Questions

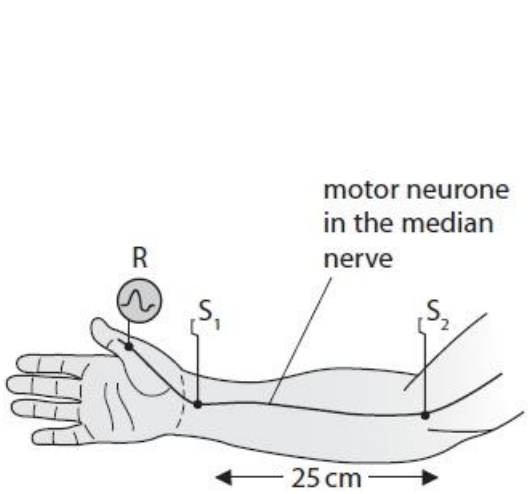
Q1.

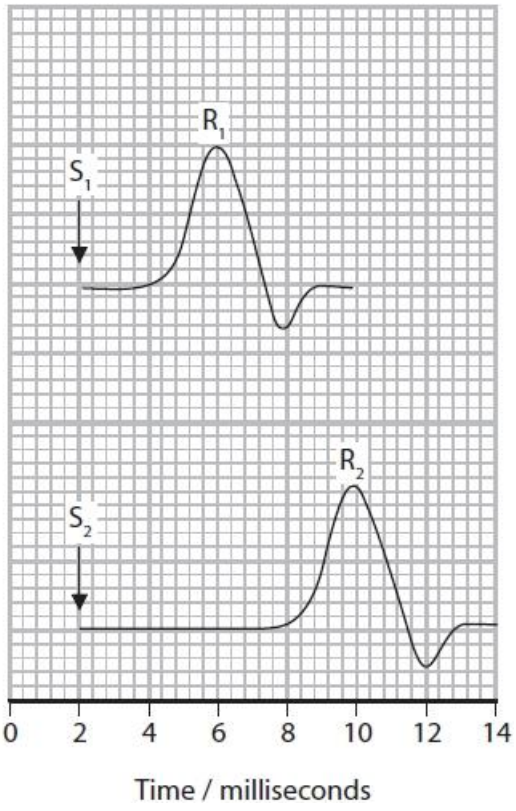
People with Guillain-Barré syndrome (GBS) suffer from a rapid onset of muscle weakness. It is thought that GBS is caused by damage to the peripheral nervous system.

The speed of conduction along a motor neurone can be calculated.

The time taken for a stimulus (S) to produce a response (R) further along the neurone is recorded.

Using two stimuli, a known distance apart, allows the speed of conduction to be calculated.





Calculate the speed of conduction for the neurone shown.

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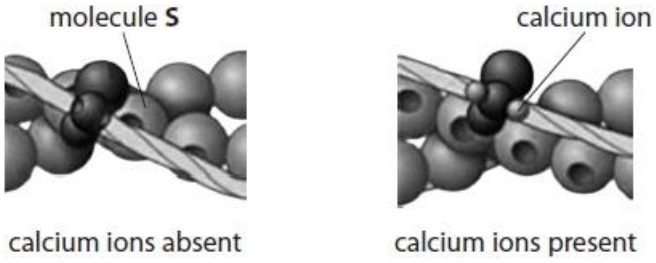
(Total for question = 2 marks)

Q2.

Muscle cells contain myofibrils. The diagrams show the arrangement of some of the molecules present in a myofibril when calcium ions are absent and when they are present.



Describe how the concentration of calcium ions around the myofibrils is controlled.

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(Total for question = 3 marks)

Q3.

The effect of being shown a cheeseburger on saliva production in a child was studied.

The mass of saliva produced by this child was measured.

The child was then shown a cheeseburger and the new mass of saliva produced was measured. The change in the mass of saliva produced was recorded.

This was repeated with the child being shown a cheeseburger on eight occasions, at five minute intervals.

The results in the table show the change in mass of saliva produced compared with the mass of saliva produced before the child being shown a cheeseburger.

Occasion	Change in mass of saliva produced / g
1	+ 0.30
2	+ 0.18
3	+ 0.05
4	+ 0.02
5	+ 0.02
6	– 0.08
7	– 0.18
8	– 0.19

(i) Describe the effect on saliva production shown by these results.

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(ii) Name the type of learning behaviour shown by the child as they were repeatedly shown a cheeseburger.

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(iii) Explain what happens at the synapse to cause a decrease in saliva production when the child was shown a cheeseburger on more than six occasions.

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(Total for question = 7 marks)

Q4.

The muscles of the earthworm (*Lumbricus terrestris*) contract when it is touched. This is known as the withdrawal response.

Contraction of the muscle in the withdrawal response is stimulated by nerve impulses. These nerve impulses can be detected using electrodes.

Explain the electrical changes in an axon that allow these nerve impulses to be detected.

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(Total for question = 4 marks)

Q5.

People with Guillain-Barré syndrome (GBS) suffer from a rapid onset of muscle weakness. It is thought that GBS is caused by damage to the peripheral nervous system.

In individuals with GBS, the immune system attacks and destroys the myelin sheath surrounding some neurones.

Neurone conduction was studied in an individual with GBS and in an individual without GBS. The results are shown in the table.

Individual	Sensory neurone		Motor neurone	
	Speed of conduction / metres per second	Size of action potential / mV	Speed of conduction / metres per second	Size of action potential / mV
With GBS	54	35	39	10
Without GBS	58	33	63	10

Explain why GBS caused muscle weakness in this individual.

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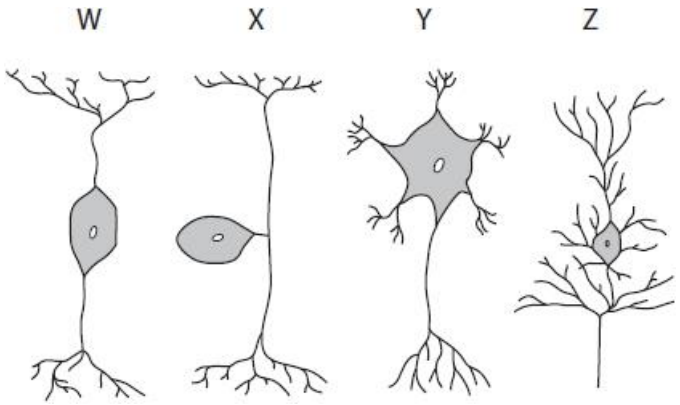
(Total for question = 4 marks)

Q6.

People with Guillain-Barré syndrome (GBS) suffer from a rapid onset of muscle weakness. It is thought that GBS is caused by damage to the peripheral nervous system.

The diagram shows some typical neurones.



(i) Which of these is a sensory neurone?

(1)

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

(ii) The axons of some neurones are surrounded by a myelin sheath.

The main component of myelin is a glycolipid.
Glycolipids are formed from lipids attached to a chain of

(1)

☒ **A** amino acids which are joined by glycosidic links

☒ **B** amino acids which are joined by peptide bonds

☒ **C** sugar molecules which are joined by ester bonds

☒ **D** sugar molecules which are joined by glycosidic links

(iii) Describe the role of the dendrites in a neurone.

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(Total for question = 5 marks)

Q7.

The muscles of the earthworm (*Lumbricus terrestris*) contract when it is touched. This is known as the withdrawal response.

Studies were carried out to investigate the withdrawal response in earthworms.

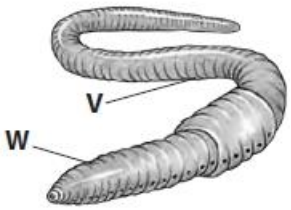
The duration of the withdrawal response is the length of time that the muscles remain contracted. If the stimulus is repeated, the withdrawal response is either reduced in duration or lost.

In one study, an earthworm was touched 20 times in one minute at point **V** as shown in the diagram. The shortening of the earthworm's body was measured after 20 stimuli.

The effect of touching point **W** in the same way was recorded and also the effect of alternating touches between points **V** and **W**.

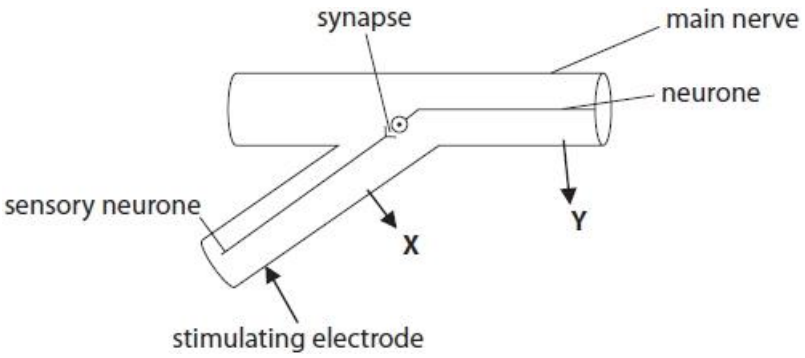
The results of this study are shown in the table.

Nature of stimulus	Change in body length after 20 stimuli / mm
All stimuli at point **V**	0
Stimuli alternating between points **V** and **W**	17
All stimuli at point **W**	0

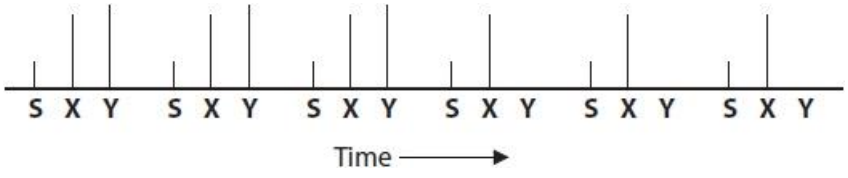


In another study, sensory neurones of an earthworm were stimulated by an electrode six times.

Nerve impulses were recorded at positions **X** and **Y** as shown in the diagram.



Nerve impulses recorded at **X** and **Y** are shown in the diagram below. The presence of a line indicates that an impulse was detected. **S** shows the stimulus.



* (i) Analyse the data from these two studies to evaluate the most likely cause of the loss of the withdrawal response.

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(ii) Devise an experiment to show that the frequency of the stimulation used in the first study should be 20 stimuli per minute.

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(Total for question = 10 marks)

Q8.

The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

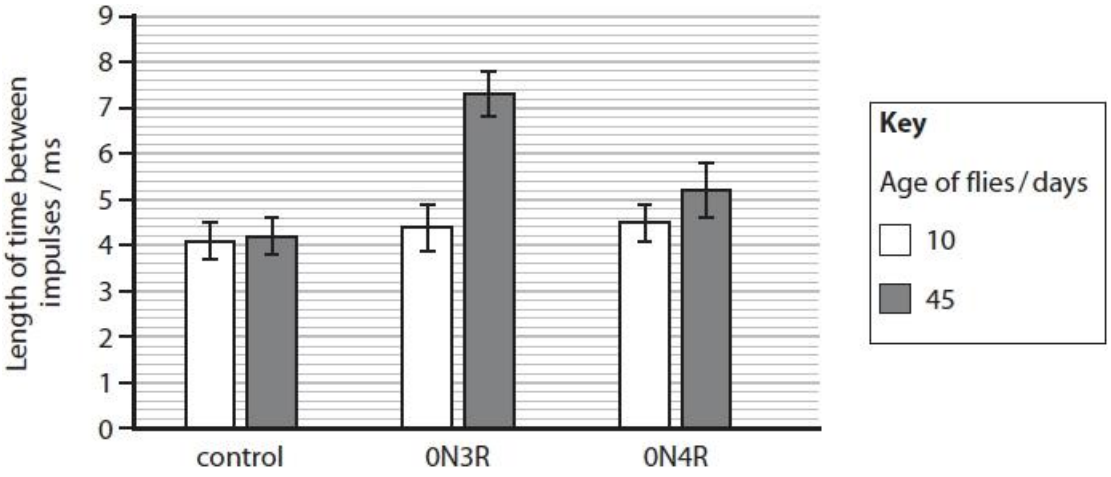
Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

In another investigation, the effect of these TAU proteins and age on the conduction of nerve impulses along the axon of neurones was studied.

The length of time between impulses was measured for *Drosophila* flies of different ages.

The results are shown in the graph.



Determine the effect of these TAU proteins on the maximum frequency at which nerve impulses can be conducted along the axon of the neurone.

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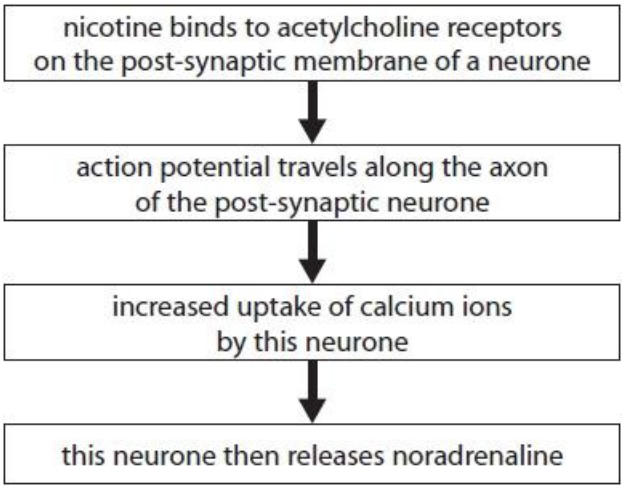
(Total for question = 4 marks)

Q9.

Nicotine is a drug found in the smoke of cigarettes.

The flow diagram shows how the presence of nicotine can cause the release of noradrenaline.



(i) Explain how nicotine causes an action potential in the post-synaptic neurone that releases noradrenaline.

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(ii) State how an increase in calcium ion uptake by the neurone leads to the release of noradrenaline.

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(Total for question = 4 marks)

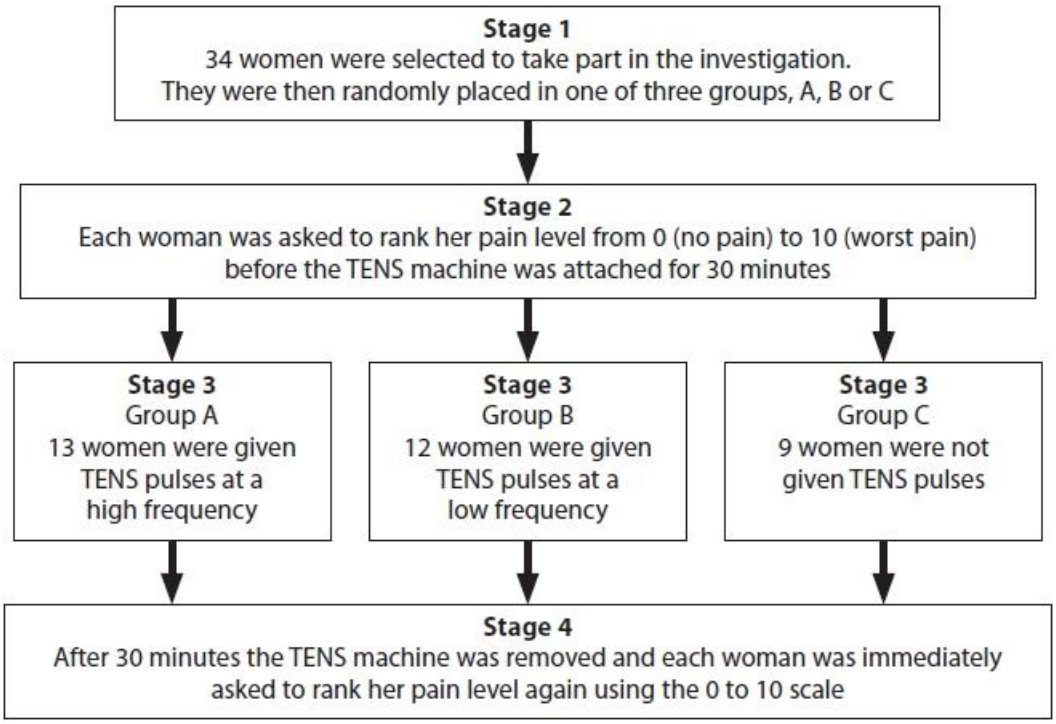
Q10.

Some women need to have surgery to aid childbirth. This can lead to pain after surgery.

A TENS (transcutaneous electrical nerve stimulation) machine releases regular pulses of electricity onto the skin surface and can be used in pain relief.

An investigation was carried out to study whether the frequency of the pulses from a TENS machine could help these women with their pain relief.

The diagram shows how the investigation was carried out.



This investigation used only one 30-minute session of TENS pulses. This was done to reduce the risk of habituation.

Describe the process that occurs at a synapse that leads to habituation.

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(Total for question = 4 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 retina of the human eye contains rod cells.
These cells detect light energy as photons.
The light energy is converted to a nerve impulse that is interpreted by the brain.

(i) The transmission of an impulse between a neurone in the optic nerve and a cell in the brain involves ions and neurotransmitter molecules.

Describe how these ions and neurotransmitter molecules are involved in the transmission of an impulse.

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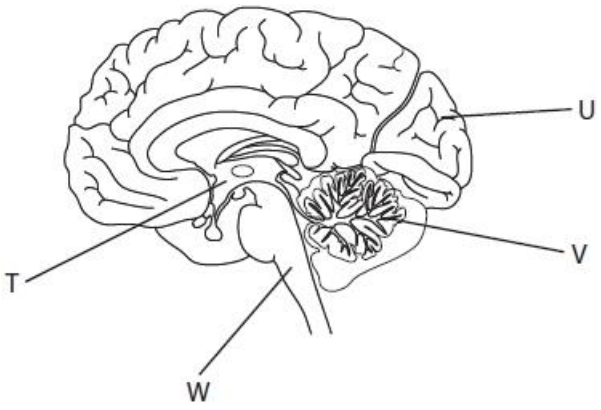
(ii) The diagram shows a human brain.



Which label on the diagram identifies the area of the brain where an image is interpreted?

(1)

- ☒ **A** T
- ☒ **B** U
- ☒ **C** V
- ☒ **D** W

(Total for question = 5 marks)

Q12.

The scientific article you have studied is from *Scientific American*.

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

Compare and contrast the structure of a sensory neurone and a motor neurone (paragraph 21).

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(Total for question = 4 marks)

Q13.

Acetylcholinesterase is an enzyme involved in regulating the transmission of nerve impulses across some synapses.

Alzheimer's disease is associated with the loss of neurones that produce acetylcholine.

It has been suggested that inhibitors of acetylcholinesterase may be useful in the treatment of Alzheimer's disease.

(i) Explain why inhibitors of acetylcholinesterase could be useful in the treatment of Alzheimer's disease.

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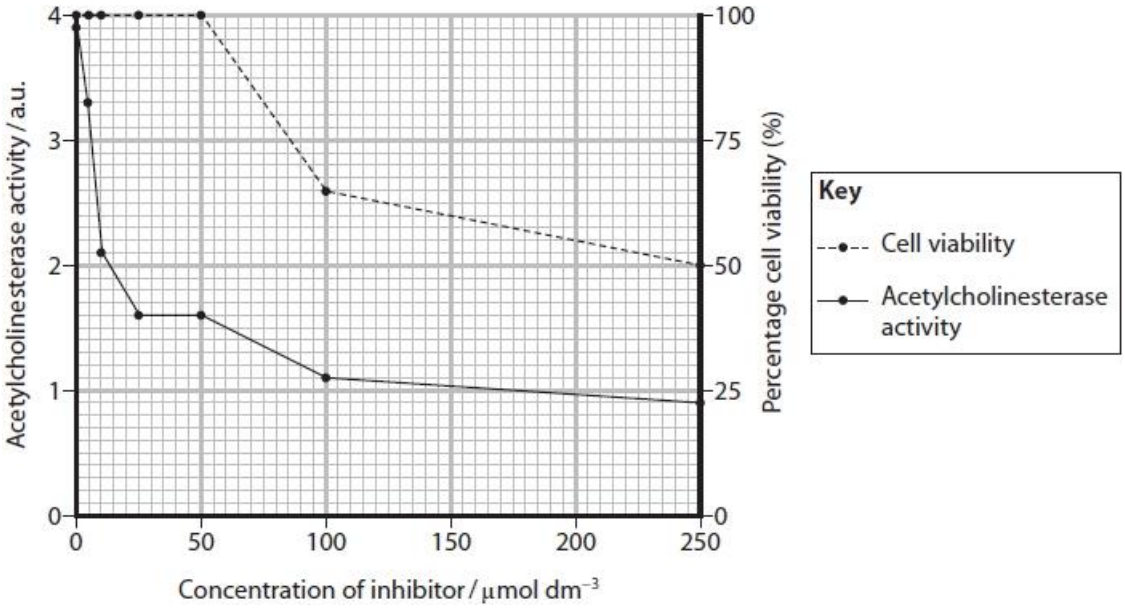
(ii) Trials of a new inhibitor were carried out using tissue cultures.

The effect of the concentration of the inhibitor on acetylcholinesterase activity and cell viability was measured.
Percentage cell viability was measured as the percentage of cells that were not killed by the inhibitor.
The graph shows the results for this inhibitor.



State and justify a suitable concentration of inhibitor to use in clinical trials.

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	• appropriate figures in formula for calculating speed distance divided by time • correct conversion of units	<u>Example of calculation</u> 25 ÷ time (ALLOW any time from 3.7 to 4.3 milliseconds) The answer multiplied by 1000 to give answer in cm s^{-1} Examples of acceptable answers: 3.7ms gives 6757 cm s^{-1} 3.8 6579 3.9 6410 4.0 6250 4.1 6098 4.2 5952 4.3 5814 Correct answer without working gains full marks	**(2)**

Q2.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following points: • calcium ions released from sarcoplasmic reticulum (1) • in response to { nerve impulse / action potential / depolarisation } (at neuromuscular junction) (1) • calcium channels open (to allow calcium ions to cross the membrane / enter the sarcoplasm) (1) • calcium ions taken back up into the sarcoplasmic reticulum by active transport (1)	ALLOW Ca^{2+} for calcium ions ALLOW calcium ions moving through channel protein	(3)

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Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to two of the following: • being shown a cheeseburger increases saliva production (1) • repeated occasions results in less saliva production (1) • after six or more occasions there is less saliva produced than before being shown a cheeseburger (1)	ALLOW negative correlation appropriately qualified	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• habituation		(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: • reduced permeability of presynaptic membrane to calcium ions / fewer calcium ions enter the pre-synaptic neurone (1) • (so fewer) vesicles { move towards / fuse with } the presynaptic membrane (1) • (therefore) less neurotransmitter binds to receptors on the post-synaptic membrane (1) • action potential may not occur in the post-synaptic neurone / membrane may not be depolarised (1)	ALLOW Ca^{2+} for calcium ions ALLOW calcium ion channels become less responsive ALLOW less exocytosis occurs at the presynaptic membrane ALLOW sodium ion channels not opening	(4)

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Q4.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: • potential difference across axon changing (1) • due to increased permeability to sodium ions / (voltage gated) sodium channels open (1) • sodium ions { move into the axon / cause depolarisation } (1) • (followed by) an increased permeability to potassium ions / potassium channels open (1) • potassium ions { move out of the axon / cause repolarisation of the membrane } (1)	e.g. when depolarised from negative to positive or from -70mV to +40mV or repolarised from +40mV to -70mV	(4)

Q5.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • no difference in action potential between individual with and individual without GBS • motor neurone conduction speed is reduced • due to { loss of myelin / demyelination } of the (motor) neurone • (and therefore) loss of saltatory conduction	IGNORE reference to sensory neurone ALLOW reference to loss of Schwann cells DO NOT ALLOW destroy ALLOW impulse cannot pass between the nodes of Ranvier	**(4)**

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Q6.

Question Number	Answer	Mark
(i)	**B** - X *The only correct answer is **B*** ***A** is incorrect because W is a relay neurone* ***C** is incorrect because Y is a motor neurone* ***D** is incorrect because Z is a multipolar neurone*	**(1)**

Question Number	Answer	Mark
(ii)	**D** - sugar molecules which are joined by glycosidic links *The only correct answer is **D*** ***A** is incorrect because glycolipids are not made of amino acids* ***B** is incorrect because glycolipids are not made of amino acids* ***C** is incorrect because sugar molecules are not joined by ester bonds*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to three of the following: • { form synapses / connections } with other neurones (1) • { integrate / receive } impulses from other neurones (1) • involved in summation • { propagate a signal / initiate an action potential } to the {cell body / axon}		**(3)**

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Q7.

Question number	Answer
* **(i)**	Answers will be credited according to candidate's 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 from table: • stimulated at just one point (V or W) – response lost after repeated stimulation • if the repeated stimulation is alternated between two points (V and W) the worm still responds by contracting its muscles / no habituation when stimuli alternated between different locations • different nerves / neurones / stimulated (by V and W) from diagrams: • there is a response at X every time the neurone is stimulated • { repeated stimulation / after three stimuli } there is no longer an impulse recorded at Y • electrode X is close to where the stimulus is applied and it detects an impulse each time • electrode Y is further from where the stimulus is applied • there is a synapse between the stimulus and the neurone monitored at Y Knowledge and understanding of habituation: • after repeated stimulation the impulse cannot cross the synapse • lack of neurotransmitter / not enough time to produce more neurotransmitter • calcium ion channels not opening when impulse arrives at the synapse • threshold not reached on the post-synaptic neurone and no action potential produced

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Level	Mark	Descriptor	Additional Guidance
0	0	No awardable content	
1	1-2	Limited scientific judgement made with a focus on mainly just **one** study. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	One study focused on – probably the table of data Idea of different nerves involved
2	3-4	A scientific judgement is made through the application of relevant evidence from **both** studies. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Analysis refers to the table of data – idea of difference when stimulus at one place or alternating **and** the diagrams showing effects of stimulating nerves X and Y. Links made to impulses not present post synapse and an explanation for that
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.	Analysis of both studies **linked** to knowledge and understanding of habituation, **links** made to location of synapse and reasons why neurotransmitter not released.

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following points: • description of suitable range of (at least five) frequencies (1) • a method for making application of stimuli consistent / control of recovery time between tests (1) • a method for checking for habituation in earthworms (1) • repeats with other earthworms of same { species / size } (1)	ALLOW range of five different frequencies above and below 20 per minute e.g. (touch with a cotton bud) to same place each time e.g. give 2 minutes between each test e.g. observing for no response to touch / finding no change in length of earthworm (Maximum of 2 marks if investigation described in context of snails)	(4)

Q8.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • frequency is {the same / similar} for all flies at 10 days (1) • for older flies with {0N4R the error bars overlap with thecontrol (1) • therefore 0N4R has {no / little} effect on the frequency ofimpulses (1) • for older flies 0N3R the error bars do not overlap withthe control } (1) • therefore 0N3R decreases the frequency of impulses (1)	ALLOW length of time between impulses ALLOW frequency decreases from 220 to 190impulses per second ALLOW length of time between impulses IGNORE unqualified length of time / increase ALLOW frequency decreased from 227 to 137impulses per second ALLOW more significant / greatest effect ALLOW length of time between impulses IGNORE unqualified length of time / increase ALLOW effect was greater in older flies if MP2 to 5not awarded	Choose an item. (4)

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Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: • nicotine similar in shape to acetylcholine (1) • increases permeability of membrane to sodium ions / changes shape of { receptors / channel proteins } (1) • nicotine causes the depolarisation of the post-synaptic membrane (1) • depolarisation reaches threshold level (1)	ALLOW { sodium ion / Na^+ } channels open ALLOW sodium ions { diffuse / move down concentration gradient } into the neurone	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • (calcium ions cause) vesicles (containing noradrenaline) to fuse with { cell (surface) membrane / presynaptic membrane } (1)	ALLOW (calcium ions cause) vesicles to release noradrenaline through exocytosis	(1)

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Q10.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following: • (repeated stimulus) decreases {sensitivity / permeability} of pre-synaptic membrane / calcium channels not opening **(1)** • so {fewer / no} Ca^{2+} ions move into pre-synaptic neurone **(1)** • so {fewer / no} vesicles {move towards / fuse with} (pre-synaptic) membrane **(1)** • so {less / no} neurotransmitter {released / can diffuse across gap} **(1)** • {action potential / depolarisation} less likely to occur in post-synaptic neurone **(1)**	ALLOW calcium channels less or not responsive	**(4)**

Q11.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following: • calcium ions enter presynaptic neurone so vesicles with neurotransmitter can {move towards / fuse withpresynaptic membrane} (1) • neurotransmitter molecules diffuse across thesynapse (1) • neurotransmitter to bind with receptors on postsynaptic membrane (on the brain cell) (1) • sodium ions diffuse into {brain cell / post-synaptic cell}leading to {a depolarisation / an action potential } (1)	ALLOW calcium ions enter presynaptic neurone leading to exocytosis of neurotransmitter from vesicles ALLOW named neurotransmitter such as acetylcholine, dopamine, noradrenaline ALLOW enter for diffuse	**(4)**

Question Number	Answer	Mark
(ii)	**The only correct answer is B - U – This is the site in the brain where the image is interpreted** ***A*** *is not correct because* T is not the site in the brain where the image is interpreted ***C*** *is not correct because V* is not the site in the brain where the image is interpreted ***D*** *is not correct because* W is not the site in the brain where the image is interpreted	**(1)**

Q12.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: Similarities • both have a cell body containing a nucleus (1) • both have an axon (1) • both have dendrites at one end of neurone and terminal branches at the other end (1) Difference • location of cell body (1)	IGNORE descriptions of function ALLOW motor neurone cell body is at one end of the axon whereas in the sensory neurone the cell body is located along the axon	**(4)**

Q13.

Question number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following: • acetylcholinesterase breaks down acetylcholine (1) • inhibitor prevents break down of acetylcholine (1) • so more (acetylcholine) is available to bind to post-synaptic {membrane / receptors} (1) • therefore compensating for the {reduced production of acetylcholine / loss of acetylcholine producing neurones} (1)	ALLOW blocks acetylcholinesterase ALLOW inhibiting acetylcholinesterase maintains higher concentrations of acetylcholine (in synapse) (1)	Choose an item. (3)

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: • concentration between 25 and 50 µmol dm^{-3} (1) • concentration having greatest inhibitory effect (1) • but having no effect on cell viability (1)	ALLOW any value between 25 and 50 ALLOW suitable description of effect e.g. reduces enzyme activity by {more than 50% / 60% / 2.4 a.u. ALLOW viability remains at 100%	Choose an item. (3)