Modeling a Neuron

Grade Levels

This lesson could be made easier or more difficult for 4th through 6th grade, but was designed for 5th grade in particular. This lesson makes connections to Models/Simulations, Place value, Measurement, Multiplication, and Exponents.

Introduction

Every human, animal, and living thing is made up of one or more tiny cells so minuscule you need a microscope to see them. One type of cell that humans have is called a neuron. These cells make up the brain, but can be found throughout your body from layers of your skin to your muscles. In fact, without neurons you wouldn't be able to move at all, and wouldn't be able to see, taste, feel, stand up straight, or think! Neurons send information about the world to your brain, and neurons send information to your muscles and other organs telling them what to do.

Neurons have three major parts. If you were to zoom in on a neuron in a microscope, you would first notice a long, thread-like part of the cell; this is called the axon, and electricity runs along the axon sending information to other neurons. At the center of the cell the axon becomes a large bulge, called the cell body, which has many of the basic necessities for the cell to stay alive. Connected to this part are the dendrites, which receive information from other neurons and pass it through the cell body to the axon.

One type of neuron commonly found in the brain is called the pyramidal neuron; unsurprisingly, the cell body looks like a pyramid. In this lesson we will cover how to create a scale model of a pyramidal neuron.

Objectives

Students will work in pairs to build their own scale model of a neuron. With enough students, the pairs of students could put together their neuron models to create a basic neural circuit.

Materials and Resources

Paper, pencils, and rulers for sketching the neuron prototype. Various materials for building the actual neuron models; suggested materials include string for axons and dendrites, and play-doh for the cell body. Pipe cleaners could also be used to construct the model neuron. In our class, we let the students brainstorm about what materials they would like to use.

Time Commitment

This project will take about 6 classes if you include lessons on exponents, scaling, place value, measuring (nanometer through meter scale), and anatomy and function of a neuron.

Math and Science Standards Addressed

Math Standards

- 5.*NBT*.1
  - I can understand base-ten place value when a number in one place is 10 times bigger than the place to its right.
  - I can understand base-ten place value when a number in one place is $1/10$ of the place to its left.
- 5.*NBT*.2
  - I can use exponents to show powers of 10.
- 5.*MD*.1
  - I can convert a measurement from one unit to another unit.
  - I can solve multi-step problems using conversions.
- 5.*MD*.2
  - I can measure objects using fractions of a measurement unit.
  - I can construct a line plot to show the measurement data.
- 5.*NBT*.5
  - I can multiply multi-digit whole numbers without a calculator.

Science HCPS III Benchmarks

- $5.1.1$ *(Scientific Inquiry)*
  - Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments.
- $5.1.2$ *(Scientific Inquiry)*
  - Formulate and defend conclusions based on evidence.
- $5.2.1$ *(Unifying Concepts and Themes)*
  - Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

Day 1: Neuroanatomy Lesson

Reference Day 1 Teacher's Notes and the Day 1 handout.

Typical Dimensions of a Pyramidal Neuron

- 3-5 dendrites
- Each dendrite is usually about 300 micrometers long (3.0×10^{-4} m, or 0.0003 m)
- The cell body usually has a diameter of about 20 micrometers (2.0×10^{-5} m)
- axon is usually quid ing, around 2 cm (2.0×10^{-2} m, or 0.02 m)

There is a great diversity in the size and shape of neurons, and it may help to alter the dimensions of the original neuron you use to allow for easier scaling.

Discussion Questions

- Would you make the neuron model $10\times$ bigger? $1,000\times$ bigger?
- What materials would you use for your model?
- How might your model neuron transmit information?

Day 2: Function of a Neuron

Action Potentials

- Messages are sent via action potentials.
- Action potentials are electrical spikes.
- Electricity is measured in voltage.
- Action potentials travel around 110 meters per second (what is this in mph if 1 mile is $1,609$ meters?)

Connections between Neurons

- Connections between neurons are called synapses.
- An example neural circuit is the eye blink reflex (see stylized figure below).

Day 3: Scale

Today we will cover how to calculate the scale of the neuron model. Refer to the Day 3 handout.

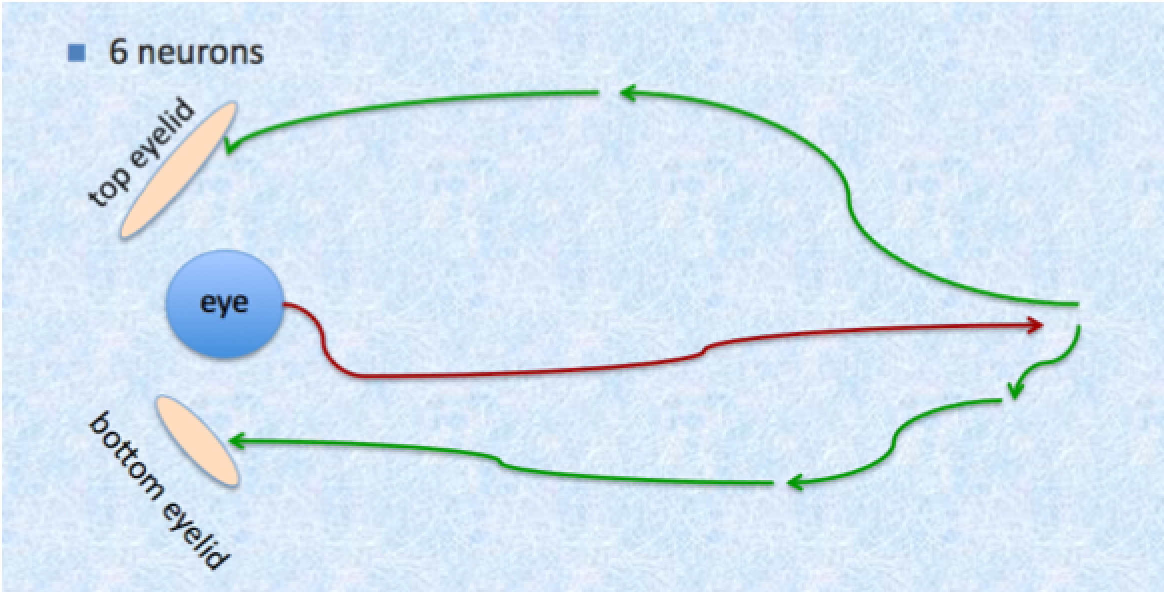

Figure 1: Stylized eye blink reflex

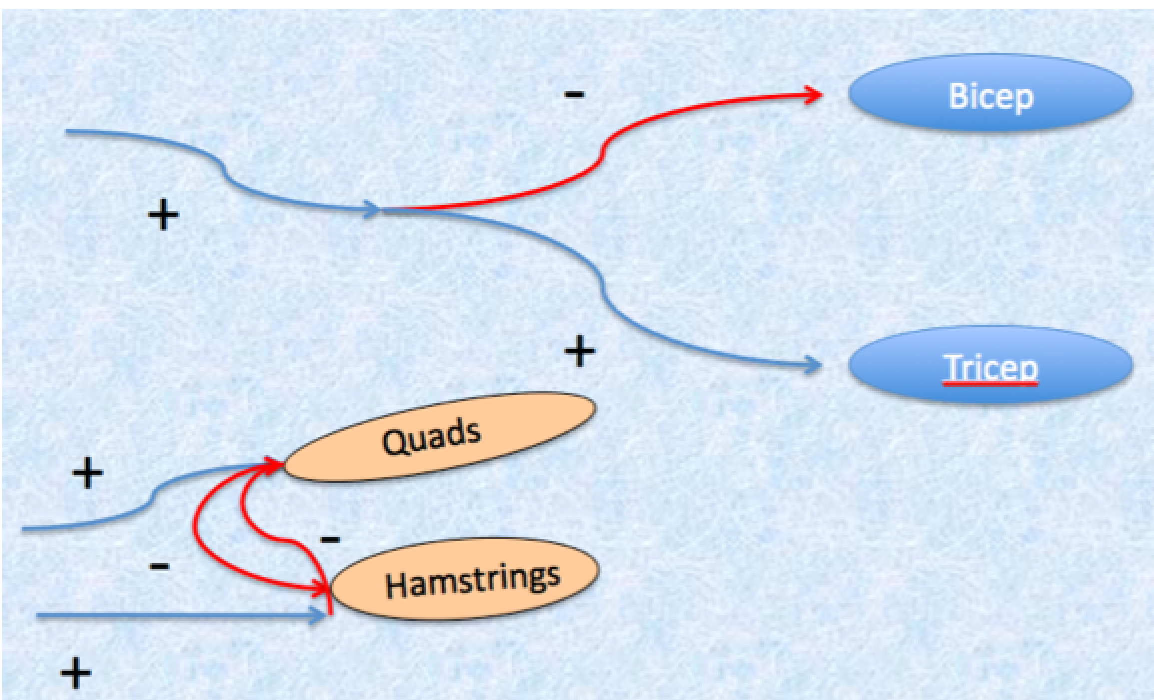

Figure 2: Stylized excitatory (blue) and inhibitory (red) synapses as demonstrated in arm flexing (top) and kicking (bottom)

Day 4: Conversions

For this day students should choose other objects around the classroom (glue bottles, tape dispenser, etc.) as their "nonstandard" unit of measurement. After measuring different parts of the classroom, the class will work on converting between the different nonstandard unites of measurement. Refer to the Day 4 handout.

Day 5: Building the Neuron

Today can be spent building the neuron.

Day 6: Demonstration

- 15 minutes – Wrap up building the neuron.
- 10 minutes – Review structure and function of a neuron – i.e., where does the signal start? What part of your neuron transmits the message to the next neurons?
- 10 minutes – Brainstorm on how we can represent the message passing along their neuron and onto their neighbor's neuron. (In our implementation, students sat down when their neuron was not excited, and stood up when the action potential passed through their neuron.)
- 5 minutes – Display eye blink reflex circuit (Figure 1).
- 15 minutes – Have class arrange their neurons to form the eye blink reflex (for simplicity, we could stick with the simplified circuit we used in the Anatomy presentation).
- 5 minutes – Assign one student the privilege of being a mote of dust heading for the class' eye, and assign two students to be the top and bottom eyelid.
- 10 minutes – The 'mote of dust' student runs toward the eye, causing the reflex to activate, leading to the 'top eyelid' and 'bottom eyelid' students coming together, causing the class' eye to blink.