I have decided to name this crossword "Brain Teaser" as a play on words, given that it is both a puzzle to be solved, and that its answers pertain to the topic of Lecture 11, Resting Membrane Potential. The following description, without explicitly giving anything away, contains all of the words that were selected as answers to this puzzle. It is meant to serve as an explanation of how each one plays a specific role in the process of a neuronal cell firing.

First, a brief overview of the neuron structure reveals that there are five components of the neuronal cells that develop upon differentiation from precursor Schwann cells and oligodendrocytes. These components are the dendrocytes, soma, axon, myelin sheath, and synaptic cleft, which is not so much a structural component as it is a mechanistic necessity for successful signal transduction. Dendrites from the postsynaptic neuron are what first receive a stimulus, which is then sent through the soma and down along the axon, carrying the message in the form of an action potential from one neuron to another. Myelination of the axon allows for more efficient signal transduction, providing insulation for the axon.

There are five stages in the firing of an action potential, the first being the neuron at resting membrane potential, which has been reliably measured approximately as -70 mV across the cell. When the cell is at resting membrane potential, there are more positive charges on the extracellular side of the cell membrane as compared to within. The presence of ions, and their movements with or against their respective electrochemical and concentration gradients are what serve to establish the resting membrane potential.

Starting with a cell that has not yet established a resting membrane potential, we should first consider the organic anions, which are produced outside of the cell and shuttled in via active transport mechanisms. As neurons start to accumulate organic anions, OA-, a small membrane potential is generated, typically around -5 mV. At this point, there is an electrical force on the OA-, such that they want to diffuse outside. However, impermeability of the cell membrane to these ions makes this impossible. At this point, we can consider the sodium/potassium pump, which is working to generate a greater membrane potential by actively pumping three sodium ions out of the cell and two potassium ions into the cell, against their concentration gradients. As this happens, the membrane potential becomes more negative, around -10mV. At this point, the forces on potassium ions are opposing; the electrochemical force is driving them into the less negative cell, whereas the diffusion force is pushing them out. At a membrane potential of -10 mV, the diffusion force is much greater, and thus, potassium ions leave the cell through leak channels and sodium ions enter through leak channels. However, as a result of the Na^+/K^+ pump displacing more sodium ions outside than potassium inside, and the diffusion of potassium ions out, the membrane potential becomes more negative and the cell continues to polarize. At around -70 mV, the electrochemical force and diffusion force are equal and opposite one another, and the cell is said to have achieved resting membrane potential.

At the same time, the membrane becomes impermeable to sodium ions until a graded potential is received. When a high frequency of graded potentials is received, or a large enough graded potential is received, the cell's excitation threshold is met. At this point, the neuron enters the second stage, during which action potential fires. When this occurs, voltage-gated sodium channels open and sodium rushes into the cell, causing rapid depolarization. This continues until a peak potential is reached at approximately +50 mV, when the electrochemical and diffusion forces of the sodium become equal in magnitude, though in opposite directions. The second stage is followed by a rapid repolarization, characterized by the closing of voltage-gated sodium channels, and the opening of voltage-gated potassium channels. However, as a result of voltage-gated potassium ions being slower to close, the cell enters a state of hyperpolarization, around -90mV, referred to as the refractory period. When the cell is in this stage, it is completely inhibited and thus, unresponsive to graded potentials.

When the action potential reaches the end of the axon, calcium molecules enter the presynaptic neuron, which stimulate the release of the neurotransmitter into the synaptic cleft, where it can be taken up by the postsynaptic neuron through various receptor-mediated paths, determined by the specific type of neurotransmitter.

This puzzle, along with the description of action potentials firing provided above, is intended to help students as they prepare for the final exam. An answer key, submitted separately, has been provided and should be accessible for those who wish to use this as a resource. Happy studying, and good luck on the final!

Sincerely,

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