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Date________________________ Professor/TA________________________

Activity 48.2 How do neurons function to transmit information?

Working in groups of three or four, construct a dynamic (claymation-type) model of the transmission of an action potential along a neuron and then across a synapse to generate an action potential in a postsynaptic neuron.

When developing and explaining your model, be sure to include definitions or descriptions of the following terms and structures.

Neurons or Parts of Neurons

dendrite
axon
cell body
synaptic vesicles
presynaptic neuron
postsynaptic neuron

Ions

K^+
Na^+
negative organic ions
Ca^{++}

Gates

voltage-gated ion channels
Na^+ gates or channels
K^+ gates or channels
Ca^{++} gates or channels

Building the Model

- Using chalk on a tabletop or a marker on a large sheet of paper, draw the membranes of two neurons and the synaptic region between them. Each neuron should each be at least 4 inches across and a foot or more in length.
- Identify the axon, cell body, and dendrite(s) on your drawing.
- Make the ions and gates from playdough or cutout pieces of paper. Indicate the placement of gates in the membranes and ions inside the membrane versus outside the membranes.
- Include a key for your model that indicates how ions and gates are differentiated from each other. You may use color coding for the ions and gates.
- Start the model by "initiating" an action potential in the axon hillock.
- Indicate how this action potential is propagated along the axon and how it can lead to production of an action potential in the postsynaptic neuron.
- When you have completed your model, explain it to another student or to your instructor.

Use your understanding of how action potentials are generated and propagated to answer the questions.

1. All cells maintain an ionic (and therefore electrical) potential difference across their membranes. In most cells, this potential difference is between –50 and –100 mV. That is, the inside of the cells is more negative than the outside by 50 to 100 mV. Although all cells in the body maintain this potential difference across their membranes, only certain cells (for example, neurons) are capable of generating action potentials.

   a. How is this potential difference across the cell membrane generated?

   b. What characteristics of membranes allow cells to concentrate or exclude ions?

   c. What is it about neurons (nerve cells) that makes their properties different from those of other cells? In other words, what enables nerve cells to produce action potentials?

   d. How is an action potential started and propagated?

   e. Is any direct or indirect energy input required to generate an action potential? If so, when and where is the energy used?

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f. What happens in time and space (along the axon) once an action potential begins?

g. What factors ultimately limit the ability of the nervous system to respond (that is, to continue to generate impulses)?

2. If an axon is stimulated in the middle of its length, nervous signals (action potentials) will move out from the point of stimulus in both directions. Normally, however, nerve signals move in only one direction along neurons. Explain.

3. Whether or not an action potential is generated in a postsynaptic neuron depends on a number of factors. What are they? What ultimately determines whether or not an action potential is generated in the postsynaptic neuron?

4. Diffusion is efficient over only very short distances. In fact, as you can see in this table, diffusion is efficient only for distances of about 1 to 100 μm.

Diffusion distance (μm)	**Time required for diffusion**
1	0.5 msec
10	50 msec
100	5 sec
1,000 (1 mm)	8.3 min

a. How wide is a synapse?

b. If a synapse were two times as wide, what effect would it have on the transmission of nerve signals from one neuron to the next? How would this change affect the response time of an organism?

5. If you examine neuron transmission within an organism, you discover that every action potential generated is stereotyped; for example, every action potential reaches the same maximum height and the same minimum height. In addition, the generation of action potentials is an all-or-none phenomenon. That is, once the potential difference across the membrane reaches threshold, an action potential will be generated. Given this, how does the nervous system signal differences in intensity of signal?