Electrical Model of Neurons
Teaching Team

Introduction
This demonstration has two components - a single neuron and a neural network - that can be done together or separately. This demonstration takes 10-15 minutes and can be expanded using the optional information on action potentials for a classroom setting or condensed as needed for more informal, one-on-one teaching.

Materials
Quantities per student/demonstration. Multiply by expected number of students.

One lightswitch box per student/participant
Tupperware or small bag
Extension cord
Lightbulbs for boxes
Handfuls of M&Ms (or similarly small candy)
Optional: print copies of figures on last page

Demonstration #1: Electrical Model of A Single Neuron

Background Information
In this demo, students will learn about the main cell that makes up the nervous system: neurons.

1. Explain to the class that our bodies are made up of thousands of different cells. Probe the students' current knowledge of cells (size, shape, components, etc.).
    a. How big are cells? What shape are they? How many does the human body have?
    b. What are their three main components? (Hint: cell membrane, nucleus, cytoplasm)
    c. Older kids: Can anyone name some of the organelles in the cytoplasm?
2. Explain to the class that neurons are the main cells in our brain. They have special jobs so they have special parts.
3. Explain to the class the three main parts of a neuron. Either print off several copies of the first figure on the last page or (if possible) project it so the whole classroom can see it.
    a. **Soma:** the large, circular, "computer center" of the neuron. Has all of the components that have other cells have (nucleus, mitochondria, etc.)
    b. **Dendrites:** the "input centers" of the neuron. Has many branches that reach all over (like Medusa's snake hair) to collect information from other neurons or the environment.
    c. **Axons:** the single "output" part of the neuron. Long and similar to a tail. Carries electronic impulses to communicate with other cells.

Activity: How Does A Neuron Work?

4. Each student takes a light box (the **dendrite**), which will be receiving information from the environment (that student). Instruct them that when you say "GO!", they should decide which way the switch should be (on or off).

5. Another student (or parent/educator) acts as the **soma** to control the light switch on another light box (the **axon**). Instruct this participant to only flip their switch if more than half of the other lights (**dendrites**) are turned on. Demonstrate that when the **soma** flips the switch, the **axon's** light bulb turns on to send the signal on to the next cell.

6. Say "GO!" - the **dendrites** (most students) should flip their light switches on/off, the **soma** (one participant) should decide what message the **axon** (their light bulb) should send. Pause to explain what happened: either the threshold for activity was reached or it was not.

7. Keep saying "GO!", where **dendrites** should make new decisions. Rounds should get faster and faster for about a minute until the **soma** cannot keep up anymore.

Discussion/Summary

- The soma integrates incoming signals from dendrites using a **threshold**.
    - Neurons are binary - they are either on or off.
    - The threshold means that neurons must have a minimum input in order to pass on their signal to another neuron/the brain.
- Dendrites receive incoming information (from other neurons or the environment)
- An axon is the single output of each neuron cell
- Neurons work REALLY fast! That is how your brain can think thoughts and keep you alive!

Optional Discussion: Action Potentials (For Older Students And/Or Classroom Settings)

1. Neurons are actually electrical. They use movement of charged ions to send their signals.

2. Explain that these signals are called **action potentials**. Either print off several copies of the second figure on the last page or (if possible) project it so the whole classroom can see it.

    a. Over time (x-axis), the membrane potential or charge (y-axis) on the cell changes. It gets more positive when it receives GO signals from the dendrites.

    b. Point out the threshold: this is when enough positive signals come in for the soma to "decide" to send a signal down the axon.

3. Note: if you have the background, you can also explain concepts like voltage gated ion channels, myelin sheath,or sodium and potassium gradients.

4. However, the basic concept of an electrical signal must reach a certain level to be passed on does NOT require explanation of these concepts.

Demonstration #2: Electrical Model of A Neural Network

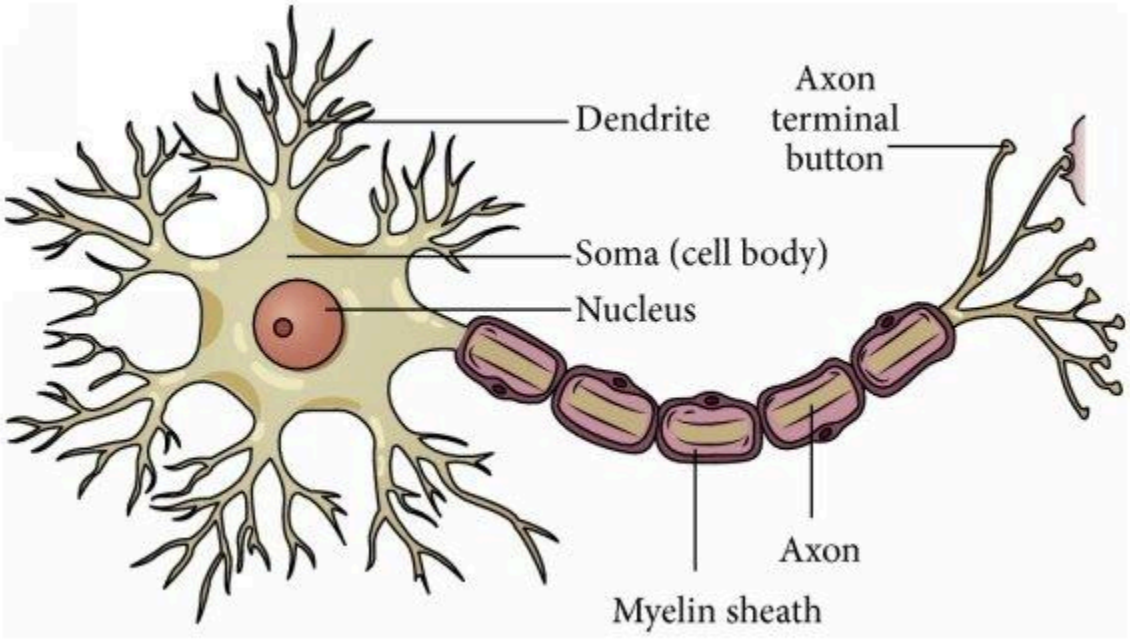
Background Information
In this demo, students will learn how multiple neurons communicate with each other.

1. Remind the class of the three components of a neuron: a SOMA, DENDRITES, and AXON
    a. Explain that, for this activity, we are just looking at a single dendrite and axon. In the real brain, different types of neurons have different numbers of dendrites and axons.
2. Explain to the class that neurons communicate by changing ELECTRICAL signals into CHEMICAL signals, and then back again.

Activity: How Do Neurons Communicate?
3. Split the classroom into groups of three. Each student is a neuron and should have a light box. Each student should be assigned to watch the light box of another student.
4. Give the first student a few pieces of small candy, like M&Ms. This is the “GO!” signal.
5. Once they receive the candy, that student should turn on their light box. This converts the chemical (candy) signal into an electrical signal. The signal goes through the **soma** (student) and turns on the light bulb at the **axon**.
6. The second student watching the light bulb sees the light and pushes the **neurotransmitter** (more candy) across the **synapse** (a gap between students) to the third student. The third student at the next dendrite eats the candy, which causes them to turn on their light switch.
7. Repeat this cycle for all three neurons.
8. Give candy to any “pre-synaptic” volunteers so they do not feel left out!

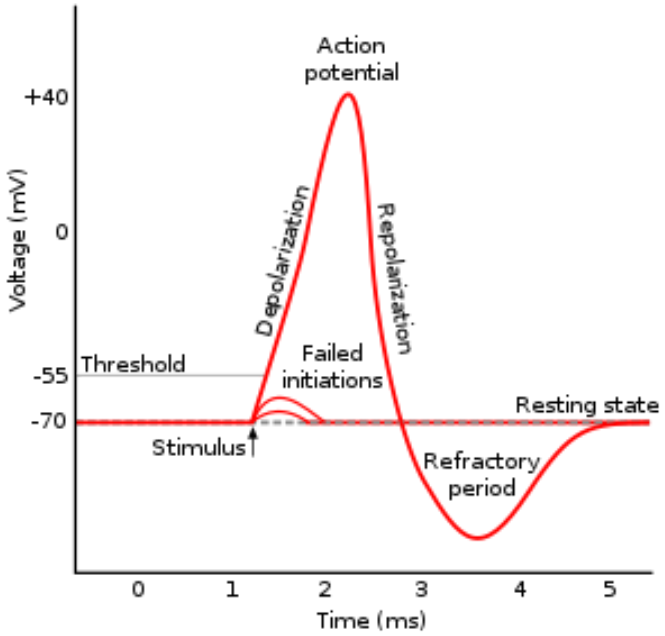
Discussion/Summary
- The synaptic signal was both electrical (light switch) and chemical (candy).
- It takes almost no time for the electrical signal, but there was a delay with the candy. Relate this to how an actual neuron functions.
- The signal went all the way around the table - just like signals go all around the brain!

Figure 1: Components of a Neuron Cell



(Reference: https://doi.org/10.1155/2014/348526)

Figure 2: Action Potentials



(Reference: https://en.wikipedia.org/wiki/Action_potential)