



Activity 2

The Brain and Drugs

Core Concept:

Addictive drugs affect signaling at the synapses in the reward pathway of the brain.

Class time required:

Approximately 40-60 minutes

Teacher Provides:

For each student

- Copy of student handout entitled "**The Brain and Drugs.**"
- Copies of note sheet for "**Crossing the Divide: How Neurons Talk to Each Other *** "
*Created by Lisa Brosnick, North Collins High School, North Collins, NY

For each team:

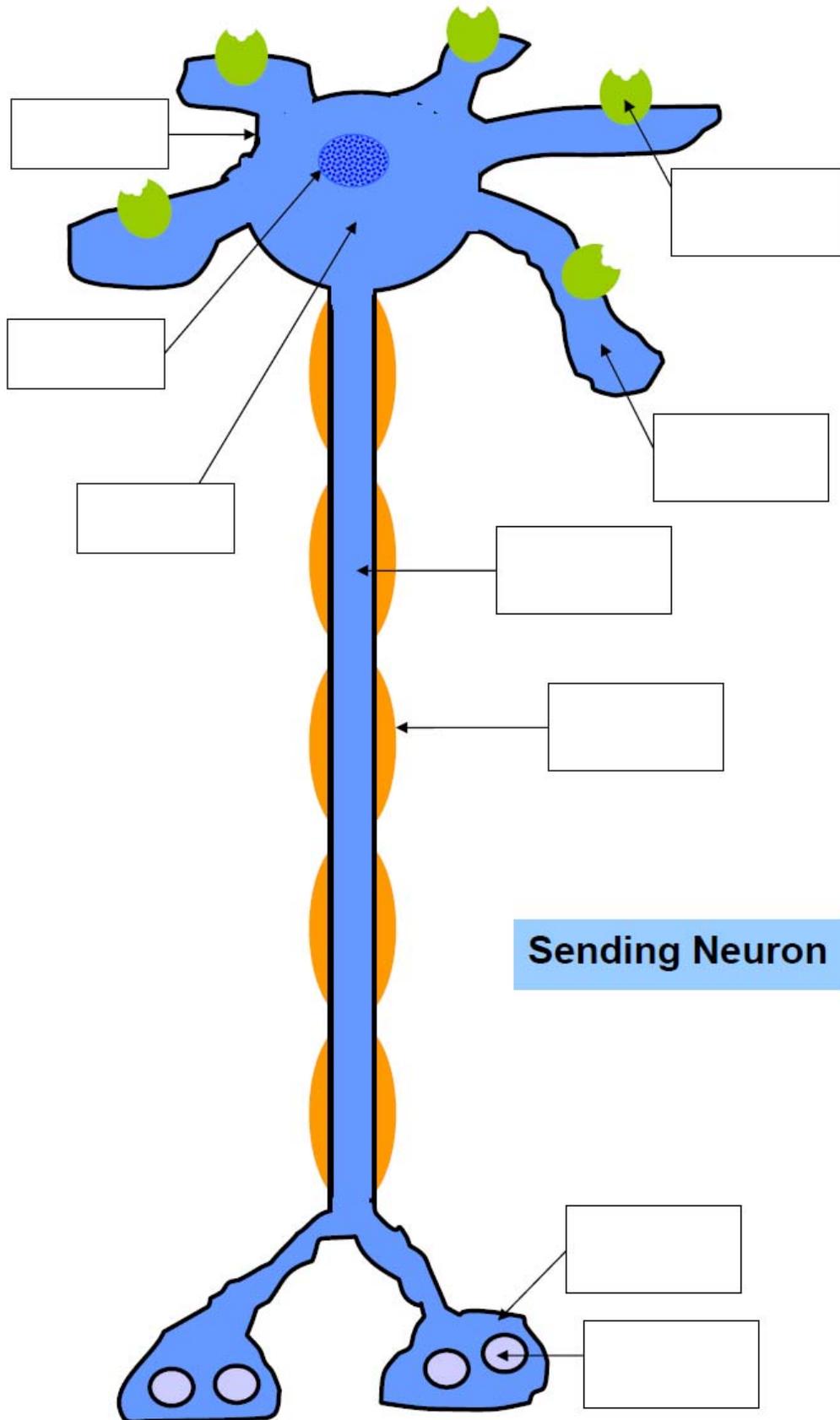
- Color copies of **Sending Neuron** diagrams that are enlarged to print on 11" X 17" or larger paper. Considering laminating this for use with multiple classes.
- Color copies of **Sending Neuron** that are enlarged to print on 11" X 17" or larger paper. Considering laminating this for use with multiple classes.
- A bag containing:
 - 10 tri-beads (Purchase at a craft store. These should be a single color.)
 - 2 **Impulse** cut-outs.
 - One set of label cards. Consider laminating these for use with multiple classes.
- Access to computers with Internet (as a class or small groups of students) for viewing **Crossing the Divide: How Neurons Talk to Each Other**
<http://learn.genetics.utah.edu/content/addiction/reward/neurontalk.html>

This project was generously funded by Science Education Drug Abuse Partnership Award R25DA021697 from the National Institute on Drug Abuse. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Drug Abuse or the National Institutes of Health.

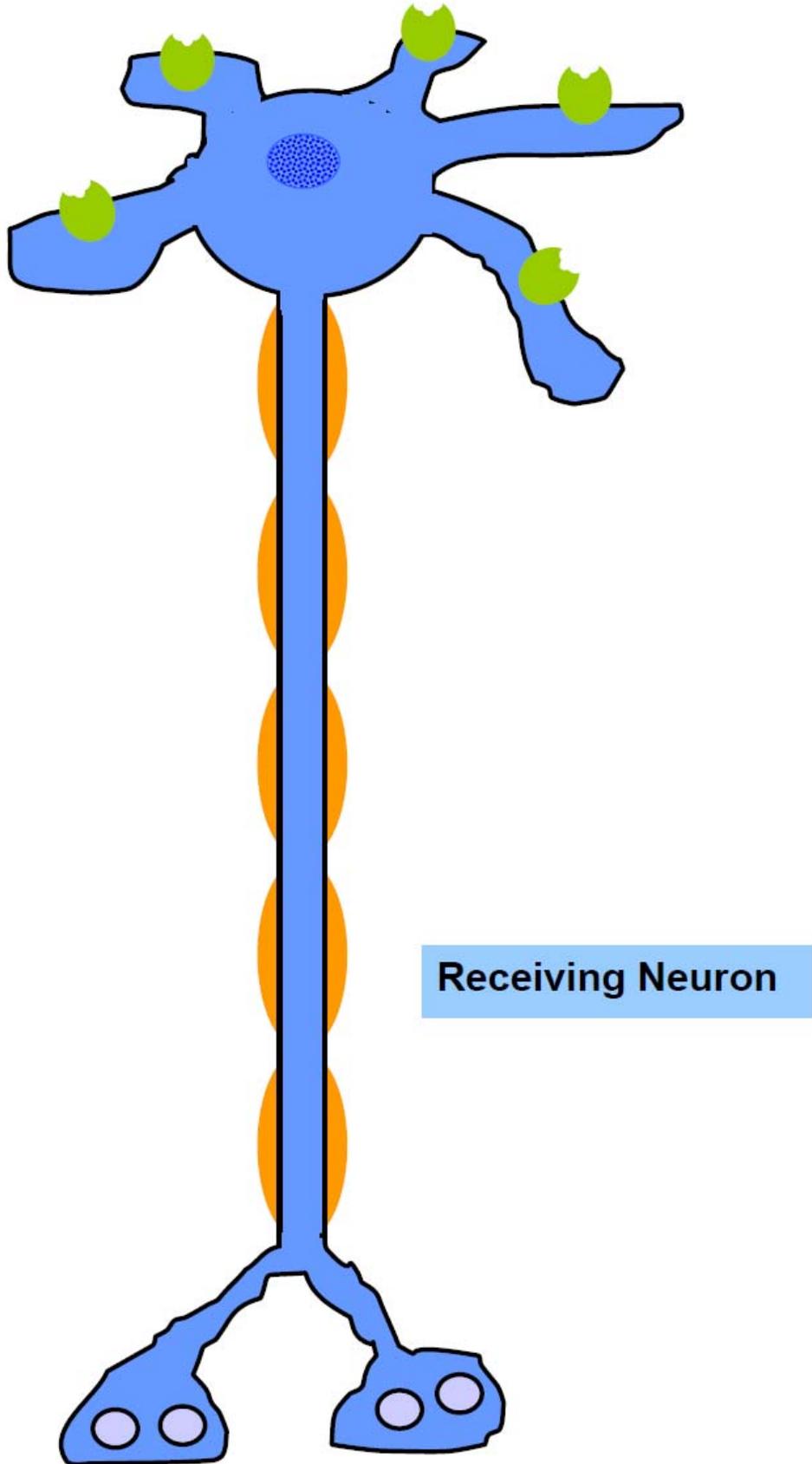
Suggested Class Procedure:

1. Distribute a copy of the student handout entitled “**The Brain and Drugs**” to each student.
2. Ask students to read (aloud in class) the information in the box at the beginning of “**Biology Brief: Brain Cells and Drugs**” aloud to the class.
3. Distribute large **Sending Neuron** and **Receiving Neuron** diagrams to teams of 2-4 students.
4. Distribute bag containing tri-beads, **Impulse** cut-outs, and label cards to each team of students.
5. Allow time for students to work in teams of 2-4 students to follow the instructions and answer the questions in the student handout. Encourage students to refer to the refer to the “**Biology Brief: Brain Cells and Drugs**” as they work.
6. Distribute copies of note sheets “**Crossing the Divide: How Neurons Talk to Each Other**” <http://learn.genetics.utah.edu/content/addiction/reward/neurontalk.html>. Show the tutorial to the class or have students work in small groups at computers. As they view this tutorial, they should complete the note sheets.
7. If time permits, students could share and discuss their answers to the questions in this activity and the tutorial questions and note sheet as they complete each one.

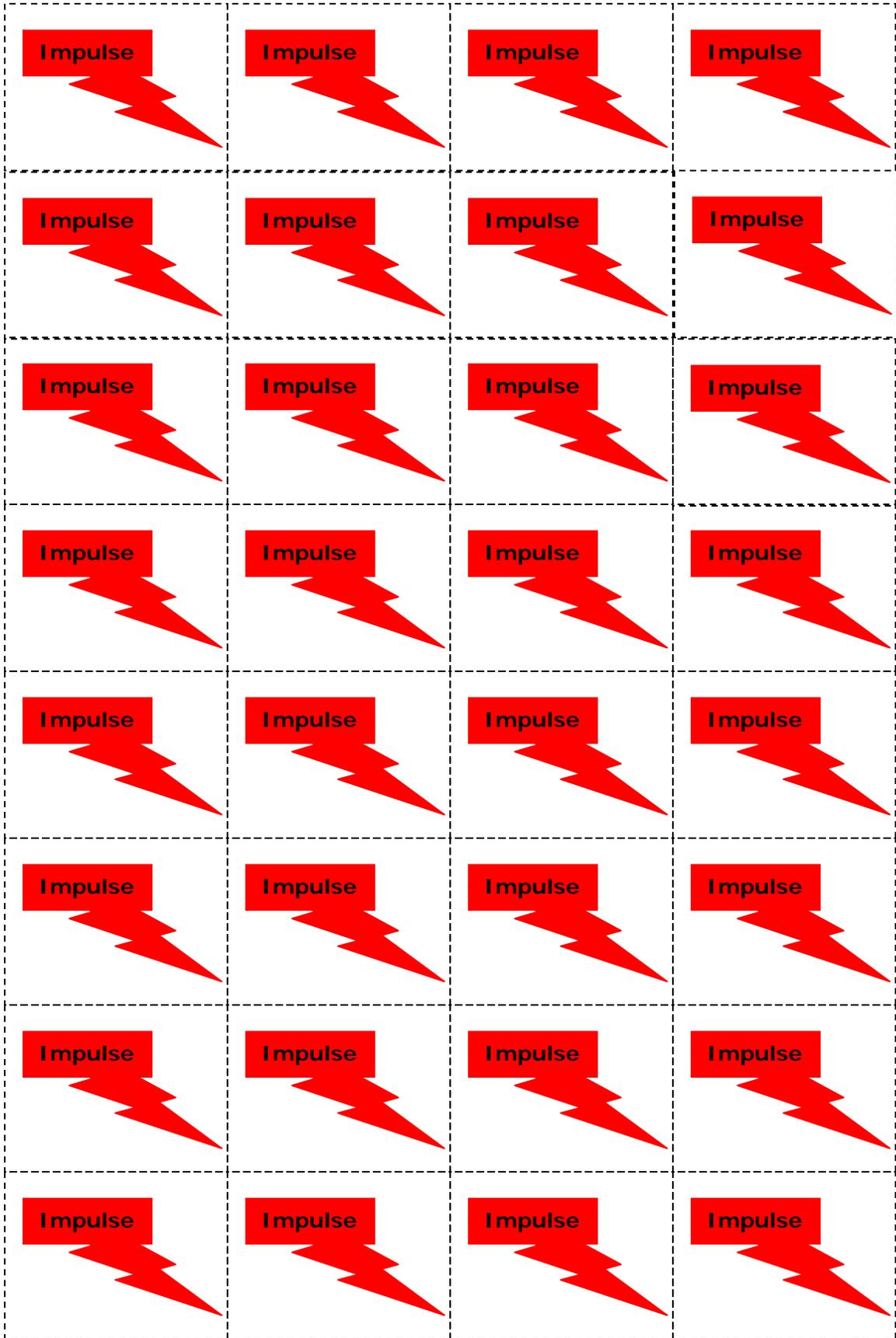
Credit: Thanks to Kathy Hoppe, instructional support specialist at Monroe 2 BOCES, who provided the idea for the large neuron manipulative model used in this activity.



Sending Neuron



Receiving Neuron



Cut along dotted lines to create sets of label cards.

Receptor	Myelin Sheath (Insulating Covering)	Nucleus of neuron
Cell Membrane of neuron	Terminal Branches (Sending Branches)	Vesicle (Contains neurotransmitter)
Cytoplasm of neuron	Dendrites (Receiving Branches)	Axon (Conducting Branch)
Receptor	Myelin Sheath (Insulating Covering)	Nucleus of neuron
Cell Membrane of neuron	Terminal Branches (Sending Branches)	Vesicle (Contains neurotransmitter)
Cytoplasm of neuron	Dendrites (Receiving Branches)	Axon (Conducting Branch)
Receptor	Myelin Sheath (Insulating Covering)	Nucleus of neuron
Cell Membrane of neuron	Terminal Branches (Sending Branches)	Vesicle (Contains neurotransmitter)
Cytoplasm of neuron	Dendrites (Receiving Branches)	Axon (Conducting Branch)

Activity 2 Brain Cells Drugs

Biology Brief: Brain Cells and Drugs

Brain nerve cells are called **neurons**. Neurons have a **cell body** that contains the nucleus. Attached to the cell body are two types of branches: short **dendrites** (receiving branches) and a long **axon** (conducting branch). The axon is covered by an insulating **myelin sheath**. The axon ends in branches with **terminal branches** (sending branches). The knobs on the ends of the terminal branches contain vesicles that store and release **neurotransmitters**.

Neurons conduct electrical signals called **impulses** through the nervous system. Neurons do not touch each other. Instead, they are separated by a tiny gap called a **synapse**. Electrical impulses cannot jump this gap.

When an impulse (an electrical signal) reaches the end of a sending neuron, **neurotransmitter** molecules are released. These neurotransmitters diffuse across the synapse and attach to **receptors** on the surface of the receiving neuron. Receptors are like key holes into which only a specific key can fit. Specific neurotransmitters are like the keys that can fit into specific receptors. When neurotransmitters attach to receptors, it causes the receiving neuron to make a new impulse.

1. Obtain two large diagrams of neurons and a set of 9 label cards.

Use the information in the reading (***Biology Brief: Brain Cells and Drugs***) to place the label cards in the correct boxes on the Sending Neuron diagram. Then label the diagram of a sending neuron on page 3.

2.

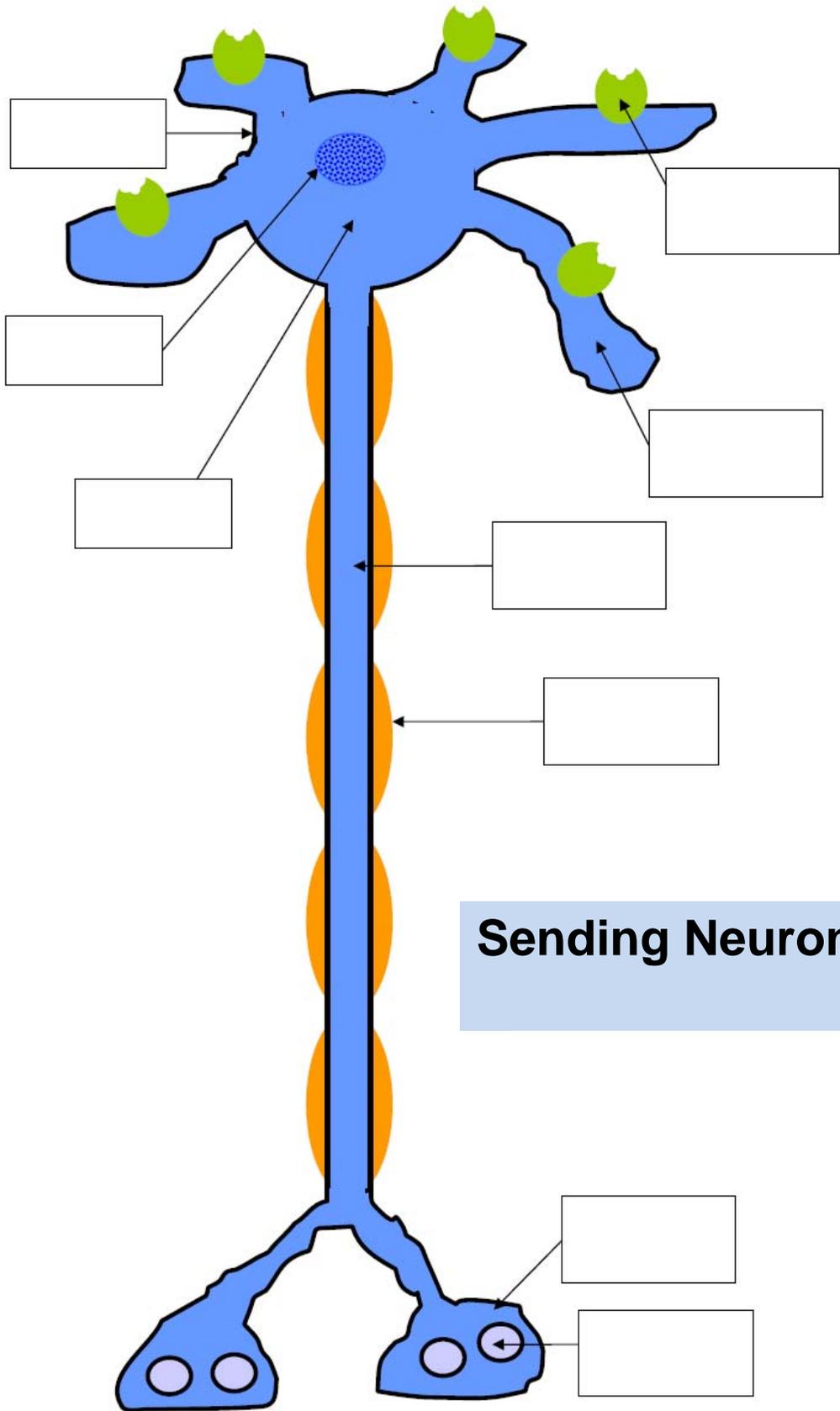
- Put 2 beads in each of the vesicles on the sending neuron and the receiving neuron. Vesicles are small sacs that store neurotransmitter molecules. The beads represent neurotransmitter molecules.

3. Place an “impulse” diagram on cell body of the sending neuron. Move the impulse diagram along the axon and the terminal branches to a terminal branch.

4. When the impulse reaches the terminal branches, it causes the vesicles to release neurotransmitter into the synapse. The neurotransmitter then diffuses across the synapse and attaches to the receptors.

- Model the release and movement of neurotransmitters by moving the beads out of the vesicles, across the synapse, and into the binding sites on receptors.

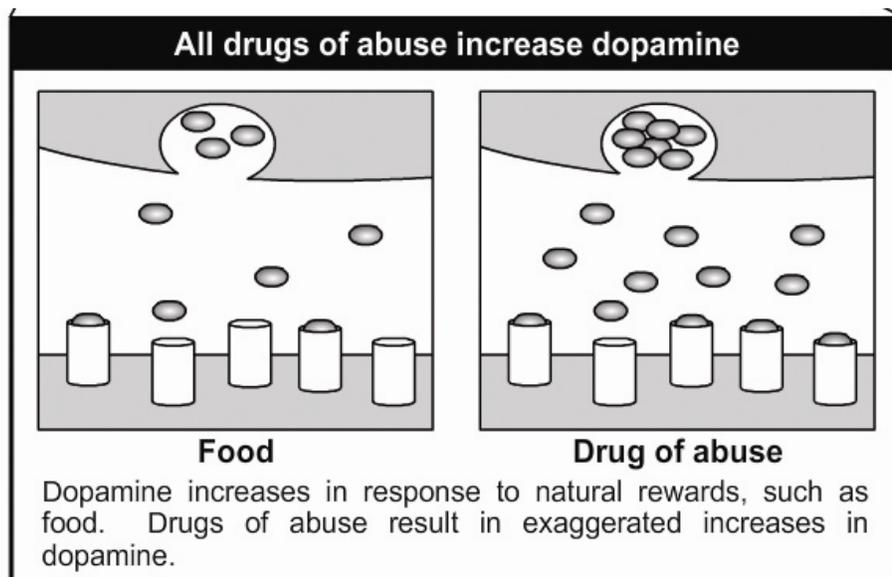
5. When a neurotransmitter binds to the receptor, the receptor triggers an impulse that travels through the receiving cell.
- Place another impulse diagram on the receiving cell and move it along the axon to the terminal branches.
 - When the impulse reaches the terminal branches, the receiving neuron becomes a sending neuron that releases its neurotransmitters to messages to other neurons.
6. Meanwhile, back at the synapse, there are **reuptake carriers** in the terminal branches that collect neurotransmitter molecules and return them to the vesicles so that the neurotransmitters to not remain in the synapse.
- Act like a reuptake carrier by returning all of the beads to the vesicles.
7. Circle the number of the statement which best explains why a nerve impulse (electrical signal) cannot pass directly from one nerve cell to another.
1. ***There is a synapse between nerve cells***
 2. Nerve cells do not have receptors
 3. Nerve impulses only occur in the brain
 4. Nerve cells do not receive chemical signals
8. What causes the sending nerve cell to release neurotransmitters into the synapse?
- An impulse travelling through the sending neuron.***
9. How does the receiving cell “know” that neurotransmitters are present in the synapse?
- The neurotransmitter attaches to receptors on the cell surface.***
10. What happens in the receiving nerve cell after neurotransmitters have attached to receptors on the receiving cell?
- The receiving neuron makes a new impulse.***
11. Cocaine blocks the reuptake carriers on the sending cell. Explain how the neuron model action would be different in a cocaine user’s brain.
- This would cause the neurotransmitter to remain in the synapse. As a result, the receiving cell would keep getting signals to make impulses.***



Sending Neuron

Dopamine is one type of neurotransmitter that is produced in areas of the reward regions of the brain that are associated with pleasure. An experience that we find enjoyable is actually caused by an increase of dopamine in the synapses of our brain reward regions. Dopamine levels can be slightly increased by natural pleasurable experiences such as eating or listening to music.

All drugs of abuse act by causing large increases of dopamine in the brain reward regions. When dopamine is increased in the synapses, more dopamine receptors are activated and more impulses are then sent from one neuron to other neurons. This large increase in neuron impulses in the reward regions of the brain causes an increase in pleasurable sensations – a “high” feeling.



12. What parts of the neuron model that you used would represent dopamine molecules?

The beads

13. How could you change the neuron model to show how drugs of abuse affect the communication between neurons in the brain reward regions?

You could increase the amount of dopamine in the synapse which increases the number of dopamine receptors that are activated and the number of impulses in the receiving neuron.

Crossing the Divide: How Neurons Talk to Each Other

<http://learn.genetics.utah.edu/content/addiction/reward/neurontalk.html>

Slide #	Write answers below each question.
1	<p>What is the reward pathway made of?</p> <p><i>Nerve Cells</i></p>
2	<p>What analogy describes how neurons send signals?</p> <p><i>Like passing a note in a classroom</i></p>
3	<p>What happens at the synapse?</p> <p><i>Signals move between neurons</i></p>
4	<p>What is a synaptic cleft?</p> <p><i>A gap between two neurons.</i></p> <p>Sketch a synaptic cleft. Label the synaptic cleft, sending cell, and receiving cell.</p> <p><i>Labeled sketch like one shown in animation.</i></p>
5	<p>What are the vesicles in the sending cell filled with?</p> <p><i>Neurotransmitter</i></p> <p>What is the name for the neurotransmitter in the reward pathway?</p> <p><i>Dopamine</i></p>
6	<p>Where are receptors located?</p> <p><i>One the receiving cell membrane</i></p>

7	<p>What triggers the release of neurotransmitter into the synapse?</p> <p><i>An electrical impulse in the sending cell</i></p>
8	<p>Why does dopamine dock (bind) with the receptor?</p> <p><i>It fits the receptor like a key fitting into a lock.</i></p>
9	<p>What change happens in the receiving cell with dopamine binds to receptors?</p> <p><i>It makes second messengers.</i></p>
10	<p>Where does the neurotransmitter go after it does its job in the synapse?</p> <p><i>Back into the sending cell via reuptake transporters</i></p>
11	<p>What does the second messenger do?</p> <p><i>It starts an impulse in the receiving cell that travels down the axon.</i></p>
12	<p>What happens when an impulse reaches the end of an axon?</p> <p><i>It triggers the release of neurotransmitter and starts the whole process all over again.</i></p>
13	<p>What is an inhibitory neurotransmitter?</p> <p><i>It prevents an impulse from being passed on.</i></p>
14	<p>Approximately how many neurons will one neuron synapse with in order to perform complex functions?</p> <p><i>1,000</i></p>