InkBiology

ANSWER BOOK

The action potential: the same size, however hard you push

Nervous coordination, receptors, muscles and behaviour · Unit B14

AQA 3.6.2.1 · OCR A 5.1.3 · Edexcel A Topic 8.8–8.10 · CAIE 15.1.3–15.1.5

7 questions · 25 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 **B1** the resting potential is about -70 mV, with the inside negative relative to the outside. **B1** the pump moves three sodium ions out for every two potassium ions in. [2]

SECTION B · Standard, 3 to 5 marks

B1 **B1** the pump hydrolyses ATP to move three sodium ions out for every two potassium ions in, both against their concentration gradients. **B1** three positive charges leave for every two that enter, so each cycle of the pump makes the inside slightly more negative. **B1** the membrane has many potassium channels open at rest and very few sodium channels, so it is far more permeable to potassium than to sodium. **A1** potassium therefore leaks back out down the steep gradient the pump has built, carrying positive charge with it, while large negatively charged proteins are trapped inside and cannot leave. [4]

B2 **B1** at about -55 mV voltage-gated sodium channels open and sodium ions diffuse in, so the inside becomes less negative. **B1** the depolarisation opens more sodium channels, which is positive feedback, and the potential overshoots zero to reach about +40 mV. **B1** at the peak the sodium channels inactivate and the slower voltage-gated potassium channels are now open, so potassium leaves and the potential falls back: repolarisation. **A1** the potassium channels are slow to shut, so potassium keeps leaving past the resting value to about -80 mV, and the sodium-potassium pump then restores the resting potential. [4]

B3 **B1** below threshold no action potential is produced at all, and the small depolarisation simply fades away. **B1** at or above threshold a full action potential occurs and reaches the same peak of about +40 mV whatever the size of the stimulus, because the positive feedback runs to completion on its own. **B1** a stronger stimulus increases the frequency of impulses along a neurone. **A1** a stronger stimulus also recruits more neurones, as receptors with higher thresholds are brought in, and nothing about the amplitude of any impulse changes. [4]

B4 **B1** during the absolute refractory period the voltage-gated sodium channels are inactivated, so no stimulus of any size can produce another action potential. **B1** during the relative refractory period that follows the membrane is hyperpolarised, so an unusually strong stimulus is needed. **B1** the patch of membrane behind the impulse has just fired and is refractory, so only the membrane ahead can be depolarised and the impulse travels in one direction. **A1** the refractory period sets a minimum interval between impulses, so it keeps them as separate countable events and puts an upper limit on the frequency a single neurone can reach. [4]

B5 **M1** velocity is distance divided by time, with both converted to metres and seconds: 8.4 cm is 0.084 m and 1.2 ms is 1.2×10^{-3} s. **A1** 0.084 ÷ 0.0012 gives a conduction velocity of 70 m s^{-1}. **M1** time is distance divided by velocity, so 1.4 ÷ 1.0. **A1** 1.4 s, which is more than a thousand times the 20 ms the myelinated axon would take over the same distance. [4]

B6 **B1** with the voltage-gated sodium channels blocked, sodium ions cannot rush into the axon, so the membrane cannot depolarise to +40 mV and no action potential is generated. **B1** no impulses therefore reach the brain from the receptors in the tooth, and pain is only felt when impulses arrive there. **B1** the drug cannot distinguish one neurone from another, so it blocks the channels in every axon it reaches, including those carrying impulses from touch receptors in the lip. [3]