**Review Worksheet ANSWERS: Action Potentials**

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1: What is the role of the Na+/K+ pump in the neuron cell membrane?

(4.5 marks)

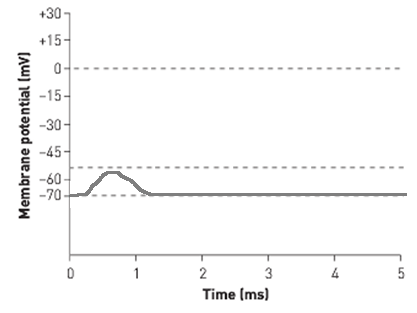
*The Na+/K+ pump works continuously (0.5), using ATP (active transport)(0.5) to move 3 Na+ out of the cell (0.5) and 2 K+ into the cell (0.5) against the concentration gradient (0.5). In the resting neurone membrane (0.5), this maintains a resting membrane potential of -70mV (0.5), as it keeps the outside of the cell relatively more positive than the inside of the cell (0.5). It also works to return the neuron membrane to rest (0.5) after hyperpolarisation at the end of the Action Potential (AP)(0.5)*

2: What is the resting membrane potential of the neuron cell membrane?

(1 mark)

*-70 mV*

3: On the graph, show what the change in membrane potential would look like if the threshold was not reached.\*

 (1 mark)

4: What is the depolarisation threshold at which an AP will be triggered?

(1 mark)

*-55 mV*

5: If each individual neuron is an “all or nothing” response, why does it hurt more when we drop a hammer on our foot compared to a slice of bread?

(5 marks)

*It hurts more when we drop a hammer on our foot because more neurons are triggered to transmit the information to the brain (1), and pain receptors are specifically triggered (rather than pressure receptors) (1) because of the force with which the hammer hits the foot (1). A piece of bread hits the foot with less force, so fewer neurons experience enough local stimulation to reach threshold (1), and there is not enough force to trigger pain receptors. (1)*

6: At the end of repolarisation, the membrane potential is briefly at -70mV, the same as the resting membrane potential. What is different about the distribution of ions at this point compared to when the membrane is at rest?

(4 marks)

*At the end of repolarisation, there are more K+ ions outside of the cell (1) and Na+ ions are inside the cell (1). The outside is still relatively positive compared to the inside of the membrane (1), but it is because of the large number of K+ ions outside the membrane rather than the Na+ ions that are outside the membrane during resting membrane potential. (1)*

7: What happens to return the neuron to resting membrane potential (RMP) after hyperpolarisation?

(4 marks)

*The Na+/K+ pump works to move Na+ ions out of the neuron (1) and K+ in (1), restoring the original membrane potential(1) and ion distribution (1).*

8: Fill in the following table showing what is happening to membrane channels, ion movement and the membrane potential at each stage of an AP.

(14 marks)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Membrane channel activity** | **Ion movement** | **Membrane potential** |
| **Resting Membrane Potential (RMP)** | *Gated Na+ and K+ channels are closed. (0.5)*  *Na+/K+ pump working (0.5)* | *Na+ diffuses constantly across the membrane (0.5)*  *Na+/K+ pump uses ATP (active transport) to move 3 Na+ out of the cell and 2 K+ in, so inside is relatively negative (0.5)* | *-70 millivolts (mV) (0.5)* |
| **Depolarisation** | *Local stimulation causes some Na+ to move into the cell. (0.5)  If the threshold potential is reached: (0.5)*  *Gated Na+ channels open (0.5)* | *Na+ floods into the cell through the Na+ channels. (0.5) Inside of cell becomes relatively positive. (0.5)*  *Na+ still diffusing across and Na+/K+ pump still working but not enough to maintain RMP. (0.5)* | *Threshold: -55 mV (0.5), then rising to peak depolarisation of +30 mV (0.5)* |
| **Repolarisation** | *Membrane potential of +30mV (0.5) triggers opening of gated K+ channels (0.5)* | *K+ floods from inside of cell to outside. (0.5)*  *Inside becomes relatively more negative. (0.5)*  *Na+/K+ pump and Na+ diffusion still working but not enough to overcome other ion movement (0.5)* | *From +30mV (0.5), then falling to -70mV again. (0.5)* |
| **Hyperpolarisation** | *K+ channels stay open for a while (0.5)* | *K+ continues to move in. (0.5)*  *Na+/K+ pump and Na+ diffusion still working but not enough to overcome other ion movement. (0.5)* | *Membrane Potential falls to below -70mV (0.5)* |
| **Return to RMP** | *K+ and Na+ channels close (0.5)* | *Na+/K+ pump works to pump 3 Na+ out of the cell and 2 K+ in. (0.5) Ion distribution eventually stabilises to resting levels (0.5) with more Na+ outside, making inside relatively negative. (0.5)* | *Membrane potential climbs to*  *-70mV and stabilises. (0.5)* |

9: Explain how an AP is propagated and moves along and unmyelinated axon.

(5 marks)

*The AP that is generated in the first section of membrane (1) stimulates the next part of the membrane to depolarise (1), which triggers the next (1), and so on. In this way, a series of action potentials (1) move down the membrane in a wave. (1)*

10: Explain how an AP is propagated and moves down a myelinated axon.

(5 marks)

*A myelinated axon is covered in a myelin sheath (0.5) made of Schwann cells (0.5), with a small gap between each Schwann cell called a Node of Ranvier (0.5). The myelin sheath prevents ion movement across the membrane in the sections where it occurs (it insulates it) (0.5). The AP of the first section of membrane (0.5) causes Na+ ions to diffuse rapidly down the inside of the axon (0.5) to trigger an AP at the next Node of Ranvier (0.5), which in turn causes Na+ ions to diffuse to the next and so on (0.5). In this way, the Action Potentials jump from node to node, down the axon.(0.5) This is called saltatory conduction. (0.5)*

11: List two advantages of an axon being myelinated.

(2 marks)

*An AP moves more quickly in a myelinated axon, meaning that transmission is faster (1)*

*The outer part of the Schwann cells from the neurilemma (0.5) which allow damaged nerves to regrow (0.5) if the neurilemma is undamaged.*

12: Explain why an AP can travel only in one direction along a nerve cell membrane.

(7 marks)

*During an AP, in the time between the threshold for depolarisation being reached (1), and the return to RMP (1), a new AP cannot be started in that section of membrane (1). This is called the refractory period (1). This means that new APs are only stimulated in the next part of membrane that has not yet depolarised (1), because the part that has already depolarised will not respond to further stimulus (1) until it reaches RMP again (1).*

13: What effect does axon diameter have on the speed of nerve transmission?

(1 mark)

*The greater the axon diameter (0.5) the quicker the speed of nerve transmission (0.5)*