Surname	Date	Tutor
First name(s)		

BioWelsh

GCE A LEVEL

BW-A2-3.8-W1

TOPIC WORKSHEET 1 – 3.8 THE NERVOUS SYSTEM

BIOLOGY – A2 unit 3

Energy, Homeostasis and the Environment

Suggested time: 3 hours 5 minutes

For Tutor's use only

Question	Maximum Mark	Mark Awarded	Question	Maximum Mark	Mark Awarded
1.	11		9.	11	
2.	9		10.	9	
3.	10		11.	9	
4.	8		12.	9	
5.	10		13.	9	
6.	8		14.	9	
7.	9		15.	9	
8.	9		Total	139	

ADDITIONAL MATERIALS

In addition to this worksheet, you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name and the date in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you are working on screen, write your answers on paper and number each one clearly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question. The worksheet is out of **139** marks.

The assessment of the quality of extended response (QER) will take place in question **15**.

The quality of written communication will affect the awarding of marks.

This worksheet is written by BioWelsh in the style of the WJEC A level Biology examination, following the WJEC specification (topic 3.8). It is not an official WJEC paper.

Tutor only

Answer **all** questions.

1. A student measured their reaction time with a ruler-drop test. A partner held a metre rule vertically above the student's open hand and dropped it without warning. The student caught it as quickly as possible and the distance the rule fell was recorded. **Table 1.1** shows the results of five trials.

Table 1.1

Trial	1	2	3	4	5
Distance fallen / cm	18.2	16.5	17.0	29.4	16.8

(a) Identify the receptor, the coordinator and the effector in this response. [3]

Receptor ....

Coordinator ....

Effector ....

(b) Calculate the mean distance fallen, leaving out any anomalous result. Give your answer to **1 decimal place**. [2]

Mean distance = ... cm

The reaction time can be calculated from the distance fallen using the equation:

$$\text{reaction time} = \sqrt{(2d \div g)}$$

where d is the distance fallen in metres and g is 9.81 m s^{-2}.

(c) Use your answer to (b) to calculate the reaction time in milliseconds. Give your answer to the nearest millisecond. [2]

Reaction time = ... ms

(d) Withdrawing the hand from a hot object is a reflex that takes about 40 ms. Explain why catching the ruler takes much longer. [2]

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2

Tutor only

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(e) Suggest **two** ways in which the student could improve the validity of this investigation. [2]

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11

Tutor only

2. **Image 2.1** is a light micrograph of a transverse section (T.S.) of a spinal cord from a prepared slide. The dorsal side is at the top.

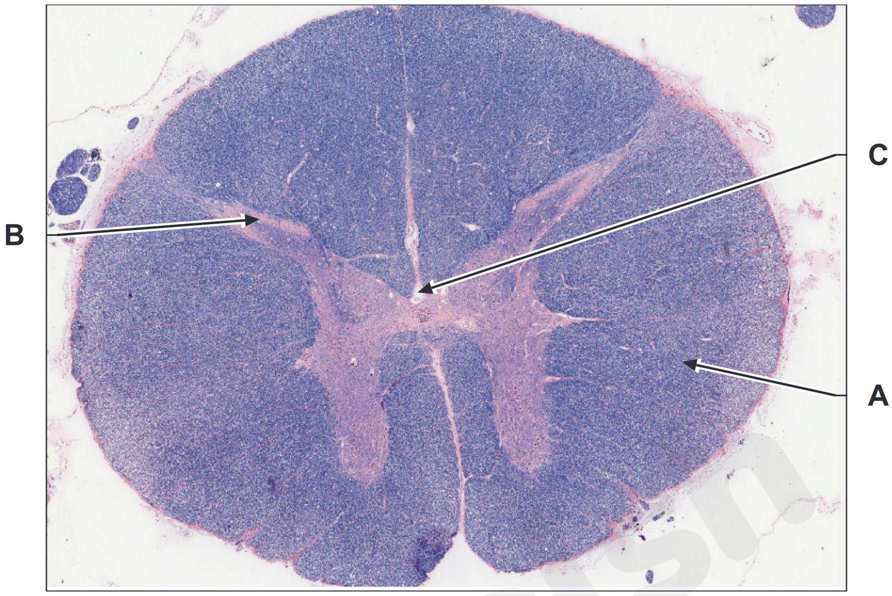

Image 2.1

(a) Identify the regions labelled **A**, **B** and **C**. [2]

A ....

B ....

C ....

(b) Explain why regions **A** and **B** look different. [2]

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(c) On **Image 2.1**, label with an **M** a region where the cell bodies of motor neurones are found. [1]

(d) The spinal cord in **Image 2.1** is 12 mm wide. In a printed copy of the micrograph it measured 96 mm across. Calculate the magnification of the printed copy. [1]

Magnification = × ....

Tutor only

Each spinal nerve joins the spinal cord by a dorsal root and a ventral root.

(e) Complete **Table 2.2** to compare the two roots. [3]

Table 2.2

Feature	Dorsal root	Ventral root
Type of neurone	....	....
Direction of impulses	....	....
Position of cell bodies	....	....

9

Turn over.

Tutor only

3. A person steps on a sharp stone and quickly lifts their foot. **Image 3.1** shows the reflex arc involved. It is not drawn to scale.

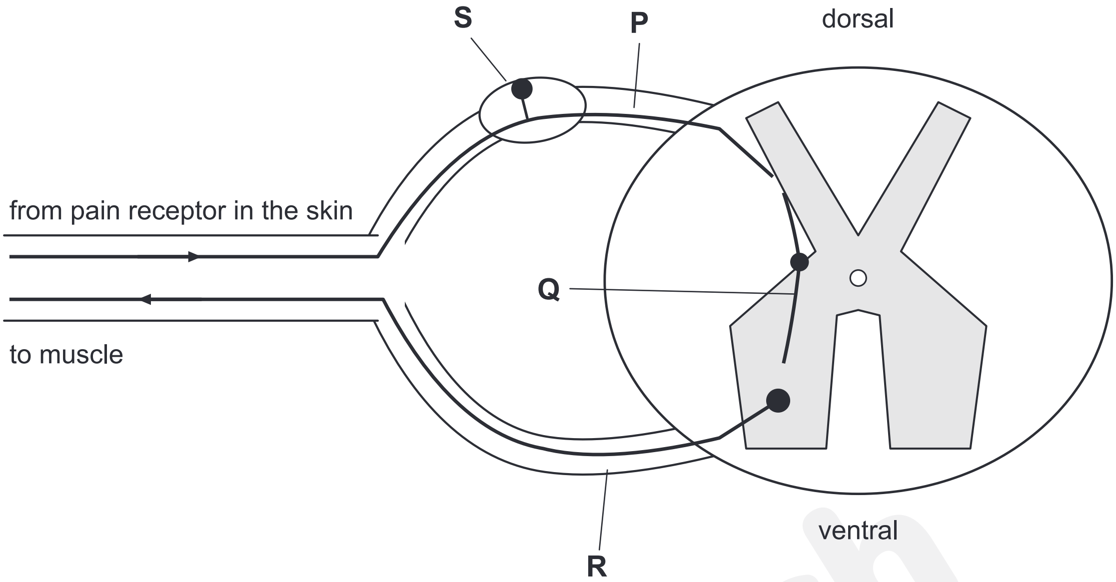

Image 3.1

(a) Name the types of neurone labelled **P**, **Q** and **R**. [2]

P ....

Q ....

R ....

(b) Name structure **S** and state what it contains. [1]

....

(c) Explain why this response is described as rapid, protective and involuntary. [3]

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Tutor only

(d) A patient's ventral root at this level is cut in an accident. The dorsal root is not damaged. Suggest how this would affect the response to stepping on a sharp stone. Explain your answer. [2]

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(e) Explain why impulses can pass in only one direction through this reflex arc. [2]

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Turn over.

4. *Hydra* is a freshwater cnidarian about 1 cm long. **Image 4.1** shows a *Hydra* attached to a water plant, with its long tentacles hanging down.

Image 4.1

Image 4.2 shows how the neurones are arranged in its body wall.

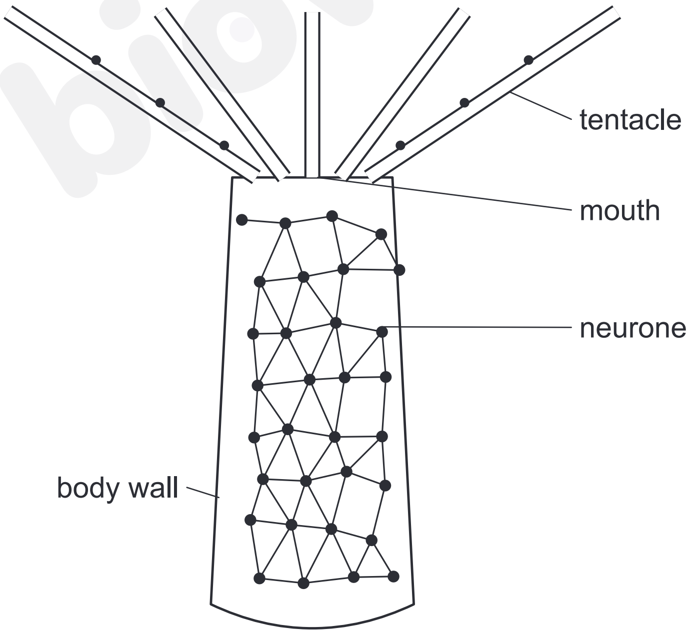

Image 4.2

Tutor only

(a) Complete **Table 4.3** to compare the nervous system of *Hydra* with that of a mammal. [3]

Table 4.3

Feature	*Hydra*	Mammal
Central nervous system	....	....
Myelin sheath	....	....
Direction of impulses	....	....

(b) Impulses spread through the nerve net of *Hydra* at about 0.15 m s^{-1}. Impulses in a human sensory neurone travel at about 60 m s^{-1}. Calculate how many times faster the human neurone conducts. [1]

Answer = ... times

(c) Using **Image 4.2**, explain why impulses are conducted slowly in *Hydra*. [2]

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(d) Suggest why a nerve net is suitable for an animal such as *Hydra*, which stays attached in one place and has tentacles all round its mouth. [2]

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8

Turn over.

Tutor only

5. **Image 5.1** is a light micrograph of a motor neurone from a smear of spinal cord.

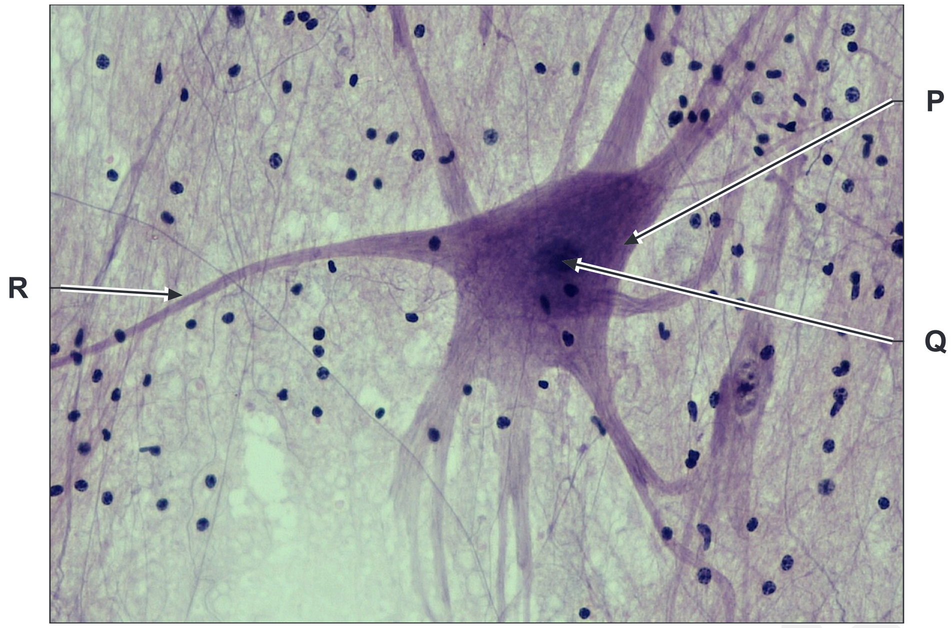

Image 5.1

(a) Identify the structures labelled **P**, **Q** and **R**. [2]

P ....

Q ....

R ....

(b) Draw and label a diagram of a myelinated motor neurone. [4]

Tutor only

(c) The axon of a motor neurone that runs from the spinal cord to a muscle in the foot is 1.0 m long. Impulses travel along it at 80 m s^{-1}. Calculate the time taken for an impulse to travel the length of the axon, in ms. [2]

Time = ... ms

(d) Motor neurones contain many mitochondria. Suggest **two** reasons why. [2]

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Turn over.

Tutor only

6. **Image 6.1** shows three types of protein, **A**, **B** and **C**, in the membrane of an axon at rest.

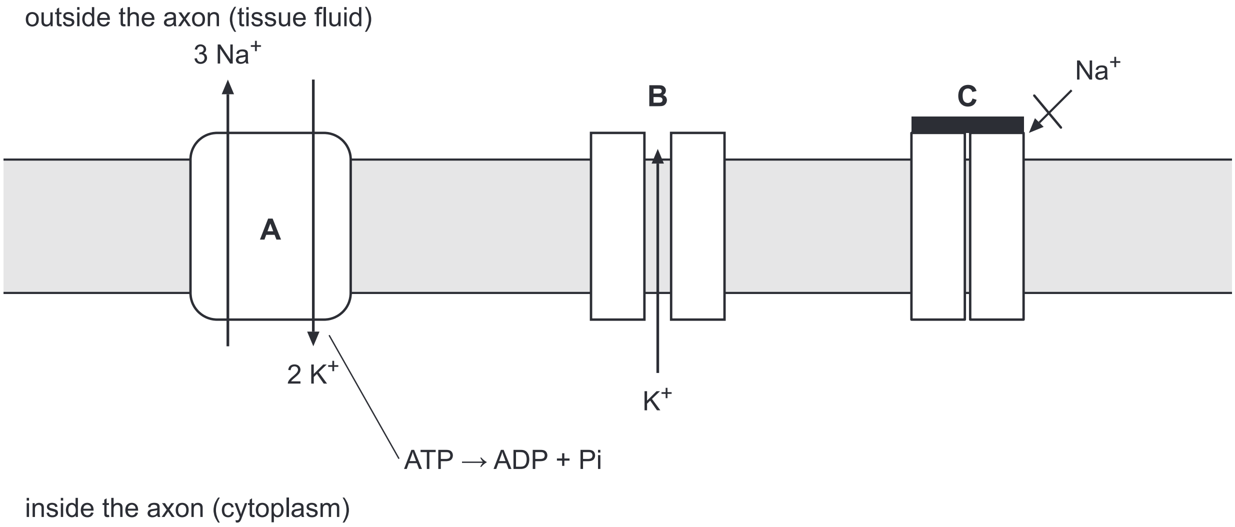

Image 6.1

Table 6.2 shows the concentrations of sodium and potassium ions inside and outside a squid giant axon.

Table 6.2

Ion	Concentration inside / mmol dm^{-3}	Concentration outside / mmol dm^{-3}
Na^+	50	440
K^+	400	20

(a) State the value of the resting potential of a mammalian neurone. [1]

....

(b) Use **Table 6.2** to calculate how many times greater the concentration of K^+ is inside the axon than outside. [1]

Answer = ... times

(c) Using **Image 6.1**, explain how the resting potential is maintained. [4]

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Tutor only

(d) Ouabain is a toxin from the seeds of some plants. It inhibits protein **A**. Suggest and explain the effect of ouabain on the resting potential of a neurone over the following hours. [2]

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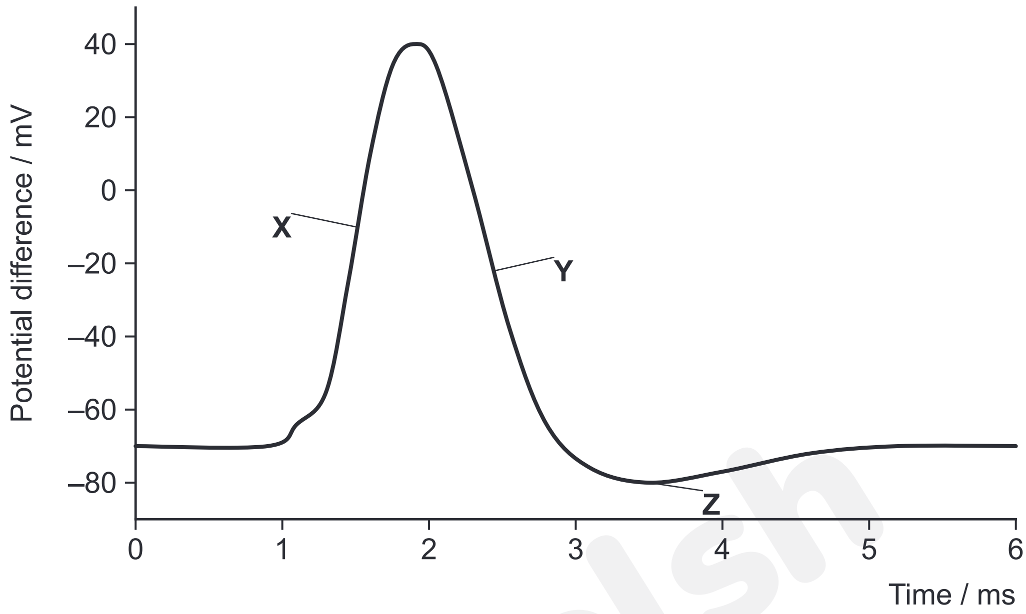
7. **Graph 7.1** shows an oscilloscope trace of one action potential recorded from an axon.



Graph 7.1

(a) Calculate the amplitude of the action potential. [1]

Amplitude = ... mV

(b) Use **Graph 7.1** to find the time taken from the start of depolarisation to the peak of the action potential. [1]

Time = ... ms

(c) Explain the changes in the membrane that cause the part of the trace labelled **X**. [3]

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Tutor only

(d) Explain the shapes of the trace at **Y** and **Z**. [3]

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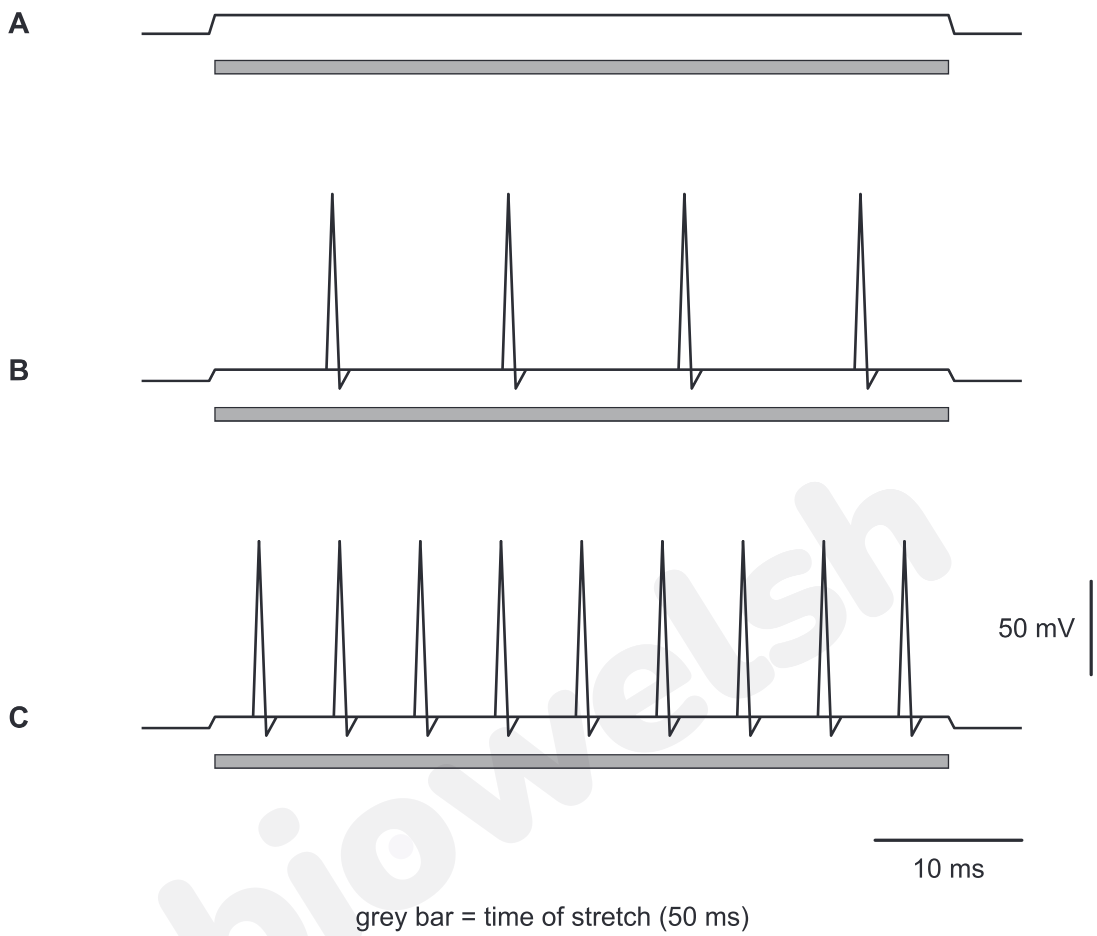
(e) The refractory period of this neurone lasts 4 ms. Calculate the maximum number of action potentials it could carry in one second. [1]

Maximum = ... s^{-1}

9

Tutor only

8. Crayfish have stretch receptor neurones in the muscles of their abdomen. Scientists stretched the muscle by three different amounts, each for 50 ms, and recorded the action potentials in the stretch receptor neurone. **Graph 8.1** shows the traces.



Graph 8.1

(a) Explain why the stretch in trace **A** produced no action potentials. [2]

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....

(b) Calculate the frequency of action potentials in trace **C**, in action potentials per second. [2]

Frequency = ... s^{-1}

Tutor only

(c) Using **Graph 8.1**, explain how the nervous system distinguishes a large stretch from a smaller one. [2]

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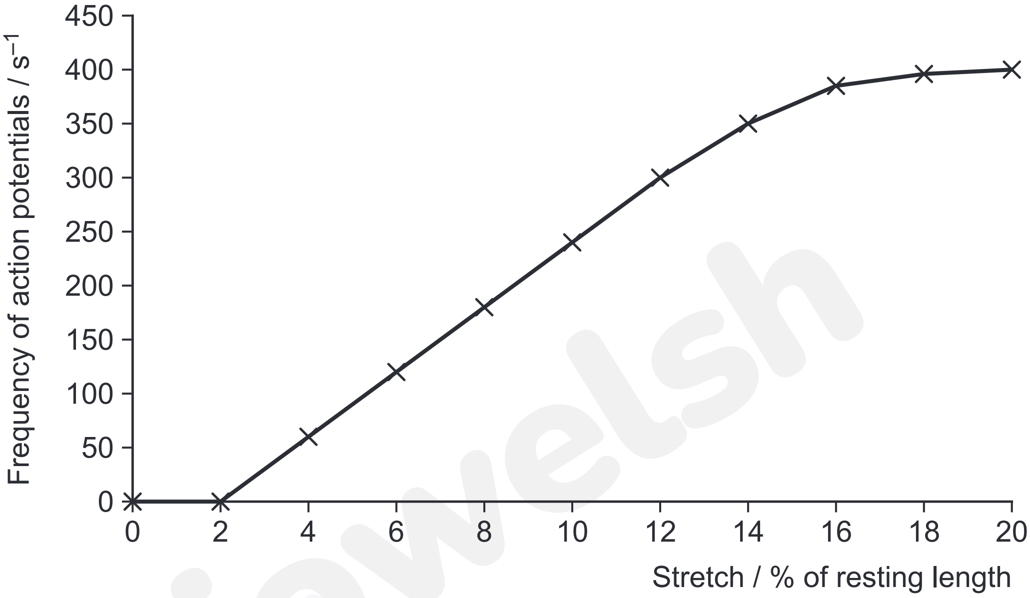
Graph 8.2 shows the frequency of action potentials at different amounts of stretch.



Graph 8.2

(d) (i) Use **Graph 8.2** and your answer to (b) to estimate the stretch used in trace **C**. [1]

Stretch = ... %

(ii) Explain why the frequency levels off at 400 action potentials per second. [2]

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Turn over.

Tutor only

9. **Table 9.1** shows the conduction speed of non-myelinated axons of different diameters from several invertebrates. The largest is the giant axon of a squid.

Table 9.1

Axon diameter / µm	10	50	100	200	300	500
Conduction speed / m s^{-1}	3.5	7.9	11.2	15.8	19.4	25.0

(a) Plot a graph of the data in **Table 9.1** on the grid below. Draw a smooth curve of best fit. [4]

(b) Describe the relationship shown by your graph. [2]

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(c) A myelinated mammalian axon of diameter 10 µm conducts at 60 m s^{-1}. Calculate how many times faster this is than a non-myelinated axon of the same diameter. [1]

Answer = ... times

Tutor only

(d) Explain why the myelinated axon conducts impulses so much faster. [3]

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(e) Suggest why a squid has giant axons rather than myelinated axons for its escape response. [1]

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11

Tutor only

10. In multiple sclerosis (MS), the immune system damages the myelin sheaths of neurones in the brain and spinal cord, including the optic nerve. In a test, a patient looks at a changing pattern on a screen and the time taken for impulses to reach the visual area of the brain is measured. **Table 10.1** shows the results for two groups of people.

Table 10.1

Group	Mean time for impulses to reach the brain / ms
people without MS	100
people with MS	128

(a) Calculate the percentage increase in the time taken for people with MS. [2]

Percentage increase = ... %

(b) Explain why damage to the myelin sheath increases the time taken. [2]

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(c) People with MS often feel very tired. Suggest how damage to the myelin sheath could contribute to this. [2]

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(d) Suggest **two** other symptoms that could result from damage to myelinated neurones in the brain and spinal cord. [2]

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Tutor only

(e) Suggest why the symptoms of MS differ from one patient to another. [1]

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Tutor only

11. **Image 11.1** shows the structure of a cholinergic synapse.

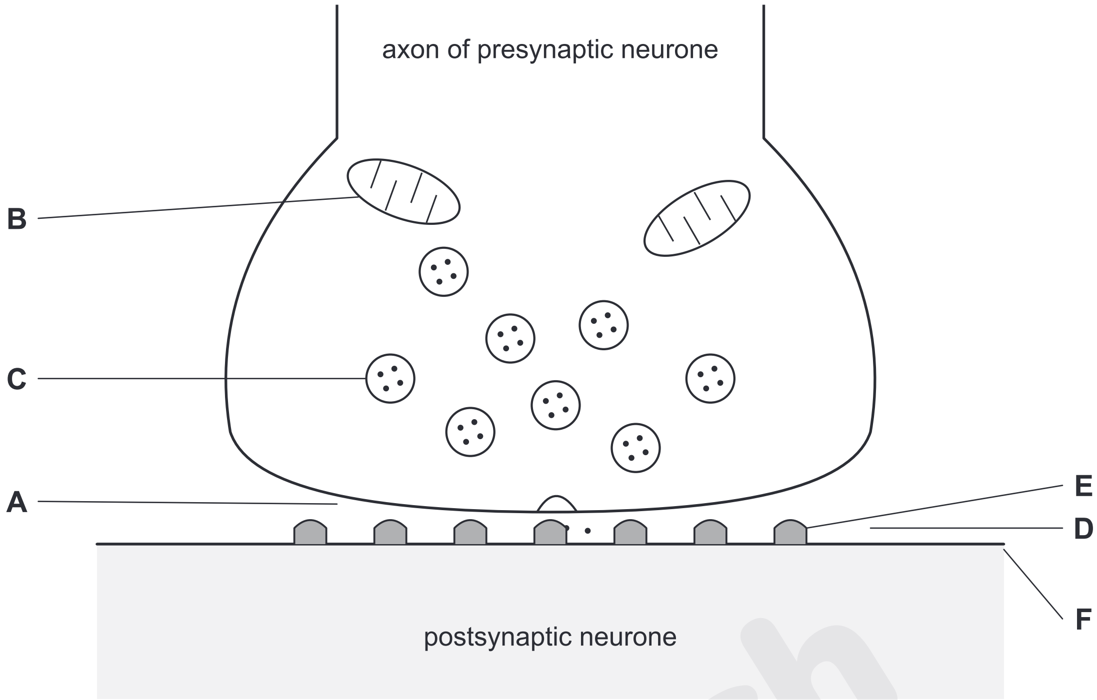

Image 11.1

(a) Name the structures labelled **A** to **F**. [3]

A ....

B ....

C ....

D ....

E ....

F ....

(b) The synaptic cleft is 20 nm wide. In the original drawing of **Image 11.1** it was drawn 10 mm wide. Calculate the magnification of the original drawing. **Give your answer in standard form.** [2]

Magnification = × ....

Tutor only

(c) Explain the role of structure **B** in synaptic transmission. [2]

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(d) When a presynaptic neurone is stimulated at a very high frequency for several minutes, the postsynaptic neurone stops responding. Suggest why. [2]

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Tutor only

12. **Table 12.1** lists the events of synaptic transmission at a cholinergic synapse in the wrong order.

Table 12.1

Letter	Event
P	Acetylcholine diffuses across the cleft and binds to receptors.
Q	Calcium ion channels open and Ca^{2+} diffuse into the synaptic knob.
R	An action potential arrives at the synaptic knob.
S	Vesicles fuse with the presynaptic membrane and release acetylcholine by exocytosis.
T	Sodium ion channels open and the postsynaptic membrane is depolarised.
U	Acetylcholinesterase hydrolyses acetylcholine.

(a) Give the letters in the correct order, starting with the first event. [2]

Order ....

(b) Explain why event **U** is essential for synaptic transmission to work normally. [2]

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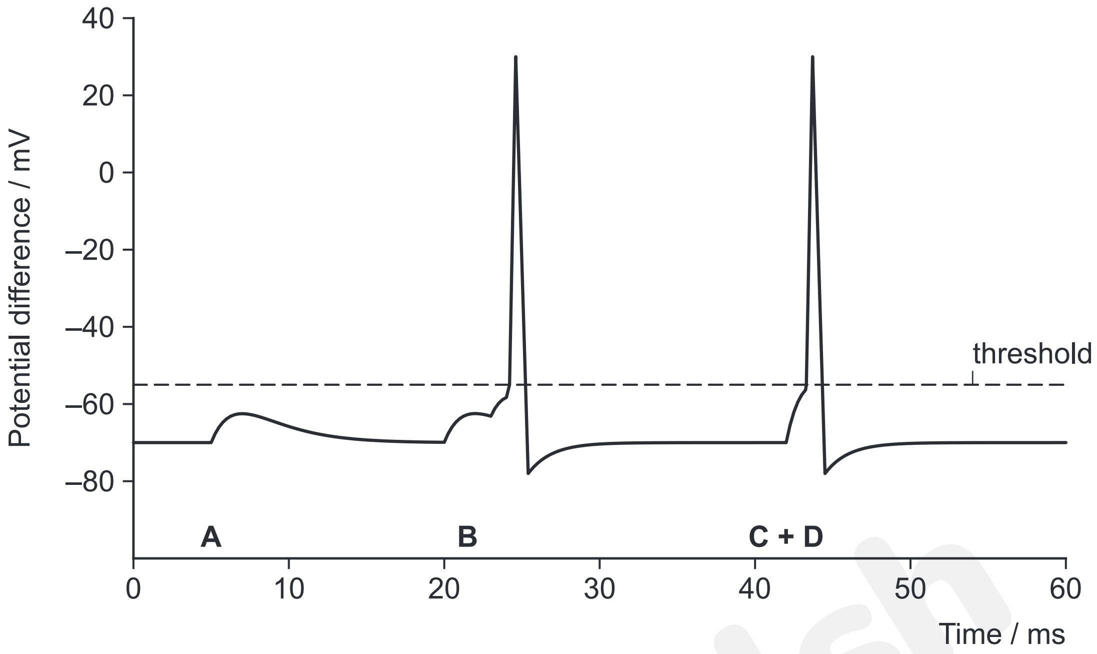
Tutor only

Graph 12.2 shows the potential difference across a postsynaptic membrane. At **A** one impulse arrived at one synapse. At **B** two impulses arrived at the same synapse 3 ms apart. At **C + D** impulses arrived at the same time at two different synapses.



Graph 12.2

(c) (i) State the threshold potential of this postsynaptic neurone. [1]

....

(ii) Explain why no action potential was produced at **A**. [1]

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....

(iii) Name the processes shown at **B** and at **C + D** and explain how each produced an action potential. [3]

B ....

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C + D ....

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Tutor only

13. Until the late 1990s, sheep in Wales were dipped in organophosphate insecticides to kill parasites such as sheep scab mites. Organophosphates inhibit acetylcholinesterase. In a study, the activity of acetylcholinesterase in the blood of farmers was measured before and after dipping sheep. **Table 13.1** shows the results.

Table 13.1

Group of farmers	Before dipping / %	1 day after dipping / %	2 weeks after dipping / %
did not wear gloves	100	72	88
wore rubber gloves	100	94	98

Values are mean acetylcholinesterase activity as a percentage of the activity before dipping.

(a) Explain how organophosphates affect transmission at a synapse. [3]

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(b) Calculate the percentage decrease in activity one day after dipping for farmers who did not wear gloves. [1]

Percentage decrease = ... %

(c) Use **Table 13.1** to suggest how most of the organophosphate entered the farmers' bodies. Explain your answer. [2]

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(d) Suggest why the enzyme activity had increased again after two weeks. [1]

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Tutor only

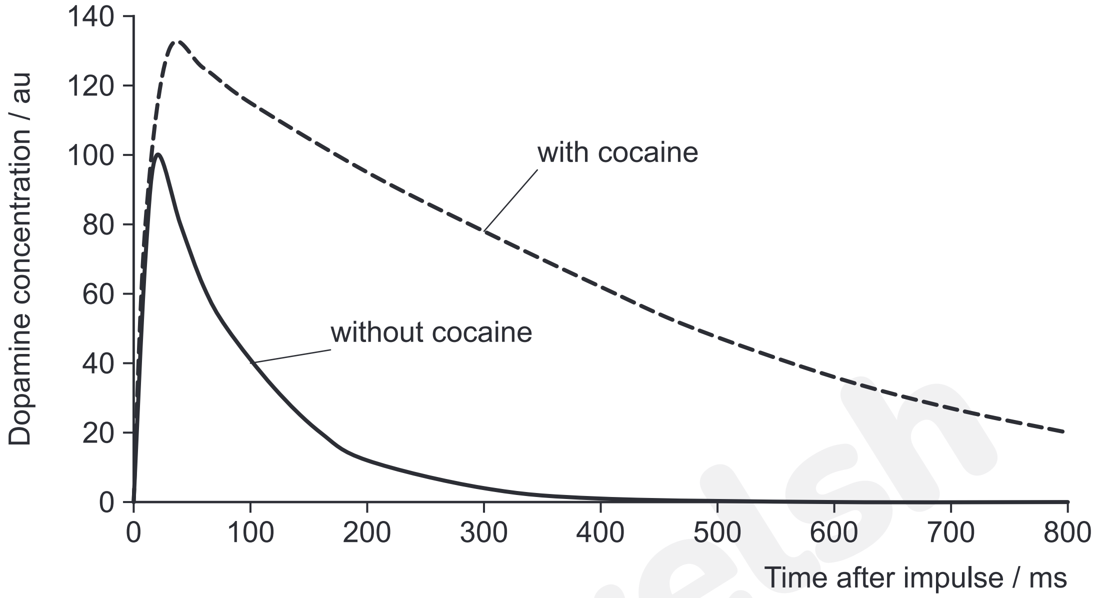
(e) Atropine is given as an antidote to organophosphate poisoning. It binds to some acetylcholine receptors without opening their ion channels. Suggest how atropine reduces the symptoms of poisoning. [2]

9

Turn over.

Tutor only

14. Dopamine is a neurotransmitter in the brain. After it has been released, it is taken back into the presynaptic neurone by transporter proteins in the presynaptic membrane. Cocaine blocks these transporter proteins. **Graph 14.1** shows the concentration of dopamine in a synaptic cleft after one impulse, with and without cocaine.



Graph 14.1

(a) Describe **two** differences between the results with and without cocaine. [2]

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(b) Calculate how many times longer it takes the dopamine concentration to fall to 50 au with cocaine than without cocaine. [2]

Answer = ... times

(c) Explain how cocaine causes the results shown in **Graph 14.1** and the effect this has on the postsynaptic neurone. [3]

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Tutor only

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(d) In regular cocaine users, the number of dopamine receptors on postsynaptic membranes decreases. Suggest why these people need more cocaine to produce the same effect. [2]

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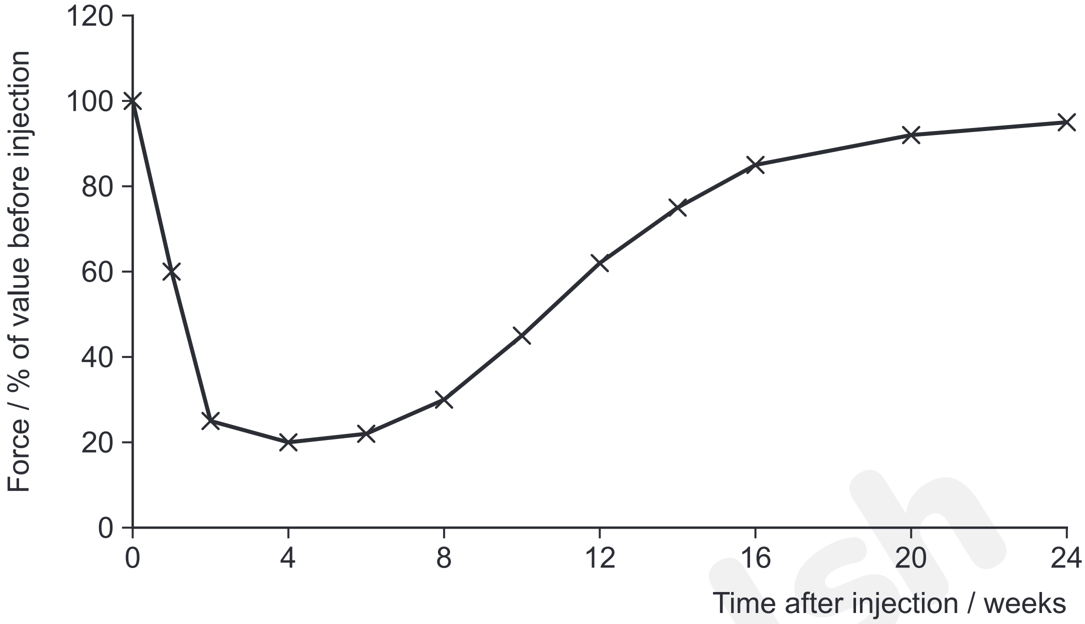
Tutor only

15. Botulinum toxin is made by the bacterium *Clostridium botulinum*. At neuromuscular junctions it prevents the synaptic vesicles from fusing with the presynaptic membrane. Very small doses are injected into muscles to treat painful muscle spasms. Over several weeks, the motor neurone grows new axon terminals. **Graph 15.1** shows the force of contraction of a treated muscle, when its motor neurone was stimulated, over 24 weeks after one injection.



Graph 15.1

Describe how an action potential is generated and passes along a myelinated motor neurone. Describe how the impulse normally passes across the neuromuscular junction to stimulate the muscle. Use **Graph 15.1** and the information above to explain the effect of botulinum toxin on the muscle during the 24 weeks. [9 QER]

Tutor only

END OF WORKSHEET

9

Turn over.

A Tutor Meets Tutee project

BioWelsh worksheets are written and checked by Tutor Meets Tutee tutors for WJEC A level Biology students.

Mark this worksheet with the BioWelsh mark scheme **BW-A2-3.8-W1** (MS).

Acknowledgements

Image 2.1: Micrograph: OpenStax, CC BY 4.0 (Wikimedia Commons, '1313 Spinal Cord Cross Section'), https://creativecommons.org/licenses/by/4.0. Cropped to the micrograph only; letters and label lines added.

Image 4.1: Photo: Marta Boroń, CC BY 2.0 (Wikimedia Commons, 'Hydra oligactis'), https://creativecommons.org/licenses/by/2.0. Cropped and resized.

Image 5.1: Micrograph: Berkshire Community College Bioscience Image Library, CC0 (Wikimedia Commons, 'Nervous Tissue Spinal Cord Motor Neuron'). Cropped; letters and label lines added.