FALL 2018
PSYC250 Brain & Behavior: Introduction to Neuroscience
Earlham College

MAKE YOUR OWN NEURAL CIRCUITS

INTRODUCTION

In this set of lab activities, we will explore neural circuits. In the class so far, we have talked about neurons, action potentials, synaptic transmission, and neurotransmitters. We've also looked at the role of these things within sensory systems. An individual neuron has a relatively simple set of signaling functions. Neurons receive input on their dendrites. They integrate this input, and when the total excitatory signal is over threshold, an action potential is generated. The action potential travels down the axon to release neurotransmitter on partner neurons. In general, the transmitter can either excite or inhibit these partners.

Although simple, these signaling functions enable neurons to form *circuits*, and circuits of even a few neurons can generate fascinating and complex behaviors. Although we have been discussing circuits implicitly, our goal in this lab is to get a better feel for how amazing circuits are and how they underlie complex behaviour. We will do this through exploration—the key in this set of labs is to *be curious*—that is, to try things, to make predictions, to change things, etc. The more you explore, the better sense you will get for how neural circuits can work.

SETTING UP "CARTOON NETWORK"

Cartoon Network is a simulator program. This means that we can use it to mimic some important actions of neurons and their connections.

- Navigate to https://github.com/rcalinjageman/cartoon_network
- Click the file "cartoon network.jar", then click the download button.
- Save the file on your computer, find it, then double-click it to launch. If you are using a mac, use the cartoon network.jar file in the mac folder.

HOW THE SIMULATOR WORKS

The simulator lets you design circuits of neurons by clicking, dragging, and manipulating through various modes. The simulator uses a 'mode' system: you press a key to change the mode, and the mode determines what clicking the screen will do. The mode is always reported in the top left-hand of the screen. If you click on the current mode, it will make a menu appear that enables you to select a mode using the mouse.

Design Mode:

- 'a' –enters add mode; clicking the screen adds neurons
- 'd' –enters delete mode; clicking a neuron deletes it
- 'g' –enters grow mode; clicking a neuron stretches it length-wise
- 's' –enters shrink mode; clicking a neuron shrinks it length-wise
- 'r' –enters rotate mode; clicking a neuron rotates it 20 degrees counter-clockwise
- 'x' –enters stimulation mode; clicking a neuron stimulates it

Edit Properties Mode:

- ‘w’ –enters transmitter mode; clicking a neuron brings up a dialog for selecting if the neuron will release glutamate (excitatory) or GABA (inhibitory)
- ‘t’ –enters type mode; clicking a neuron brings up a dialog for selecting if the neuron will be Silent (no spontaneous activity), Spontaneously active (spikes even with no input), or Bursting (not yet implements, but the neuron fluctuates regularly between silent and active).
- ‘l’ – enters activity mode; clicking a neuron brings up a dialog for selecting the max firing rate of a neuron from 1 (slow) to 10 (rapid)
- ‘q’ –enters transmitter mode; clicking a neuron brings up a dialog to select how many molecules of neurotransmitter will be released with each AP—default is 10; options are from 1 to 40.

Note that, like real neurons, NT **anywhere** *on the neuron causes an effect, not just on the dendrites. The only exception is NT the neuron itself released.*

Adapted from Dr. Robert Calin-Jageman (Dominican University)

LAB ACTIVITIES

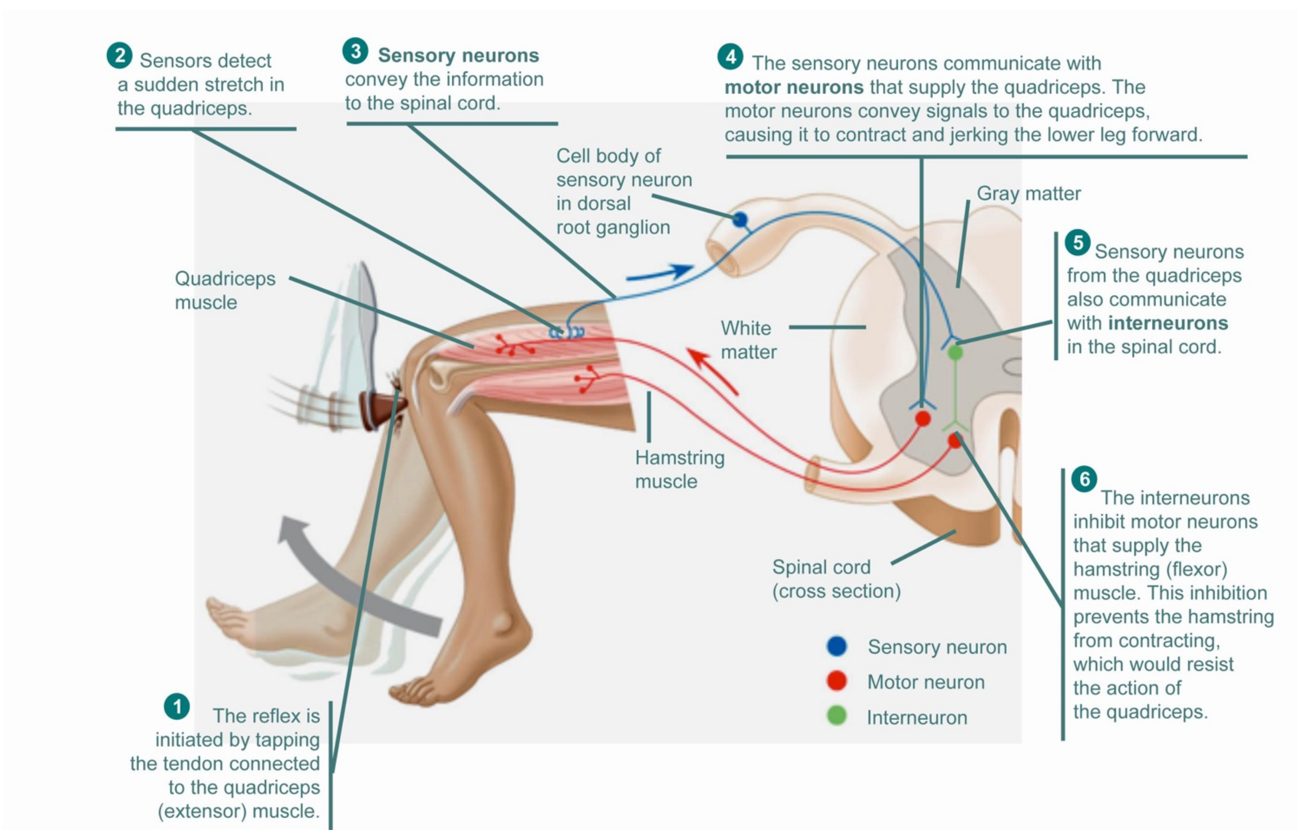
1. Explore!

This step is easy: explore! Play around with the modes and functions. Make a neuron fire, make one neuron stimulate another one, try things out.

2. Knee-jerk reflex

Description. One of the best understood examples of how neural circuits underlie behaviour is the simple knee-jerk response. In this reflex, a neurologist uses a rubber hammer to tap the tendon in the knee (Figure 1 below). This causes the leg to suddenly become extended. How does this work? The tapping of the hammer creates a stretch in the quadriceps muscle this stimulates the sensory neuron which projects from the muscle to the spinal cord. The kick occurs when the motor neurons (from spinal cord back to muscles) stimulate the quads to contract and the neural circuit in the spinal cord ultimately allow the hamstring to be stretched (i.e. not contracted).

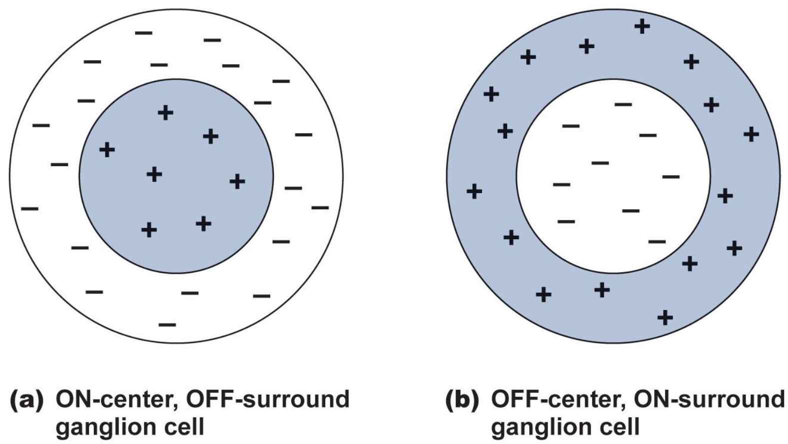
To do. This diagram gives you a good idea of how the knee-jerk reflex works, including the circuit within the spinal cord. Now, you build the neural circuit (the neurons) including where excitation and inhibition needs to occur. You won't be able to color code the neurons on Cartoon Network, but you can certainly make the same circuit.



To turn in. When you think you've got it, call Michelle or one of the TAs over to your work station to show them your knee-jerk flex circuit.

3. **Sensory systems**

Description. Sensory neurons in most sensory systems have a particular "receptive field." A sensory neuron's receptive field refers to the region of sensory space (e.g. visual space) in which a stimulus will modify that neuron's firing. Receptive field can have interesting patterns which interact in a top-down and bottom-up way with higher order regions.



To do. Your task is to design a circuit that would give rise to (1) an on-center/off-surround receptive field and another circuit for (2) an off-center/on-surround receptive field. Hint: How does the early visual system do this?

To turn in. When you think you've got it, call Michelle or one of the TAs over to your work station to show them your circuit!