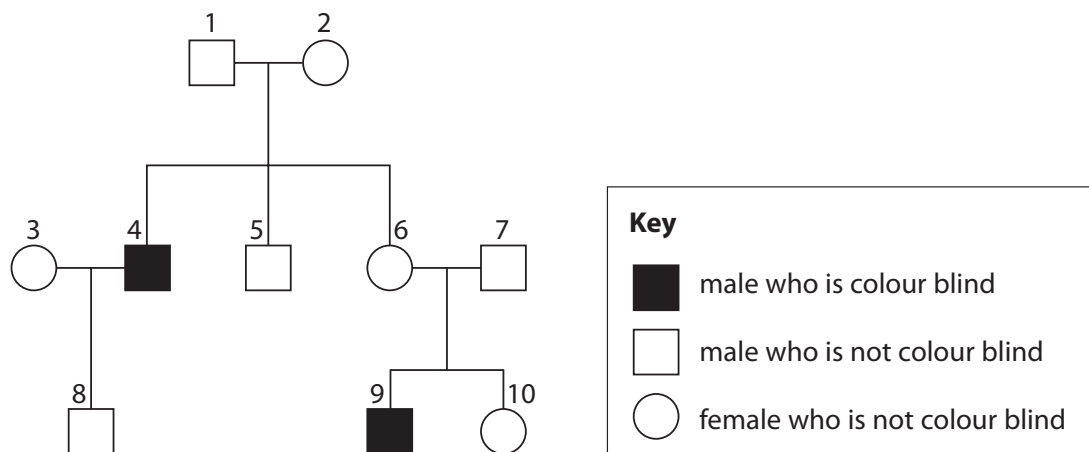
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- (b) Red-green colour vision is controlled by a single gene located on the X chromosome. Colour blindness is caused by a recessive allele for the red-green colour vision gene. The diagram shows the inheritance pattern of colour blindness for a family.



- (i) Explain how the diagram shows that red-green colour blindness is caused by a recessive allele.

(2)

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- (ii) Use a genetic diagram to determine the probability that the next child of individuals 6 and 7 is a male who is colour blind.

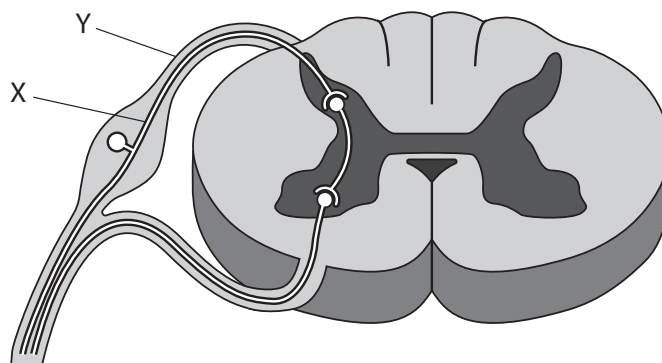
(3)

Answer

(Total for Question 4 = 10 marks)



- 2 (a) (i) The diagram shows a section through the spinal cord.



Which row correctly names the structures labelled X and Y?

(1)

	X	Y
☐ A	motor neurone	dorsal root
☐ B	motor neurone	ventral root
☐ C	sensory neurone	dorsal root
☐ D	sensory neurone	ventral root

- (ii) Which region of the brain only controls breathing and heart rate?

(1)

- ☐ A cerebellum
- ☐ B cerebrum
- ☐ C hypothalamus
- ☐ D medulla oblongata

- (b) Explain how the resting potential is maintained in a neurone.

(4)

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(c) The photograph shows a blue-ringed octopus.

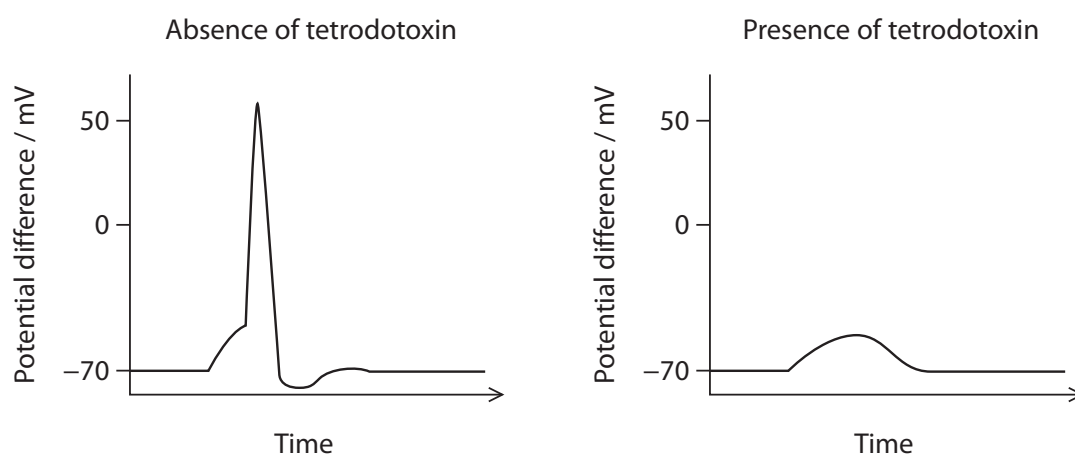


This octopus produces tetrodotoxin that it uses to paralyse its prey.

The effects of tetrodotoxin on a neurone were investigated.

A neurone was stimulated in the absence of and in the presence of tetrodotoxin.

The graphs show the results of this investigation.



Comment on how tetrodotoxin affects the potential difference of a neurone when the prey of the octopus is paralysed.

(4)

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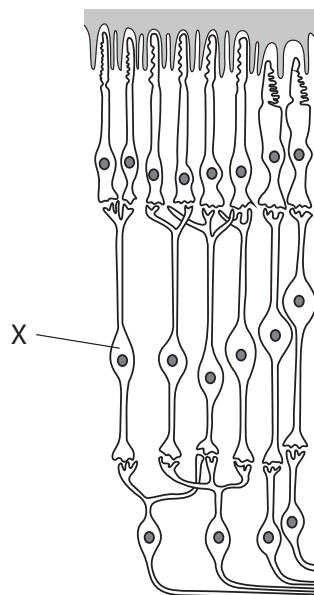
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5 The diagram shows a section of a human retina.



(a) Which of the following is the name of the cell labelled X?

(1)

- ☐ A bipolar neurone
- ☐ B ganglion neurone
- ☐ C motor neurone
- ☐ D optic neurone

(b) Explain the role of rhodopsin in the generation of a nerve impulse in cell X when light falls on the retina.

(3)

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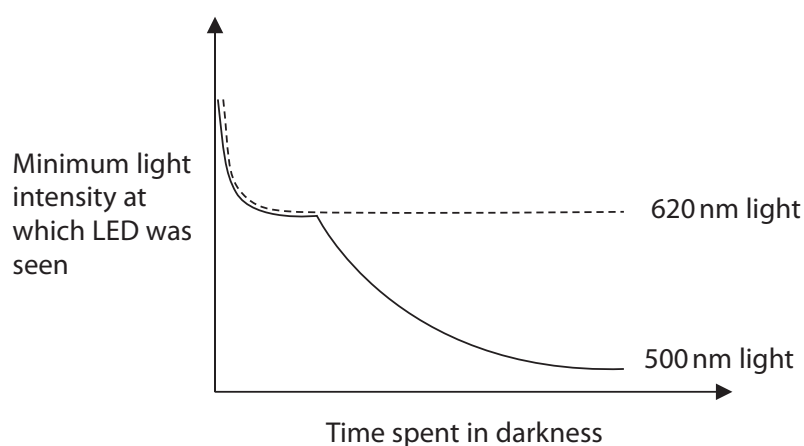
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*(c) A scientist investigated the effect of how the length of time a volunteer spent in darkness affected the sensitivity of their retina to light.

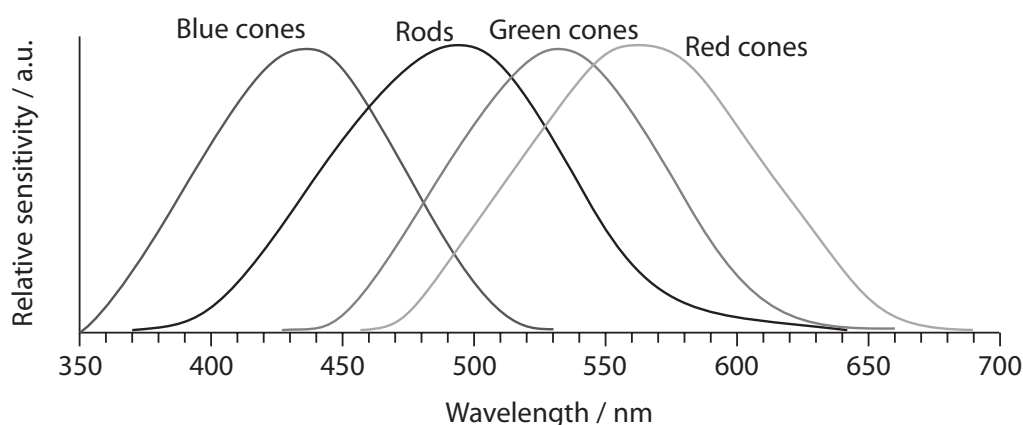
This is the method used:

- the volunteer sat in a room illuminated with white light for twenty minutes
- the lights were switched off and the room was placed into total darkness for one minute
- an LED emitting light of wavelength 500 nm at low light intensity was switched on
- the light intensity was gradually increased until the volunteer was able to see the LED and this minimum light intensity was recorded
- this was repeated with increasing lengths of time that the volunteer was kept in total darkness
- the investigation was then repeated with an LED that emitted red light with a wavelength of 620 nm.

The graph shows the results of this investigation.



The graph shows the relative sensitivity of rods and three types of cone to light of different wavelengths.

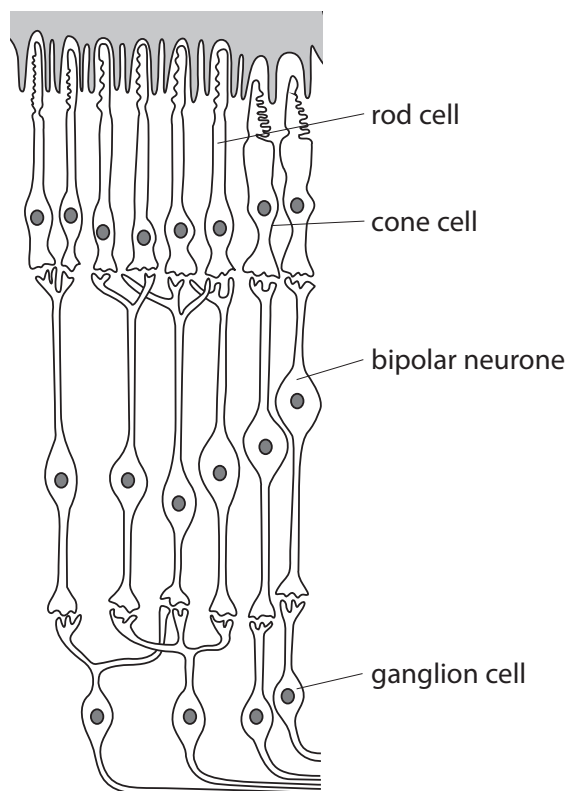


Analyse the graphs to explain the results of this investigation.

(6)



- 9 The diagram shows a section through the central area of a human retina.



- (a) (i) Draw an arrow on the left of the diagram to show the direction that light travels through the retina.
- (ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(1)

(3)

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*(b) A student investigated the retinal structures of different mammals.

The student collected information about:

- the structure of the retina of the cat (a predator that hunts at night)
- the distribution of rods and cones in the retina of humans and cats
- the total number of rods and cones in the retinas of species active in the day and species active at night.

The diagram shows part of the retina of a cat.

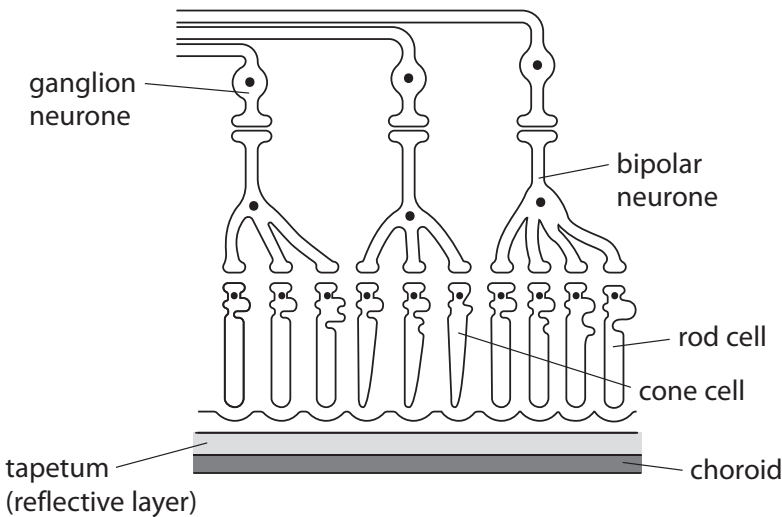


Table 1 and Table 2 show some of the data collected by the student.

Table 1

Distribution of rods and cones	Density of cells in retina / cells per mm ²	
	human	cat
Highest cone density	199 000	27 000
Highest rod density	160 000	460 000
Cone density around edge of retina	5 000	<3 000
Rod density around edge of retina	40 000	250 000

Table 2

Species	When active	Total number of cells $\times 10^6$	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

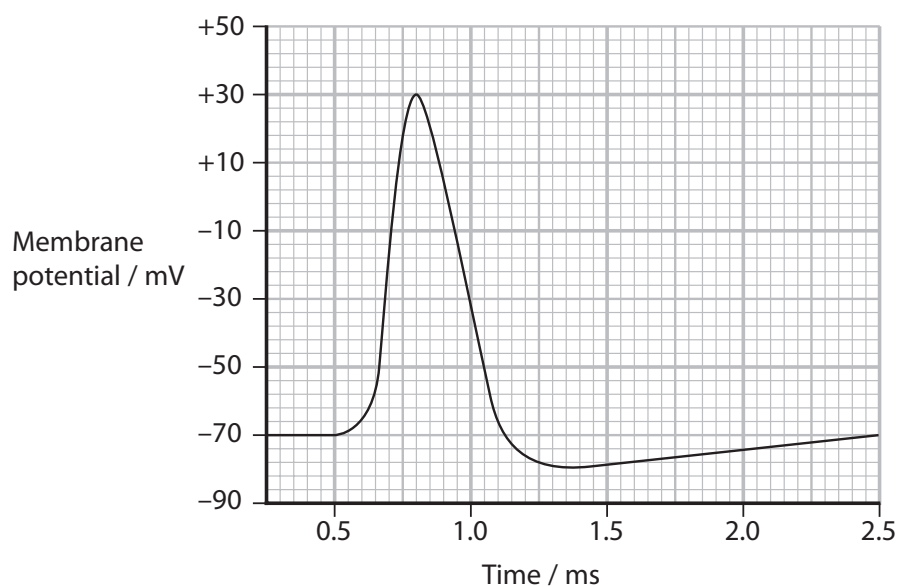
Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)



- 6 The speed of a nerve impulse along a neurone depends on the diameter and the presence or absence of myelin.

(a) The graph shows an action potential in a neurone.

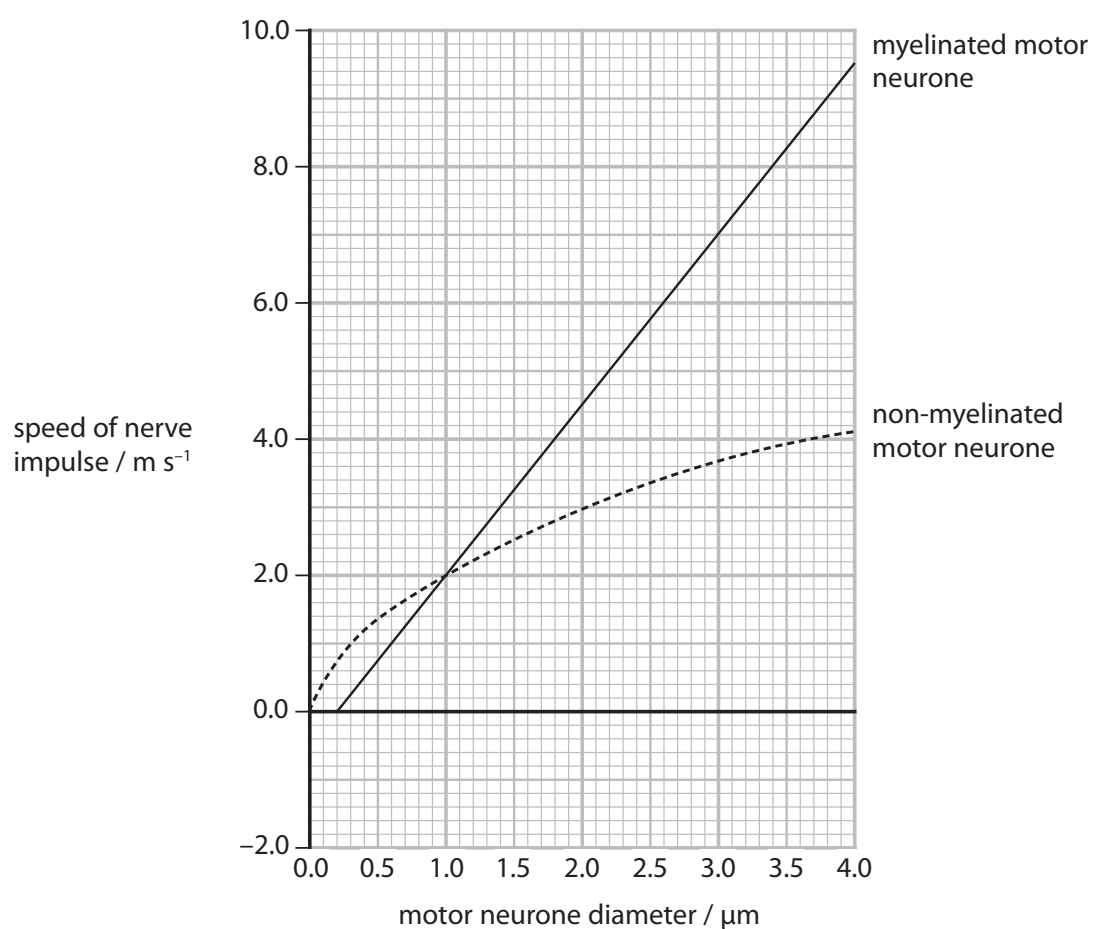


When are voltage-gated sodium channels open?

(1)

- ☐ A 0.25 ms
- ☐ B 0.75 ms
- ☐ C 1.00 ms
- ☐ D 1.25 ms

- (b) The graph shows the relationship between the diameter of the neurone and the speed of nerve impulses along myelinated and non-myelinated motor neurones.



- (i) Compare and contrast the effect of diameter on the speed of an impulse in myelinated and non-myelinated motor neurones.

(4)

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- (ii) Determine the speed of a nerve impulse along a myelinated motor neurone with a diameter of $5\text{ }\mu\text{m}$.

The equation for a linear relationship is $y = mx + c$

(3)

Answer



(iii) Multiple sclerosis (MS) is a disease that results in the loss of myelin around motor neurones.

Explain why the speed of nerve impulses along axons is slower in people with MS. (3)



5 The human retina contains photoreceptors called rod cells and cone cells.

(a) (i) Which of the following occur in the rod cell when it is stimulated by light?

(1)

- 1 rhodopsin breaks down into retinal and opsin
- 2 there is a decrease in the release of neurotransmitter molecules
- 3 there is more diffusion of sodium ions into the rod cell

- ☐ **A** 1 and 2
- ☐ **B** 1 and 3
- ☐ **C** 1, 2 and 3
- ☐ **D** 2 and 3

(ii) Explain why the centre of the retina is less sensitive to low intensity light than the outer areas.

(2)

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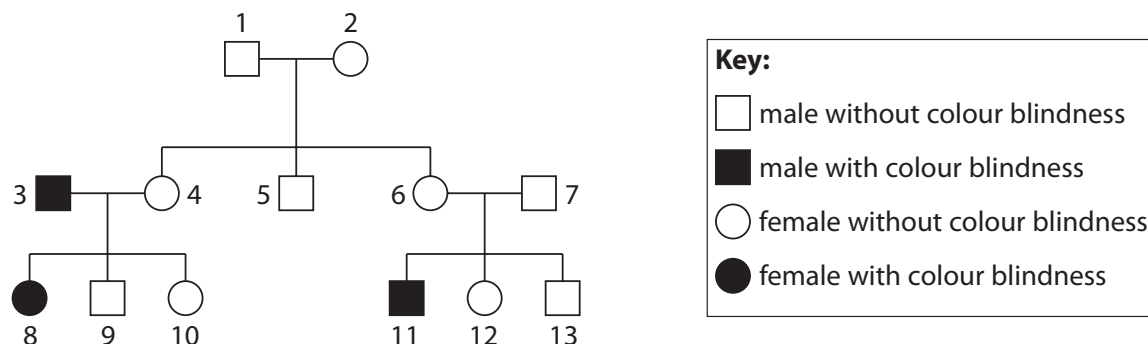
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- (b) Red-green colour blindness is a sex-linked genetic condition. People with this condition are unable to detect differences between red and green colours.

The pedigree diagram shows the inheritance of red-green colour blindness in a family.

The allele for red-green colour blindness, X^r , is recessive to the allele for colour vision, X^R .



- (i) How many of the individuals in the family must have a genotype of $X^R X^r$?

(1)

- ☐ A 2
- ☐ B 3
- ☐ C 4
- ☐ D 5

- (ii) Explain how this pedigree diagram demonstrates that red-green colour blindness is caused by a recessive allele.

(2)

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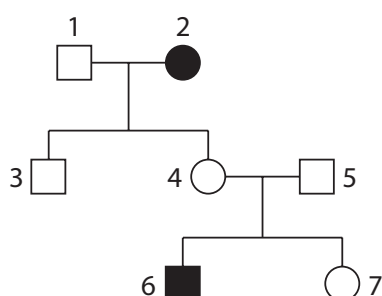
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(c) Pingelap is an isolated island in the Pacific Ocean.

On Pingelap, between 4% and 10% of the population has a condition called achromatopsia. This means that they are unable to see any colour.

In most other countries, the incidence of achromatopsia is around 0.003%.

(i) The pedigree diagram shows the people who are and are not affected with achromatopsia in a family.



Key:

- ☐ male without achromatopsia
- ☒ male with achromatopsia
- ☐ female without achromatopsia
- ☒ female with achromatopsia

Deduce how achromatopsia is inherited.

Use the information in the pedigree diagram to support your answer.

(3)

(ii) In 1755, a tsunami reduced the population to 20 people and there has been little immigration to the island.

In 2022, the human population of Pingelap was approximately 250.

Explain why the incidence of achromatopsia is higher in Pingelap than in other countries.

(2)

- 8 (a) Explain why a double circulatory system enables mammals to have a high metabolic rate.

(2)

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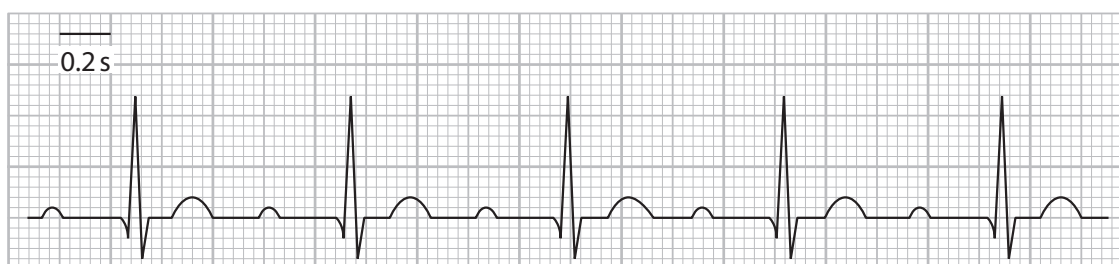
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- (b) Abnormal heart rhythms can be identified in ECG traces.

The diagram shows ECG traces of a person with a regular, healthy heart rhythm and a person with an abnormal heart rhythm.



Person with regular heart rhythm



Person with abnormal heart rhythm

- (i) Calculate the heart rate, in beats per minute, of the person with an abnormal heart rate.

Give your answer to the nearest whole number.

(2)

Answer beats per minute

- (ii) Explain how the ECG traces show this abnormal heart rhythm is due to damage to the septum in the centre of the heart between the left and right sides.

(2)

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- (iii) Bradycardia is a heart condition that results in a heart rate that is slower than normal.

Atropine is a drug that can be used to treat some forms of bradycardia.

Atropine is a competitive inhibitor of acetylcholine.

Explain why atropine will lead to an increase in heart rate.

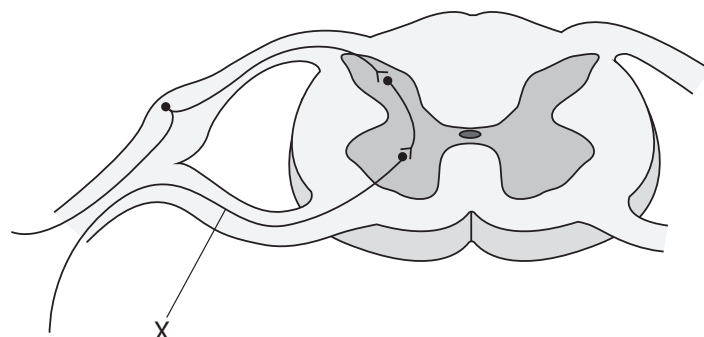
(3)

- (iv) Describe how exercise leads to the stimulation of the cardiac centre in the medulla oblongata.

(4)

8 Animals use nervous systems to coordinate their behaviour.

(a) The diagram shows a cross section of a spinal cord.



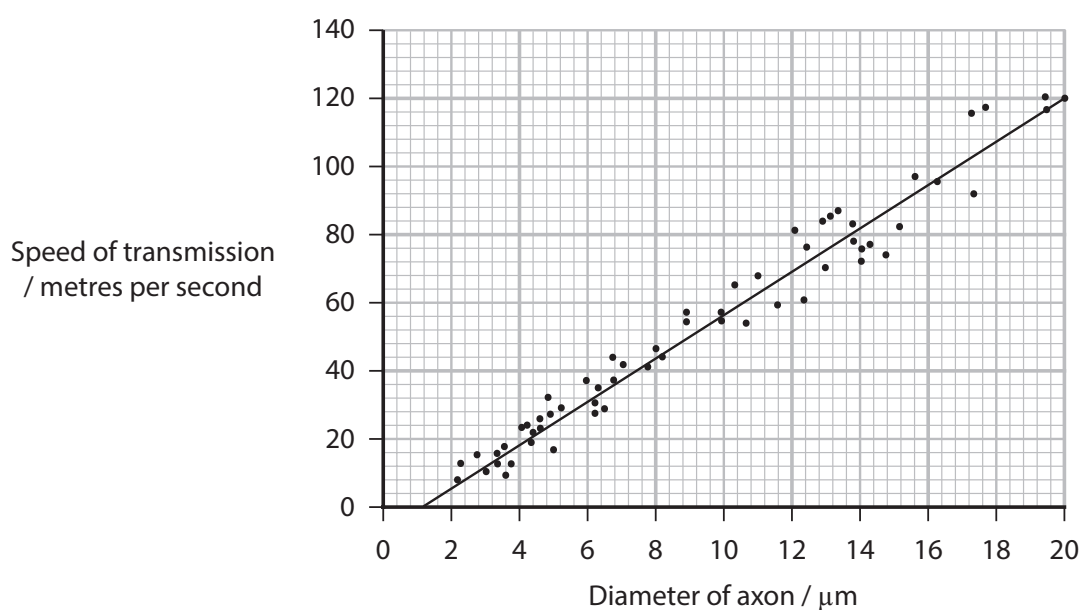
Which of the following are the name and location of the neurone labelled X?

(1)

- ☐ A motor neurone in the dorsal root
- ☐ B motor neurone in the ventral root
- ☐ C sensory neurone in the dorsal root
- ☐ D sensory neurone in the ventral root

(b) Most vertebrate neurones are myelinated.

The graph shows the relationship between the speed of transmission of a nerve impulse and the diameter of myelinated axons.



- (i) Calculate the distance that an action potential would move in 400 milliseconds along a myelinated axon with a diameter of $12\text{ }\mu\text{m}$.

Give your answer in metres.

(2)

Answer m

- (ii) Some varieties of dog can have delaminating disease when the myelin sheath of neurones is lost.

Explain why dogs with delaminating disease respond more slowly to stimuli.

(2)

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(c) The photograph shows a type of animal called a cone snail.



(Source: © Colin Marshall / Alamy Stock Photo)

Many species of cone snail produce toxins that paralyse their prey.

(i) These toxins are protein molecules held together by disulfide bonds.

Which other types of bond hold together the tertiary structure of a protein?

(1)

- ☐ **A** hydrogen bonds only
- ☐ **B** ionic bonds only
- ☐ **C** hydrogen bonds and ionic bonds only
- ☐ **D** peptide bonds only

(ii) Describe how the arrival of an action potential at a presynaptic neurone leads to the generation of an inhibitory postsynaptic potential (ipsp) in the postsynaptic neurone.

(4)

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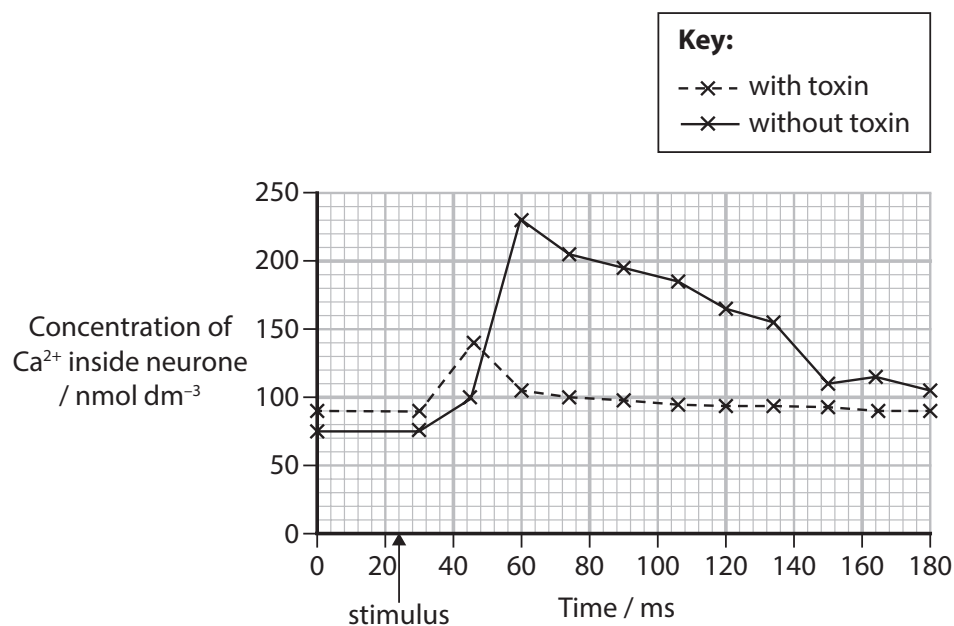
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- (iii) The graph shows the changes in concentration of calcium ions inside the **presynaptic terminal** of a neurone after stimulation with toxin and without toxin.



Analyse the data to explain why this toxin causes paralysis of prey animals.

(3)

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10 When a mouse is put in a new environment, it will move around to find a safe place to live.

This is called exploratory behaviour.

A student investigated exploratory behaviour by putting a mouse into a large box.

The bottom of the box was marked into squares. There were four corner squares (C), two middle squares (M) and six side squares (S).

The marked bottom of the box is shown in the diagram.

C	S	S	C
S	M	M	S
C	S	S	C

The mouse moved about on the bottom of the box. The square occupied by the mouse was recorded every 10 seconds for 10 minutes.

The table shows the results of this investigation.

Total number of times square occupied by the mouse		
Corner square	Middle square	Side square
42	6	12

The student tested the null hypothesis that mice show no significant preference for corner, middle or side squares.

(a) (i) Calculate the Chi squared value using the formula shown.

(2)

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Answer

(ii) The table shows some critical values of Chi squared at different degrees of freedom.

Degrees of freedom	<i>p</i> value				
	0.900	0.500	0.100	0.050	0.010
1	0.016	0.455	2.706	3.841	6.635
2	0.211	1.386	4.605	5.991	9.210
3	0.584	2.366	6.251	7.815	11.345
4	1.064	3.357	7.779	9.488	13.277

Use your calculated Chi squared value and this table to comment on the conclusion the student should make about the null hypothesis.

(4)

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(b) The method used by the student had limitations.

Justify how the student could modify the investigation to address these limitations.

(3)

(c) The mouse uses its eyes when exploring in the box.

Describe the role of rod cells in initiating action potentials to the brain of the mouse.

(5)



6 Acetylcholine is a neurotransmitter released by neurones in the autonomic nervous system.

(a) (i) Which of the following substances bind to acetylcholine receptors?

(1)

1. cobra venom
2. nicotine
3. lidocaine

- ☐ **A** 1 and 2
- ☐ **B** 1 and 3
- ☐ **C** 1, 2 and 3
- ☐ **D** 2 and 3

(ii) Which row is correct for acetylcholine?

(1)

	Type of neurone that releases acetylcholine	Effect of acetylcholine
☐ A	parasympathetic neurone	increases heart rate
☐ B	parasympathetic neurone	decreases heart rate
☐ C	sympathetic neurone	increases heart rate
☐ D	sympathetic neurone	decreases heart rate

(iii) Describe the events that lead to the release of acetylcholine at a synapse.

(3)

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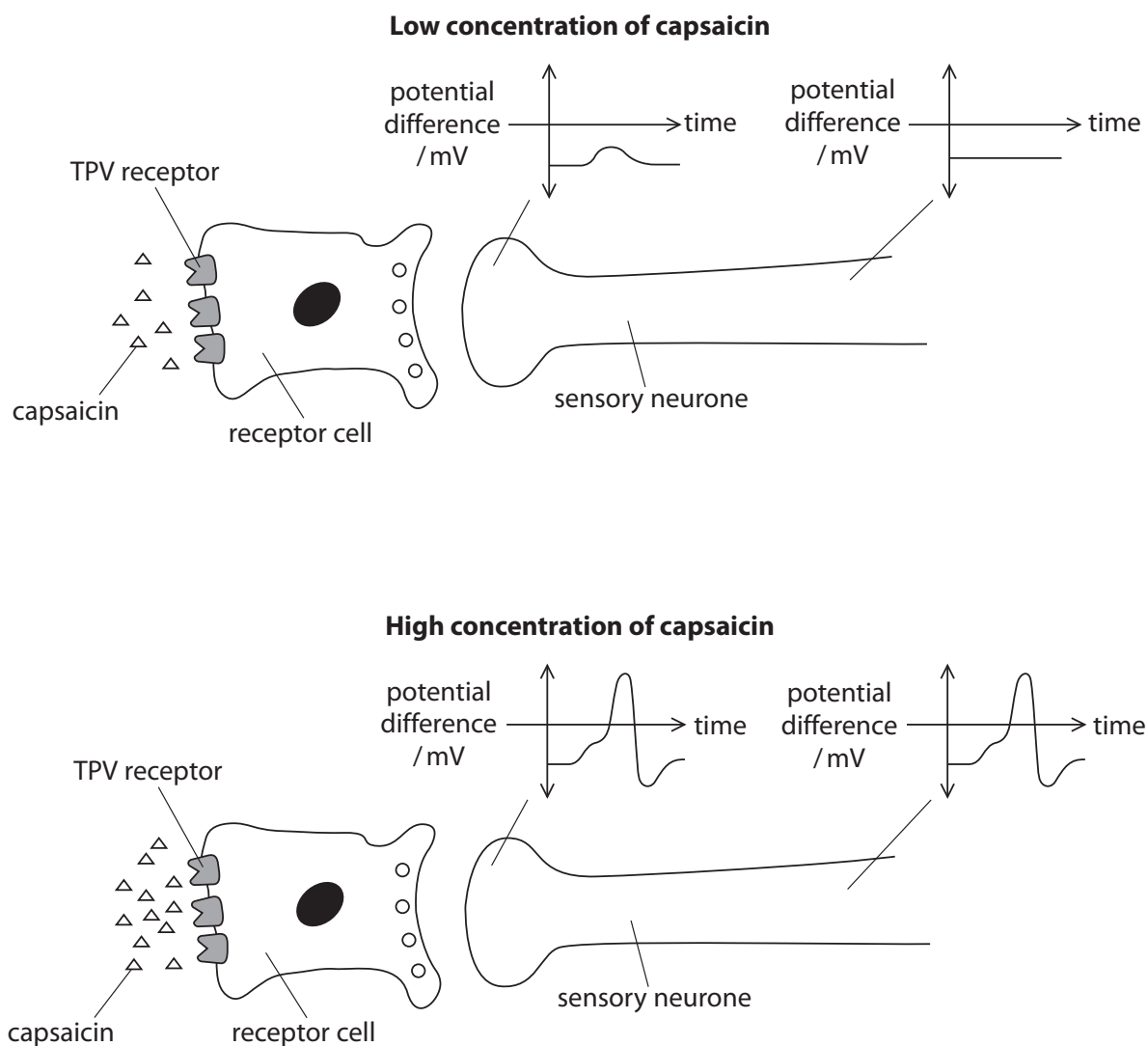
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(b) Capsaicin is a substance found in chilli plants that makes them taste 'hot.'

Capsaicin binds to temperature receptor proteins called TPV receptors. This stimulates impulses along sensory neurones that send impulses to the brain.

The effect of capsaicin on the depolarisation of the membrane of a sensory neurone was investigated. The potential difference across the membrane was measured at two places on the sensory neurone after adding capsaicin.

The results for a high concentration and a low concentration of capsaicin are shown in the diagram.



(i) Explain the effect of capsaicin on the depolarisation of the sensory neurone.

(3)



- *(ii) Capsaicin affects sweat production. It has been suggested that capsaicin could be used to lower the temperature of people with fevers.

The effect of three different doses of capsaicin on sweat production was investigated.

Five students took one 10 mg tablet of capsaicin each day, for one week.

The mass of sweat produced from a 10 cm² area of skin was measured one hour after taking each tablet of capsaicin.

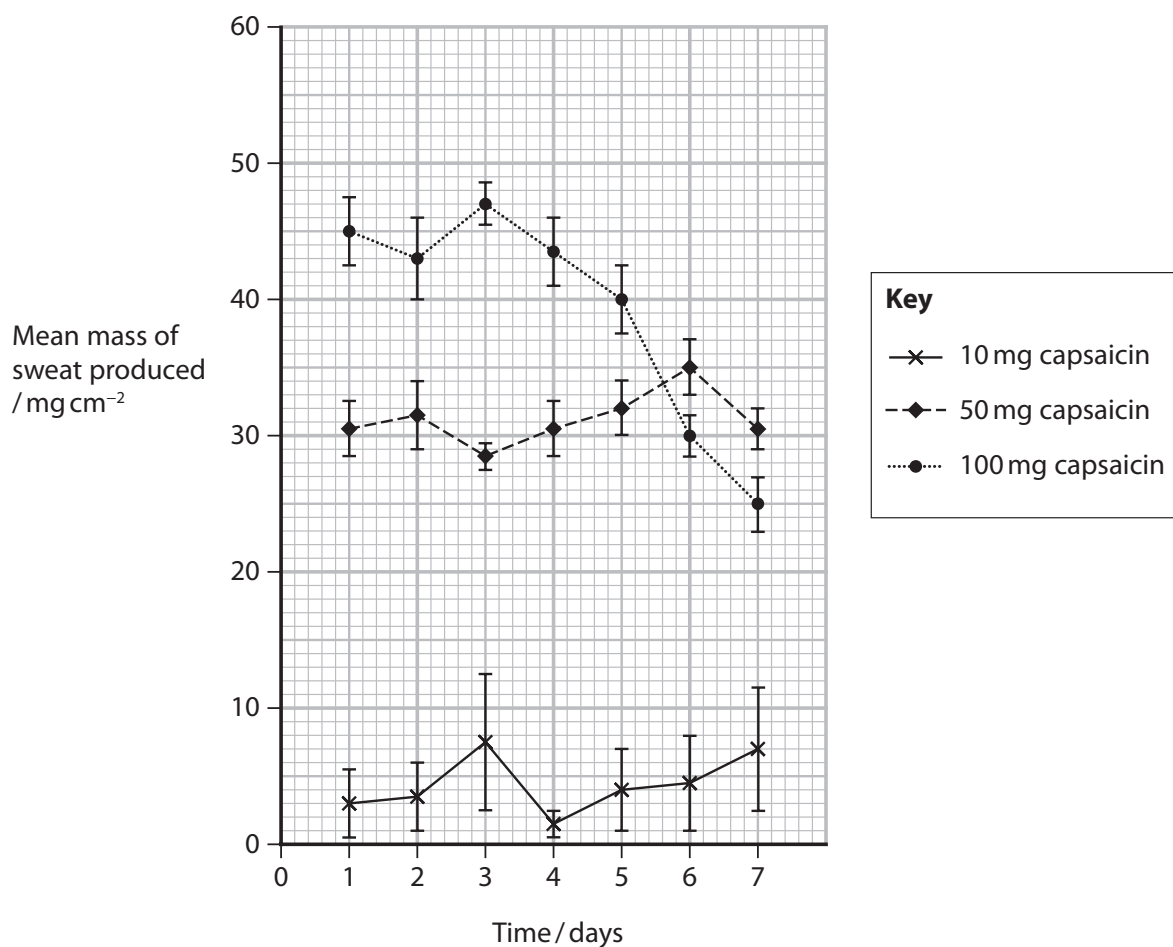
The mean mass of sweat per square centimetre of skin for the group of students was calculated for each day.

This was repeated with different groups of students taking 50 mg of capsaicin and taking 100 mg of capsaicin.

Most of the students who were given 100 mg of capsaicin reported a burning sensation and redness of the skin.

The results are shown in the graph.

Error bars represent standard deviations.



Analyse the data to discuss the use of capsaicin to lower the temperature of people with fevers.

(6)



MARK SCHEMES

official Pearson Edexcel mark schemes



Additional Guidance	Mark
auxin is higher than lateral shoot growth stops gibberellin is higher than lateral shoot growth occurs	(3)

Additional Guidance	Mark
connected to each other ribosomes are not branched ribosomes do not contain ribosomes do not contain hydrogen bonds	(3)

Additional Guidance	Mark
1 and statement 2) does not prevent the ribosome is also found in the ribosome does not	(3)

Question Number	Answer	Mark
5 (a)	The only correct answer is A <i>B is incorrect as auxin does not stimulate flowering</i> <i>C is incorrect as auxin does not stimulate flowering</i> <i>D is incorrect as auxin does not stimulate flowering</i>	1



Question Number	Answer	Additional guidance	Mark
5(b)(i)	Calculation of percentage difference (1)	Example of calculation $1.3 - 0.7 / 0.7 = \mathbf{86}$ Allow 86, 87, 88	1

Question Number	Answer	Additional guidance	Mark
5(b)(ii)	An answer that makes reference to four of the following: 1. increasing auxin concentration causes an {increase then decrease of root length / increase then decrease of biomass} (1) 2. (positive) correlation between root growth and biomass (1) 3. as (longer roots can) obtain more {minerals / water} / root length limits {mineral / water} uptake (1) 4. nitrates for {amino acid synthesis / protein synthesis / nucleic acids / chlorophyll} / calcium for {calcium pectate / cell wall synthesis} / phosphate for {DNA / RNA / phospholipids / membranes} / magnesium for {for chlorophyll} (1) 5. correct reference to overlap of (error) bars (1)	Allow {longest root / highest biomass / optimal concentration} in the range of 10^{-4} and 10^{-1} Allow any number in this range Allow correct examples of minerals Allow shorter roots take up fewer minerals / water Allow other correct functions for named minerals e.g. may be no difference in root growth if bars overlap / difference if no overlap	4

(Total for Question 5 = 6 marks)

Indicative content	
in both plants	ing to candidates' deployment of knowledge and understanding of the material in relation to in the generic mark scheme.
out with limited interpretation or analysis of the scientific information with a scientific information.	not prescriptive and candidates are not required to include all the material which is content included in the response must be scientific and relevant.
information with some attempt made to link knowledge and	period of light / short period of dark hort period of light / long period of dark plant / Sedum is a long day plant means Sedum flowers / Kalanchoe does not flower dark period means Sedum does not flower / Kalanchoe flowers
casual evidence of analysis, interpretation and/or evaluation of both pieces and lines of scientific reasoning with some structure.	between P_R and P_{FR}
ported throughout by sustained application of relevant evidence of analysis both pieces of scientific information.	rapidly ng dark period converts P_R to P_{FR} (low) P_R to flower / Kalanchoe needs (high) P_R / (low) P_{FR} to flower
oped and sustained line of scientific reasoning which is clear and logically	should flower ould not flower but does because Kalanchoe produces florigen / growth factor / diffusible is transported between the two plants

Number	Answer	Additional Guidance	Mark
2 (a)(i)	The only correct answer is: C low auxin, high cytokinin <i>A is incorrect as high auxin inhibits lateral shoots</i> <i>B is incorrect as high auxin inhibits lateral shoots</i> <i>D is incorrect as low cytokinin inhibits lateral shoots</i>		(1)

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An explanation that makes reference to three of the following points: - auxin binds with {receptor / transcription factor} (inside cell / in cytoplasm / in nucleus) (1) - transcription factor becomes active / is activated (1) - transcription factor binds to {DNA / promoter} (1) - switches on / causes {transcription / production of RNA} (1)	Accept forms auxin-receptor complex Accept forms hormone-receptor complex Do not accept if receptor on cell membrane Accept transcription factor changes shape Accept auxin-receptor complex becomes a transcription factor Accept auxin-receptor complex binds to DNA / promoter (1)	(3)

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to four of the following points: more seeds germinate when last colour is red (1) - number of exposures to light makes no difference (1) - significant difference when last colours are different as standard deviations do not overlap (1) - red light converts P_R into P_{FR} / far red light converts P_{FR} into P_R (1) {P_{FR} stimulates/ P_R inhibits} {germination / gibberellin release / activation of amylase / abscisic acid}	Allow converse for FR light Accept no significant difference when last colours are same as standard deviations overlap (1) Accept P725 or P730 for P_{FR} / P665 or P660 for P_R Accept high P_{FR} : low P_R ratio stimulates germination	(4)

Question Number	Answer	Additional Guidance	Mark
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Number	Answer	Additional Guidance	Mark
4(a)(i)	A description that includes the following - dilution by {1 in 1000 / 1 : 999} (1) - dilution in ratio of {3 in 10 / 3 : 7} (1)	Answer must be volumes not mass Accept other suitable dilutions. eg 1 cm³ of stock plus 999 cm³ water eg 300 cm³ stock plus 700 cm³ water correct volumes given in one step gain 2 marks eg 0.3 cm³ stock + 999.7 cm³ water 3 cm³ stock + 9997 cm³ water etc Correct answer with no working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An answer that includes one from step 2 and one from step 3: Step 2 - embryo {produces / releases / contains} gibberellin (1) - endosperm {half / part} produces the amylase (1) Step 3 {kill {bacteria / fungi / microbes} / sterilise the grain} (1) {bacteria / fungi / microbes} may produce amylase (1)	Accept if embryo discarded, there is no gibberellin to affect results Ignore {bacteria / fungi / microbes} stop growing	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	A description that includes one abiotic and one biotic factor: Abiotic - control pH by adding buffer (to agar) (1) Biotic - control {mass / length / surface area} of grains, with suitable method of measurement described (1)	Accept control temperature by using an incubator Accept control {age / species / variety / type} with suitable method described eg collect from same {parent / packet / named species} Accept use of aseptic technique to prevent {contamination / growth of microbes}	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	A description that includes three of the following: - rinse grains in water after soaking in hypochlorite (1) - use more than one grain for each concentration (1) - example of aseptic technique (1) - measure diameter of clear zone several times (1) - use a control with 0% gibberellin (1)	Accept repeat {the experiment / at each concentration} Accept measure area as clear zone may not be circular	(3)

(Total for Question 4 = 9 marks)

Number	Answer	Additional Guidance	Mark
9(a)	An explanation that makes reference to three from: • auxin is released from the terminal bud (1) • and (diffuses down the stem) to inhibit cytokinin action / inhibit lateral shoot growth (1) • cytokinin stimulates lateral shoot growth (1) • and is produced from base of shoot (1)	Allow one mark for antagonistic effect if no MP1 or MP3?	3

Question Number	Answer	Additional Guidance	Mark
9(b)	An explanation that makes reference to two from: • uncharged auxin can diffuse through the {uncharged / hydrophobic / nonpolar} fatty acid tails (1) • (negatively) charged auxin has to move through protein channels / carrier proteins (1)		2

5(a)	endosperm		(1)
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Question Number	Answer	Additional guidance	Mark
5(b)(i)	A description that makes reference to two the following: - DNA strands separate (1) - antisense strand used as template (for mRNA) (1) - RNA polymerase synthesises mRNA (1)		(2)

Question Number	Answer	Additional guidance	Mark
5(b)(ii)	A description that makes reference to five of the following: - mRNA leaves through nuclear pores (1) {translation occurs at / mRNA travels to} ribosomes / rough endoplasmic reticulum (1) - codons (on mRNA) pair with anticodons on tRNA / tRNA brings amino acid (to the ribosome) (1) - peptide bonds form between amino acids (1) - amylase enters Golgi and is {modified / processed} / amylase {is packaged into vesicles / travels in vesicles} (1) - exocytosis releases {amylase / protein} (1)	Accept protein for amylase Accept description for exocytosis	(5)

Question Number	Answer	Additional guidance	Mark
5(c)	An answer that makes reference to five of the following: (soak grains in) range of at least five salt concentrations (1) - use {surface sterilised seeds / sterile agar / sterile Petri dishes} (1) {wash / cut} grains and place onto starch agar (1) - leave for 24-48 hours (1) - add iodine (solution) (1) - measure {diameter/area} of clear zone (1)	Accept wash grains with bleach Accept leave {washed / cut} seed in starchy solution If alternative method used (grain in starch solution), accept use a colorimeter to measure absorbance	(5)

Answer	Mark	Answer	Mark
four of the following: cies / type} are kept / es / varieties} are kept / y are kept (1) perature (1) sture / dry} (1) xygen} containers (1) seeds to detect embryoc	1		
Additional Guidance			
DO NOT ACCEPT in cells ACCEPT adenylate cyclase activated ACCEPT glycogen phosphorylase is phosphorylated			
of the following: ic} bonds (1) apid / easy {breakdown / hydrolysis} (1) s not {affect osmosis / leave cells / solute	3	DO NOT ACCEPT beta glucose once	
Answer			
olysis reaction breaking actions forms glycogen not phosphodiester bond not phosphodiester bond			

Additional Guidance	Mark
ACCEPT low genetic diversity / small number of different alleles	2

Additional Guidance	Mark
Example of calculation $15 \div 1400 = 0.0107$ $p = 0.897$ $q = 0.103$ $2pq = 2 \times 0.897 \times 0.103 = 0.185$ $0.185 \times 1400 = 259$ Correct answer with no working gains full marks ACCEPT one mark for: $q^2 = 0.01$ to 0.0107 $p = 0.897$ to 0.9 and $q = 0.1$ to 0.103 ACCEPT $2pq = 0.18$ to 0.187 in final answer for 3 marks	4

Additional Guidance	Mark
ing) and IGNORE habitat / area	1

Additional Guidance	Mark	Answer	Mark
	(1)		(1)

Additional Guidance	Mark	Additional Guidance	Mark
	(3)	one of the following: increased / dilute / decreased / concentrated water ADH osmosis water potential baroreceptors aquaporins	(3)

3 (a)	- large numbers of mitochondria (1) - to provide ATP for active uptake of {glucose / salts / amino acids} (1) - microvilli providing large surface area (1) - for many carrier proteins for {glucose / salts / amino acids} (1)	Accept correct named minerals	4
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Question Number	Answer	Additional Guidance	Mark
3(b)(i)	B ☒ B 1 and 3 <i>A is incorrect because facilitated diffusion does not move substances against a gradient</i> <i>C is incorrect because facilitated diffusion does not move substances between phospholipids</i> <i>D is incorrect because facilitated diffusion does not move substances against a gradient</i>		1

Question Number	Answer	Additional Guidance	Mark
3 (b)(ii)	C increased permeability of the collecting duct to water, producing more concentrated urine <i>A is incorrect because ADH increases the permeability of the collecting duct</i> <i>B is incorrect because ADH increases the permeability of the collecting duct</i> <i>D is incorrect because ADH results in more concentrated urine</i>		1

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following:		

Number			
6 (a)	The only correct answer is B W and X A is incorrect because glucose passes out of the glomerulus C is incorrect because glucose is absorbed in the PCT D is incorrect because glucose is absorbed in the PCT		(1)

Question Number	Answer	Additional Guidance	Mark
6 (b)(i)	An explanation that makes reference to three of the following points: • there is more protein in plasma than tissue fluid (1) • because plasma proteins are too large to pass out of the capillary (1) • and oncotic pressure generated by (plasma) proteins (1) • (so fluid moves in) as {oncotic / osmotic} pressure is greater than hydrostatic pressure (1)	Accept converse Accept converse	(3)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to four of the following points: • sodium ions are not removed from the ascending limb (1) • so the water potential of medullary fluid is higher (1) • therefore less water is removed from the descending limb (1) • and less water is removed from the {collecting duct / distal tubule} (1) • (a higher volume of) {dilute / low concentration} urine is produced (1)	Accept less negative water potential Accept water potential gradient is lower Accept osmotic gradient is lower	(4)

Number	Answer	Additional Guidance	Mark
2(a)(i)	An explanation that includes the following: (urea moves) from {blood vessel / capillaries / glomerulus / blood} into capsule (1) - by ultrafiltration (1)	Accept description of high blood pressure forcing {urea / small molecules} into capsule for mp1 and 2 Accept due to high blood pressure / hydrostatic pressure	(2)

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An explanation that includes three of the following: - concentration of ions is higher {outside nephron / in medulla} (than inside nephron) (1) - water moves out of {descending limb / collecting duct} (1) - by osmosis (1) (loop of Henle acts as a) countercurrent multiplier (1)	Accept causes lower water potential outside / higher water potential in nephron Accept lowers the water potential in the medulla Accept correct ref to hypertonic / hypotonic Accept interstitial fluid for fluid in medulla Accept concentration of sodium ions is highest at the bottom of the loop Accept down a water potential gradient / from high to low water potential Accept concentration (of urine) increases <u>along length of loop of Henle</u>	(3)

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	correct ratio determined (1)	3.9 : 2 : 1 Accept 4 : 2 : 1 3.93 : 2 : 1 Accept numbers in any order if qualified	(1)

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that includes two of the following: - nephron has (relatively) long loop of Henle (1) - so {long(er) distance for gradient to build up / (fluid in) medulla can become (more) concentrated / large(er) gradient can build up} / greater countercurrent multiplier effect (1) OR - thick medulla compared to cortex (1) - as loops of Henle are longer (1) OR - highly folded cell membrane around (epithelial) cells lining nephron (1) - so large(er) surface area for absorption (1) OR - high numbers of mitochondria in (epithelial) cells lining nephron (1) - so (more) ATP for active transport (1)	Accept large numbers of juxtamedullary nephrons / thin descending loop of Henle is relatively long Accept many ions can be pumped out (due to long length) Accept mitochondria (in epithelial cells) have many cristae	(2)

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	{hide in burrows during the day / nocturnal / feed at night / leave burrows for a short time only} (1)		(1)

Total for Question 2 = 9 marks

Question Number	Answer	Additional Guidance	Mark
	An answer that includes the following		

Number	Answer	Mark
8(a)	The only correct answer is B <i>A is not correct because X is the pelvis</i> <i>C is not correct because W is the cortex</i> <i>D is not correct because W is the cortex</i>	(1)

Question Number	Answer	Additional Guidance	Mark
8(b)	An explanation that makes reference to the following: (substances) with higher (relative molecular) mass have a {lower ratio / ratio less than 1.00} (1) - small(er) substances pass through / large substances do not pass through (1) - because of the size of the pores in the {glomerulus / capillary / renal capsule / (basement) membrane} (1)	ACCEPT a ratio of 1.00 means substance passes through / a ratio less than 1.00 means not all substance passes through ACCEPT substances with a mass lower than 180 pass through	(3)

Question Number	Indicative content
*8 (c)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: Proximal convoluted tubule: (P) - glucose is all reabsorbed - by active transport / use of energy / use of ATP - urea concentration rises as water is reabsorbed - sodium ions absorbed because concentration does not increase (despite less water) Loop of Henle: (L) - urea concentration rises - sodium ion concentration rises in descending limb - water reabsorbed from descending limb - by osmosis - sodium ion concentration falls in ascending limb - sodium ions actively pumped out of ascending limb - reference to countercurrent multiplier Distal tubule and collecting duct: (C) - urea and sodium ion concentration rise - water is reabsorbed - by osmosis - ADH affects permeability

Level	Marks	
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. Any number of descriptions from graph = 1 point Answer with description only and no explanation max 1 1 REGION and at least one explanation = 2
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts to provide the explanation being presented. Lines of argument occasionally supported through the application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows some linkages and lines of reasoning with some structure. 2 REGIONS and 3 to 4 points
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to provide the explanation being presented. Line(s) of argument supported throughout by sustained application of relevant evidence (scientific ideas, processes, techniques and procedures). The explanation shows a well-developed and sustained line of reasoning which is clear, coherent and logically structured. 3 REGIONS and 5 plus points with no MAJOR errors e.g. urea moving into nephron, sodium ions moving into the nephron

Question Number	Answer	Mark
7(a)	The only correct answer is C <i>A is incorrect as it is the medulla</i> <i>B is incorrect as it is the pituitary gland</i> <i>D is incorrect as it is the cerebellum</i>	(1)

Question Number	Answer	Additional guidance	Mark
7(b) (i)	An explanation that makes reference to four of the following: • {muscle contraction / respiration} releases heat (energy) (1) • core temperature does not rise as much as skin temperature (1) • (blood) temperature rise detected by {hypothalamus / thermoregulatory centre} / impulses from {hypothalamus / thermoregulatory centre} to {skin / sweat glands / shunt vessels} (1) • vasodilation causes {skin temperature to rise / skin to heat up} (1) • <u>water</u> from sweat <u>evaporates</u> (1) • {evaporation / radiation} {removes heat / cools skin} so (skin temperature rise levels off / prevents further increase (1)	Accept exothermic reactions Can piece together Accept increased blood flow to skin increases (skin) temperature Ignore vasodilation of veins / capillaries	(4)

Question Number	Answer	Additional guidance	Mark
7(b)(ii)	• an example of behavioural thermoregulation	Allow correct examples of behaviour e.g. pressing body down onto hot sand or seek shade in hot conditions Candidates may answer this in a variety of ways	(1)

Question Number	Answer	Additional guidance	Mark
7(b)(iii)	An explanation that makes reference to the following: • if the body cools (positive feedback) makes it even colder / when temperature drops it causes a larger temperature drop (1) • because respiration is slower / enzymes have less (kinetic) <u>energy</u> / metabolism is slower / exothermic reactions are slower (1) • (respiration / metabolism / exothermic reactions) release (even) less heat (energy) (1)	Accept idea that (positive feedback) is when a change in conditions causes a further change away from the normal	(2)

Question Number	Answer	Additional guidance	Mark
7(c)	A description that makes reference to three of the following: • {high blood salt concentration / low blood water potential} stimulates osmoreceptors (in hypothalamus) (1) • causing ADH release from <u>pituitary</u> (1) • ADH causes increase in permeability of collecting duct / ADH causes more aquaporins in membranes of collecting duct (cells) (1) • more (re)absorption of water into <u>blood</u> (1)	Accept low blood water concentration Accept from hypothalamus Accept more water goes into <u>blood</u>	(3)

(Total for Question 7= 11 marks)

Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following: - osmosis is occurring (1) - at 3%, water has left the red blood cells (by osmosis) (1) - at 0.5% and 0.3%, water has gone into the cells (by osmosis) (1) - at 0.5% and 0.3% the cells have burst (and cannot be seen) (1) 0.7% is close to the water potential of the cells' cytoplasm (1)	Allow correct reference to {hypertonic / hypotonic / isotonic} solution or to water potential Allow at 3% water leaving RBC by diffusion Allow water potential of cells' cytoplasm is between 0.7 and 1%	(4)

Question Number	Answer	Additional Guidance	Mark
7(b)	An explanation that makes reference to the following: - the osmotic potential of the red blood cells is equivalent to 3% glucose or 6% sucrose (1) - because the molecular mass of sucrose is twice that of glucose (1) - because it is the number of molecules that determine the osmotic potential, not % concentration (1)	Allow twice the concentration of sucrose is needed to have the same effect Accept sucrose as a disaccharide whereas glucose is a monosaccharide	(3)

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	An answer that makes reference to the following: hypothalamus		(1)

Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	An explanation that makes reference to four of the following: - sweating occurs causing loss of water from the blood (1) - therefore the water potential of the blood falls (1) - osmoreceptors are stimulated (1) - causing the pituitary gland to secrete {antidiuretic hormone / ADH} (into the blood) (1) - causing the {collecting ducts / kidney tubules} in the kidney to reabsorb more water (into the blood) (1)		(4)

Question Number	Answer	Mark
7 (a) (i)	The only correct answer is D <i>A is incorrect as lactose does not contain fructose</i> <i>B is incorrect as lactose does not contain fructose</i> <i>C is incorrect as maltose does not contain fructose</i>	1

Question Number	Answer	Mark
7 (a) (ii)	The only correct answer is B <i>A is incorrect as ester bonds are found in lipids</i> <i>C is incorrect as hydrogen bonds do not join monosaccharides</i> <i>D is incorrect as peptide bonds do not join monosaccharides</i>	1

Question Number	Answer	Mark
7 (a) (iii)	The only correct answer is A <i>B is incorrect as there should be 21 oxygens</i> <i>C is incorrect as there should be 42 hydrogen</i> <i>D is incorrect as there are 21 oxygen</i>	1

Question Number	Answer	Additional guidance	Mark
7 (b)(i)	three arrows going in correct directions (1)		1

Question Number	Answer	Additional guidance	Mark
7 (b)(ii)	An explanation that makes reference to two of the following. - in dry weather {inulin / it} is more soluble / more able to dissolve (1) - so (in dry weather / with less fructose) water potential becomes {lower / more negative} (1) - so {in dry weather / with fewer fructose} water moves into {cells / root / plant} / {in dry weather / with fewer fructose} water {is not lost / is retained / stored / is absorbed} (1)	Allow insulin Allow in wet weather {inulin / it} is less soluble / less able to dissolve (1) Allow so (in wet weather / with more fructose) water potential becomes {higher / less negative} (1) Allow {in wet weather / with more fructose} less water {taken in / absorbed} (1)	2

Question Number	Answer	Additional guidance	Mark
7 (c)(i)	- correct answer for rate within given range and to two decimal places (1) $\text{mg dm}^{-3} \text{ min}^{-1}$ / $\text{mg dm}^{-3} \text{ s}^{-1}$ (1)	Example of calculation Allow range between (-)7.50 to (-)8.99 (must be two d.p.) Allow range between (-)0.12 to (-)0.15 (must be two d.p.) (if in seconds) Allow mg dm^{-3} per minute Allow $\text{mg} / \text{dm}^3 / \text{min}$ Allow $\text{mg dm}^{-3} / \text{min}$ Allow mg dm^{-3} per second Allow $\text{mg} / \text{dm}^3 / \text{s}$ Allow $\text{mg dm}^{-3} / \text{s}$ Allow any other correct answer using different appropriate units Correct answer with no working gains full marks.	2

Question Number	Answer	Additional guidance	Mark
7(c)(ii)	An explanation that makes reference to two of the following: - ultrafiltration occurs (1) (inulin passes from) glomerulus into Bowman's capsule (1) - because inulin is small enough to pass through {basement membrane / pores / fenestrations} (1)	Allow (high) hydrostatic pressure moves inulin Allow through gaps between podocytes Allow insulin for inulin	2

Question Number	Answer	Additional guidance	Mark
7(c)(iii)	An explanation that makes reference to two of the following: • inulin has no function in humans (1) • inulin is not reabsorbed (1) • because there are no inulin {channels / carriers / pumps} in {proximal convoluted tubule / PCT} (1)	Allow insulin for inulin Allow inulin is a waste product / is not needed Allow absorbed back into blood Allow first convoluted tubule	2

(Total for Question 7 = 12 marks)

7 (a)	50 (1)		(1)
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Question Number	Answer	Additional Guidance	Mark
7 (b)	An explanation that makes reference to the following: - because food attracts mouse into trap (1) - because {small entrance / size of trap} allows {small animals / mice} to enter trap / larger animals cannot enter trap (1) - because door slides down when the mouse {approaches the food / walks on board} (1)	Accept the entrance is big enough for mice to enter the trap	(3)

Question Number	Answer	Additional Guidance	Mark
7 (c)	An explanation that makes reference to four of the following: - mice have large surface area to volume ratio (1) (therefore) {lose a lot of heat / lose heat quickly} (1) - heat generated by {metabolism / respiration} (1) - insufficient food to {maintain (high) metabolic rate / release enough energy} (1) - no bedding {for insulation / to prevent heat loss} (1)		(4)

Question Number	Answer	Additional Guidance	Mark
7 (d)	An answer that makes reference to five of the following: Inaccurate because {births / deaths} may occur (1) - migration may occur (1) - marking may affect survival (1) - mice may lose bands (1) - food encourages capture / trap discourages capture (1) Accurate because {time / a week} is long enough for random dispersal (1) - a lot of traps were set / sample size large (1) - traps were randomly placed (avoids bias) (1)	Accept that some animals are more or less likely than others to enter trap	(5)



Answer	Additional Guidance	M
reference to the following: up from amino acids / deamination (1) with carbon dioxide (1) releases urea (1)		(3)
Answer	Additional Guidance	M
	Do not accept incorrect spelling	(1)
Answer	Additional Guidance	M
		(1)
Answer	Additional Guidance	M
reference to the following: pass through (1) other molecules or ions are reabsorbed (1) against a concentration gradient (1) pass (1)		(4)

9BI



	Additional Guidance	Mark
following: ascending limb by in medulla (1) celler (1) cts) by osmosis		(5)

	Additional Guidance	Mark
		(1)

9

Number	Answer	Additional Guidance	Mark
3(a)	An explanation that makes reference to the following: - release energy / make ATP (1) - for {ion pump / Na⁺ - K⁺ pump / active transport of ions / regeneration of rhodopsin / combine opsin and retinal /convert trans retinal into cis retinal} (1)	DO NOT ACCEPT active transport alone	(2)

Question Number	Answer	Additional Guidance	Mark
3(b)	A description that makes reference to four of the following: - rhodopsin involved (1) - retinal changes from cis to trans form / opsin and retinal formed (1) {Na⁺ / cation} channels close / Na⁺ stop diffusing into rod cell (1) - Na⁺ still moves out / inside cell becomes more negative / hyperpolarisation (1) - stops {glutamate / neurotransmitter} release (1)	ACCEPT blocks sodium channels	(4)

	Additional Guidance	Mark
	Accept any number between and including 127.6 and 130.4 beats per minute / bpm	(1)

	Additional Guidance	Mark
wing: creases / aorta ntre / ve / ode (1)	 Do not accept signal / message Do not accept signal / message Accept adrenaline stimulates SA node	(4)

	Additional Guidance	Mark
e and Z Z controls a and Y		(1)
	Additional Guidance	Mark
not closed , not closed not open		(1)

Number	Answer	Additional Guidance	Mark
2 (a)	An answer that makes reference to at least one similarity and one difference: Similarities • both contain {nerve cells / neurones} (1) • both contain synapses (1) Differences • PNS is divided into somatic and autonomic systems, but CNS is not (1) • only the PNS has sensory input and motor output (1) • only the CNS carries out processing of information (1)	Allow both carry nerve impulses Allow both use neurotransmitters Allow PNS contains sympathetic and parasympathetic systems, but CNS does not	(3)

Question Number	Answer	Additional Guidance	Mark
2 (b)(i)	An answer that makes reference to the following: • (the cerebellum is for) {balance / coordination (of muscles) / posture} (1)	Allow {motor memory / learning complex motor skills}	(1)

Question Number	Answer	Additional Guidance	Mark
2 (b)(ii)	An answer that makes reference to the following: • cerebrum (1)	Allow {cerebral cortex / motor cortex / cerebral hemisphere}	(1)

Question Number	Answer	Additional Guidance	Mark
2 (b)(iii)	An explanation that makes reference to two of the following: • the damage is to the left side of the cerebellum (1) • so movement of the right arm is no longer automatic / co-ordinated (1) • therefore the soldier compensates by having to think about it (1)	Allow no impulses from cerebellum to (right) arm Allow impulses pass from cerebrum to right arm (to move arm)	(2)

Number	Answer	Additional Guidance	Mark
1(a)(i)	resting potential (1)		(1)

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	A description including four of the following • {sodium / Na} channels open (1) • sodium ions flow into {axon / cell / neurone} (1) • this causes depolarisation (1) • {sodium / Na} channels close at {0.8ms / 30mV} (1) • {potassium / K} channels open at {0.8ms / 30mV} (1)		(4)

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that includes the following • there is no action potential until the stimulus is greater than 45 (mV) (1) • this is the threshold value (1)	Accept range between 45-55 (mV) / 46 -55 (mV) Accept threshold potential / threshold voltage	(2)

Total for Question 1 = 7 marks

Question	Answer	Additional Guidance	Mark
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Question Number	Answer	Mark
6(a)(i)	The only correct answer is C (movement of sodium ions into the neurone) <i>A is incorrect as calcium channels are closed</i> <i>B is incorrect as potassium channels are closed</i> <i>D is incorrect as sodium ions move in</i>	1

Question Number	Answer	Additional guidance	Mark
6(a)(ii)	An explanation that makes reference to two of the following: • (voltage gated) potassium channels open (1) • and sodium channels close (1) • so that potassium ions diffuse out of the neurone repolarising the membrane (1)	Allow potassium channels become (more) permeable Allow sodium channels become impermeable Allow K⁺	2

Question Number	Answer	Mark
6(b)(i)	The only correct answer is B (1, 2 and 3) <i>A is incorrect as the rat has physiological adaptations</i> <i>C is incorrect as the rat has behavioural adaptations</i> <i>D is incorrect as the rat has anatomical adaptations</i>	1

Question Number	Answer	Additional guidance	Mark
6(b)(ii)	An explanation that makes reference to three of the following: - fewer sodium ions are pumped out (of the neurone) / fewer potassium ions pumped in (1) - so that the resting potential is reduced / not maintained (1) - there is a lower (diffusion) gradient for sodium ions / sodium ions leak through membrane (1) - so sodium ions will not {diffuse / move} in (during stimulation) / membrane cannot depolarise (if stimulated) / action potential cannot occur (1)	Only penalise once for not referring to ions Allow inside is no longer more negative / outside membrane is less positive / no potential difference (across membrane) Allow {movement of ions / membrane} is at equilibrium	3

Number	Answer	Additional Guidance	Mark
2(a)(i)	An answer that includes the following: arrow drawn in correct direction (1)	From right to left (only)	(1)

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	A description that includes three of the following: (acetylcholine) released from vesicles (into synaptic cleft) (1) (acetylcholine) diffuses across synaptic cleft (1) {attaches / binds} to receptors (on post synaptic membrane) (1) - this causes {sodium ions to move into (post synaptic) neurone / an action potential / depolarisation} (in post synaptic neurone) (1)	Accept vesicles (containing ACh) fuse with pre-synaptic membrane / exocytosis (of neurotransmitter) Allow diffuses across gap / synapse Allow opens (voltage-gated) Na ⁺ channel Ignore sodium channel unqualified	(3)

Question Number	Answer	Additional Guidance	Mark
2(a)(iii)	produce the ATP needed for the synthesis of acetylcholine (1)	Accept for neurotransmitters Accept choline and {acetate / acetyl / ethanoic acid} are combined to make acetylcholine, this requires ATP Allow for exocytosis and endocytosis Allow for loading acetylcholine into vesicles Allow for movement of vesicles to membrane Allow for active transport of calcium / potassium / sodium ions Ignore for active transport of ions if not named	(1)

Question Number	Answer	Additional Guidance	Mark
2(b)	An explanation that includes the following: - insulates (the neurone) (1) - so nerve impulse jumps from node to node (1)	Accept myelin is not conductive / allows {low / no} conduction / blocks sodium ion channels Allow gaps for nodes Accept saltatory {conduction / transmission}	(2)

Total for Question 2 = 7 marks

Additional Guidance	Mark	Additional Guidance	Mark	Additional Guidance
accept EPSP is greater than IPSP accept because enough sodium ions enter the neurone / enough sodium channels open accept excitatory transmitter for acetylcholine accept IPSP is greater than EPSP accept inhibitory transmitter for glutamate accept description of hyperpolarisation e.g. inside becomes more negative	(3)			Refer to the following: and $X^{R^R}X^{r}$ (1) $X^{r}X^{R^R}$, $X^{R^R}Y$, $X^{r}Y$ (1) Accept TE for parents if ; Accept 25 %
			(1)	Refer to four of the following: pulse} at presynaptic Ca²⁺ ions enter (presynaptic membrane) presynaptic membrane (1) released into} the synaptic membrane {opening of Ca²⁺ ions to enter} (1) Accept calcium ions enter presynaptic membrane Do not accept calcium ions enter presynaptic membrane Accept neurone releases acetylcholine

Number	Answer	Additional Guidance	Mark
1(a)	E		(1)

Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that makes reference to three of the following: - slows {transmission / impulse} (1) - because reduced {myelin sheath / Schwann cells} (1) - affects saltatory conduction / affects jumping between nodes of Ranvier (1) (change to membrane) affects action potential / ion movement / ion channels (1)		(3)

Question Number	Answer	Additional Guidance	Mark
1(c)	An answer that makes reference to the following: - neurone at resting potential (1) - because (voltage gated) sodium (ion) channels {closed / blocked} (1) - therefore no movement of sodium (ions) into neurone / into cell / into axon / across membrane (1) - therefore prevents {depolarisation / action potential} (1)	ACCEPT not open DO NOT ACCEPT nerve	(4)

Number	Answer	Additional Guidance	Mark
9(a)(i)	C 2 <i>A is incorrect as the nucleus and mitochondria have double membranes</i> <i>B is incorrect as the nucleus and mitochondria have double membranes</i> <i>D is incorrect as only the nucleus and mitochondria have double membranes</i>		1

Question Number	Answer	Additional Guidance	Mark
9 (a)(ii)	A 1 only <i>B is incorrect because voltage gated channels will not open when light affects rod cells</i> <i>C is incorrect because less neurotransmitter is released when light affects rod cells</i> <i>D is incorrect because less neurotransmitter is released when light affects rod cells</i>		1

Question Number	Indicative content
9 *(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. - no light is seen at 15 degrees (D) - as there are no rods or cones at the blind spot (D) - cones are less sensitive than rods / can only detect bright light (R) - because they do not have spatial summation / rods have spatial summation (R) - cones are only found in the fovea / between 5° and 5° (R) - rods are not found in the fovea / between 5° and 5° / found everywhere except fovea / between 5° and 5° (R) - rods are stimulated by green light / 525 nm light (R) - rods are not stimulated by red light / 670 nm light (R) - dim red light / 670 nm light is not seen at any angle because rods cells are not sensitive to red light / light of 670nm (S) - and cone cells are not sensitive enough (S) - bright red light / 670 nm light is only seen when on the fovea / between 5° and 5° because red cones are only on the fovea / not found outside the fovea (S) - and rod cells can not detect red light (S)



	• bright green light / 525nm light is seen everywhere apart from the blind spot / 15° because cone cells detect it in the fovea (S) • and rod cells detect green light / 525 nm light away from the fovea (S) • dim green light / 525 nm light is seen at angles greater than 10° because rod cells are sensitive to green light / 525 nm light (S) Level 1: Only description (any 1 or 2 from B or R) Level 2: Elements of description of data and explanation but not fully linked (any 3 or 4 from B, R or S) Level 3: Description and explanations and linked well and no major errors (any 5 or 6 from B, R, S)	
Level	Marks	
Level	Marks	
0	0	No awardable content
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of all pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of all pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

2 (a)	• {action potential / impulse} arrives at (presynaptic) terminal / membrane / synaptic knob (1) • calcium channels open (1) • calcium ions diffuse into the neurone (1) • vesicles move towards the (presynaptic) membrane (1) • vesicles fuse with presynaptic membrane / exocytosis occurs (1)		4
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Question Number	Answer	Additional Guidance	Mark
2 (b)(i)	An explanation that makes reference to the following: • {charge / shape} of active site changes (1) • so acetylcholine will not bind / can no longer form E/S complex (1)		2

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to three of the following: • acetylcholine (from parasympathetic neurone) is not broken down / builds up in synaptic cleft (1) • so continues to bind to (acetylcholine) <u>receptors</u> (in SA node) (1) • so fewer impulses from SA node (1) • and noradrenaline has no / less effect (1)	Accept fewer depolarisations from SA node	3

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following:		

ditional Guidance	Mark		Additional Guidance	Mark	Additional Guidance
ifferent letters e.g. X^{BX^b} or mp2 and mp3 for wrong sex-linked % if cross is not sex-linked	(3)	are following: r / 2 / 6) is not heterozygous / % chromosome is o they must be 6 / mother} be colour blind	Accept {4 / 9} is colour blind and the parents are not colour blind Accept {6 / 2} are not colour blind but have a son who is colour blind Do not accept both parents are heterozygous / carriers	cept converse for cones / cell Y cept converse for cell Z cept iodopsin (in cones / cell Y) is less sensitive to light	Additional Guidance
ditional Guidance	Mark				Additional Guidance
ium ions pass through apt calcium ions enter rotransmitters for	(4)			(2)	(3)

Mark		Additional Guidance	Mark
1	eg:	ACCEPT Na ⁺ for sodium ions and K ⁺ for potassium ions	
	ions) move in (1)	DO NOT ACCEPT potassium channels are open so potassium ions enter	
	nels (1)	ACCEPT only a few sodium channels are open / only a few sodium ions move in	
2	ACCEPT no depolarisation		4
	ACCEPT less sodium ions enter		
	ACCEPT effector for muscle / blocked} (1)		

rate
of
transmission

5 (a)	A bipolar neurone <i>B is incorrect because ganglion neurones are after bipolar neurones</i> <i>C is incorrect because motor neurones are not found in the retina</i> <i>D is incorrect because optic neurone is an incorrect term</i>	1 comp
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Question Number	Answer	Additional Guidance	Mark
5 (b)	An explanation that makes reference to three of the following points: - rhodopsin breaks down into opsin and (trans) retinal (1) - causing sodium channels (on the rod cell) to close / to be blocked (1) - leading to the (rod cell) hyperpolarising (1) - so that less { (inhibitory) transmitter / glutamate} is released (1)	Accept cis retinal is converted to trans retinal Do not accept voltage gated sodium channels Accept sodium ions stop moving into the cell Accept blocks cation channels Accept membrane becomes more positive outside / more negative inside Accept correct descriptions of hyperpolarising	(3)

Question Number	Indicative content
5 (c)*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. - spending longer in the dark reduces the minimum intensity at which light is seen / increases sensitivity D - retina is less sensitive to 620 nm light / more sensitive to 500 nm light / D - sensitivity continues to increase over time with 500 nm light / levels off with 620 nm light D 620 nm light stimulates cones but not rods D 500 nm light stimulates rod cells and cones D - exposure to light bleaches / breaks down rhodopsin / iodopsin B - trans retinal is converted back to cis retinal in the dark B - rhodopsin / iodopsin is (re)synthesised in the dark B (cis) retinal binds to opsin (in dark) B - cone cells / iodopsin dark adapt faster than rod cells B - rhodopsin takes longer to be reconverted from opsin and retinal than iodopsin B - rhodopsin is more sensitive than iodopsin B - rod cells are more sensitive / stimulate at lower minimum light R - due to spatial summation / (retinal) convergence of rods R - so that several rod cells are stimulated to overcome a threshold / generate action potential in bipolar cells R - levelling off with 620 nm light shows that cone cells are less sensitive than rod cells R

Level 0	Marks	No awardable content
Level 1	1-2 (1-3)	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. 1 mark : one point from D, R or B 2 marks : one from D and one from D, R or B
Level 2	3-4 (4-6)	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. D with some of R or B 3 marks: 1D and 2 from R or B OR 2 D and 1 from R or B 4 marks: 2 D and at least 2 from R or B OR 1 D and at least 2 from R or B
Level 3	5-6 (7-9)	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. D, B and R 5 marks : at least two descriptions of data and one R and one of B 6 marks : at least two descriptions of data and at least two of R and two of B

Question	Answer	Additional Guidance	Mark
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Question Number	Answer	Additional guidance	Mark
9(a)(i)	Arrow from bottom to top (1)		1

Question Number	Answer	Additional guidance	Mark
9(a)(ii)	A description that makes reference to three of the following: 1. rhodopsin is converted into (trans) retinal and opsin (1) 2. (opsin causes) sodium channels to close (1) 3. sodium ions accumulate outside / sodium ions do not enter cell (1) 4. sodium potassium exchange pump continues (1) 5. {less / no} {neurotransmitter / glutamate} is released (1)	Allow prevents sodium channels opening Allow depolarisation stops / dark current stops Allow sodium continue to be pumped out Allow membrane becomes hyperpolarised	3

Question Number	Indicative content	Mark
9(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Descriptions about cat v human retina (C) - cat cones have spatial summation in cats (unlike humans) / have three / several cones per bipolar neurone - in cats rods and cones have same resolution / sensitivity (due to summation) - cat has more rods than humans (all over retina) - cat has fewer cones than human - cat has more rods in periphery of retina - cat have better peripheral vision - cat has a reflective tapetum to help see in dark Descriptions about data for other mammals (M) - nocturnal animals have more rod cells (than cones) - rat has fewer rods than night monkey - animals active in day have more cone cells (than nocturnal animals) - night monkey, rat and saimiri monkey have more rods than cones - marmoset monkey has more cones than rods / most animals have more rod cells than cone cells - saimiri monkey is different from others (in terms of activity and rod / cone number) - saimiri monkey may live in shaded areas Conclusions and General points (G) <i>animals active in day / humans can see detail / have better acuity / can see colour</i> <i>animals / cats active at night are sensitive to low light intensity / dim light* (ignore dark(er) light)</i> - rhodopsin is more sensitive than iodopsin - rods are more sensitive to lower light intensity than cones - rods are more sensitive as they have spatial summation / description of many rods joining to one bipolar neurone / cones usually have one bipolar neurone - cones have high acuity / rods have low acuity - rods are only black and white vision / cones are colour vision - only a limited survey / only a few animals investigated - rat is different as less related to the three monkeys Level 1: 1 mark: any 1 point 2 mark: any 2 points Level 2: 3 marks: any 3 points from at least two of C, M, or G 4 marks: any 4 points from at least two of C, M, or G Level 3: 5 marks: any 5 points with at least one from each of C, M, and G 6 marks: any 6 points with at least one from each of C, M, and G at least one must be italics*	6

Number	Answer	Additional Guidance	Mark
6 (a)	B 0.75 ms A is incorrect because at 0.5s it is a resting potential C is incorrect because sodium channels are closed D is incorrect because sodium channels are closed		1

Question Number	Answer	Additional Guidance	Mark
6 (b)(i)	An answer that makes reference to four from the following: similarity • same speed at 1 μm • speed increases for myelinated and unmyelinated axons (1) differences (max 3) • for axon diameters of more than 1 μm, myelinated are faster (1) • myelinated have a steeper / greater increase (1) • myelinated axons are slower below 1 μm in diameter (1) • myelinated is linear relationship	At least one similarity and one difference Accept converse Accept ref to numerical comparison Accept converse Accept proportional increase / Accept converse for non-myelinated	4

Question Number	Answer	Additional Guidance	Mark
6 (b)(ii)	• correct extrapolation to y axis to calculate c (1) • correct calculation of gradient • correct calculation of speed at 5 μm diameter (1)	-0.5 (Accept -0.4 to -0.6) $2/0.8 = 2.5$ 12 m s^{-1} (Accept between 11.9 and 12.1) Accept 12 for two marks Correct answer gains full marks	3

Question Number	Answer	Additional Guidance	Mark
6 (b)(iii)	An explanation that makes reference to three of the following: • saltatory transmission does not occur (1) • because there are {fewer / no} nodes of Ranvier (1) • so impulse does not jump (between nodes) (1) • and sodium channels have to stimulate local current flow along each section of membrane / sodium channels have to open in every part of membrane / depolarisation has to occur along the whole length (1)		3

Question Number	Answer	Mark
5 (a)(i)	The only correct answer is A (1 and 2) <i>B is incorrect as there is reduced diffusion of sodium ions into the cell</i> <i>C is incorrect as there is reduced diffusion of sodium ions into the cell</i> <i>D is incorrect as there is reduced diffusion of sodium ions into the cell</i>	1

Question Number	Answer	Additional guidance	Mark
5 (a)(ii)	An explanation that makes reference to two of the following: - more cones in {centre / fovea} / fewer rods in {centre / fovea} (1) - cone cells are less sensitive (to low light levels) (1) - as (only) one (cone) attaches to each (bipolar) neurone / cones do not have {(spatial) summation / convergence} (1)	Allow fovea Allow more rods in periphery / fewer cones in periphery Allow rhodopsin is more sensitive (than iodopsin) / iodopsin is less sensitive (than rhodopsin) Allow several rods attach to one (bipolar) neurones / have {summation / convergence}	2

Question Number	Answer	Mark
5 (b)(i)	The only correct answer is C (4) <i>A is incorrect as 2, 4, 10 and 6 are heterozygotes</i> <i>B is incorrect as 2, 4, 10 and 6 heterozygotes</i> <i>D is incorrect as 2, 4, 10 and 6 heterozygotes</i>	1

Question Number	Answer	Additional guidance	Mark
5 (b)(ii)	An explanation that makes reference to the following: - cross 6 and 7 produces {11 who is colourblind / colourblind child} (1) - because 6 must be {a carrier / heterozygous / have a hidden recessive allele} (1) OR - cross 3 and 4 produces {8 who is colourblind / colourblind child} (1) - because 8 has inherited recessive alleles from both parents / 4 must {be a carrier / be a heterozygote} OR (it is not dominant because) 10 (and 8) from cross 3 v 4 would be colour blind (1) - as they would inherit a (dominant) allele from 3 (1) OR (it is not dominant because) - neither 6 or 7 is colour blind (1) - and because {11 / one child} is colour blind 6 would have to be colour blind (1) OR 1 and 2 produce 4/6 {who is a carrier} (1) - so 2 must have a recessive allele / is a carrier / 4/6 must have inherited a recessive allele from 2 (1)	Mark in pairs Allow 11 is colourblind but has parents who are not Do not accept both parents are carriers / heterozygotes Do not accept both parents are carriers / heterozygotes Allow 3 and 4 must both have recessive alleles	2

Question Number	Answer	Additional guidance	Mark
5(c)(i)	An answer that makes reference to three of the following: - the condition is recessive (1) - but not sex linked / is on an autosome (1) - because 4 and 5 are not affected but 6 is affected / 4 and 5 must both be {carriers / heterozygous} (1) - it cannot be sex linked as 3 is not affected (1)	autosomal recessive = 2 marks Allow not X-linked Allow from correct genetic diagram Allow 3 would be affected if the allele were sex linked	3

Question Number	Answer	Additional guidance	Mark
5(c)(ii)	An explanation that makes reference to two of the following: • there has been a (genetic / population) bottleneck / founder effect (1) • which increases frequency of affected allele / reduces the frequency of the unaffected allele (1) • few new alleles introduced (as little immigration) (1) • so there is a higher chance of two {heterozygotes / carriers} having children together (1)	Allow more people will carry the affected allele Allow small gene pool / little genetic variation Allow many people are {carriers / heterozygous} Allow high chance of inheriting two recessive alleles	2

Question Number	Answer	Additional guidance	Mark
8(a)	An explanation that makes reference to the following: {fast transport of / more} oxygen for respiration / so that oxygen for respiration is delivered (to tissues) at a high rate (1) and one from - keeps oxygenated and deoxygenated blood separate (1) - maintains high pressure to body / maintains lower pressure to lungs (1) - pulmonary (lungs) and systemic circulatory (body) systems are separate (1)		2

Question Number	Answer	Additional guidance	Mark
8(b)(i)	- correct reading from graph for duration of one heart cycle - correct division of 60 seconds by the duration of one heart cycle	0.80 – 0.86 (s) or $60 \div \text{duration of one beat} = \text{one mark}$ 70 – 75 (bpm) (2) Correct answer with no working gains both marks	2

Question Number	Answer	Additional guidance	Mark
8(b)(ii)	An explanation that makes reference to three of the following: • there is a long(er) gap between the P and QRS waves / extended PQ time (1) • delay between atrial systole and ventricular systole / ventricular systole is delayed (1) • (may be damage to) bundle of His / Purkinje fibres (1)	Allow contraction Allow takes longer to pass through Purkinje fibres / bundle of His	2

Question Number	Answer	Additional guidance	Mark
8(b)(iii)	An explanation that makes reference to three of the following: • acetylcholine is released from the parasympathetic neurones / nervous system (1) • acetylcholine slows heart rate / reduces frequency of depolarisation (1) • atropine binds / blocks (acetylcholine) receptors (1) • at SAN (1) • stops / prevents / reduces acetylcholine binding (to receptor) (1)	Allow atropine stops acetylcholine inhibiting depolarisations Allow impulses Allow competes for receptor	3

Question Number	Answer	Additional guidance	Mark
8(b)(iv)	A description that makes reference to four of the following: • (increased) respiration rate so blood {carbon dioxide (concentration) increases / oxygen (concentration) decreases} • blood {pH decreases / acidity increases} (1) • detected by chemoreceptors (1) • {baroreceptors / stretch receptors} detect (changes in) blood pressure (1) • (chemoreceptors in) {aorta / carotid artery / medulla} (1) • impulses (from neurones of peripheral receptors) sent to {medulla / cardiac centre / cardio-acceleratory centre}(1)	Allow carbonic acid Allow aortic body / aortic arch / carotid body / carotid sinus Allow baroreceptors in {aorta / carotid artery / carotid body / carotid sinus / aortic body / aortic arch} Do not accept signals / messages / pulses	4

Question Number	Answer	Mark
8(a)	The only correct answer is B (motor neurone in the ventral root) <i>A is incorrect as motor neurones are not in the dorsal root</i> <i>C is incorrect as it is not a sensory neurone</i> <i>D is incorrect as it is not a sensory neurone</i>	(1)

Question Number	Answer	Additional guidance	Mark
8(b)(i)	• correct reading of speed from graph (1) • correct calculation of distance (1)	$68 \times 0.4 = 27.2 \text{ m}$ Accept answers between 27.2 up to 28.0 for 2 marks Accept number between 68 and 70 in working for one mark Accept between 27200 and 28000 for one mark Correct answer gains both marks	(2)

Question Number	Answer	Additional guidance	Mark
8(b)(ii)	An explanation that makes reference to two of the following: • <u>impulses</u> travel more slowly / longer time for <u>impulse</u> to travel (1) • less <u>saltatory</u> (conduction) (1) • impulses cannot jump between nodes of Ranvier (1)	Accept converse for when myelin present for all mps Accept there are fewer / no nodes of Ranvier Accept impulse must travel along all parts of neurone membrane (because there are no nodes)	(2)

Question Number	Answer	Mark
8(c)(i)	The only correct answer is C <i>A is incorrect as ionic bonds also make the tertiary structure</i> <i>B is incorrect as hydrogen bonds also make the tertiary structure</i> <i>D is incorrect as peptide bonds do not make the tertiary structure</i>	(1)

Question Number	Answer	Additional guidance	Mark
8(c)(ii)	A description that makes reference to four of the following: - calcium channels open and calcium (ions) enters neurone (1) - vesicles {fuse with (presynaptic) membrane / undergo exocytosis} releasing neurotransmitter (1) <u>neurotransmitter</u> binds to receptors on <u>post synaptic</u> (membrane / neurone)(1) - chloride (ions) enter the neurone (1) - membrane hyperpolarises / becomes less positive outside / more negative inside membrane (1)	Accept Ca^{2+} Do not accept Ca^+ or Ca Accept correct named neurotransmitter e.g. glutamate Accept <u>neurotransmitter</u> moves across {cleft / gap} and binds receptors Accept potassium ions move out Accept membrane potential is further from threshold value	(4)

Question Number	Answer	Additional guidance	Mark
8(c)(iii)	An explanation that makes reference to three of the following: - fewer calcium (ions) enter neurone / membrane is less permeable to calcium (ions) / calcium (ions) do not increase inside neurone (1) - toxin blocks / inhibits / binds to <u>calcium channels</u> (1) - no neurotransmitter is released / no neurotransmitter can diffuse (across synapse) (1) - no {action potential / depolarisation} in post synaptic neurone / muscles cannot <u>contract</u> (1)	Do not accept calcium (ions) are reduced Accept prevents opening Accept correct named neurotransmitter e.g. acetylcholine	(3)

(Total for Question 8= 13 marks)

Additional Guidance	M
<u>Example of calculation</u> C: $(42 - 20)^2 \div 20 = 24.2$ and M: $(6 - 10)^2 \div 10 = 1.6$ and S: $(12 - 30)^2 \div 30 = 10.8$ Chi squared value = 36.6 Correct answer gains full marks, with no working shown ACCEPT one mark in working for expected values of 20, 10 and 30 or 37.2	
Additional Guidance ACCEPT converse for all Mps if answer in (i) produces a calculated value less than 5.991	1) $= 0.05 / p = 0.01 \}$
... behave differently (1)	

	Additional Guidance	Mark
wing:		
a^+ (1)		
generator potential (1)		
s (1)		
(1)		
	DO NOT ACCEPT optic nerve	(5)



Number	Answer	Additional Guidance	Mark
6(a)(i)	A 1 and 2 <i>B is incorrect because lidocaine binds to voltage gated sodium channels</i> <i>C is incorrect because lidocaine binds to voltage gated sodium channels</i> <i>D is incorrect because lidocaine binds to voltage gated sodium channels</i>		1

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	B parasympathetic neurone reduce <i>A is incorrect because acetylcholine reduces the heart rate</i> <i>C is incorrect because acetylcholine is released by parasympathetic neurones</i> <i>D is incorrect because acetylcholine is released by parasympathetic neurones</i>		1

Question Number	Answer	Additional Guidance	Mark
6(a)(iii)	An answer that makes reference to three from: • action potential / impulse arrives at pre-synaptic {terminal / knob} (1) • calcium channels open and calcium ions diffuse in (1) • vesicles move to membrane (1) • vesicles fuse with membrane and release acetylcholine (1)	Allow action potential stimulates presynaptic membrane Allow Ca²⁺ Allow exocytosis	3

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An explanation that makes reference to three from: • capsaicin binds to (TPV) receptors in membrane of receptors cells (1) • this causes neurotransmitter (from receptors) to be released onto sensory neurone {generating an epsp / opening sodium channels / causing sodium ions to flow in} (1) • high concentrations of capsaicin generate an epsp that) overcomes threshold to form an {action potential} (1) • action potential moves along the neurone by (opening sodium channels) (1)	Allow low concentrations does not overcome threshold Allow high concentrations opens voltage gated sodium channels	3

Question Number	Indicative content	
6 (b)(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Descriptions 100 mg / 50 mg / higher doses / of capsaicin increase mass of sweat produced D - sweat production from 100 mg decreases after 5 days D 10 mg has less effect D 10 mg / 50mg have same effect for all seven days D 100 mg effect decreases after 3/4/5 days D 100 mg generates less sweat than 50 mg after 5/6 days D Explanation / Optimal Dose - increased sweating and evaporation of water E - evaporation of water requires heat energy E - latent heat of vaporisation is high for water so sweating removes a lot of heat energy E 50 mg is optimal dose E - because there 100 mg begins to lose effect after 3/4/5 days E - and 100 mg produces more side effects / burning sensations / red rash E Validity of data 50 mg dose has consistent sweat production as error bars all overlap V 100 mg and 50 mg are significantly higher than 10 mg as error bars do not overlap V 10 mg has a high variation between responses of volunteers V - no control experiment has been carried out V - sample size is small V	6

		capsaicin may interfere with other medicines / may make illness worse / no tests done on ill people V	
Level	Marks		
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made. Basic description of the effects of each dose one mark: any one from D, E, V two marks: 3D, 2D + 1E, 2D + 1V	
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made. Detailed description and either E or V three marks: at least four points from D + E or D + V four marks: at least five points from D + E or D + V	
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made. Must have elements of D, E and V. five marks: at least six points from D, E and V six marks: at least seven points from D, E and V AND must refer to standard deviations	

