Investigation 11.B: Modelling Resting Membrane Potential Answer Key

Answers to Analysis Questions

1. You should graph the number of millivolts produced vs. the time. The graph should have a "bell-shape" with a maximum voltage difference of approximately 20 mV. It will also take some time for the voltage to return to the original level because sodium ions do not diffuse through the dialysis membrane as quickly as do potassium ions.

2. The dialysis tubing is semi-permeable and is analogous to the membrane of the neuron. The K^+ ions in the potassium chloride solution are analogous to the K^+ ions that are inside the neuron. The Na^+ ions in the sodium chloride solution are analogous to the Na^+ ions that are outside the neuron. However, the dialysis tubing does not have the sodium-potassium pump that a neuron has. All movement of ions into and out of the dialysis bag is as a result of simple diffusion.

3. The resting membrane potential of the model neuron will be zero prior to lowering the dialysis tubing into the sodium chloride solution. An electric current cannot be produced in the model until the dialysis tubing is lowered into the sodium chloride solution. The resting membrane potential of a neuron is approximately –70 mV. This negative electric potential of a living neuron is the result of the sodium-potassium pump. ATP is used to pump 3 sodium ions out for every 2 potassium ions that are pumped into the neuron. This results in an unequal distribution of positive charges on either side of the neuron. The buildup of positive charges on the outside of the cell creates an electric potential. In addition, potassium ions also diffuse out of the membrane and sodium ions into the membrane, but this diffusion is unequal: more potassium diffuses out of the membrane, and less sodium diffuses into the membrane.

4. Possible sources of discrepancies could include allowing leaks in the dialysis tubing, not removing all of the insulation or oxidized material from the copper metal, using warmer or colder solutions, not connecting the multimeter correctly, or not timing accurately.

5. One possible hypothesis would be to use solutions with higher or lower concentrations. For example, if you increase the concentration of potassium chloride, you will get a greater electric potential across the dialysis tubing.

Answers to Conclusion Questions

6. **a)** The electric potential was zero at the beginning of the activity, gradually increased to approximately 20 mV, and then decreased back to zero. The electric potential was created by the diffusion of ions across the semi-permeable membrane, and then it returns to zero as ions diffuse back.

b) A neuron would be able to generate only one action potential. The neuron has to have a way of quickly repolarizing in order to transmit the next action potential.

7. **a)** Ions moving by facilitated diffusion can move across a plasma membrane through channels created by proteins embedded in the cell membrane. These proteins allow for the formation of a concentration gradient between the fluids inside and outside the cell. Facilitated diffusion cannot occur in this model because dialysis tubing is non-living and does not have special protein molecules to carry out this process. In this model, K^+ ions diffuse out of the dialysis bag into the sodium chloride solution. This creates a separation of charge because the K^+ ions moved into the sodium solution. The corresponding Cl^- ions are in equal concentration on

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both sides of the membrane. As a result, the sodium chloride solution becomes more positive than the potassium chloride solution inside the dialysis tubing. The charge then returns to zero as the Na^+ ions diffuse into the tubing. However, sodium ions take a longer time to diffuse into the dialysis tube than potassium ions take to diffuse out.

b) The factors that establish a negative resting membrane potential in a neuron are as follows:

1. Some negatively charged substances, such as proteins and chloride ions (Cl^-), are trapped inside the cell and unable to diffuse out through the selectively permeable cell membrane.
2. Sodium ions (Na^+) and potassium ions (K^+) cannot diffuse unaided from one side of the cell membrane to the other. Special membrane proteins, however, can use the energy of ATP to pump charged particles across the membrane. This sodium-potassium pump moves out *3* sodium ions for every *2* potassium ions pumped into the cell, which results in an unequal distribution of positive charges on either side of the membrane. The buildup of positive charges on the outside of the cell creates an electric potential.
3. Special transport proteins form ion-specific channels that allow potassium ions to diffuse down their concentration gradient and out of the cell. There are sodium ion channels as well, but, in a resting neuron, there are more open channels for potassium ions than for sodium ions. As a result, more potassium ions diffuse out of the cell relative to the number of sodium ions diffusing in, which contributes to the buildup of positive charges on the outside of the membrane.