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Getting Started with *BYOB*

Build Your Own Brain (*BYOB*) is an online game that lets you build a simple network of neurons and see how they might function. This guide will walk you through building your first two simple networks.

To build your network, you need to add elements like **neurons** and **sensors**. You do this using the buttons at the top left of the screen. Under these buttons are ones for **controlling** the network. Under that are **messages**, and under that is an area where **details** of your elements will appear.

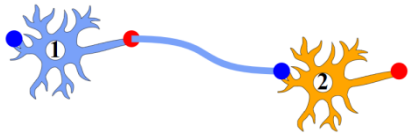
Example 1: three neurons and a muscle

For our first network, we'll connect three neurons and one muscle, just to see how the game works. Start by creating your first neuron: click the blue ***Neuron*** button under *Add elements* at the top left of the screen. A new neuron, labelled **1**, will appear in the canvas area. Drag this neuron to the center of the screen. If it is a bit small, you can zoom in using the ***+*** button in the *Controls* area.

You will notice that your neuron turned orange when you clicked and dragged it. This means it is selected. On the left of the screen, under the messages, you can now see some details about this neuron, like which neurotransmitter it uses and whether it is excitatory or inhibitory.

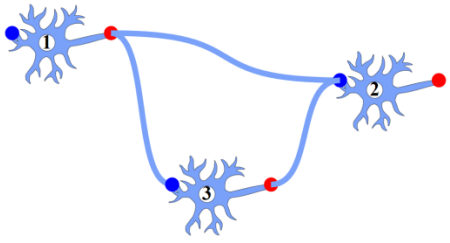
Let's add a second neuron to our network. Click the blue ***Neuron*** button again. A second neuron, labeled **2**, should appear in the canvas. Drag that one so it is to the right of neuron #1.

We can now connect our neurons to each other. Each neuron has a blue dot representing its ***dendrite***, where it can receive connections. It also has a red dot, which is its ***axon hillock***. Click the red dot of neuron #1. A short line will appear ending in a green dot. This is a new ***axon***. Grab the green dot and drag it until it is very close to the blue dot (dendrite) of neuron #2. Release the green dot and the axon should snap to the blue dot, connecting the two neurons, like this:



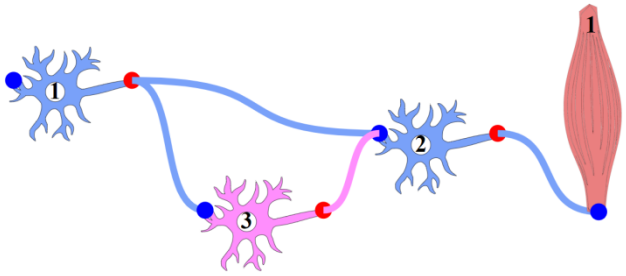
If you release the green dot too far from a dendrite, the axon will just disappear and you can try again by clicking the red dot of neuron #1.

Let's add a third neuron to the network, by clicking the ***Neuron*** button again. Place this third neuron lower down than the first two and between them. Neurons can give and receive multiple connections, so let's connect neuron #3 to both our existing ones. Click the red dot of neuron #1 to create another new axon, and connect that to the dendrite (blue dot) of neuron #3. Then connect an axon from neuron #3 to the dendrite of neuron #2. Your network should now look something like this:



All our neurons so far are ***excitatory***, which is represented by them being blue. Let's make neuron #3 an ***inhibitory*** neuron. Click the neuron to select it (it will turn orange). On the bottom left of the screen you will see its details. Click the green button labeled "*Excitatory*". It will change to pink and now read "*Inhibitory*". To save this change, click the ***save*** button at the bottom. Neuron #3 and its axon will turn pink to show that they are now inhibitory.

Brains control muscles, so let's add one of those to our network. Click the blue ***Muscle*** button under *Add elements* on the left of the screen. A new muscle will appear in the canvas. Drag it to the right of the screen. Muscles can receive connections, so your muscle has a blue dot, but they can't send signals onwards, so there is no red dot. Connect your muscle to neuron #2: click the red dot of neuron #2 and drag the new axon so it snaps to the blue dot of the muscle. Your network should now look like this:



This is the completed network we were aiming for. However, it doesn't do anything yet. None of the cells ever fires. Let's change that. Select neuron #1 by clicking it. In the details at the bottom left of the screen, let's change the *spontaneous rate* of the neuron from 0 to 1. This means that this neuron will fire on its own, without any stimulation, all the time (we could make it only fire sometimes by entering numbers less than 1). Click ***save*** to save this change.

Now we have a network that should do something. To find out, we have to run the simulation. First, let's decide how many time steps, called ***epochs***, we want the simulation to run for. In this case, 6 steps is enough to show us what the network does. Enter the number 6 in the box under *Epochs* in the *Controls* area at the left of the screen. Now click the orange *Run Simulation* button. You should get a message saying that the simulation was completed.

We can now watch our network in action. *BYOB* lets you animate your network in two ways. You can let it play, by clicking the ▶ (*play*) button, or you can step through the epochs one at a time using the ⏭ (*step forward*) button. Let's do the latter. Click the *step forward* button once. The number in blue next to the button shows you what epoch you are viewing; it should now read "1". Since we set neuron #1 to fire in every epoch, it should turn orange, to show that it is active. Click the *step forward* button again; this is epoch 2. Neuron #1 is still orange, because it fires in every epoch. Its two axons are also orange, because they were activated by the neuron. In epoch 3, neurons #2 and #3 are also firing, because the axons that connect them to neuron #1 activated them. In epoch 4, the axons of neurons #2 and #3 are also active. In epoch 5, the axon of neuron #2 has activated the muscle. However, the axon of neuron #3 – which is inhibitory – was also active. This counteracted the activation that neuron #2 received from neuron #1, so neuron #2 is not active in epoch 5 (it goes back to being blue instead of orange).

That's about all this network does. Let's try a more interesting one. To clear away the current network, click the *Clear* button in the *Controls* area.

Example 2: a reflex arc

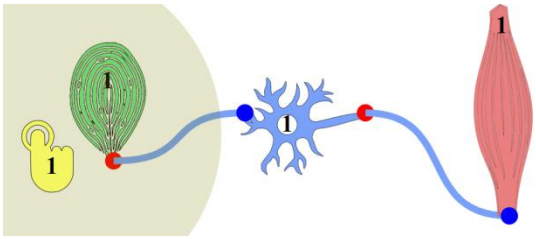
Reflex arcs are simple circuits that our bodies use for quick, automated responses to various stimuli. The most famous one is the knee-jerk reflex, so let's build that. In this case, we want our network to react to some stimulation from outside, not just to fire spontaneously. There are special kinds of neurons that react to external stimulation, which are called ***sensors*** in *BYOB*. Let's start with one of those, one that detects touch. Click the blue ***Sensor*** button under *Add elements*. From the drop-down list, select "*touch (skin)*". A green cell will appear, labeled **1**. This is a special type of neuron called a sensor (this one is a representation of a Pacinian corpuscle). It can connect to other neurons, so it has a red dot (an axon hillock) but it doesn't receive incoming connections, so there is no dendrite (no blue dot). Drag the sensor to the center of the screen.

Let's connect our sensor to something. Click the ***Neuron*** button to add a new neuron. Drag it to the right of the sensor. Now let's connect them. Click the red dot of the sensor and a new axon should appear. Drag the end of it to the blue dot of the neuron and release.

Let's complete the arc by connecting the neuron to a muscle. Add a muscle by clicking the ***Muscle*** button. Drag it to the right of the screen. Click the red dot on the neuron and connect the axon to the blue dot of the muscle.

Congratulations! You've built a reflex arc a lot like the ones you actually have in your body. However, this network doesn't do anything yet. It is designed to react to external stimulation, so we need to add some of that. *BYOB* lets you add 5 different kinds of stimulation, which have to match whatever sensors you want to activate.

Click the ***Stimulus*** button under *Add elements*. From the drop-down menu, select *Touch*, since we want to activate our touch sensor. A yellow hand should appear, representing a touch. It doesn't have either axons or dendrites, since it's not actually part of the network, it just stimulates it from outside. Click the stimulus to select it. It won't change color but a circle will appear around it. This represents the area this stimulus can affect. Any touch sensors inside the circle will be activated when the stimulus is on. Let's make the area large enough to include our touch sensor. First, drag the stimulus close to the sensor. In the details of the stimulus at the bottom left of the screen, you can change its *effect radius*. Set it to 100 and click *Save*. The circle will get bigger. Make sure that the sensor is inside the circle. Your network should now look something like this:



Next, we need to tell the stimulus when to be on and when to be off. In the details area at the bottom left of the screen, the stimulus has a feature called *Schedule*. This is a list of when it will be on or off. Type "1,0,0" into the *Schedule* box (without the quotation marks), and then click *Save*. This tells the stimulus to be on (1) in the first epoch, then off (0) in the next two. Then it will repeat that pattern, so it will be on in the fourth epoch, off for 5 and 6, and so on.

Let's set our network to run for 6 epochs again (type 6 into the box under *Epochs* in the *Controls* area), and run it by clicking the orange *Run Simulation* button. Now we can step through the animation using the *step forward* button.

In the first epoch, the circle around the stimulus comes on, indicating that it is active. In epoch 2, the sensor turns orange, showing that it was activated by the stimulus (if it doesn't, maybe it was too far away; move the stimulus closer and run the simulation again). The stimulus is off in this epoch, like we told it to be. As we keep going, the activation of the sensor moves down its axon (epoch 3), activating the neuron (epoch 4), and then the muscle (epoch 6). This represents someone touching your knee (the stimulus activating the sensor), which then causes you to kick out with that leg (activating the muscle).

Let's save our reflex arc network. Click the  button at the top of the screen. From the drop-down menu, select *Save network*. At the bottom left of the screen, you will be prompted for a name for your file. Type in "Reflex arc" and click *Save*. The network will be saved in a text file on your local hard drive. You can load it back in any time using the *Load network* option from the same menu.

I should note that the reflex arc we made is over-simplified. In reality, reflexes not only stimulate one muscle, they also relax the opposing muscle. To see what a reflex arc is actually like, you can load the example file. Click the  button again and select *Load network*. At the bottom left of the screen, click the *Select example* button. From the drop down menu, select *reflex arc*. A new network will be loaded showing a more realistic reflex arc. You can change, run, and animate it just like you did your own.

These two simple examples don't cover everything you can do with *BYOB*. For more details, read the **instructions** file, which explains all the options, or just play around with things.