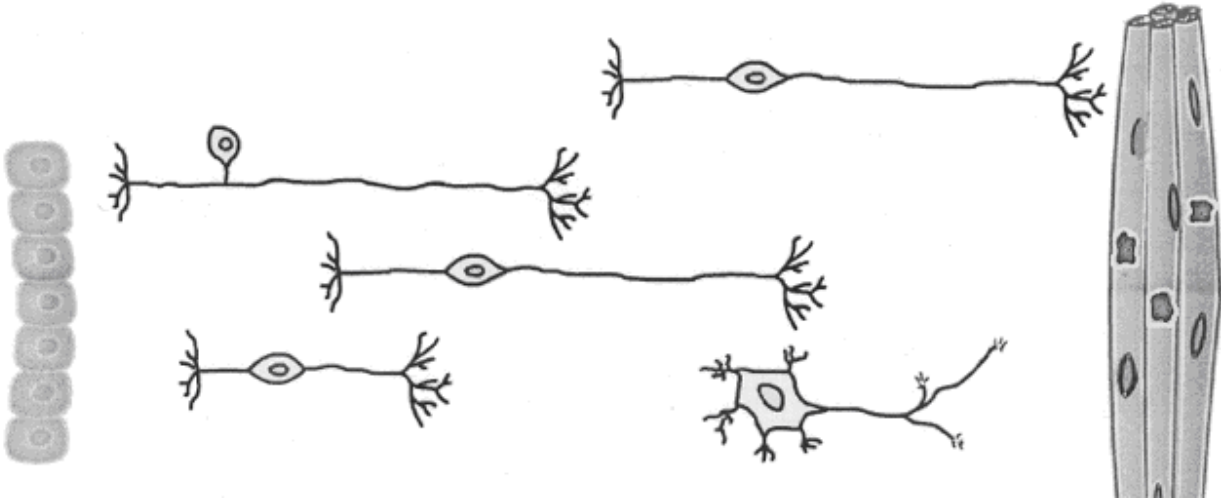


To begin follow your teacher's directions to open the Virtual Neuron software.

On the left side of the screen is a group of skin cells. On the right side of the screen is a group of muscle fibers. In the middle are different types of neurons.



### Part 1 – Making the initial neuron connection

**Your Mission:** to get a message from the skin cells to the muscle fibers using any or all of the neurons, causing the muscle fibers to twitch.

**How to accomplish your mission:**

1. Arrange the neurons to get a message from the skin cells to the muscle fibers.
2. After arranging the neurons, press the Start button in the upper left-hand corner of your screen to test whether the arrangement makes the muscle fiber twitch.

**NOTE Neurons cannot be moved once they are activated (just like the firing of an action potential).**

3. If the neurons are activated and you want to rearrange them, press the Stop button in the upper left-hand corner of the screen.

Draw a neuron that connects to the muscle fiber. What do you think is the name of this neuron?

Draw a neuron that receives information from the outside world (like from skin). What do you think is the name of this neuron?

Draw a connector neuron. What do you think is the name of this neuron?

Part 2 – Changing neuron connections

Once you have successfully made the muscle twitch, more tests can be conducted. Try the following suggestions and write down the names of the neurons you used.

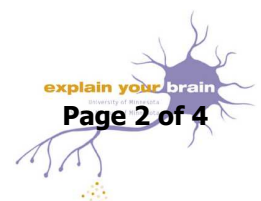
- 4. Make the muscle twitch using two neurons. \_\_\_\_\_
- 5. Make the muscle twitch using three neurons. \_\_\_\_\_
- 6. Make the muscle twitch using four neurons. \_\_\_\_\_
- 7. Identify which neuron type would be MOST likely to.....
  - a. be connected to the skin of your finger: \_\_\_\_\_
  - b. have its axons and dendrites in the spinal cord: \_\_\_\_\_
  - c. be connected to your bicep: \_\_\_\_\_
  - d. be connected to a taste bud: \_\_\_\_\_
- 8. Set up a series of three neurons, one of each neuron type, so that the muscle twitches.
  - a. Press the Start button. Let the circuit run for 15 seconds. Click on the Stop button RIGHT AWAY when the time reaches 15 seconds. How many twitches happened?  
\_\_\_\_\_
  - b. Calculate the “rate” of twitching. “Rate” means the number of times something happens in a certain period of time. To calculate the twitch rate, you divide the number of twitches by the number of seconds.

Calculation

$$\text{Twitch Rate} = \frac{\text{\# of Twitches}}{\text{\# of Seconds}}$$

$$\text{Your Twitch Rate} = \frac{\text{_____ Twitches}}{\text{_____ Seconds}} = \text{_____ twitches/second}$$

- c. Based on your calculated twitch rate, how many twitches do you think will happen in a minute (60 seconds)? \_\_\_\_\_ twitches
- d. Test your prediction by letting the circuit run for a minute.
  - How many twitches really happened in a minute? \_\_\_\_\_
  - Was your estimate correct? \_\_\_\_\_
  - If not, what might explain the difference in the number of twitches?  
\_\_\_\_\_



**Part 3 – Causing the neurons to activate (or fire)**

1. Click on the **Setup** menu and then select **Go To**.
2. Enter the password your teacher provides.
3. The Neuron Setup window allows you to change the number of neurons to work with and allows you to activate new features.
  - a. Check the **Action Potential Meters** box.
  - b. Check the **Change Neuron Threshold** box.
4. Click the **Save Setup and Start** button.
5. At the top of the screen, there are **Action Potential Meters** for each neuron.
  - An **action potential** is an electrical signal that travels along the axon, away from the cell body, to the axon terminal where it triggers the release of neurotransmitters.
  - The number of times an action potential triggers the releases of neurotransmitter is recorded at the bottom right of each **Action Potential Meter**.
  - The green bar across the action potential represents the neurons' **threshold**, or the point at which a neuron produces an action potential.
6. Set up a series of three neurons, one of each neuron type, so that the muscle twitches and let the circuit run for 10 seconds.
  - a. How many action potentials did the sensory neuron create? \_\_\_\_\_
  - b. How many action potentials did the interneuron create? \_\_\_\_\_
  - c. How many action potentials did the motor neuron create? \_\_\_\_\_
  - d. How many times did the muscle twitch? \_\_\_\_\_
  - e. Why is the number of times the muscle twitches different than the number of times the sensory neuron produces an action potential?
7. The green threshold bar can be moved up or down to change the set point at which the neuron produces an action potential. To change the threshold, click on the bar and slide it up or down.
  - a. Decrease the threshold, or move the bar down, for the neurons.
    - How does this affect the speed at which the action potential occurs?
    - How does this affect the number of times the muscle twitches?
  - b. How do you think increasing the threshold will affect is the speed an action potential is produced and the number of times the muscle twitches.
  - c. Test your prediction. Explain how your results compare with your prediction.

**Part 4 – Designing experiments**

Design an experiment to test how a different arrangement of neurons (number and/or type) affects the muscle twitch rate. You will need to set up one circuit, test it, and then set up a new circuit and test it. You will not be able to set up two circuits at the same time.

**Virtual Neurons Experiment**

Write this on a separate sheet of paper.

**Problem Statement:** Write a scientific question that you can test.

**Prediction:** Write down what you think the answer to your question might be and explain why you think so.

**Materials:** Make a list of the materials you need to do this experiment

**Procedure:** Write the steps needed to test your prediction. Be sure to have a control circuit -- the original circuit before you make any changes -- that will serve as the muscle twitch baseline.

**Data:** What information do you need to record to help you answer your prediction? Make a table to record your data. Make a graph to display your data. Write a few sentences to summarize the data.

**Conclusion:** Write your conclusion as a paragraph. Be sure to include the following information:

- Identify whether your prediction was what you expected.
- Explain what your data allows you to conclude.
- Address whether or not your results support your prediction.
- List possible sources of error.
- List ways the experiment could have been done better.
- List any new problem statements that you thought of while you were doing the experiment or analyzing the results.