Modeling Excitatory and Inhibitory Chemical Synapses

Student Handout III

In review, a **synapse** is the place where signals are transmitted from a neuron, the **presynaptic neuron**, to another cell. This second cell may be another neuron, muscle cell or glandular cell. If the second cell is a neuron, it is called the **postsynaptic neuron**.

There are two types of synapses, **electrical** and **chemical**. Electrical synapses (which are NOT the focus of our model) allow electrical current to flow directly from on neuron to another. The majority of synapses are **chemical synapses** which function by releasing a chemical called a **neurotransmitter** from the presynaptic neuron. Over 50 different neurotransmitters have been identified with another 50 suspected of being neurotransmitters. These neurotransmitters act to excite or inhibit postsynaptic cells by binding to specific receptor proteins embedded in the postsynaptic cell.

Depending on the receptor, the same neurotransmitter may have excitatory effects at some synapses while having inhibitory effects at others. For example, acetylcholine excites skeletal muscle cells but inhibits cardiac muscle cells.

In this simulation you will determine how excitatory and inhibitory neurotransmitters alter the release of dopamine from the last neuron in a series. Use the “Neuronal Signaling Simulation Sheet” on page 5 and the two interneurons to model each of the cases described on page 3.

Modeling Excitatory and Inhibitory Chemical Synapses

Instruction for the Simulation:

(Adapted from "The Brain: Understanding Neurobiology Through the Study of Addiction" by the National Institutes of Health.)

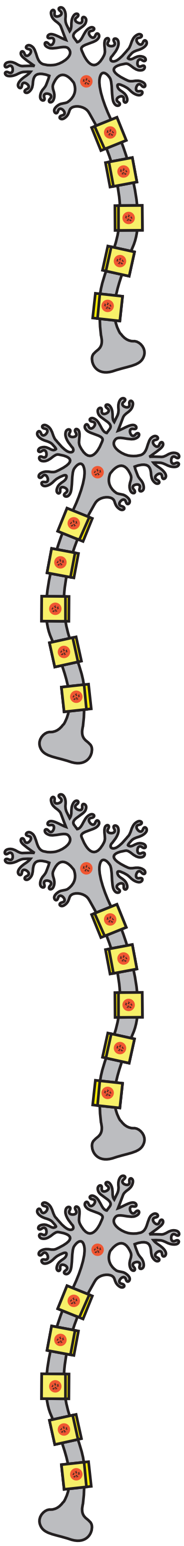
In this simulation you will determine how excitatory and inhibitory neurotransmitter effects alter dopamine release from the last neuron in a series. Use the laminated sheet and the small foam neurons to model each of the cases described on the next page. Answer each of the following as you move through the pathway for each case described.

1. Indicate which arrow in the model below illustrates if the signaling molecule is **excitatory** or **inhibitory**.
2. Indicate which arrow illustrates if the **activity** of neuron #1 increases or decreases.
3. Record which **neurotransmitter** is released from neuron #1 in this case study.
4. Indicate which arrow in the model below illustrates if the neurotransmitter released from neuron #1 is **excitatory** or **inhibitory**.
5. Indicate which arrow illustrates if the **amount** of neurotransmitter released in the synaptic cleft from neuron #1 increases or decreases.
6. Indicate which arrow illustrates if the **amount** of neurotransmitter released in the synaptic cleft from neuron #1 increases or decreases.
7. Indicate which arrow illustrates if the **activity** of neuron #2 increases or decreases.
8. Indicate which arrow illustrates if the **amount** of dopamine released from neuron #2 increases or decreases.

Record your observations in the table provided below as you move through the simulation:

Case	1. Signal Molecule: Excitatory? Inhibitory?	2. Neuron #1 Activity: Increase? Decrease?	3. Identity of Neurotransmitter Released from Neuron #1	4. Neurotransmitter Amount Released from Neuron #1: Increase or Decrease?	5. Neurotransmitter Released from Neuron #1: Excitatory or Inhibitory?	6. Neuron #2 Activity: Increase or Decrease?	7. Neurotransmitter Amount Released from Neuron #2: Increase or Decrease?	8. Identity of Neurotransmitter Released from Neuron #2
A								
B								
C								
D								

Modeling Excitatory and Inhibitory Chemical Synapses



Case A.

The signal molecule that affects neuron #1 in this case is excitatory. It increases the chances that neuron #1 will fire. Thus, it acts to increase the activity of neuron #1. If neuron #1 is more active, it releases more neurotransmitter. Neuron #1 produces glutamate, an excitatory neurotransmitter. The increased level of neurotransmitter release from neuron #1 leads to an increased level of activity of neuron #2. If neuron #2 is more active, it will release more dopamine.

Case B.

The signaling molecule is inhibitory. Neuron #1 releases glutamate as its neurotransmitter. Neuron #2 releases dopamine as its neurotransmitter. Model this neurotransmission. Record what happens in the table.

Case C.

The signaling molecule is inhibitory. Neuron #1 releases GABA, an inhibitory neurotransmitter. Neuron #2 releases dopamine as its neurotransmitter. Model this neurotransmission. Record what happens in the table.

Case D.

The signaling molecule is excitatory. Neuron #1 releases GABA as its neurotransmitter. Neuron #2 releases dopamine as its neurotransmitter. Model this neurotransmission. Record what happens in the table.

Questions:

1. Do all neurotransmitters affect a neuron in the same way? What evidence can you supply to support your answer?

____

____

2. Must all of the neurons in a series release the same neurotransmitter? What evidence can you supply to support your answer?

____

____

Modeling Excitatory and Inhibitory Chemical Synapses

3. Design another series using different neurotransmitters or more neurons below! Explain your model.

Neuronal Signaling Simulation Sheet

Case: ____________________

3. Neuron #1 Neurotransmitter: ____________________

2. Neuronal #1 Activity

Increase **Decrease**

6. Neuron #2 Activity

Increase **Decrease**

7. Neurotransmitter Amount

Increase **Decrease**

4. Neurotransmitter Amount

Increase **Decrease**

1. Signaling Molecule

Excitatory **Inhibitory**

5. Neurotransmitter Released

Excitatory **Inhibitory**

8. Neuron #2 Neurotransmitter: ____________________