LESSON PLAN: Knot Familiar with Neurons?

Topic: Illustrating Chemical Transmission and Action Potentials | Functional Processes

Subject | Stream:
Biology
Science

Grade Level:
Intermediate (7-10)
Senior (11 & 12)

Objective(s):

- To familiarize students with the properties of chemical transmission and the conduction of action potentials.
- To illustrate the parts of a neuron, including the dendrites, cell body, axon, and synaptic terminals.
- To reinforce the *all-or-none* principle of action potentials.

Brief Summary:

This activity employs an interactive model of a neuron to demonstrate the all-or-none principle of action potentials as they travel down an axon to the synaptic terminals. Participants are encouraged to use this demonstration to familiarize themselves with the process of chemical transmission.

Background Information:

- Neurons employ neurotransmitters, chemical messengers that enable neurotransmission, to communicate with each other. When neurotransmitters cross the synaptic cleft, a gap junction between neighboring neurons, they bind to receptors on the dendrites.

- The binding of a neurotransmitter to its designated receptor site results in a change in the electrical potential of a neuron.

- Excitatory postsynaptic potentials result when a neuron becomes depolarized; its electrical potential is raised from -70 mV baseline towards threshold value (-55 mV).

Such increases in electrical potential raise the likelihood of firing an action potential.

- Inhibitory postsynaptic potentials result when a neuron's electrical potential is lowered, decreasing the likelihood of generating an action potential.

- Action potentials are generated/fired down an axon when electrical potentials are raised enough to surpass the threshold value.

Resources | Materials Required per Pair:

- A large rope (to be cut into enough pieces to represent dendrites and a long axon).
- 20 ping pong balls (roughly 10 in the synaptic terminal bucket and 10 held by the volunteer).
- Two large plastic ice cream containers / tubs (one for the cell body and another for the synaptic terminal).
- A diving ring (or any other household material that may be attached to the rope to represent an action potential).
- Several volunteers (numbers may vary depending on total class size).

Activity Instructions:

Preparing the Model Neuron:

- The facilitator must cut 3-4 one-foot long pieces of rope to be used as dendrites.
- Another 10-15-foot-long piece of rope must be cut and set aside - to be used as the axon.
- Thread a diving ring onto the 10-15-foot-long axon rope fragment and tie a knot to secure it in place - the diving ring will represent the action potential.
- Drill 3-4 holes in a large plastic ice cream container (tub) and string the 3-4 dendrite rope fragments and axon rope fragment through the holes.
    - Tie a knot in the ropes to ensure that they do not slip through the holes of the container.
    - Ensure that the axon rope fragment is secured onto the container with the diving ring already attached.
- Drill a hole into another large plastic ice cream container / tub and secure it on the open-end of the 10-15-foot-long rope fragment (representing the axon) - this plastic container will represent the synaptic terminal.
- Fill the synaptic terminal container with 10 ping pong balls.

Positioning Volunteers:

Step 1: Recruit participants to hold each of the dendrites.
The facilitator may opt to include more or fewer dendrites depending on the class size.

Step 2: Recruit one volunteer to hold the cell body (the ice cream container/tub) and another volunteer to hold the synaptic terminal (the ice cream container/tub on the other end of the axon rope).

Step 3: Recruit one volunteer to hold more neurotransmitter molecules near the volunteers that represent the dendrites (i.e. hold 10 ping pong balls that are in addition to those already within the synaptic terminal container).

Step 4: Recruit one participant to hold the action potential (i.e. the diving ring that is attached to the axon rope).

Demonstration:

Step 1: The facilitator must ask that the volunteer holding the additional molecules of neurotransmitter toss the ping pong balls to the participants representing the dendrites. These participants must then attempt to catch the balls as they are being tossed.

- The facilitator is encouraged to discuss this action with the class. In this case, this specific action is modeling the release of neurotransmitter molecules from 'neighboring' neurons and their binding to receptor sites on the dendrites.

Step 2: When at least three ping pong balls are caught by the participants representing the dendrites, the volunteer that is holding onto the action potential (diving ring) can slide down the axon rope fragment.

- The facilitator is encouraged to discuss this action with the class. In this case, the class is being shown the depolarization of a neuron above its threshold value to generate an action potential.

- Once the action potential (diving ring) reaches the synaptic terminal, the participant holding this second ice cream container/tub is asked to toss some of the ping pong balls (neurotransmitter molecules) that were being held there onto the floor.

- *Note: It is expected that the axon rope is stretched tightly so that the diving ring travels down to the terminal as quickly and smoothly as possible. Such an action would accurately demonstrate the all-or-none concept of action potentials.*

Step 3: The facilitator is encouraged to reinforce these demonstrated principles in classroom discussion.

- Once the action potential begins to travel down the axon, it continues without interruption.

- The size of an action potential remains constant as it travels down the axon and is enough to stimulate the release of neurotransmitter molecules.

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