Neuronal Communication

Model Answers 1

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Communication, homeostasis and energy
Topic	Neuronal communication
Booklet	Model Answers 1

Time allowed: **72 minutes**

Score: **/53**

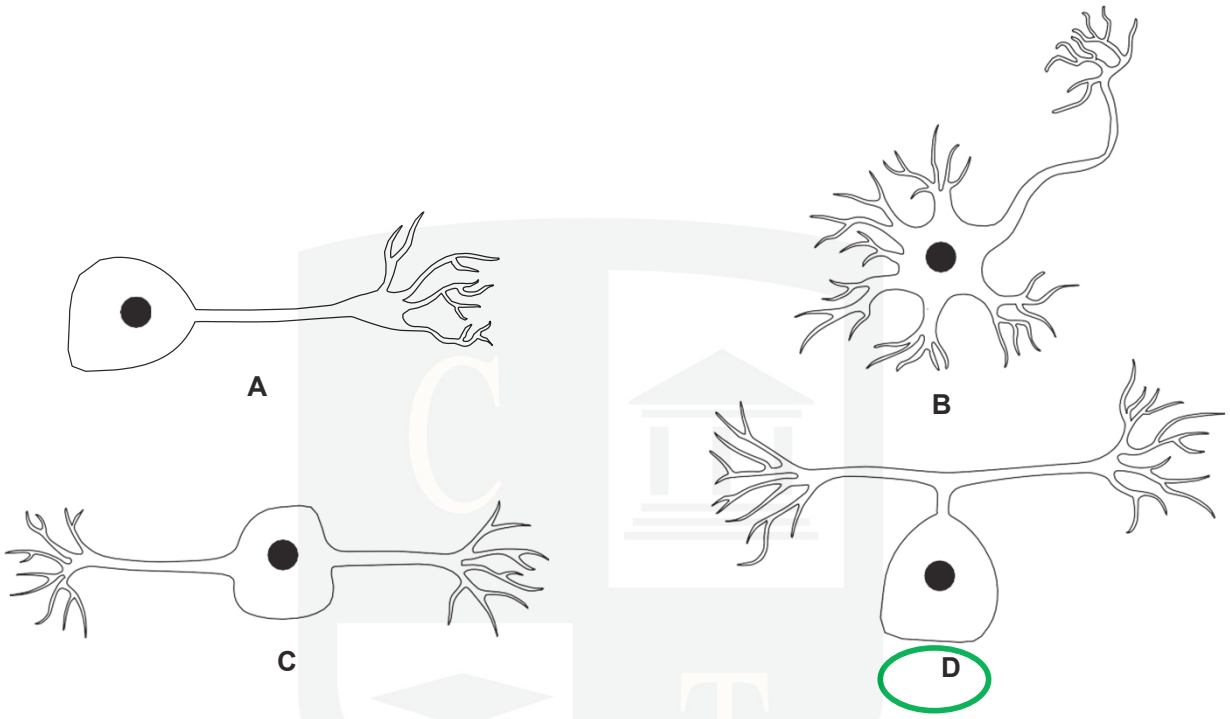
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

Which of the following diagrams, **A** to **D**, shows a sensory neurone?



[1]

Motor neurones have no dendron and very long axons so A and B could be those.

C is wrong as the cell body is not part of the dendron and axon but separate to these structures. Hence D but what D doesn't tell you the length of the dendron and axon

Question 2

The table below shows the membrane potentials of different neurones at a cholinergic synapse. The data were recorded on five separate occasions, as shown in the five rows.

	Membrane potential (mV)			
	Presynaptic neurone A	*Presynaptic neurone B*	*Presynaptic neurone C*	*Postsynaptic neurone*
1	+40	–70	–70	–70
2	–70	+40	–70	–70
3	–70	–70	+40	–70
4	+40	+40	–70	–70
5	+40	+40	+40	+40

Which of the following, **A** to **D**, explains these data?

A. divergence

B. hyperpolarisation

C. spatial summation

D. temporal summation

[1]

Some of the neurones are at resting potential of -70 whilst some are at the action potential of +40, so some are firing at the same time and some are not. When action potentials arrive at the same time at a cholinergic synapse, this an example of spatial summation

Question 3

Animals receive different stimuli from their environment. Their synapses can manage multiple stimuli, often resulting in one response (such as a muscle twitching).

This action of the synapse is an example of

A spatial summation

B all or nothing response

C temporal summation

D cell signalling

[1]

When action potentials arrive at the same time from different neaurones

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Question 4

Plasma membranes are very important for many processes involved in the functioning of cells, both in animals and plants.

(a) Fig. 4.1 represents part of the plasma (cell surface) membrane of an axon.

Structures labelled **A** to **D** represent the involvement of proteins in the movement of ions during **depolarisation** of the membrane.

D represents a voltage-gated protein.

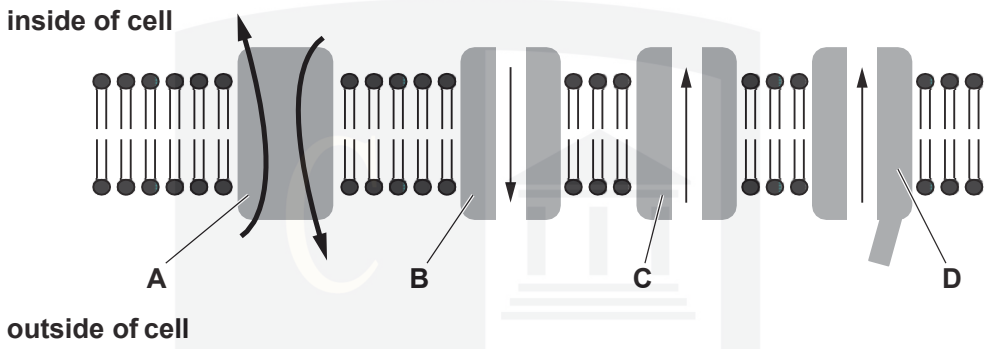

Fig. 4.1

Identify, using the appropriate letter(s), which of the proteins **A**, **B**, **C** or **D**:

(i) need(s) ATP to function **[1]**

A needs ATP to function as this is the sodium/potassium pump which carries out active transport

(ii) transport(s) potassium ions (K^+) **into** the cell **[1]**

A is still the sodium/potassium pump which transports ie pumps potassium ions into the cell

(iii) allow(s) potassium ions (K^+) **out of** the cell **[1]**

B is the potassium ion channel which opens to allow potassium ions to diffuse out of the cell

(iv) allow(s) or transport(s) sodium ions (Na^+) **into or out of** the cell. **[1]**

A,C and D all allow, or transport sodium ions into or out of the cell

Active transport relies on carrier proteins and they use ATP, its pumps molecules from an area of low to high concentration against the diffusion gradient. Channel proteins allow a process known as facilitated diffusion whereby large or polar molecules diffuse from an area of high to low concentration without the use of energy, which is a passive process. Small and non-polar molecules such as oxygen and carbon dioxide and can diffuse directly through the phospholipid bilayer.

With reference to C:

C is a simple Na+ channel. During the establishment of the resting potential, the Na/K pump will pump K+ into the cell and Na+ out of the cell (as, indeed, it does constantly). Na+ will diffuse back in slowly through **C** and K+ will diffuse back out slowly through **B**. The movement of Na+ back in is much less than the movement of K+ back out. As **B** and **C** are not voltage-gated they will remain open at all times, even during depolarisation. The diffusion of the ions through **B** and **C** depends on both the relative concentration of the ions and the electrochemical gradient and will be small or, at times, negligible.

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(b) Fig. 4.2 represents part of the plasma (cell surface) membrane of a cell that responds to adrenaline.

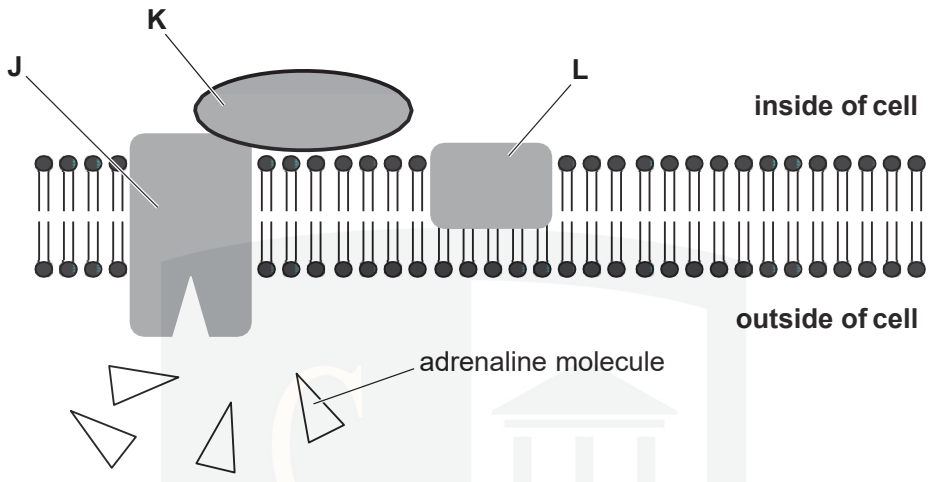

Fig. 4.2

Describe the involvement of **J**, **K** and **L** in the cell's response to adrenaline.

In your answer, you should use appropriate technical terms, spelled correctly. **[5]**

- Adrenaline attaches to J, which is a receptor protein
- Adrenaline has a complementary shape to the binding site on the receptor (J)
- The receptor changes shape
- This causes the G protein (K) to change shape and be released from the receptor
- The G protein activates the enzyme adenyl cyclase (L)
- Adenyl cyclase converts ATP to cyclic AMP (cAMP)

Sometimes the arrival of a hormone at the surface receptor on the membrane results in the formation of cyclic AMP which is known as the second messenger. This activates enzymes which could result in the production of particular transcription factors. In this way hormones can trigger a response in a target cell by stimulating the production of transcription factors, which allow transcription to take place resulting in the production of a particular protein such as an enzyme.

(c) Fig. 4.3 represents part of the **inner** membrane of a cell organelle. The letters represent substances involved in one stage of aerobic respiration.

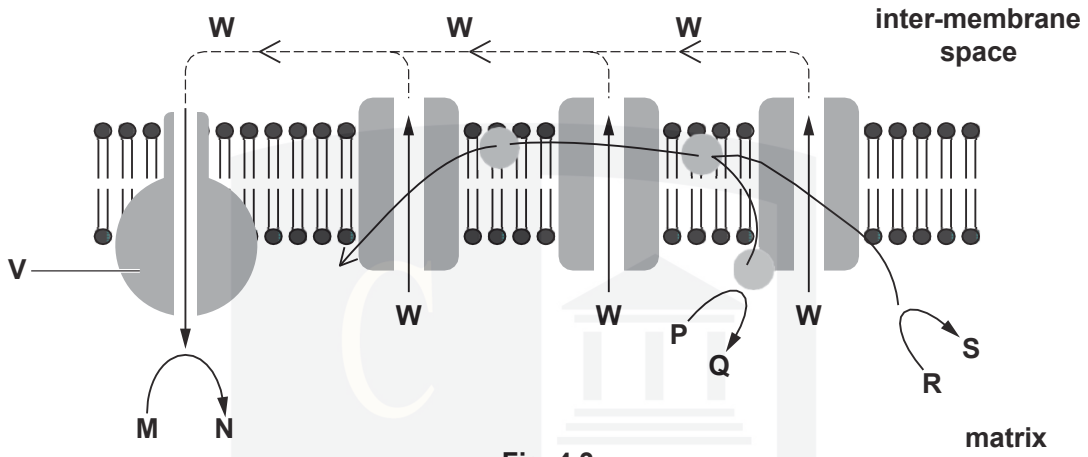

Fig. 4.3

(i) In which organelle would this inner membrane be found? **[1]**

- This inner membrane would be found in the mitochondria

Note the first sentence refers to the process of aerobic respiration so this narrows it down somewhat

(ii) Identify **V**. **[1]**

- V is ATP synthase.

This complex allows hydrogen ions to diffuse back into the matrix, often referred to as a molecular pump, the energy released as the hydrogen ions return is used to phosphorylate ADP to ATP

(iii) Identify **W**. **[1]**

- Label W is pointing to hydrogen ions

The hydrogen ions were pumped into the intermembrane space by the energy released when electrons were passed along the electron transport chain

(iv) Which letter **from Fig. 4.3** represents a reduced coenzyme? **[1]**

- P and R are pointing to reduced coenzymes

Reduced NAD and FAD are passing their hydrogen atoms to the start of the electron transport chain, here they split into electrons and protons.

(v) Which letter **from Fig. 4.3** represents ATP? **[1]**

- Molecule N is ATP which is generated by the energy released as hydrogen ions return to the matrix vis ATP synthase

In the process of oxidative phosphorylation, reduced NAD gives up its two hydrogens to the first part of the electron carrier system. The first molecule in the electron carrier system is known as FAD, after this step the two hydrogen atoms are split into two hydrogen ions or protons and two electrons, the electrons are passed along the electron carrier proteins releasing energy as they are passed from one to the next. At the last step the 2 electrons and 2 protons recombine and are accepted by oxygen, which is known as the final hydrogen or electron acceptor. The energy released is used to pump hydrogen ions from the matrix of the mitochondria into the inter membrane space. The build-up of

hydrogen ions creates a proton motive force, the hydrogen ions then diffuse back into the matrix through structures known as stalked particles or ATP synthase complexes, otherwise known as chemiosmosis.

The hydrogen ions then pass down an electrochemical gradient releasing energy as they return to the matrix. This energy is used to phosphorylate ADP to ATP.

This also explains why the inner membrane of mitochondria is so highly folded. The folds or cristae create a large surface area for the attachment of electron transport chains and ATP synthase complexes. The larger the surface area, the more ATP can be made by that mitochondrion

[Total: 14]

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Question 5

(a) Fig. 1.1 represents a cross section through a myelinated neurone.

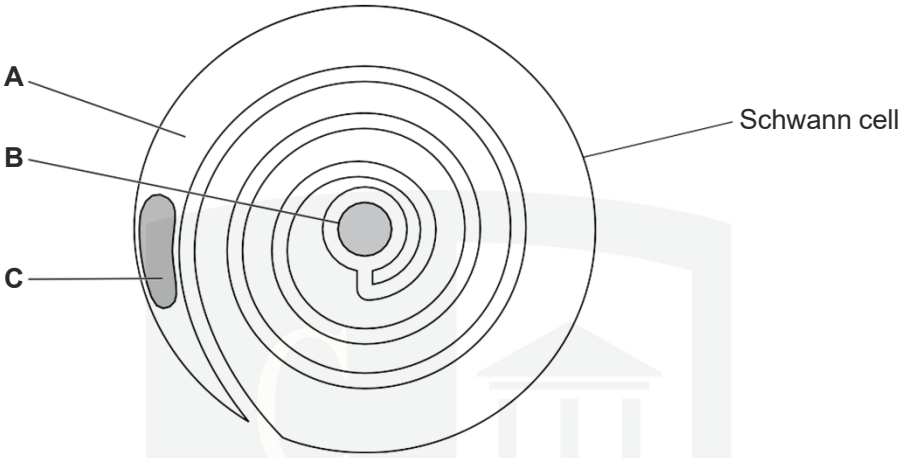


Fig. 1.1

(i) Identify **A** to **C**. **[3]**

- A cytoplasm
- B cell membrane / axon
- C nucleus

(ii) Name the gap between two adjacent Schwann cells along the length of the neurone. **[1]**

Node of Ranvier

(b) There are a number of differences between myelinated and non-myelinated neurones. One difference is the distribution of voltage-gated sodium ion channels in the membrane.

myelinated neurone

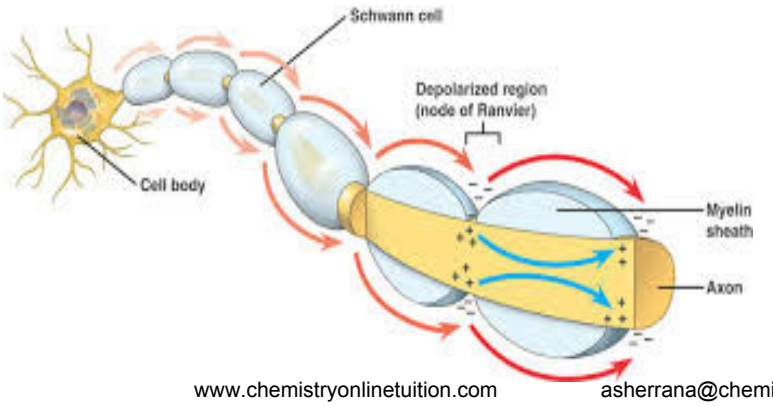
- voltage-gated sodium ion channels only occur at gaps between Schwann cells
- each gap is approximately 2 μm long
- gaps occur at approximately 1000 μm intervals

non-myelinated neurone

- voltage-gated sodium ion channels occur along the total length of the neurone

Use the information above to explain the difference in the speed of conduction of an action potential along the length of a myelinated neurone and a non-myelinated neurone. **[4]**

- The speed of conduction is faster in myelinated neurones
- Depolarisation can only occur where the voltage gated ion channels are present
- Myelinated neurones have longer sections without voltage gated ion channels
- Ion transfer can only take place at the nodes
- Local circuits are longer
- The action potential jumps from node to node
- This is known as saltatory conduction



(c) A family of membrane proteins known as SNARE proteins are attached to vesicle membranes and cell surface membranes.

Fig. 1.2 summarises the mechanism by which vesicles secrete acetylcholine from a neurone.

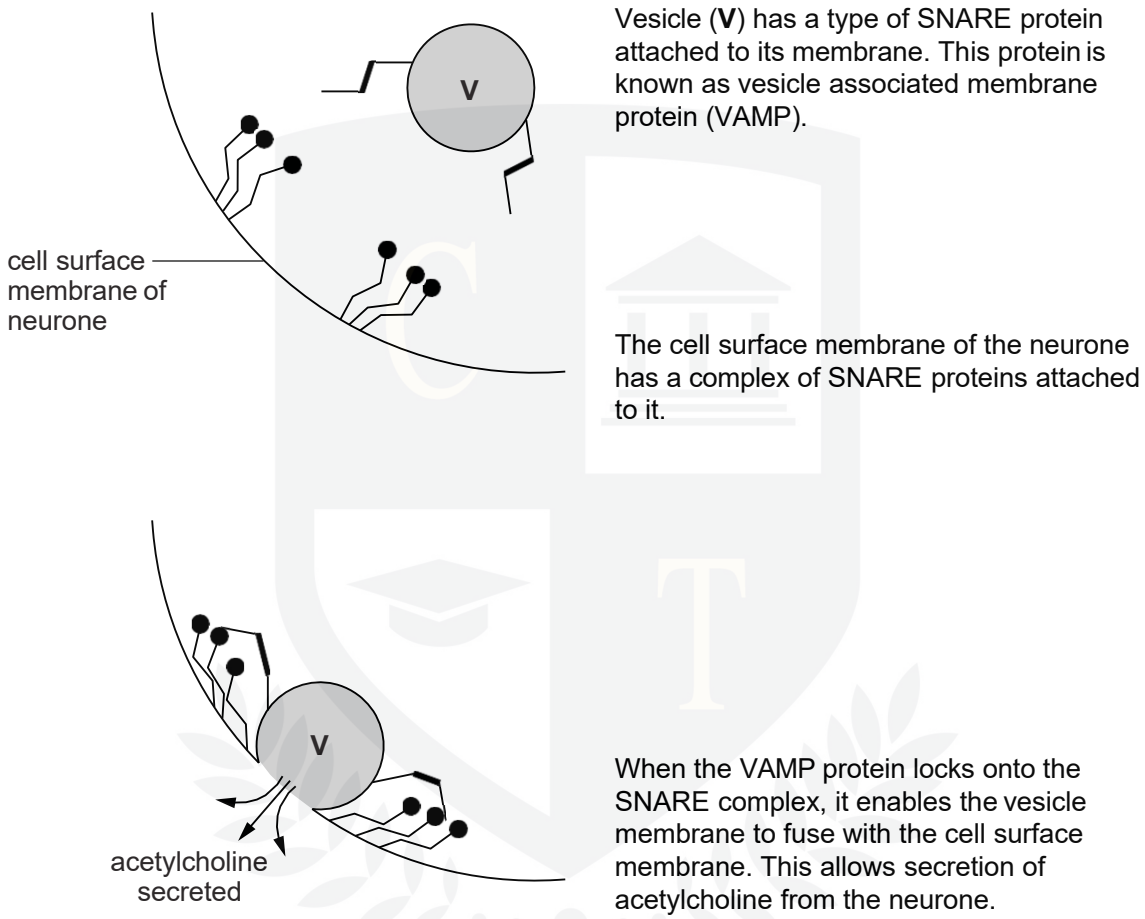


Fig. 1.2

(i) Name the process by which the acetylcholine is secreted. **[1]**

Acetyl choline is secreted by exocytosis

(ii) Name the part of a neurone from which acetylcholine is secreted. **[1]**

Acetyl choline is secreted from the presynaptic membrane / synaptic knob

(iii) Botulinum toxin is a protease that is produced by the bacterium, *Clostridium botulinum.* If this toxin is present in the body, for example as a result of eating contaminated food, the toxin enters neurones.

With reference to Fig. 1.2, suggest, with reasons, the effects that botulinum toxin may have once it has entered a neurone. **[2]**

- The protease enzyme produced by the bacterium will hydrolyse the proteins of the SNARE or VAMP protein
- The VAMP protein cannot bind with the SNARE complex
- Vesicles cannot bind with the membrane so acetyl choline isn't released

Don't let the complex description of the VAMP or SNARE complexes put you off. The question is all about a protease enzyme and proteins. Note: '**hydrolyse'** is better than '**breaks down'**. It is A level after all!

[Total: 12]

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Question 6

(a) Fig. 1.1 represents a sensory neurone connected to its associated receptor cells.

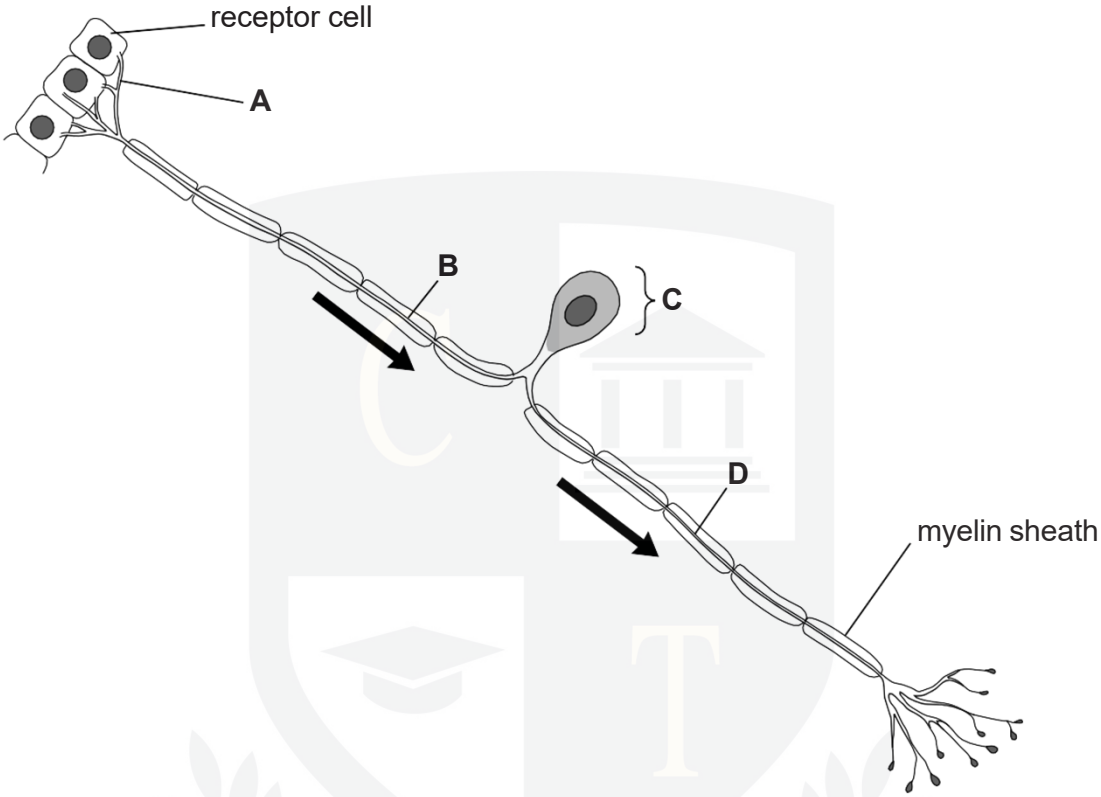


Fig. 1.1

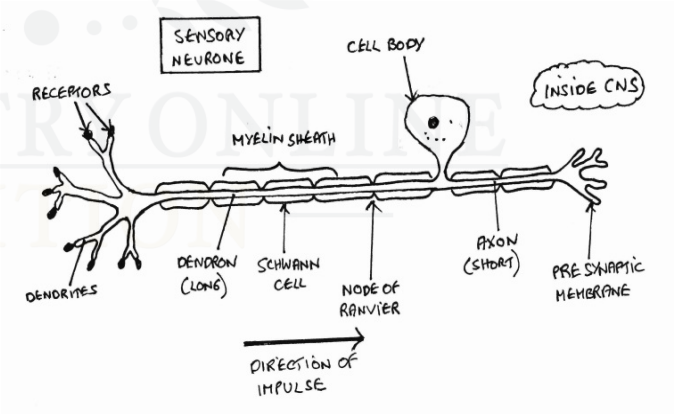
(i) Identify the parts of the neurone labelled **A** to **D**. **[4]**

A .....dendrite.....

B .....dendron.....

C .....cell body.....

D .....axon.....



(ii) What is represented by the arrows on Fig. 1.1? **[1]**

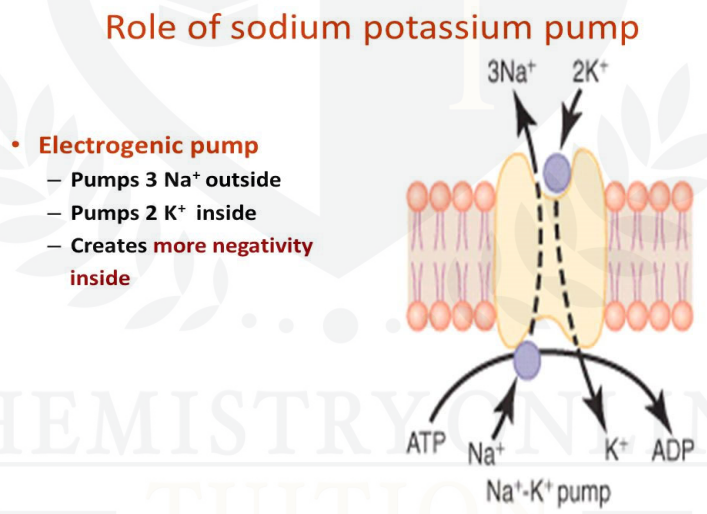
- The arrow represents the direction of the action potential

(b) Describe and explain how the **resting potential** is established **and** how it is maintained in a sensory neurone.

In your answer, you should use appropriate technical terms, spelled correctly.

[4]

- The sodium potassium pump uses ATP to actively transport ions in and out of the cell
- The pump moves 3 sodium ions out for every 2 potassium ions that come in
- The voltage gated sodium ion channels are closed preventing their return
- Most of the potassium ion channels are closed but some leak back out of the cell
- This causes a build-up of positive ions outside the neurone and the neuron inside is charged to a value of -70 mV



(c) Fig. 1.2 shows the changes in the membrane potential of a sensory neurone when the receptor cells are stimulated.

Fig. 1.3 indicates the strength of the stimuli that results in the corresponding changes in membrane potential.

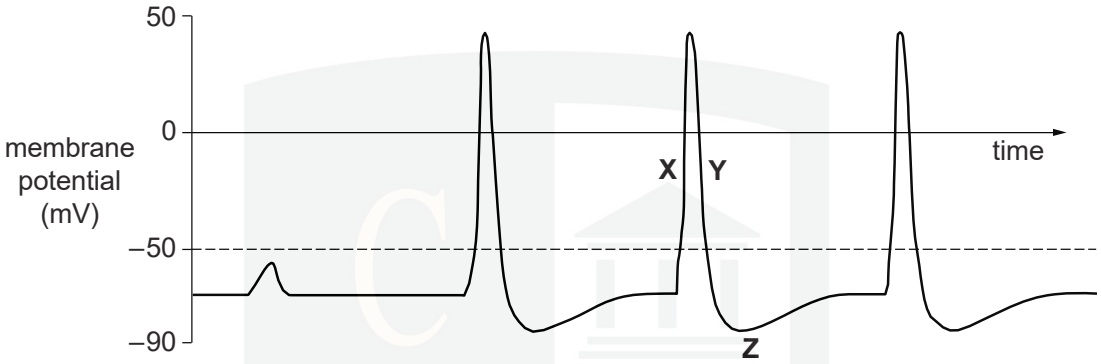


Fig. 1.2

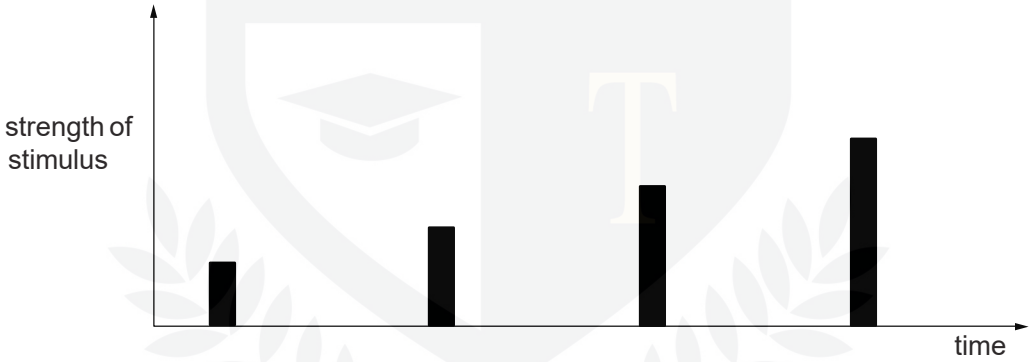


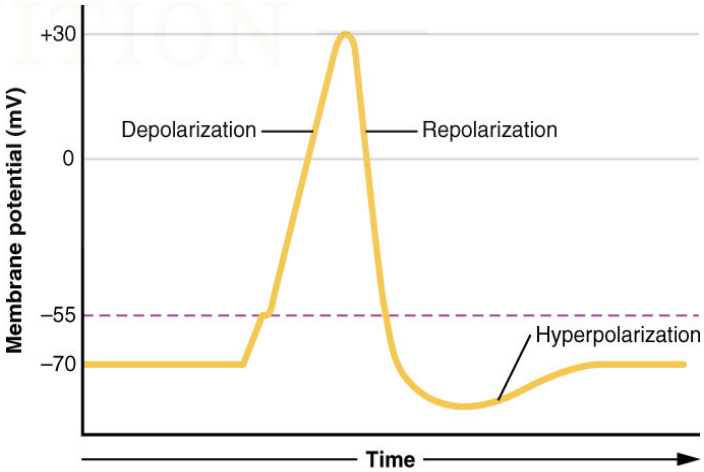
Fig. 1.3

(i) State the term used to describe what is happening at each of the points **X**, **Y** and **Z** on Fig. 1.2. **[3]**

X .....depolarisation.....

Y .....repolarisation.....

Z .....hyperpolarisation.....



(ii) What term is used to refer to the value of −50 mV on Fig. 1.2? **[1]**

- Threshold potential

Enough sodium ion channels have to open before the threshold potential is reached. Once the sodium ions have diffused in and the potential of -50mv is exceeded then an action potential occurs

(iii) Comment on the relationship between the strength of a stimulus, as shown in Fig. 1.3, and the resulting action potential, as shown in Fig 1.2.

[2]

- Only stimuli that are greater than the threshold potential of -50 mV will produce an action potential
- An action potential either occurs or does not occur at all, this is the all or nothing law
- The action potential is always the same magnitude or size regardless of how strong the stimulus
- A strong stimulus produces more frequent action potentials

[Total: 15]

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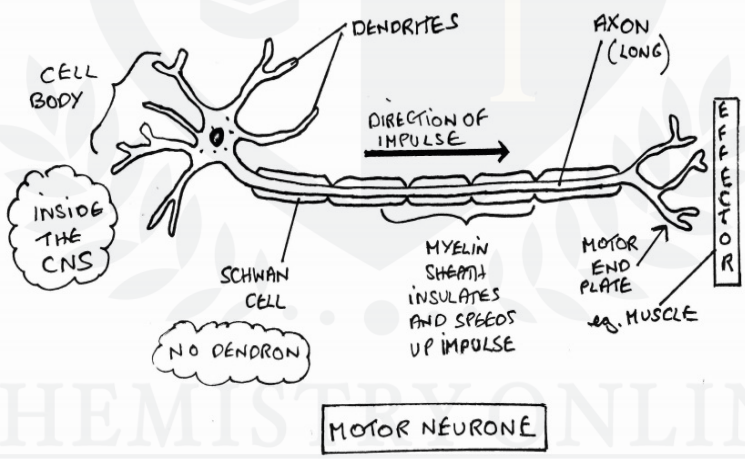
Question 7

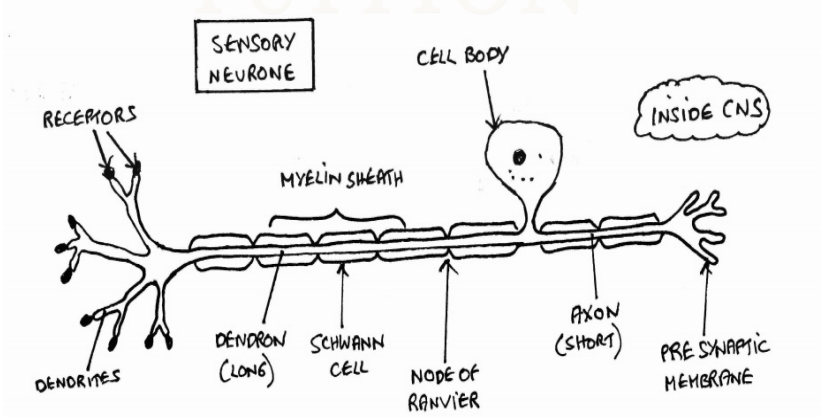
(a) The nervous system is made up of a number of different types of neurone, which transmit electrical impulses.

Complete the table below by stating **three** differences in the structure of motor and sensory neurones.

[3]

Motor neurone	Sensory neurone
Cell body in CNS	Cell body just outside CNS
Cell body at the end of the neurone	Cell body not at the end
Long axon	Short axon
Dendron absent	Dendron present
Ends at a motor end plate	Starts at a receptor





(b) Complete the following passage, using the most appropriate term(s) in each case.

When an impulse is not passing along a neurone, a resting potential of .....-70 mV.....mV is established. When the neurone is stimulated, it causes .....depolarisation..... of the cell surface membrane. This will not generate an action potential unless it is large enough to exceed the .....threshold potential..... .....

A neurone will either conduct an action potential or not; this is described as the .....all or nothing..... - ..... - .....law.

Action potentials all have the same .....magnitude..... . The only way in which the intensity of a stimulus can be interpreted is by the .....frequency..... of the action potential. **[6]**

[Total: 9]

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