

PEARSON EDEXCEL IAL BIOLOGY • YBI11

BIOLOGY



EXAM QUESTION PACK

UNIT 5: COORDINATION, RESPONSE AND GENE TECHNOLOGY

SCORE

/240

PERCENTAGE

%

STEMUP

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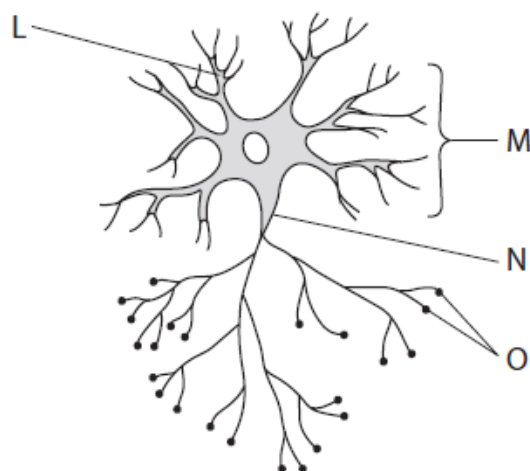
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Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows a relay neurone.



(a) (i) Complete the table by filling in the names of each labelled part.

(2)

Label	Part
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M	
N	
O	

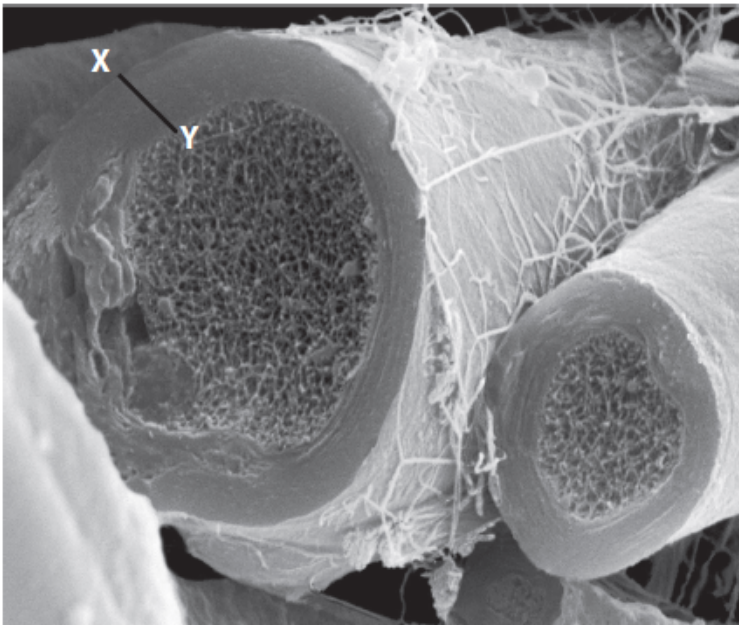
(ii) Lidocaine is a drug that is used as a local anaesthetic.

Lidocaine works by

(1)

- ☐ **A** blocking the binding of acetylcholine to its receptor
- ☐ **B** blocking the release of acetylcholine
- ☐ **C** inhibiting potassium ion channels
- ☐ **D** inhibiting sodium ion channels

(b) The photograph shows a nerve with an outer layer of connective tissue.



(Source: © Science Photo Library/Alamy Stock Photo)

Magnification $\times 3300$

(i) State the type of microscope used to produce this image.

(1)

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(ii) Calculate the thickness of the connective tissue layer between the points X and Y.

Give your answer in micrometres (μm).

(2)

Answer μm

(iii) The nerve shown in the photograph contains many myelinated neurones.

Explain why a myelinated neurone conducts an impulse faster than a non-myelinated neurone of the same diameter.

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(Total for question = 9 marks)

Q2.

Alpha-1 antitrypsin (AAT) deficiency is an inherited disease that can affect different organ systems.

Alpha-1 antitrypsin (AAT) is a protein produced in the liver.

(a) Investigation of the breathing of a patient with AAT deficiency found that the:

- resting tidal volume (V_T) was 500 cm^3
- dead space (DS) was 150 cm^3
- resting respiratory rate (RR) was 12 breaths per minute.

Calculate the volume of air that enters the alveoli (A_V) **each hour**.

$$A_V = (V_T - DS) \times RR$$

Give your answer to 2 significant figures with appropriate units.

(3)

Answer

(b) Activity of the heart was investigated in the same patient.

The trace shows a normal electrocardiogram (ECG).



(i) Name the stage of the cardiac cycle at T on this ECG.

(1)

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(ii) The ECG of the patient with AAT is shown in the trace.



Calculate the mean heart rate shown in this ECG trace.

(1)

Answer

(iii) Compare and contrast the ECG trace of this patient with the normal ECG trace.

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(c) One potential treatment for AAT deficiency uses adenoviruses to genetically modify cells in an affected person.

Adenoviruses contain double-stranded DNA.

Explain how adenoviruses can be used to treat AAT deficiency in a person.

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(Total for question = 12 marks)

Q3.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Animals and plants can detect and respond to light.

(a) Rod cells respond to light by producing action potentials in the optic nerve.

(i) In which structure are rod cells located?

(1)

- ☐ **A** iris
- ☐ **B** pupil
- ☐ **C** retina
- ☐ **D** spinal cord

(ii) Describe the role of rhodopsin in rod cells.

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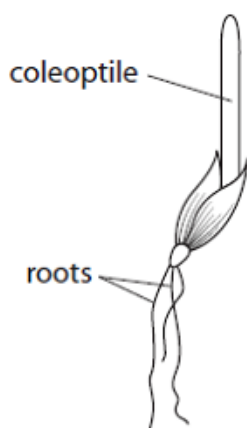
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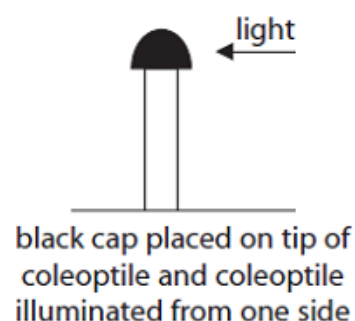
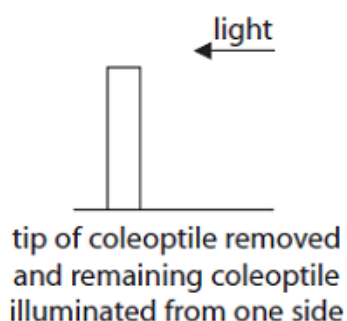
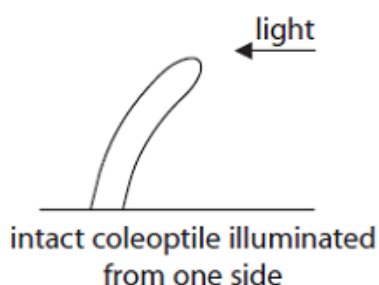
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*(b) The drawing shows the results of some experiments investigating phototropisms.

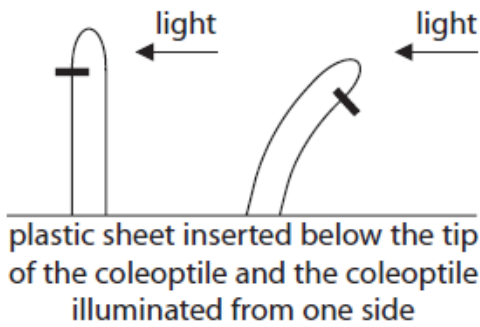
The diagram shows a coleoptile of a seedling.



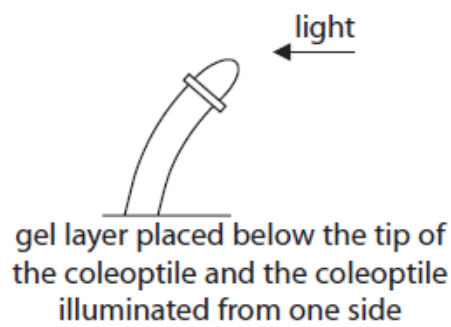
Experiment 1:



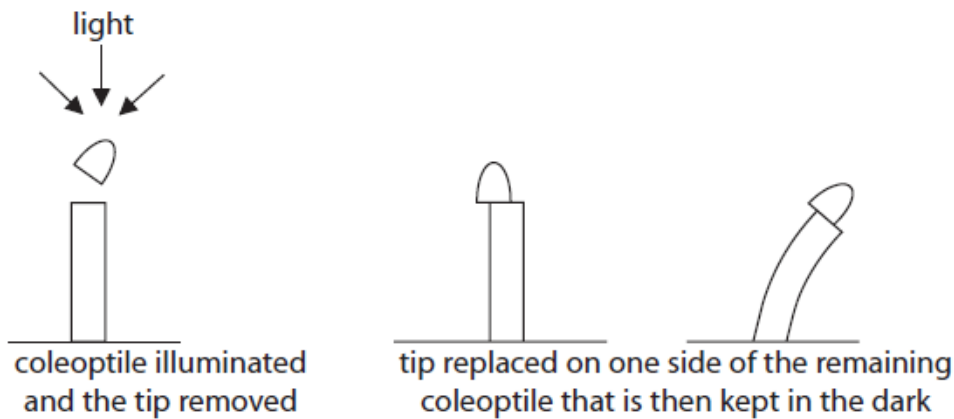
Experiment 2a:



Experiment 2b:



Experiment 3:



Scientists concluded that these results suggest a plant growth substance is involved in regulating the phototropic response.

Discuss how the results of these experiments support the role of a plant growth substance in the phototropic response of plants.

Use the information for these experiments and your own knowledge to support your answer.

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(Total for question = 10 marks)

Q4.

Animals and plants can respond to light.

(a) The photograph shows the front of a human eye.



(Source: © SCIENCE PHOTO LIBRARY)

(i) The size of the pupil changes when moving from dim to very bright light.

Explain how this change occurs.

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(Total for question = 13 marks)

Q5.

Parkinson's disease is caused by a loss of neurones in part of the brain called the substantia nigra.

Co-beneldopa is used to treat Parkinson's disease.

Co-beneldopa is a mixture of L-dopa and a drug that prevents the conversion of L-dopa into dopamine in the blood.

(a) Explain why using Co-beneldopa will be more effective than using L-dopa alone to treat Parkinson's disease.

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(b) In an investigation, tomato plants were genetically modified to convert the amino acid tyrosine into L-dopa.

Three genes were used in this investigation:

- a control gene that is not involved in the production of L-dopa
- MYB12, a plant gene that produces a transcription factor
- CYP76, a gene found in beetroot that codes for an enzyme that converts tyrosine into L-dopa.

The table shows the concentration of L-dopa in the tomato fruit from genetically modified plants.

Genes used to modify the tomato plants	Concentration of L-dopa in the tomato fruit / mg 100g ⁻¹
none	1.2
control gene	1.2
MYB12	1.5
CYP76	10.2
CYP76 and MYB12	14.6

(i) Explain the effects of these three genes in this investigation.

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(ii) Describe how tomato plants could be genetically modified to make the enzyme that converts tyrosine to L-dopa.

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(Total for question = 10 marks)

Q6.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

(a) The body length of the medicinal leech decreases when touched.



(Source: © Mit Kapevski/Shutterstock)

The body length of the leech decreases less each time the leech is touched.

(i) What is the name of this effect?

(1)

- ☐ **A** absorption
- ☐ **B** adaptation
- ☐ **C** habituation

☐ **D** sensitivity

(ii) Why is it an advantage for the leech to respond in this way?

(1)

☐ **A** it filters out what is important and what is not important to react to

☐ **B** it enables the animal to react more quickly to the stimulus

☐ **C** it keeps the habitat of the animal protected

☐ **D** it helps the animal find food more easily

(b) The photograph shows a fiddler crab.



(Source: © Jay Gao/Shutterstock)

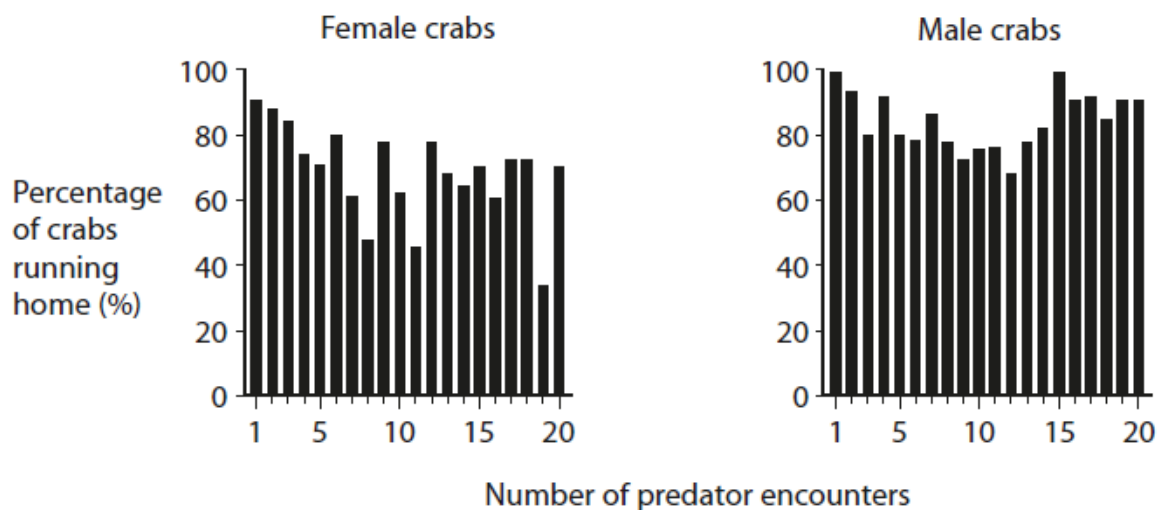
In an experiment, the fiddler crab was used to investigate responses to a predator. The responses by females and males were compared.

A predator approached a group of female crabs from one direction.

The percentage of crabs running home was recorded. This was repeated 20 times.

This experiment was repeated with a group of male crabs.

The graphs show the percentage of crabs running home for both groups of crabs against the total number of times each group of crabs encountered a predator.



(i) Comment on the results of this experiment.

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(ii) Which statistical test would be used to analyse the effect of the increase in the number of predator encounters on the percentage of crabs running home?

(1)

- ☐ **A** correlation coefficient
- ☐ **B** Hardy-Weinberg
- ☐ **C** index of diversity
- ☐ **D** Student's t-test

(Total for question = 6 marks)

Q7.

Many neurones in the human nervous system are myelinated.

(a) A myelinated axon conducts impulses faster than a non-myelinated axon of the same diameter.

Explain this difference.

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(b) Polyneuropathy is a disorder that damages the myelin sheath of neurones throughout the body.

One symptom is muscle weakness. Muscle weakness is the reduced strength in one or more muscles.

Suggest how damage to the myelin sheaths of neurones can lead to muscle weakness.

(2)

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(c) Dementia is a condition associated with the ongoing decline of brain functioning. There are many types of dementia.

The relationship between myelin in brain tissue and types of dementia has been investigated.

The mean quantity of myelin in samples of brain tissue from groups of people with types of dementia and from a control group was measured.

The table shows the results of this investigation.

Group	Mean quantity of myelin in a brain tissue sample / a.u.	Standard deviation
Control (no dementia)	52	± 3.2
Patients with vascular dementia	25	± 5.9
Patients with Alzheimer’s dementia	32	± 4.1
Patients with Lewy Body dementia	42	± 5.0

A student concluded that there was a relationship between the quantity of myelin in the brain of a person and whether or not they had dementia.

Comment on the validity of this conclusion.

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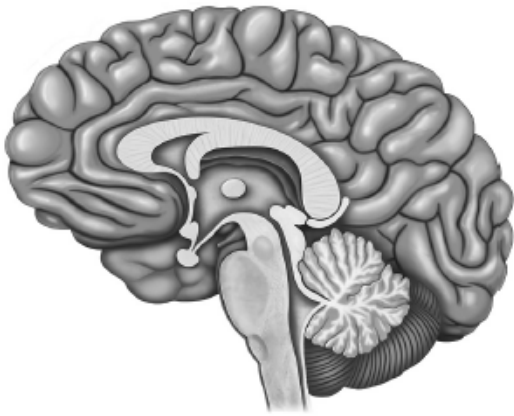
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(Total for question = 7 marks)

Q8.

The brain is made up of more than 1×10^{11} neurones.

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



(Source: © ilusmedical/Shutterstock)

Label the diagram to show the location of the following:

- pituitary gland
- medulla oblongata
- cerebral hemisphere (cerebrum)

(3)

(b) Complete the table to show the parts of the brain and their functions.

(2)

Part of the brain	Function
cerebellum	
	control of heart rate
cerebral hemisphere (cerebrum)	

(Total for question = 5 marks)

Q9.

The scientific document you have studied is adapted from articles in *StatPearls: Anatomy, Autonomic Nervous System*, *British Journal of Cardiology: Postural Orthostatic Tachycardia Syndrome (POTS)* and *Cellular and Molecular Life Sciences: The enteric nervous system in gastrointestinal disease etiology*.

Use the information from the scientific document and your own knowledge to answer the following questions.

(a) The autonomic nervous system regulates aspects of respiration (paragraph 1).

Describe how the autonomic nervous system regulates the breathing rate when a person is resting.

(4)

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(b) Explain how neurones can respond to different neurotransmitter substances (paragraph 4).

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(c) Suggest how the activity of the sympathetic nervous system in immune organs could

regulate
inflammation (paragraph 7).

(2)

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(d) Explain how an electrocardiogram could be used to show that a person has postural orthostatic tachycardia syndrome (POTS) (Box 1).

(2)

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(e) Explain how reflex circuits in the gut cause a bolus to move (paragraphs 10 and 11).

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(f) State what is meant by the term ischemia (paragraph 12).

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(g) Suggest why embryological ENS cells may fail to colonise the bowel in a developing embryo (paragraph 13).

(1)

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(h) Explain how the interaction of microbial and other factors could result in gastrointestinal inflammation such as IBD (Box 2).

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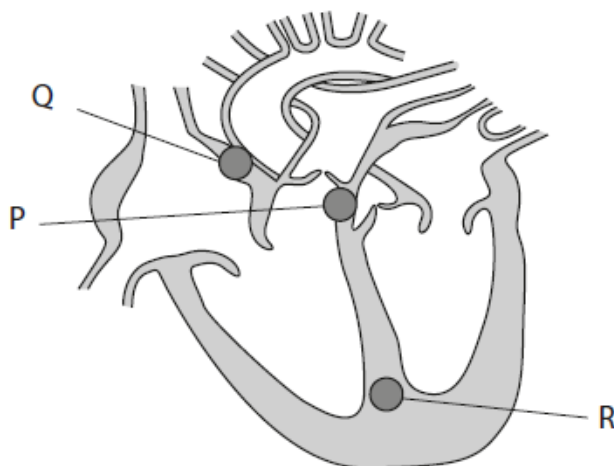
(Total for question = 20 marks)

Q10.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

In humans the sinoatrial node, atrioventricular node and bundle of His are involved in regulation and coordination of the cardiac cycle.

(a) The diagram shows a human heart.



(i) Which **one** of the following statements is correct?

(1)

- ☐ **A** Q is the sinoatrial node (SAN) and R is the atrioventricular node (AVN)
- ☐ **B** Q is the sinoatrial node (SAN) and P is the atrioventricular node (AVN)
- ☐ **C** Q is the bundle of His and R is the sinoatrial node (SAN)
- ☐ **D** R is the sinoatrial node (SAN) and P is the Purkinje fibres

(ii) The electrical impulse that initiates the cardiac cycle begins without the need for a nerve impulse.

What is the term for this process?

(1)

- ☐ **A** diastole
- ☐ **B** myogenic
- ☐ **C** polarisation
- ☐ **D** systole

(b) A football player undertook regular exercise as part of a training programme.

During exercise there is a change in the duration of the cardiac cycle.

(i) Explain why there is a change in the cardiac cycle during this exercise.

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(ii) The table shows the effect of the training programme on the cardiac output and resting heart rate of this football player.

When measurements were made	Cardiac output / cm ³ min ⁻¹	Resting heart rate / bpm
Before training	4500	72
After training	4500	51

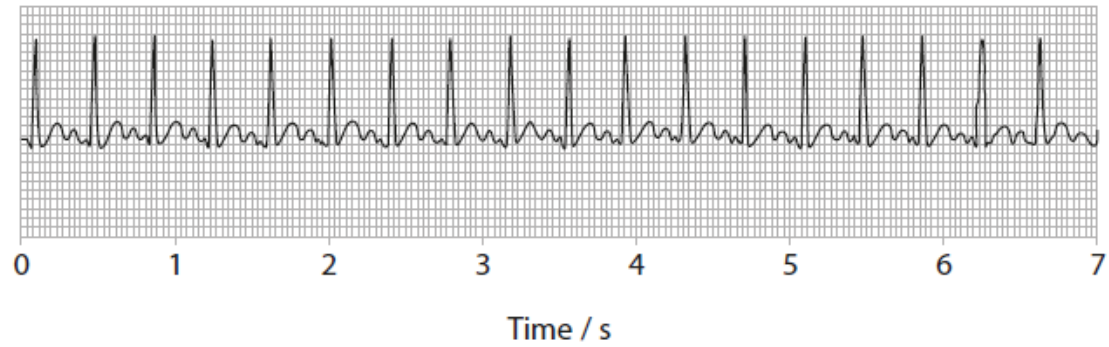
Calculate the stroke volume of this football player, after training.

(1)

Answer cm³

(iii) After training, the footballer had an ECG.

This ECG trace is shown in the diagram.

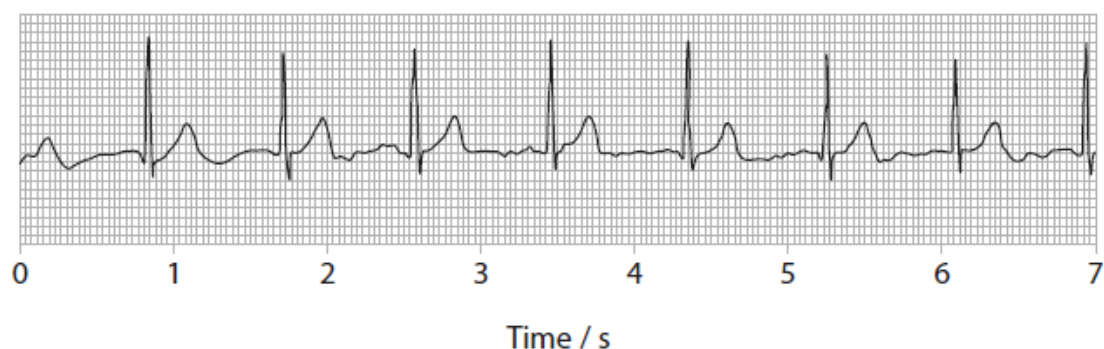


Calculate the heart rate of the footballer using the ECG in this diagram.

(1)

Answer

(iv) Two hours later a second ECG was recorded.



Comment on the changes that have occurred in the activity of the heart as shown in these two ECG traces.

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(Total for question = 10 marks)

Q11.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The nervous system enables an organism to respond to environmental stimuli.

(a) Several types of neurone are found in the nervous system.

(i) Which term describes the space between a sensory neurone and a relay neurone?

- ☐ **A** axon
- ☐ **B** cell body
- ☐ **C** postsynaptic membrane
- ☐ **D** synaptic cleft

(ii) Compare and contrast the function of a sensory neurone and a motor neurone.

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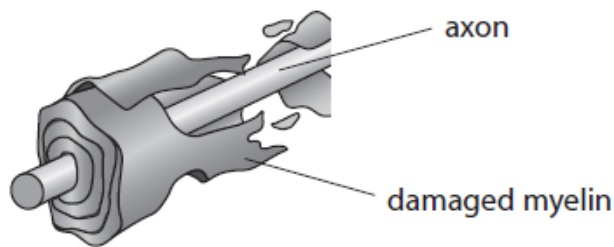
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(b) Guillain-Barré syndrome is a disorder of the nervous system.

The immune system damages the myelin sheath surrounding the axons of individuals with Guillain-Barré syndrome.



Symptoms of this disorder include:

- inability to maintain steadiness when walking
- inability to feel any sensations in the limbs
- loss of reflexes such as knee jerk.

Suggest why a person with Guillain-Barré syndrome will suffer from the symptoms of this condition.

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(c) Mutations in the genes coding for voltage-gated calcium ion channels have been linked to neurological conditions.

Explain how these mutations might cause these neurological conditions.

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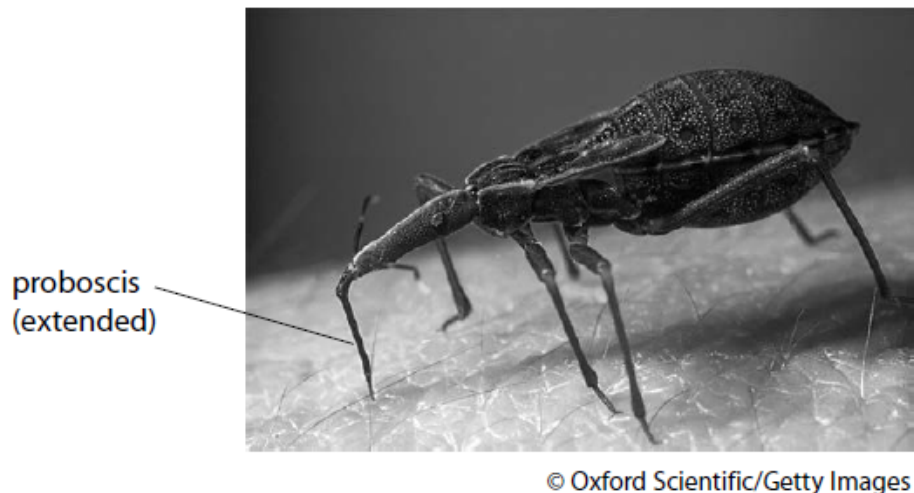
(Total for question = 11 marks)

Q12.

A number of insects can transmit disease when they bite their hosts.

The photograph shows *Rhodnius prolixus*, a blood-sucking insect that transmits Chagas disease between humans.

This insect feeds on blood by extending its proboscis and pushing it through the skin of a person. It is thought to do this when it detects body warmth.



© Oxford Scientific/Getty Images

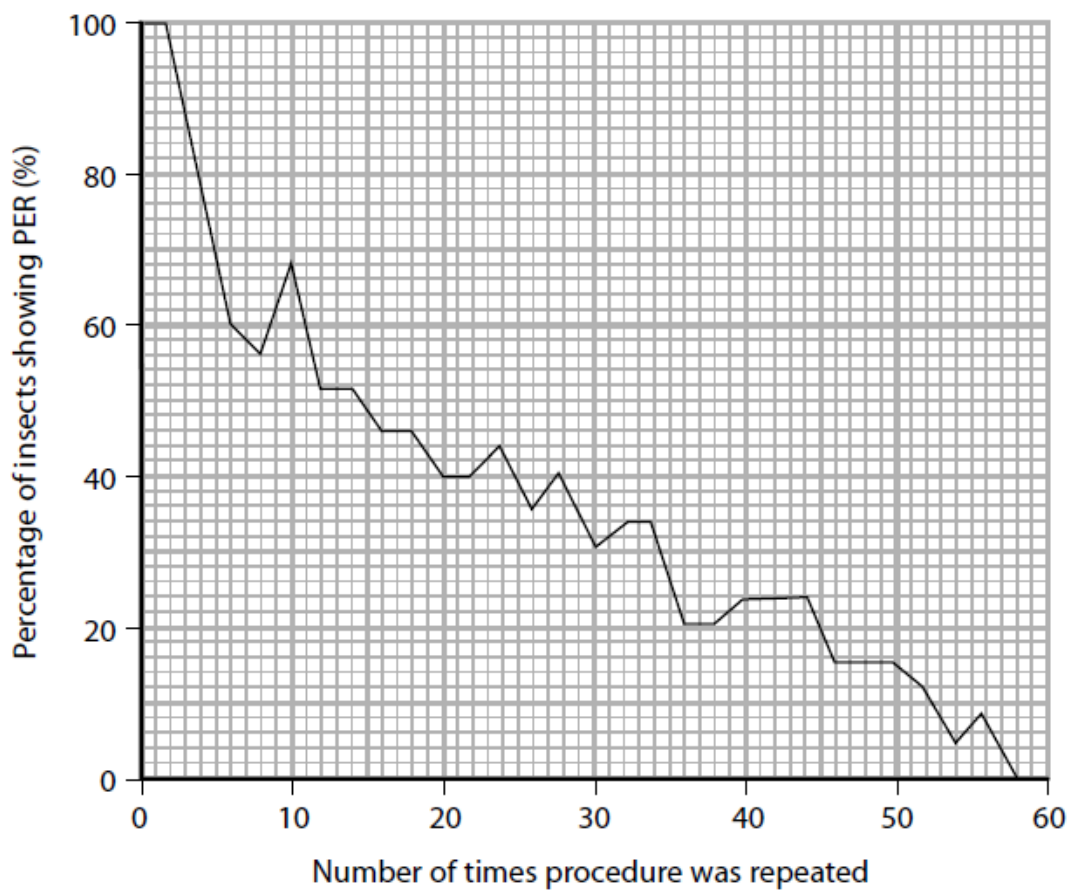
An investigation was carried out to study the effect of a heat stimulus on the proboscis extension response (PER).

Insects were kept in a temperature-controlled container with a heat pad placed in front of them. The heat pad could be touched by the proboscis when fully extended.

The heat pad was initially set at 25 °C. It was then heated up to 35 °C and the number of insects with a fully-extended proboscis were counted. It was then returned to a temperature of 25 °C.

This procedure was repeated a number of times.

The graph shows the results of this investigation.



(a) In this investigation, 350 insects were used.

Calculate the mean decrease in the number of insects showing PER each time the procedure was repeated.

(3)

Answer

(b) Explain the results of this investigation.

(3)

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(c) Suggest why a drop in PER to a heat stimulus could be an advantage to these insects.

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(Total for question = 8 marks)

Q13.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Plants respond to external stimuli.

(a) Phytochrome molecules are found in plants.

Phytochrome exists in two forms, Pr (P_{660}) and Pfr (P_{730}).

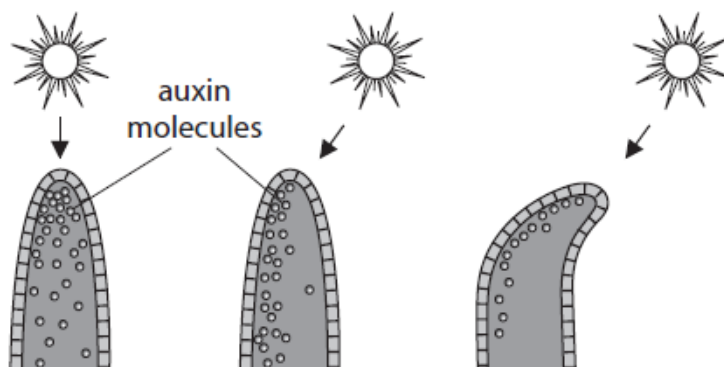
Which row shows the action of these two forms of phytochrome?

(1)

		Absorbs far red light	Breaks down in the dark
☐	A	Pfr	Pfr
☐	B	Pfr	Pr
☐	C	Pr	Pfr
☐	D	Pr	Pr

(b) Auxins (IAA) are plant growth substances.

The diagram shows auxin molecules producing a phototropic response in a shoot.



Explain the role of auxins in this phototropic response.

Use the information in the diagram to support your answer.

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(c) Seeds contain starch. This starch is used to supply energy when the seed germinates.

Gibberellins are a group of naturally occurring plant growth substances.

Gibberellins regulate starch hydrolysis in the seed.

Explain how gibberellins can produce this effect on the seed.

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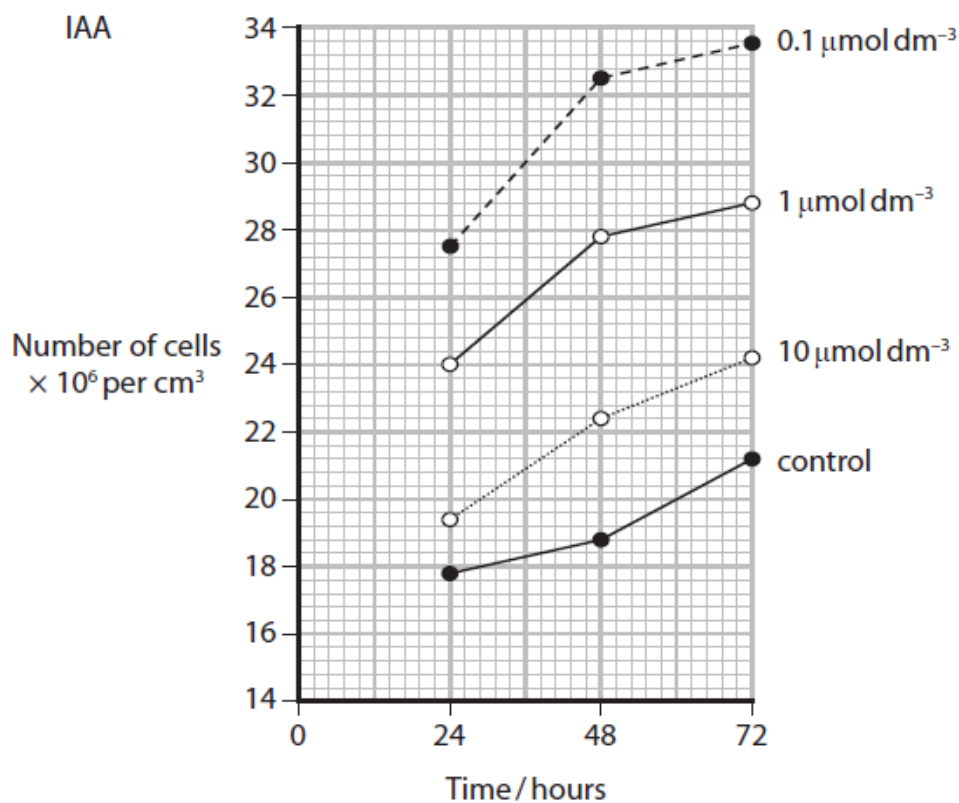
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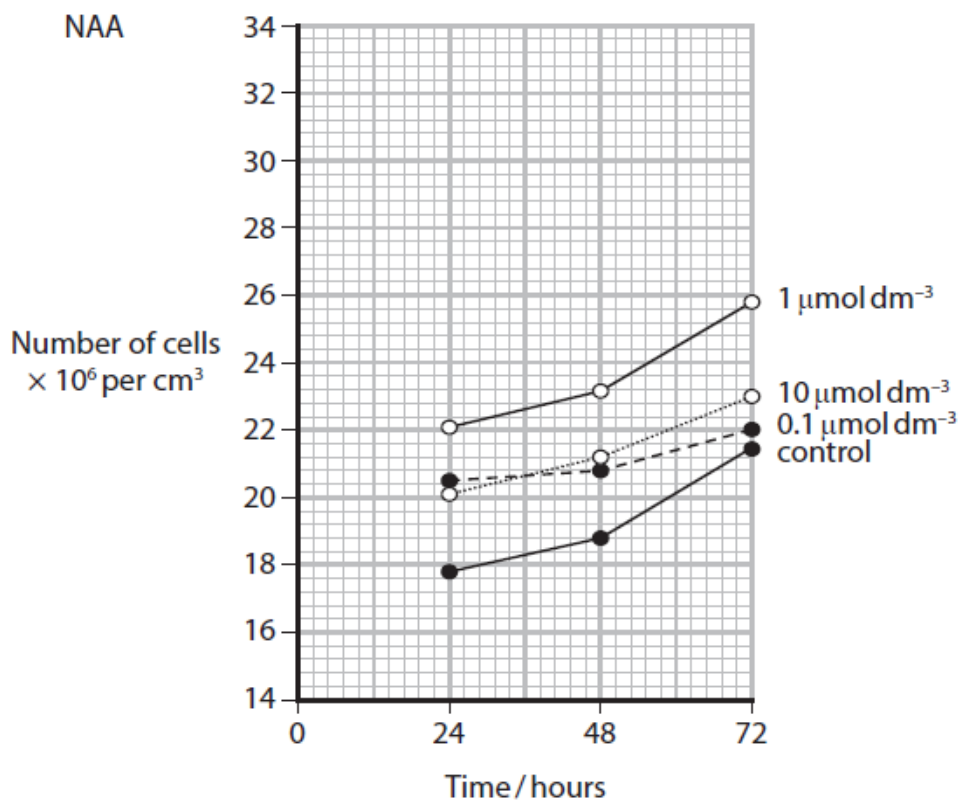
(d) Indole acetic acid (IAA) is a natural plant auxin. 1-Naphthaleneacetic acid (NAA) is a synthetic auxin.

The effects of these two auxins on the growth of *Chlorella* was investigated.

Chlorella is a single-celled photosynthetic organism.

The graphs show the effect of different concentrations of the auxins on the growth of *Chlorella*.





Comment on the effect of these auxins on the growth of *Chlorella*.

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(Total for question = 12 marks)

Q14.

Vitamin A is an essential component of the human diet.

Rice is a staple food in parts of the world where a lot of people have vitamin A deficiency.

Rice contains no β -carotene or vitamin A.

Cells in the human intestine can convert β -carotene from the diet to vitamin A.

Some soil bacteria can produce large quantities of β -carotene.

(a) Describe how genetic engineering could be used to produce rice that contains β -carotene.

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(b) (i) Describe the possible risks of growing genetically modified rice plants.

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(ii) Suggest how one of these risks could be reduced.

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(Total for question = 8 marks)

Q15.

The scientific article you have studied is adapted from *Rethinking Alzheimer's* in *New Scientist* (February 2019).

Use the information from the scientific article and your own knowledge to answer the following questions.

(a) Memory and cognitive function are two processes that occur in the brain (paragraphs 2 and 13).

Different parts of the brain are responsible for specific functions.

Complete the table showing which parts of the brain are responsible for different functions.

(2)

Part of brain	Function
cerebellum	
	interpretation of information from the retina
medulla oblongata	
	secretion of ADH

(b) Some forms of dementia can be diagnosed using brain scans.

Compare and contrast the use of functional magnetic resonance imaging (fMRI) and computed tomography (CT) scans to identify structures like plaques in the brain (paragraph 6).

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(c) Suggest how the amyloid protein may prevent bacterial infection in the brain (paragraphs 7 and 22).

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(d) Explain how the bacterium *Porphyromonas gingivalis* that causes gum disease may invade the brain and cause inflammation in brain regions affected by Alzheimer's disease (paragraphs 10, 20 and 21).

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(e) Suggest how gingipains may have a degrading effect on the memory of a person suffering from Alzheimer's disease (paragraph 12).

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(f) The team found genetic material from *P. gingivalis* in the cerebral cortex (paragraph 13).
Describe how the team could show that this genetic material is active.

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(Total for question = 20 marks)

Q16.

Animals and plants can be genetically modified.

- (a) Recombinant human erythropoietin (rHE) is a protein drug that can be given to patients with low haemoglobin concentrations.
- (i) Sheep have been genetically modified to produce rHE in their milk.

Explain how a sheep could be genetically modified to produce rHE in its milk.

(4)

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(ii) In a clinical study, 4382 patients were treated with rHE. They showed a mean increase in blood haemoglobin from 80 g dm^{-3} to 142 g dm^{-3} .

Calculate the percentage increase in the mean blood haemoglobin concentration as a result of rHE treatment.

(1)

Answer %

(iii) Some patients receiving rHE develop anti-rHE antibodies.

Describe how these antibodies may be produced.

(4)

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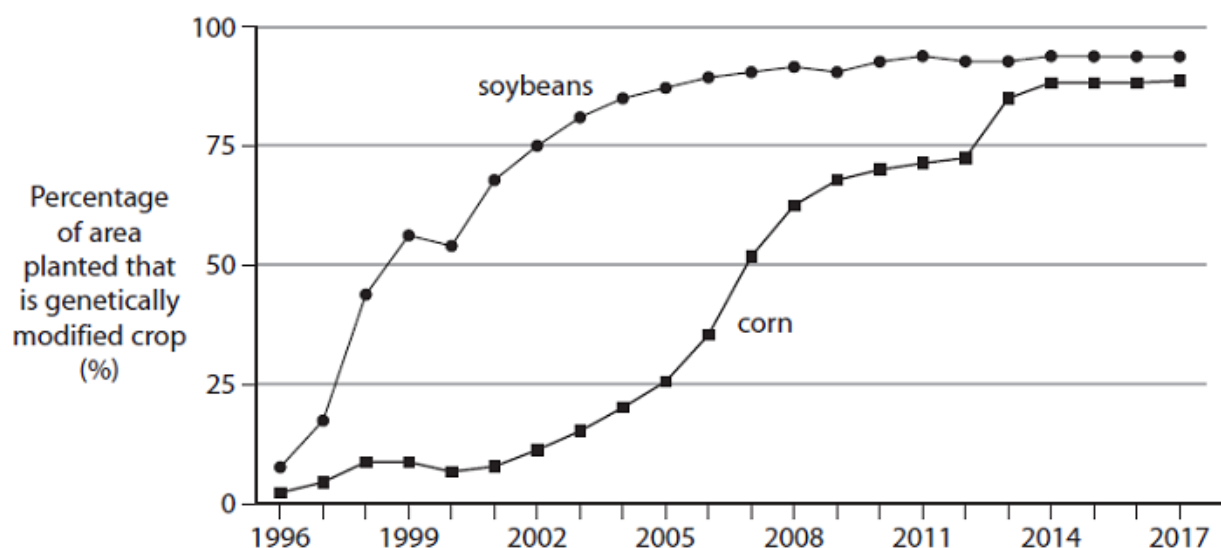
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(b) Advances in genetic engineering have allowed for precise control of the genetic changes introduced into plants.

The table describes some examples of the use of genetic modification in plants.

Trait	Plant	Details
herbicide tolerance	soybean	glycophosphate herbicide tolerance using a gene from the bacterium <i>A. tumefaciens</i>
insect resistance	corn	resistance to European corn borer using a gene from <i>B. thuringiensis</i>

The graph shows the increase in the use of genetically modified crops in the United States from 1996 to 2017.



Discuss the risks and benefits of genetic modification in valuable agricultural plants.

Use all the data and your own knowledge to support your answer.

(6)

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(Total for question = 15 marks)

Q17.

Answer the question with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Whales are large mammals.

The photograph shows a beluga whale and a human diver.



(Source: © Andrey Nekrasov/Alamy Stock Photo)

(a) (i) A beluga whale can become habituated to human divers.

How many of the following statements about habituation are correct?

(1)

- habituation is an example of anatomical adaptation
- habituation is only observed in mammals
- habituation only occurs after repeated exposure to the same stimulus

☐ **A** 0

☐ **B** 1

☐ **C** 2

☐ **D** 3

(ii) A beluga whale can respond to a stimulus using a spinal reflex arc.

Which row is correct?

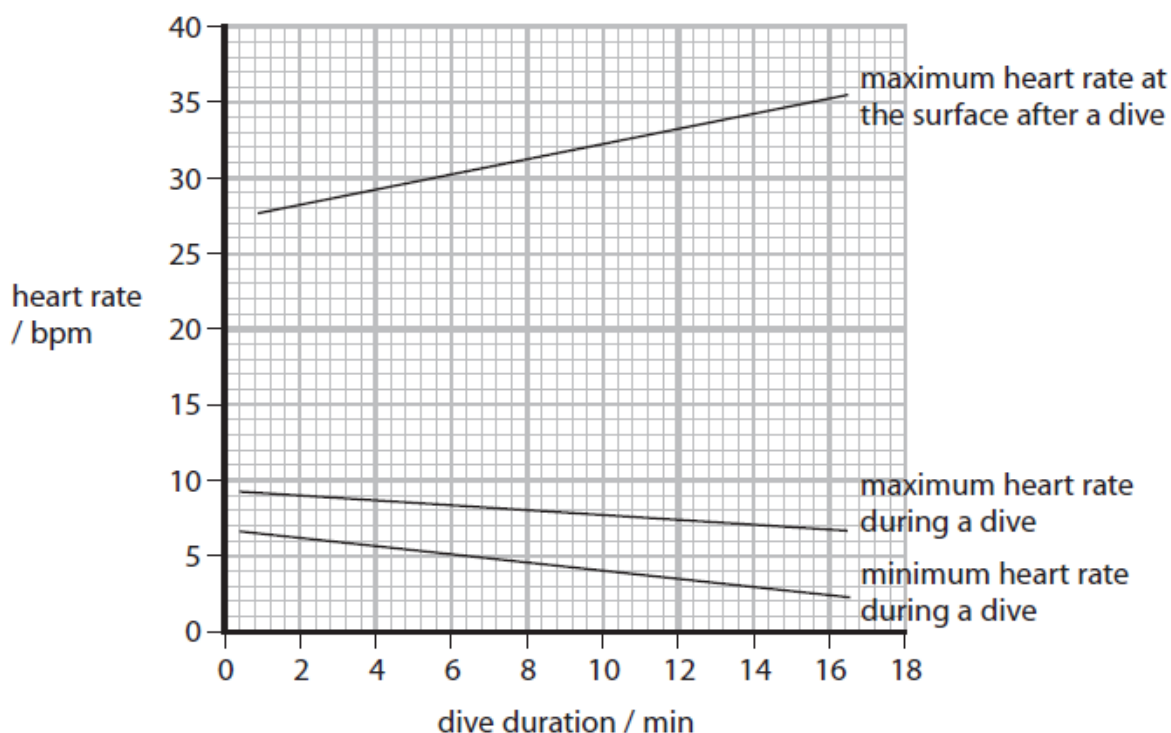
(1)

	Location of relay neurone	Location of cell body on the sensory neurone
☐ A	grey matter of spinal cord	at the end of the axon
☐ B	grey matter of spinal cord	in the middle of the axon
☐ C	white matter of spinal cord	at the end of the axon
☐ D	white matter of spinal cord	in the middle of the axon

(b) The heart rate of a whale changes when it is diving.

The graph shows the changes in heart rate that occur during dives of different durations.

The maximum heart rate at the surface is when the whale returns to the surface after a dive.



(i) Comment on the changes in heart rate of the whale when diving.

(3)

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(ii) Explain how the changes in heart rate are controlled when the whale returns to the surface immediately after the dive.

(3)

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(Total for question = 8 marks)

Q18.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

Chemicals are used to regulate responses in both plants and animals.

(a) In mammals antidiuretic hormone (ADH) is involved in regulating plasma concentration and blood volume.

(i) Which of the following produces ADH?

(1)

- ☐ **A** adrenal gland
- ☐ **B** hypothalamus
- ☐ **C** medulla oblongata
- ☐ **D** pituitary gland

(ii) Which structures does ADH act on?

(1)

- ☐ **A** capillaries
- ☐ **B** collecting ducts
- ☐ **C** proximal tubules

☐ **D** ureters

(iii) The control of plasma concentration and blood volume in the body is an example of which type of process?

(1)

☐ **A** countercurrent multiplier

☐ **B** habituation

☐ **C** negative feedback

☐ **D** positive feedback

(iv) Name the type of receptor in the body that detects changes in the plasma concentration.

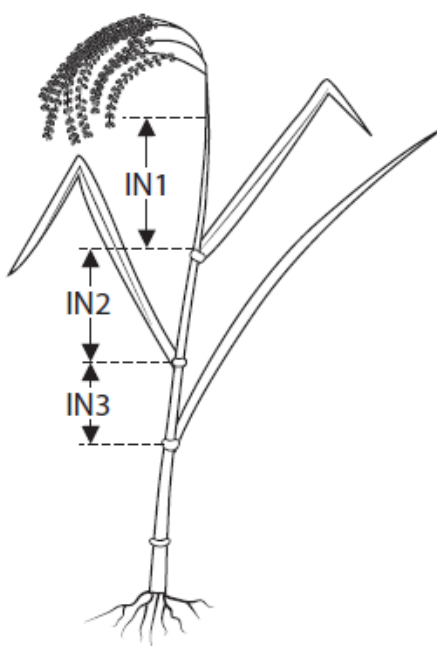
(1)

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(b) The effect of a gibberellin on the growth of cereal plants was investigated.

Different concentrations of the gibberellin were sprayed on cereal plants.

The lengths of the first, second and third internodes (IN1, IN2, IN3) were measured, as shown in the diagram.



The table shows the effect of the gibberellin on the mean lengths of the first, second and third internodes.

Concentration of the gibberellin / ppm	Mean length / cm		
	first internode	second internode	third internode
0	36	19	14
10	36	19	14
100	41	21	14
1000	52	22	15
2500	56	22	15

(i) Comment on the effect of the gibberellin on the growth of cereal plants.

(2)

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(ii) Suggest how the gibberellin causes this effect.

(3)

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(Total for question = 9 marks)

Q19.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

The mammalian retina is a tissue that detects light.

(a) Rod cells and bipolar neurones are cell types found in the retina.

(i) What is the name of the chemical formed when light is absorbed by the photopigment found in rod cells?

(1)

- ☐ **A** cis-retinal
- ☐ **B** phytochrome
- ☐ **C** rhodopsin
- ☐ **D** trans-retinal

(ii) Which row in the table shows the effects of light absorption on cells in the retina?

(1)

	Rod cell	Bipolar neurone
☐ A	hyperpolarised	hyperpolarised
☐ B	hyperpolarised	depolarised
☐ C	depolarised	hyperpolarised
☐ D	depolarised	depolarised

(b) An investigation studied the effects of light intensity on the mammalian retina.

Samples of retina were exposed to different light intensities and the mean potential difference of the bipolar neurones was recorded.

The results are shown in the table.

Light intensity /a.u.	Mean potential difference /mV
2	11
4	17
8	19
12	20
16	20
20	20

(i) Describe the effect of light intensity on the mean potential difference of bipolar neurones.

(2)

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(ii) Calculate the percentage change in the mean potential difference when the light intensity increases from 4 to 12 a.u.

(2)

Answer

(iii) Give **two** reasons why some people might have objections to the use of mammalian retinas in this investigation.

(2)

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(c) Which statement describes the response of the muscles in the iris to increasing light

intensity?

(1)

- ☐ **A** circular and radial muscles contract
- ☐ **B** circular and radial muscles relax
- ☐ **C** circular muscles contract and radial muscles relax
- ☐ **D** circular muscles relax and radial muscles contract

(Total for question = 9 marks)

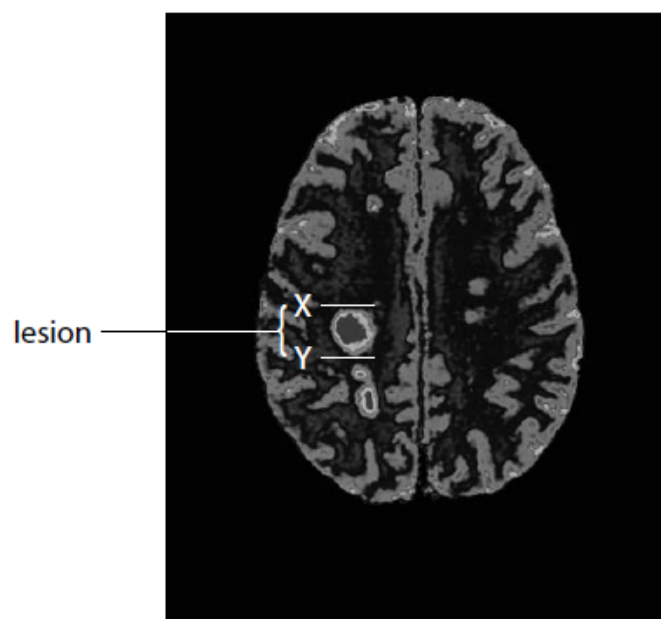
Q20.

Multiple sclerosis (MS) is a disease that causes the destruction of the myelin sheaths around neurones.

This destruction is caused by the person's own immune system.

Lesions form in the brain where myelin is destroyed.

(a) The photograph shows lesions in the brain of a person with MS, as seen using magnetic resonance imaging (MRI).



© M210/0087 SGI/Science Photo Library

The actual length of this brain is 15 cm.

Calculate the actual diameter, in mm, of the lesion between X and Y.

Answer mm

(b) The table shows the speed of conduction of an impulse along non-myelinated and myelinated neurones with axons of different diameters.

Type of neurone	Diameter of axon / μm	Speed of conduction of impulse / m s^{-1}
non-myelinated	1	2.3
non-myelinated	2	3.1
non-myelinated	4	4.2
myelinated	1	2.6
myelinated	2	8.5

(i) Show that the effect of diameter on the speed of conduction of an impulse is six times greater in a myelinated neurone than in a non-myelinated neurone.

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(ii) Explain the effect of the myelin sheath and the diameter of the axon on the speed of conduction of an impulse.

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(iii) Symptoms of MS can include blindness in one eye and lack of coordination.

Suggest why a person with MS could have these symptoms.

(3)

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(Total for question = 11 marks)

Q21.

The scientific document you have studied is adapted from an article in nature.com:
Microgravity elicits reproducible alterations in cytoskeletal and metabolic gene and protein expression in space-flown Caenorhabditis elegans.

Use the information from the scientific document and your own knowledge to answer the following questions.

(a) Suggest why the authors of this article have named the species of nematode used in this study (paragraph 2).

(1)

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(b) State **one** ethical issue of using nematodes in this study.

(1)

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(c) Describe how microgravity can cause changes in gene expression in these nematodes (paragraph 4).

(3)

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(d) Suggest why there was a lower fat accumulation and shorter body length in nematodes grown in microgravity (paragraph 4).

(3)

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(e) Explain why there were reduced levels of a number of metabolic proteins in nematodes grown in microgravity (paragraph 6).

(4)

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(f) Explain why microarrays could be used to show that mitochondrial electron transport genes are downregulated, whereas the sirtuin gene was upregulated (paragraph 7).

(3)

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(g) Explain why Sudan Black was used in this study (paragraph 8).

(2)

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(h) Comment on the reliability of the data presented in Table 1 (paragraph 9).

(3)

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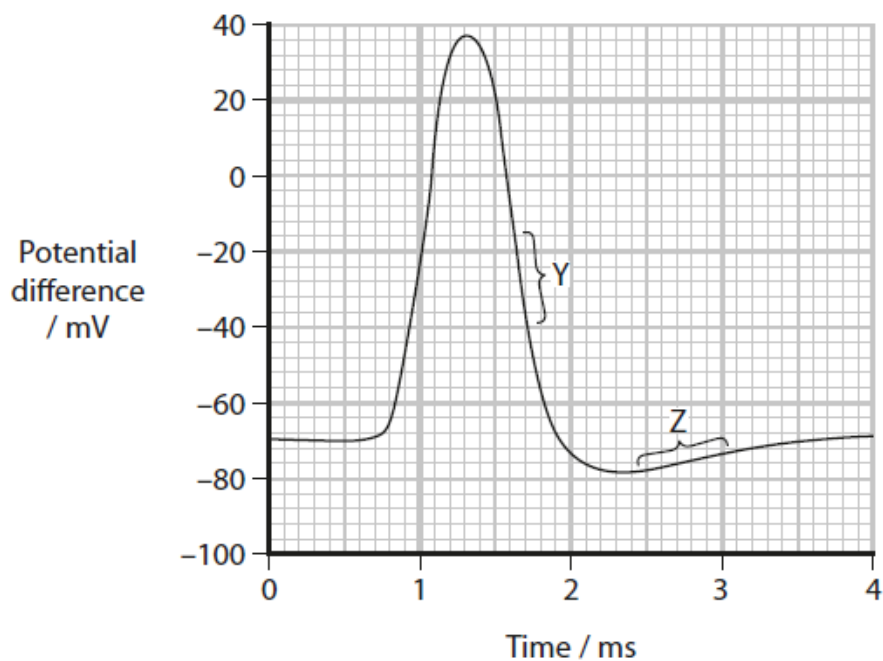
(Total for question = 20 marks)

Q22.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Nerve impulses travel along axons as action potentials.

(a) The graph shows an oscilloscope trace for an action potential in an axon.



(i) Which is the resting potential for this axon?

(1)

- ☐ **A** -70 mV
- ☐ **B** -78 mV
- ☐ **C** 38 mV
- ☐ **D** 108 mV

(ii) Both voltage-gated sodium and voltage-gated potassium ion channels are involved in generating an action potential.

Which of these voltage-gated channels are open at Y?

(1)

- ☐ **A** no voltage-gated ion channels are open
- ☐ **B** voltage-gated sodium ion channels only
- ☐ **C** voltage-gated potassium ion channels only
- ☐ **D** both sodium and potassium voltage-gated ion channels

(iii) Which is the state of polarisation of the membrane at Z?

(1)

- ☐ **A** depolarised
- ☐ **B** hyperpolarised
- ☐ **C** hypopolarised
- ☐ **D** unpolarised

(iv) How many of the following statements are correct?

- the magnitude of the action potential is proportional to the strength of stimulus that generates the action potential
- action potentials spread out in both directions along the axon
- following an action potential, there is a refractory period during which it is not possible to generate a new action potential

(1)

☐ **A** none

☐ **B** one

☐ **C** two

☐ **D** three

(b) Explain why maintaining a resting potential requires ATP.

(3)

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(Total for question = 7 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark										
(a)(i)	An answer that includes the following points <table><tr><th>Label</th><th>Part</th></tr><tr><td>L</td><td>dendrites</td></tr><tr><td>M</td><td>cell body / centron</td></tr><tr><td>N</td><td>axon</td></tr><tr><td>O</td><td>{pre}synaptic {endings /knob/bulb}</td></tr></table>	Label	Part	L	dendrites	M	cell body / centron	N	axon	O	{pre}synaptic {endings /knob/bulb}	all correct 2 marks 1 or 2 or 3 correct 1 mark 0 correct 0 marks accept dendrite / dendron accept axon terminal do not accept synapse(s)	Graduate (2)
Label	Part												
L	dendrites												
M	cell body / centron												
N	axon												
O	{pre}synaptic {endings /knob/bulb}												

Question number	Answer	Additional guidance	Mark
(a)(ii)	D is the correct answer - A in not correct because lidocaine inhibits sodium ion channels - B in not correct because lidocaine inhibiting sodium ion channels - C in not correct because lidocaine inhibiting sodium ion channels		Computer (1)

Question number	Answer	Additional guidance	Mark
(b)(i)	(scanning) electron (microscope) /sem / em (1)	Do not accept electric / electrical /electronic Do not accept transmission electron microscope / tem Do not accept microgram	Graduate (1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A calculation showing the following steps - correct measurement of X-Y in μm (1) - calculation of thickness of connecting tissue (1) OR - calculation of thickness (1) - conversion to μm (1)	11 000 μm $(11\ 000 \div 3300) = 3.3 / 3.33 / 3.333 / 3\ \mu\text{m}$ 1 mark for power of 10 errors e.g. 0.33 or 0.0033 or 333 $(11 \div 3300) = 0.00333$ $(1.1 \div 3300) = 0.0333$ $(0.00333) \times 1000 = 3.3 / 3.33 / 3.333 / 3\ \mu\text{m}$ 1 mark for power of 10 errors e.g. 0.33 or 0.0033 or 333 No ECF	Expert (2)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An explanation that includes three of the following points • myelin (sheath) acts as an insulator (1) • gaps (in myelin sheath) are called nodes of Ranvier /nodes of Ranvier have higher number of (voltage gated) sodium channels (1) • {action potentials/depolarization} can only occur at nodes on Ranvier (in myelinated neurones)(1) • (therefore) impulse jumps from one node of Ranvier to the next(1)	accept {action potentials / depolarization} occur along the whole unmyelinated	Expert (3)

Q2.

Question number	Answer	Additional guidance	Mark
(a)	A calculation showing the following steps: • determination of tidal volume (1) • calculation of volume of air in 1 min (1) • calculation of volume of air in one hour (1)	$(500-150) = 350$ $350 \times 12 = 4.2 \text{ (dm}^3 \text{ min}^{-1}\text{)}$ Accept $4200 \text{ (cm}^3 \text{ min}^{-1}\text{)}$ $(4.2 \times 60) = 250 \text{ dm}^3 \text{ hour}^{-1}$ Accept $(4200 \times 60) = 250000 \text{ cm}^3 \text{ (hour}^{-1}\text{)}$ max 2 marks if no units / or incorrect units accept answer in standard form 2.5×10^5	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	An answer that includes the following point: • (cardiac) diastole (1)		(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	• 100	accept 1.67 beats per second accept range 100 - 125	(1)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An answer that includes three of the following points: Similarity - both traces have the same {PQRST/ described} wave (1) - R wave of similar height (1) Differences - normal ecg shows a lower heart rate (1) - in the patient trace the gap between T & P is shorter (1)	both show clear PQRST wave accept converse accept converse	(3)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes four of the following points: {identification / isolation} of (corrected) AAT gene (1) - description of one enzyme used to insert gene (1) - adenoviruses can enter host cell (1) - and combine their own genetic material with that of the cell (1) - therefore a functional AAT protein can be produced (1)	E.g. cut the adenovirus DNA using the same restriction endonuclease / insert the gene into the adenovirus DNA using DNA ligase adenovirus acts as a vector	(4)

Q3.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following points C is the correct answer - A is not the correct answer as the iris does not have rod cells - B is not the correct answer as the pupil does not have rod cells - D A is not the correct answer as the spinal cord does not have rod cells		(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	A description that includes three of the following points: - rhodopsin is the {photoreceptor / photosensitive pigment} (1) - when light absorbed cis retinal (+ opsin) is converted to trans retinal (+ opsin) (1) - causes sodium channels to close (1) - membrane becomes hyperpolarised (1)	accept absorbs light accept Na⁺ gated channels blocked	(3)

Question number	Answer	Additional guidance	Mark
(b)	An answer that includes the following points: Indicative content – description from experimental data experiment 2 shows that substance responsible for phototropism passes through gel but not plastic experiment 1 shows that cause of phototropism is chemical in nature and is produced in the tip experiment 3 chemical substance can diffuse and cause curvature even in the dark Chemical nature of responses phototropism caused by auxins receptor proteins (phototropins) activate several hormones including auxin Auxin transported down dark side and less on bright side Auxin stimulates elongation on shaded side to give curvature		(6)

	Detailed mechanism of responses Auxin stimulates decrease in cell pH which activates enzymes responsible for cell growth and elongation Auxin affects hydrogen ion pumps (proton pumps) Auxin causes intracellular reserves of hydrogen ions to increase which lowers the pH on dark side lower pH activate enzymes these disrupt hydrogen cross links in cell wall increased osmotic gradient due to movement of solutes water enters cell (and increased turgor pressure) leads to swelling of cell Level 1: Discuss some of the results from experimental data. Level 2: Discuss all of level 1 plus reference to specific chemical nature of phototropism Level 3: Discuss all of level 2 plus detailed mechanism for phototropism at molecular level		
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Question number	Answer	Additional guidance	Mark
(a)(i)	An explanation that includes four of the following points: • circular muscles contract and radial muscles relax (1) • circular muscles arrange in concentric rings around pupil and radial muscles run radially (1) • pupil reflex is the reflex contraction and relaxation of the antagonistic muscles of the iris (1) • therefore pupil becomes smaller so less light enters the eye. (1)	ignore reference to photoreceptors accept diagram	(3)

Question number	Answer	Additional guidance	Mark
(a)(ii)	A description that includes three of the following points: • (rhodopsin) absorbs light (1) • (rhodopsin) splits into opsin and retinal (1) • sodium ions are not taken up (1) • causing hyperpolarisation (1)		(4)

Question number	Answer	Mark
(b)	Indicative content Description of named responses • Many different photoresponses that affect the growth and development of plants. • Light triggering key events in a plant's growth and development – photomorphogenesis. • Photoperiodisms – a physiological response to photoperiods eg seed germination.	(6)

	Chemical nature of responses Photoreceptor receive light, reacts to it and initiates a response. Phytochromes regulate many other responses to light eg seed germination. • Seeds need sunlight to grow. Far-red light makes plants think they are not getting sunlight. As a result, too much far-red on your seedlings may prevent germination altogether. • There are two forms of phytochrome. These are Pr and Pfr. These two pigments differ in their absorption peak. • Phytochrome red (Pr): It absorbs maximum light in the red region of the spectrum. It has wavelength of 660p. Pr is the inactive form. • 2. Phytochrome far red (Pfr): It has the absorption peak in the far-red region at 730 p. Only Pfr phytochrome is physiologically active. • Metabolic activity and mitosis in embryos are stimulated by red light and inhibited by far-red light in light-sensitive seeds. • plants also use light as a source of information, allowing for the adjustment of <u>growth and development</u> in response to changing environmental conditions. This process, termed <u>photomorphogenesis</u>, is regulated by a suite of photoreceptors	
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	Detailed mechanism of responses • Photoreceptor receive light, reacts to it and initiates a response • Phytochrome red (Pr): It absorbs maximum light in the red region of the spectrum. It has wavelength of 660nm. Pr is the inactive form. Phytochrome far red (Pfr): It has the absorption peak in the far-red region at 730 nm. Only Pfr phytochrome is physiologically active. • Phytochrome has two identical subunits. The chromophore of the phytochrome is photoreversible between the two isomers depending on the wavelength of light. • Subcellular circadian rhythms include cycles in gene regulation (at the levels of transcription, transcript abundance, translation, and post-translational modification). • Germination stimulated by the hormone gibberellin. • Phytochrome red stimulates transcription. • Leads to production of enzymes that metabolise active forms of gibberellins. Level 1: Description of (a minimum of 2 specific) results from experimental data. eg. more exposure to far red light at all red light times reduces percentage germination. Less exposure to far red light increases percentage of germination in general. Level 2: Reference to specific chemical nature of the effect of red light and far red light on germination. Level 3: Detailed mechanism for at least 1 photo-response at a sub-cellular level eg. Effect on transcription.	
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Q5.

Question number	Answer	Additional guidance	Mark
(a)	An explanation that includes three of the following points: - dopamine cannot cross the blood brain barrier (1) - this drug ensures more L-dopa {is present in blood /can cross the brain barrier / reaches the brain} (1) - resulting in (a greater) increase in dopamine levels in the brain (1) - statement about why increased dopamine would help treat Parkinson's (1)	ACCEPT larger ignore large ACCEPT L-dopa (only) converted to dopamine in the brain e.g. transmission of electrical impulses to post synaptic neurones / increase in motor responses	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	An explanation that includes the following points: {control gene / genetic engineering process} has no effect (on L-dopa synthesis) (1) - MYB12 gene has {little / no} effect on L-dopa synthesis (1) - The CYP76 gene causes a {big/ 9mg} increase in concentration of L-dopa (because it codes for a protein involved in the production of L-dopa) (1) - combination of MYB12 and CYP76 produce largest concentration of L-dopa because {MYB12/ the transcription factor} increases production of CYP76 protein (1)	ACCEPT it increases it by 1.25 times/eq ACCEPT CYP76 gene gives {most / more / larger} L-dopa when used individually NOTE if they state CYP76>MYB12>control then award mp3	(4)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A description that includes the following points: • {the gene / CYP76} that converts tyrosine to L dopa is {extracted / isolated} (1) • use of same {endonuclease / restriction enzyme} to cut genetic material of plasmid (and isolated gene) (1) • method of insertion of vector into a {tomato/host} cell (1)	ACCEPT {isolate / extract / cut out / synthesise} the gene ACCEPT description of method of insertion e.g. use of {gene gun /heat shock/ liposomes / CRISPR} e.g. infect using {non-lytic virus / Agrobacterium tumefaciens}	(3)

Q6.

Question number	Answer	Additional guidance	Mark
(a)(i)	Choose an item. C is the correct answer as habituation is a long term physical change D is not the correct answer as sensitisation is a learning process resulting in amplification of a response B is not the correct answer as absorption relates to fluid movement A is not the correct answer as adaptation is a change in behaviour		(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	Choose an item. A is the correct answer B is not the correct answer C is not the correct answer D is not the correct answer		(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	An answer that includes three of the following points: - male and female crabs respond differently to the predator(1) - female crabs showed greater habituation than male crabs(1) - after 10 exposures there seems to be variability in the data(1)		(3)

Question number	Answer	Additional guidance	Mark
(b)(ii)	Choose an item. A is the correct answer because correlation being tested. B is not the correct answer as Hardy-Weinberg does not test a correlation. C is not the correct answer as index of diversity does not test a correlation D is not the correct answer as Student t test does not test a correlation		(1)

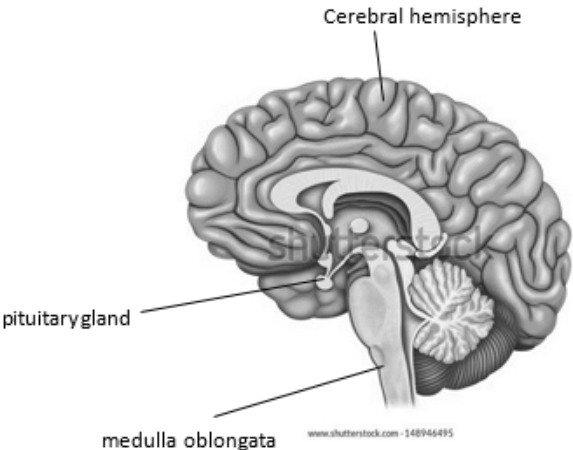
Q7.

Question number	Answer	Additional guidance	Mark
(a)	An explanation that includes three of the following points: - the myelin sheath is an (electrical) insulator - therefore the action potential only occurs at nodes of Ranvier (1) - and therefore the nerve impulse 'jumps' from one node to the next / reference to saltatory conduction (1)	Accept The influx of sodium ions at one node creates enough depolarization to reach the threshold of the next.	(3)

Question number	Answer	Additional guidance	Mark
(b)	An answer that includes two of the following points: - when the myelin sheath is destroyed transmission of the nerve impulse is impaired (1) - fewer nerve impulses reach the muscle (1) - fewer muscle fibres are stimulated to contract which leads to muscle weakness (1)	Accept suggestion impulse is slower as myelin destroyed	(2)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes two of the following points: - all types of dementia have a lower level of myelin than the control group - there is no relationship between the amount of myelin in the brain and the type of dementia - no overlap in any of the standard deviation for any type of dementia and control which suggests that the conclusions may be valid (1)	Accept converse if correct figures used	(2)

Q8.

Question number	Answer	Additional guidance	Mark
(a)	- correctly labelled pituitary gland (1) - correctly labelled medulla oblongata (1) - correctly labelled cerebral hemisphere / cerebrum (1)	 do not accept two lines from a label do not accept cerebellum label	(3)

Question number	Answer		Additional guidance	Mark
(b)	Part of the brain	Function	2 marks maximum	
	cerebellum	(coordination of voluntary) movements	ACCEPT posture, balance and speech ignore co-ordination unqualified	
	medulla oblongata	control of heartbeat and breathing	ACCEPT pons / medulla	
	cerebral hemisphere (cerebrum)	(control of) voluntary behaviour / site of intelligence	ACCEPT memory / learning / thinking/ emotions / imagination / voluntary response/ motor skills (only if they refer to cerebral cortex)	
			all 3 spaces correct = 2 marks 2 spaces correct = 1 mark 1 space correct = 0 mark	(2)

Q9.

Question number	Answer	Additional guidance	Mark
(a)	A description that includes four of the following points: • Chemoreceptors detect {pH of blood / blood CO₂ concentration} (1) • send (fewer) impulses to the {respiratory centre / ventilation centre / medulla} (1) • decreased frequency of impulses to {intercostal muscles/diaphragm} (1) • allowing (breathing muscles) to {relax / contract less frequently} (1) • rate set by the {respiratory centre / ventilation centre / medulla / pons} (1) OR • As air enters the lungs, stretch receptors in the lungs are activated (1) • Send impulses to inhibit inspiratory centre (1)	Do not accept message / signal ACCEPT impulses sent via parasympathetic nervous system	(4)
	• (resulting in) {no/fewer} impulses to {intercostal muscles/diaphragm} (1) • allowing (breathing muscles) to {relax / contract less frequently} (1) • rate set by the {inspiratory centre / expiratory centre / medulla / pons} (1)	ignore ventilation centre	

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes three of the following points: - receptors on post-synaptic membrane (1) (receptors) have (different) three-dimensional shapes/ are specific for (different) neurotransmitters (1) - description of response once the neurotransmitter has bound to the receptor (1)	ACCEPT {ion channel / gates} on post-synaptic membrane ACCEPT (receptors have) complementary shape to specific neurotransmitter e.g. opening of sodium channels / causing an action potential / depolarising membrane / inhibitory neurotransmitter prevents {depolarisation / action potential}	(3)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes two of the following points: - release neurotransmitters (1) - that act on white blood cells / (stimulate) {spleen/thymus/lymph nodes} (1) - to {release (more/ less) cytokines / release white blood cells into blood / recruit white blood cells from blood} (1)	ACCEPT release of named neurotransmitter e.g. noradrenaline / adrenaline / epinephrine / acetylcholine ignore release of chemicals ACCEPT release (more/ less) of named chemical e.g. histamine	(2)

Question number	Answer	Additional guidance	Mark
(d)	An explanation that includes the following points: - record ECG before and (for 10 minutes) after changing {posture / position} (1) - count the number of a named peaks in one minute (1) - description of how POTS is identified (1)	ACCEPT calculate heart rate e.g. {heart rate / peaks per minute} will increase by 30 bpm / heart rate will be above 120 bpm (within 10 minutes of posture change)	(2)

Question number	Answer	Additional guidance	Mark
(e)	An explanation that includes four of the following points: - bolus acts as a stimulus/ receptor detects bolus (1) - motor neurone transmits (electrical) impulse to (smooth) muscle (1) - detail of how nerve impulse stimulates muscle contraction (1) - therefore {circular muscle contracts / longitudinal muscles relax} {around/above} bolus (1) - therefore {circular muscle relax / longitudinal muscles constrict} in {front/below} of bolus (1)	ACCEPT description of food stretching gut wall ACCEPT release of neurotransmitter ACCEPT {circular muscle contracts / longitudinal muscles relax} in {propulsive / proximal} segment ACCEPT {circular muscle relax / longitudinal muscles constrict} in receiving segment	(4)

Question number	Answer	Additional guidance	Mark
(f)	inadequate blood supply to a {tissue / organ} (1)	ACCEPT a named organ e.g. heart ACCEPT {inadequate / decreased / no} blood supply	(1)

Question number	Answer	Additional guidance	Mark
(g)	An answer that includes one of the following points: • mutation (in gene expressed by embryological ENS) (1) • (embryological ENS) do not have surface {antigens/ receptors} that allow them to locate to bowel (1)	ACCEPT so embryological ENS do not differentiate (into working neurones) ACCEPT conditions in the bowel may not be suitable for the growth of the embryonic cells	(1)

Question number	Answer	Additional guidance	Mark
(h)	An explanation that includes three of the following points: • environmental factor changes conditions in the gut / causes a change in the gut flora (1) • therefore microbial {chemicals/toxins} released (1) • (chemicals / toxins / microbes) stimulate an {inflammatory response / immune response} (1) • explanation of how the inflammatory response occurs (1)	ACCEPT new microorganism / pathogen / microbe / bacteria ACCEPT release of {histamine / cytokines} e.g effect of histamine such as vasodilation / oedema occurs / recruitment of inflammatory cells / recruitment of white blood cells	(3)

Q10.

Question number	Answer	Additional guidance	Mark
(a)(i)	Choose an item. B Q is the SAN and P is the AVN A is not correct because R is not the AVN C is not correct because Q is not the bundle of His D is not correct because P is not the Purkinje fibres		(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	Choose an item. B myogenic A is not correct because diastole is when the heart muscle relaxes C is not correct because polarisation is where there is a difference in electrical charge between inside and outside of a cell D is not correct because systole is when the heart muscle contracts		(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	A explanation that includes the following points: - cardiovascular control centre detects a drop in pH of blood (or increased CO₂) - therefore SAN (stimulated) to generate more impulses per second - therefore the cardiac cycle is shorter	Accept reference to carotid / aortic bodies	(3)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A calculation showing the following step: Correct calculation of stroke volume	(4500/51) 88.24 Accept 88.2	(1)

Question number	Answer	Additional guidance	Mark
(b)(iii)	A calculation showing the following steps: correct calculation of heart beat in unit time. (1)	Eg 18 beats in 7 seconds $60/7 \times 18 = 154.3 = 154$ Do not accept fraction of heart rate.	(1)

Question number	Answer	Additional guidance	Mark
(b)(iv)	An answer that includes three of the following points: - comment on the wave pattern of the two traces (1) - comment on the frequency of heart rate in the two traces(1) - comment on the size of the R wave (1) - comment on the ST segment of the wave (1)	For each mark there must be a clear comparison between the two ecgs. Eg more normal (PQRST) wave pattern in second trace Accept wave pattern is different Eg less heart beats in second trace Accept reference to correct figures Eg R wave higher in first trace Eg no clear S segment in first trace	(3)

Q11.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following point: - D is the correct answer - A is not the correct answer as an axon is not the space between sensory and relay neurone - B is not the correct answer as a cell body is not the space between sensory and relay neurone - C is not the correct answer as a post synaptic membrane is not the space between sensory and relay neurone		(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An answer that includes three of the following points: Similarities • both transmit (electrical) impulses (1) • both may synapse with relay neurones (1) Differences • sensory neurone impulses go towards the {CNS/relay neurone} whereas motor neurone impulses go away from {CNS/relay neurone} (1) • sensory neurones transmit impulses from {receptor /sensory} cells whereas motor neurone transmit impulses to {effector/muscle} cells (1)	do not piece together – has to be in same / adjacent sentences (but not separate paragraphs) do not accept messages / signals for S1, D1 and D2 ACCEPT both release neurotransmitters (in synapse) ignore brain Note: sensory sends impulses from receptor to CNS and motor brings impulse from CNS to effector = both D1 and D2	(3)

Question number	Answer	Additional guidance	Mark
(b)	An answer that includes three of the following points: • {loss of / no} (insulating) myelin (1) • decreases speed of nerve impulse / depolarisation no longer just occurs at nodes of Ranvier (1) • motor neurones {no longer transmit impulses / impulses are transmitted slower} (causing loss of function in the affected area) (1) • impulses from receptors do not reach CNS / impulses are not transmitted along sensory neurones to CNS (1)	ACCEPT nerve impulses take longer as has to go through all neurone not just nodes of Ranvier ACCEPT saltatory conduction does not occur ignore impulses being lost ACCEPT {fewer/slower} impulses reaching {effector /muscles} (so loss of function) (slower both mp2&3) ACCEPT fewer impulses from receptors reach CNS	(3)

Question number	Answer	Additional guidance	Mark
(c)	An explanation that includes four of the following points: • a mutation changes {the base sequence (of this gene) / the amino acid sequence} (of the calcium ion channel protein) (1) • {resulting in a change in shape / prevents the opening} of the calcium ion channel (1) • this stops influx of calcium ions (across presynaptic membrane) (1) • (fewer calcium ions result in) fewer vesicles containing neurotransmitter fusing with presynaptic membrane (1) • fewer {nerve impulses/action potentials} generated at post synaptic {membrane / neurone} (1)	ACCEPT stops calcium ions passing through {membrane / ion channel} ACCEPT prevents release of neurotransmitter /less neurotransmitter will be released (into synapse) ACCEPT less depolarisation of post synaptic {membrane / neurone}	(4)

Q12.

Question number	Answer	Mark
(a)	• x values read from the graph and subtracted (1) • mean percentage drop calculated (1) • mean percentage of insects calculated (1) Example of calculation: $58 - 1 = 57$ $100 \div 57 = 1.75$ $350 \times 1.75 \div 100 = 6$	(3)

Question number	Answer	Mark
(b)	An explanation that includes the following points: • investigation demonstrates habituation (1) • because the {response / number of insects showing PER} decreased each time the stimulus was repeated (1) • because they learned that the heat pad was not a source of blood (1)	(3)

Question number	Answer	Mark
(c)	An answer that includes the following points: • energy saved by not extending proboscis (1) • less likely to damage the proboscis (1)	(2)

Q13.

Question number	Answer	Additional guidance	Mark
(a)	A is the correct answer • B is not the correct answer as Pr does not break down in the dark • C is not the correct answer as Pr does not absorb far red light • D is not the correct answer as Pr does not absorb far red light nor break down in the dark		Computer (1)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes three of the following points: - auxin accumulates on shaded side (of the tip/stem/shoot/plant) (1) {stimulating/causing} cell elongation (1) - detail of mechanism of action of auxin (1) - causing the plant to grow towards {light / sun} (1)	accept accumulates on the left of diagram accept auxins move away from the exposed light e.g. auxins stimulate the transport of Hydrogen ions into the cell wall or decrease pH activating {cell wall proteins / enzymes / chemicals / expansins} / {altering the hydrogen bonding within / decreasing strength of} the cell wall allowing elongation when water taken in / ref to activation of transcription factors accept causing positive phototropism do not accept bend towards light	Expert (3)

Question number	Answer	Additional guidance	Mark
(c)	An explanation that includes four of the following points: (gibberellin) binds to receptor / carrier molecule in the cell / acts as a transcription factor(1) (amylase) {transcription factor/gene is activated} (1) - allowing {(amylase gene) transcription / production of (amylase) mRNA / translation mRNA / production of amylase} (1) - amylase (hydrolyses/ converts) starch into {maltose / glucose} (1)	ignore amylose transcription factor binding to promotor region of gene cause the inactivation of (amylase) gene {inhibitor protein/repressor molecule} ignore monomers activates gene that produces amylase = mps 2 and 3	Expert (4)

Question number	Answer	Additional guidance	Mark
(d)	An answer that includes four of the following points: • both natural and synthetic auxin cause an increase (in cell number) (1) • {natural auxin / IAA} greater effect on growth than {synthetic auxin / NAA} (1) • IAA at $0.1 \mu\text{mol dm}^{-3}$ was the most effective at increasing {growth / cell number} (1) • $1 \mu\text{mol dm}^{-3}$ was the most effective NAA concentration at increasing {growth / cell number} (1) • IAA is {better / more effective / has more cells} at lower concentrations(1)	can piece together both natural and synthetic auxin are better than the control at all concentrations IAA gives a greater increase in number of cells than NAA Accept most cell number Accept most cell number Accept higher concentrations of auxin(IAA) {had lower increase in growth / had lower increase in number of cells} Accept converse Accept negative correlation	Expert (4)

Q14.

Question number	Answer	Additional guidance	Mark
(a)	A description that includes four of the following points: • {identify / isolate} gene(s) involved in making beta-carotene in bacteria (1) • cut {DNA sequence / extract (beta carotene) gene} using restriction {endonuclease / enzyme} (1) • insert (beta carotene) gene into vector (1) • method of inserting vector into rice described (1) • grow rice and select for modified rice plants with high yields of beta carotene (1)	ACCEPT obtain gene by reverse transcriptase from mRNA synthesize gene (from a database) ACCEPT gene isolated using restriction enzyme = 2 marks (mp1 and 2) ACCEPT a named vector eg plasmid, liposomes e.g. heat shock, gene gun. micro-injection	(4)

Question number	Answer	Additional guidance	Mark
(b)(i)	A description that includes three of the following points: - accumulation of genetically engineered material in the environment / other species (1) - cross breeding with other species (1) - unknown long term effects of eating GMOs (1) - allows production of superpests (1)	ACCEPT accumulate in non-target organisms altered gene is found in other species ACCEPT pollen transfer to related species, ACCEPT Named symptom e.g. yellowing of skin, joint pain, dizziness, bleeding, beta carotene is a gene inhibitor, ref allergies credit idea of superweeds/superpests	(3)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An answer that includes the following points: appropriate suggestion to reduce risk (1)	accept grow in secure greenhouses, grow separately GM and non GM crops	(1)

Q15.

Question number	Answer	Additional guidance	Mark										
(a)	An answer that includes the following points: <table><tr><th>Part of Brain</th><th>Function</th></tr><tr><td>cerebellum</td><td>co-ordination of (voluntary) movement</td></tr><tr><td>cerebral hemispheres</td><td>interpretation of information from retina</td></tr><tr><td>medulla oblongata</td><td>regulation of (cardiovascular / respiratory system)</td></tr><tr><td>(posterior) Pituitary</td><td>secretion of ADH</td></tr></table>	Part of Brain	Function	cerebellum	co-ordination of (voluntary) movement	cerebral hemispheres	interpretation of information from retina	medulla oblongata	regulation of (cardiovascular / respiratory system)	(posterior) Pituitary	secretion of ADH	Accept posture, balance, muscular activity accept if answers are descriptive accept cerebrum / visual cortex / occipital lobe / cerebral cortex Accept hypothalamus Two correct cells = 1 mark All four cells = 2 marks	2
Part of Brain	Function												
cerebellum	co-ordination of (voluntary) movement												
cerebral hemispheres	interpretation of information from retina												
medulla oblongata	regulation of (cardiovascular / respiratory system)												
(posterior) Pituitary	secretion of ADH												

Question number	Answer	Additional guidance	Mark
(b)	An answer that includes four of the following points: Similarity - both are (neuro-imaging) methods giving high resolution (1) - both give images of areas with plaques in the brain (1) Differences - fMRI expensive CT cheaper (1) - fMRI will show {metabolism / oxygen uptake / brain activity} CT only shows structures (1) - fMRI uses magnetic resonance CT uses X rays (1)	2 marks max for similarities, 2 marks for differences needs to be compare and contrast. ACCEPT fMRI 45 mins CT 5-10 mins fMRI does not use ionising radiation CT does (so increased risk of cancer developing) ignore fMRI has higher resolution than CT	4

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes four of the following points: - amyloid protein will cause bacteria to stick together (1) - enhancing phagocytosis of the bacteria / stimulates activity of white blood cells (1) - acts as an antibiotic / anti-microbial (1) - amyloid protein could disrupt ability of bacteria to adhere directly to host cell (1) - prevents entry of bacteria into cells (1)	ACCEPT agglutinate / sticks to the surface of the bacteria ACCEPT description of phagocytosis do not accept trigger immune response.	4

Question number	Answer	Additional guidance	Mark
(d)	An answer that includes the following points: - bacteria carried in blood from (infected) gums (1) - bacteria penetrate the blood-brain barrier (1) - bacteria / bacterial products cause the release of {histamine/ chemicals / cytokines} (1) - resulting in vasodilation (1) - consequence of vasodilation (1)	ACCEPT bacteria can invade white blood cells which cross the blood brain barrier eg increased blood flow / oedema / increase in wbc in brain / increased oxygen.	4

Question number	Answer	Additional guidance	Mark
(e)	An answer that includes three of the following points: - gingipains are enzymes (that break down proteins in membranes) (1) - degrading/break down cell membranes (1) - resulting in loss of (active) brain tissue (in the cerebrum) (1) - leads to reduction in memory (especially short-term memory) (1)	ACCEPT reference to an effect on transport channels within membrane ACCEPT in context effect on nerve impulses / action potentials	3

Question number	Answer	Additional guidance	Mark
(f)	A description that includes three of the following points: - extraction of infected part of cerebral cortex (1) - use microarray (to identify mRNAs in sample) (1) (analysis of mRNA) to identify genetic material from <i>Porphyromonas</i> (1) - use of bioinformatics / algorithms to analyse the (enormous quantity of) data (from the microarray)(1)	ACCEPT use of specific microarray eg oligo- nucleotide microarray	3

Q16.

Question number	Answer	Additional guidance	Mark
(a)(i)	A description that includes four of the following points: • {identify/isolate/ cut out} the (<u>human</u>) rHE gene (1) • Cut {DNA sequence / gene} using restriction {endonuclease / enzyme} (1) • insert the gene into a vector (1) • inserting vector into suitable target (<u>sheep</u>) {cell / tissue} (1)	gene coding for rHE is isolated using restriction enzymes = 2 marks accept named vector e.g. plasmid, virus ignore bacteria e.g. udder cells / milk (protein) producing cells /fertilized sheep egg cell / embryo /zygote	Expert (4)

Question number	Answer	Additional guidance	Mark
(a)(ii)	• 77.5 (%)	accept 77 or 78	Graduate (1)

Question number	Answer	Additional guidance	Mark
(a)(iii)	A description that includes four of the following points: • rHE acts as an antigen (1) • {(phagocyte /macrophage / APC} presents antigen to (B/T) lymphocyte (1) • T helper cells activate the B cells (1) • differentiate into plasma cells (1) • plasma cells {release/ produce} (anti-rHE) antibodies (1)	accept antigen recognized as foreign accept B cells present antigen to themselves. accept T helper cells cause the production / formation of B effector cells and B memory cells	Expert (4)

Question number	Answer Additional guidance	Mark
(b)	An answer that includes the following points: Indicative content - description from graphs and experimental data • (many) crops have been engineered to provide resistance to pests or herbicides eg. soybean, corn • soybean will not be killed by (glyphosphate) herbicides • corn will not be eaten by the corn borer • ----- • herbicide tolerant soybean went from 7% of planted area in 1996 to 95% in 2017 • insect resistant corn went from 6% in 1996 to 88% in 2017 • increase in planting of both GM soybean and GM corn • more GM soybean planted (than GM corn) • general increase in production of genetically modified crops ----- explanation of benefits • higher yields / less damage by pests • more appealing colour / useful feature • GE foods having longer shelf life • more predictable food supplies for ever growing population • ----- • improved nutritional content • 'medication' provided through GE foods • can help prevent {malnutrition / disease} • ----- • (reduced use / cost) of herbicides and pesticides • withstand environmental conditions • ----- discussion of risks • increasing demand agricultural resources and land • reducing land available to grow other crops • ----- • increasing monoculture • ----- • declining biodiversity / stated effect on (stated local ecosystem) • ----- • unknown consequences of foreign gene expression / long term effect unknown • horizontal gene transfer to other organisms and species eg antibiotic resistance, weeds becoming herbicide resistant • -----	Expert (6)

	To go in published MS Level 1: 1 mark - table or graph commented on 2 marks - both graph and table commented on Level 2: all level 1 plus: basic discussion of both benefits and risks (only 1 section) OR detailed discussion of EITHER benefits OR risks Level 3: all level 2 plus: detailed discussion of BOTH benefits AND risks selective and concise and logical	
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Q17.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following point B is the correct answer - A is not the correct answer - C is not the correct answer - D is not the correct answer		(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An answer that includes the following point: B is the correct answer - A is not the correct pathway - C is not the correct pathway - D is not the correct pathway		(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	An answer that includes three of the following points: - heart rate decreases when diving (1) - the longer the whale is diving the lower the heart rate (1) - the difference between maximum heart rate at the surface and minimum heart rate in dive increases as dive duration increases (1)	accept ref to max and min HR	(3)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An answer that includes three of the following points: - relevant physiological change during a dive described (1) {pH/oxygen / carbon dioxide concentrations} in the blood monitored by {chemoreceptors / sensors} (1) - increase in impulses from medulla to SAN (1) - increase impulses from SAN leading to increased heart rate (1)	E.g. blood oxygen decreases / {CO ₂ /lactate} increases / pH decreases / oxygen debt develops accept increased depolarisations	(3)

Q18.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following point: B is the correct answer • A is not the correct answer as adrenal glands do not produce ADH • C is not the correct answer as the medulla oblongata does not produce ADH • D is not the correct answer as the pituitary gland does not produce ADH		(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An answer that includes the following point: B is the correct answer • A is not the correct answer as ADH does not act on the capillaries • C is not the correct answer as ADH does not act on the proximal tubules • D is not the correct answer as ADH does not act on the ureters		(1)

Question number	Answer	Additional guidance	Mark
(a)(iii)	An answer that includes the following point: C is the correct answer • A is not the correct answer as the countercurrent multiplier does not control plasma volume • B is not the correct answer as habituation is a behavioural response • D is not the correct answer as control of plasma volume is not a positive feedback		(1)

Question number	Answer	Additional guidance	Mark
(a)(iv)	• osmoreceptors	ACCEPT osmotic receptor	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	An answer that includes the following points: • increasing concentration of the gibberellin increases {length / growth} (of all internodes) (1) • increase is mostly in the length of the first internode (1)	ACCEPT positive correlation ignore gibberellin increases plant growth unqualified ACCEPT {least / smallest} effect on the last/3rd internode	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An answer that includes three of the following points: • gibberellin {enters the nucleus / binds to cell surface receptors} (1) • gibberellin {acts as a transcription factor / activates transcription factor} (1) • effect of transcription factor (1) • (causing) cell elongation / cell division (and causes internode elongation) (1)	ACCEPT secondary messenger e.g. activates protein synthesis / stimulates amylase production / amylase breaking starch down into glucose for respiration	(3)

Question number	Answer	Mark
(a)(i)	The only correct answer is D A is not the correct answer as cis retinal is changed by light B is not the correct answer as phytochrome is a photoreceptor in plants C is not the correct answer as rhodopsin is a photoreceptor found in rod cells	(1)

Question number	Answer	Mark
(a)(ii)	The only correct answer is B A is not the correct answer C is not the correct answer D is not the correct answer	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	A description that includes two of the following points: - as light intensity increases up to 12 a.u. mean potential difference increases (1) - mean potential difference stays constant at 12 a.u. and above (1)	both mps may be in one sentence Accept maximum potential difference reached at 12 a.u.	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A calculation showing the following steps: - calculation of change in mean potential difference (1) - calculation of percentage change (1)	$20 - 17 = 3$ $3/17 \times 100 = 17.6 / 17.65 \%$ correct answer = 2 marks	2

Question number	Answer	Additional guidance	Mark
(b)(iii)	An answer that includes two of the following points: - removing retina (from mammals) cause {blindness/harm} (1) - using anaesthetic causes harm to mammals (1) - not ethical/ unethical (1)	do not accept killing ACCEPT benefits do not outweigh harm caused/animals cannot give consent	2

Question number	Answer	Mark
(c)	The only correct answer is C A is not the correct answer B is not the correct answer D is not the correct answer	1

Q20.

Question number	Answer	Mark
(a)	- diameter of lesion and length of brain measured (1) - diameter of lesion multiplied by the magnification (1) Example of calculation: 6 mm and 63 mm $6 \times (150 \div 63) = 14 / 14.3 / 14.29$	(2)

Question number	Answer	Mark
(b)(i)	- mean increase in conduction per 1 μm increase in diameter for each type of neurone calculated (1) - value for myelinated neurone divided by value for non-myelinated to give an answer that is at least 1 SF more (1) Example of calculation: myelinated = $(8.5 - 2.6) \div 2 = 2.95$ non-myelinated = $(4.2 - 2.3) \div 4 = 0.475$ $2.95 \div 0.475 = 6.2 / 6.21$	(2)

Question number	Answer	Mark
(b)(ii)	An explanation that includes the following points: - both an increase in diameter and the presence of a myelin sheath increase speed of transmission (1) - myelin insulates the axon because it is hydrophobic (1) - therefore {nerve impulses jump from node to node / action potentials only occur at the nodes of Ranvier / saltatory conduction occurs} (1) - as diameter increases the resistance to flow decreases (1)	(4)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An answer that includes any three of the following points: • demyelination in a person with MS will result in impulses travelling slower (1) • blindness in one eye will result from demyelination of {nerve from eye to brain / one side of the brain} (1) • lack of coordination will result from sensory neurones and motor neurones transmitting nerve impulses at different speeds (1) • {blindness in one eye / lack of coordination} will result if demyelination occurs in the part of the brain associated with {vision / coordination} (1)	Accept occipital lobe	(3)

Q21.

Question number	Answer	Mark
(a)	• so other scientists could repeat the study / because different species might respond differently to microgravity	(1)

Question number	Answer	Mark
(b)	• nematodes may be {harmed / killed}	(1)

Question number	Answer	Mark
(c)	A description that includes the following points: • epigenetic changes to {prevent / allow} gene expression (1) • transcription factors to switch {on / off} genes (1) • post-transcriptional modification to determine which protein is produced from a particular gene (1)	(3)

Question number	Answer	Mark
(d)	An answer that includes any three of the following points: • (lower fat accumulation because) the diet that the nematodes were fed did not have an energy content greater than that being used (1) • (lower fat accumulation because) nematodes did not need to store energy as they were not very active (1) • (shorter body length because) diet was low in protein (1) • genes controlling {fat accumulation / body length} had been switched off (1) • microgravity resulted in less protein being synthesised (1)	(3)

Question number	Answer	Mark
(e)	An explanation that includes any four of the following points: • less muscle {protein / named protein} synthesised because of muscle atrophy (1) • because the microgravity decreases the force that needs to be exerted by the muscles (1) • less muscle activity, therefore less ATP required (1) • therefore fewer {enzymes / named enzyme} needed for respiration (1) • fewer proteins involved in gluconeogenesis because less glucose needed for respiration (1)	(4)

Question number	Answer	Mark
(f)	An explanation that includes the following points: • microarrays analyse the {active DNA / RNA} of a cell (1) • therefore less {active DNA / RNA} for the electron transport genes and increased {active DNA / RNA} for the sirtuin gene (1) • compared to nematodes, they are not exposed to microgravity (1)	(3)

Question number	Answer	Mark
(g)	An explanation that includes the following points: • because the scientists wanted to assess the lipid stores of the nematodes (1) • Sudan Black binds specifically to fat (1)	(2)

Question number	Answer	Mark
(h)	An answer that includes three of the following points: • mean values are given throughout (1) • frequency data reliable as the standard deviations do not overlap (1) • frequency and wavelength data reliable as p values are less than {0.01 / 0.05} (1) • they are not very reliable as the sample sizes are very small (1)	(3)

Q22.

Question number	Answer	Mark
(a)(i)	A -70 mV B is not correct as -78 mV is the potential when the axon is hyperpolarised C is not correct as 38 mV is the action potential D is not correct as 108 mV is the change in potential from resting to action potential	(1)

Question number	Answer	Mark
(a)(ii)	C voltage-gated potassium ion channel only A is not correct as the voltage-gated sodium ion channels will be closed and the potassium ion channels open at Y B is not correct as the voltage-gated sodium ion channels will be closed and the potassium ion channels open at Y D is not correct as the voltage-gated sodium ion channels will be closed and the potassium ion channels open at Y	(1)

Question number	Answer	Mark
(a)(iii)	B hyperpolarised A is not correct as the membrane at Z is hyperpolarised C is not correct as the membrane at Z is hyperpolarised D is not correct as the membrane at Z is hyperpolarised	(1)

Question number	Answer	Mark
(a)(iv)	B one A is not correct as only the third statement is correct. C is not correct as only the third statement is correct D is not correct as only the third statement is correct	(1)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: • because ATP is used by the sodium-potassium pump (1) • to move sodium ions and potassium ions across the cell membrane (1) • to establish concentration gradients for sodium ions and potassium ions (1)		(3)