

## Activity 3

### Modeling Effects of Drugs on Neuron Communication

---

#### Core Concept:

Drugs affect communication between neurons.

#### Class time required:

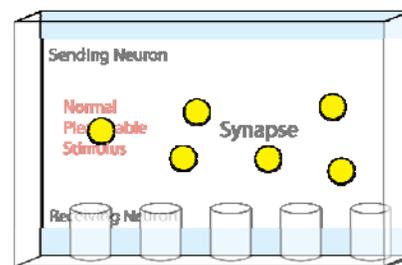
Approximately 40 minutes

#### Teacher Provides:

- Copy of student handout entitled “**Modeling Effects of Drugs on Neuron Communication**” for each student.
- 1 set of neuron models for each team of students
  - Model 1 - Synapse with normal rewarding stimulus
  - Model 2 - Synapse with first drug use
  - Model 3 - Synapse after continued drug use

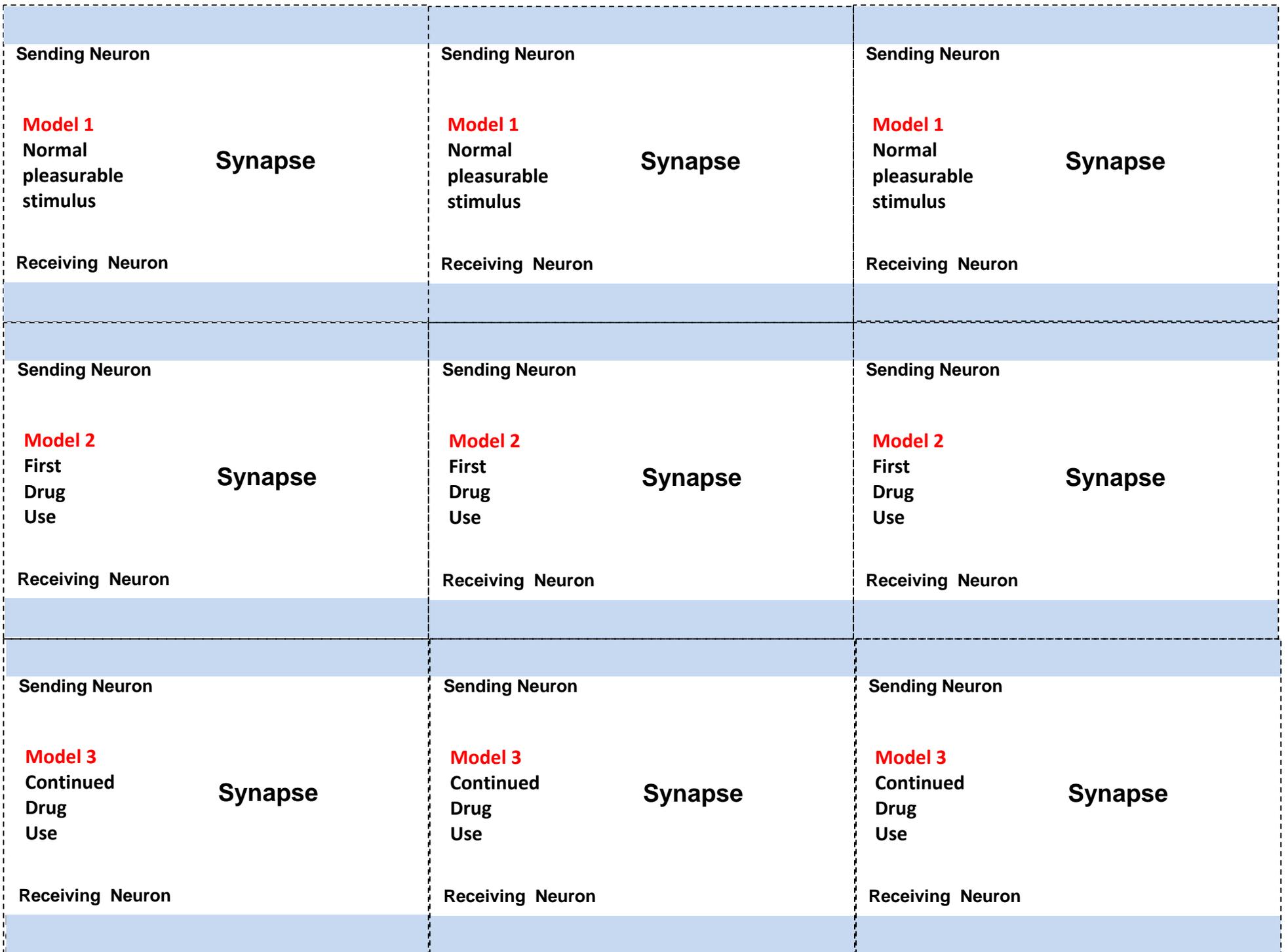
#### Instructions for Making Neuron Models:

1. Make 1 set of neuron models for each team of students. You will need 3 sports card boxes for each set of neuron models. Purchase these from TC Bulk at <http://www.tcbulk.com/scripts/prodview.asp?idproduct=287> (Item Number PM:PC25)
2. Use four glue dots to apply cards on page 3 to the bottoms of the sports card boxes:
  - Model 1 - Synapse with normal rewarding stimulus
  - Model 2 - Synapse with first drug use
  - Model 3 - Synapse after continued drug use
3. Use glue dots to attach individual small plastic wells from a well strip to the inside bottom of the plastic boxes as described below. The wells represent “dopamine receptors”. Purchase the well strips from VWR Scientific, catalog # 62402-961. These come in strips of 12 wells – break the strip into individual wells.
  - Model 1 - glue 5 wells to the bottom of the box
  - Model 2 - glue 5 wells to the bottom of the box
  - Model 3 - glue 3 wells to the bottom of the box



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.

4. Add plastic 4 mm red beads to the boxes (purchase from Consumer Crafts <http://www.consumercrafts.com/store/details/catalog/jewelry-plastic-and-acrylic-beads/06122-7-01> The beads represent “dopamine” molecules.
  - Model 1 - add 10 beads
  - Model 2 - add 20 beads
  - Model 3 - add 5 beads
  
5. Use small pieces of clear tape to tape lids to the boxes.



### **Suggested Class Procedure:**

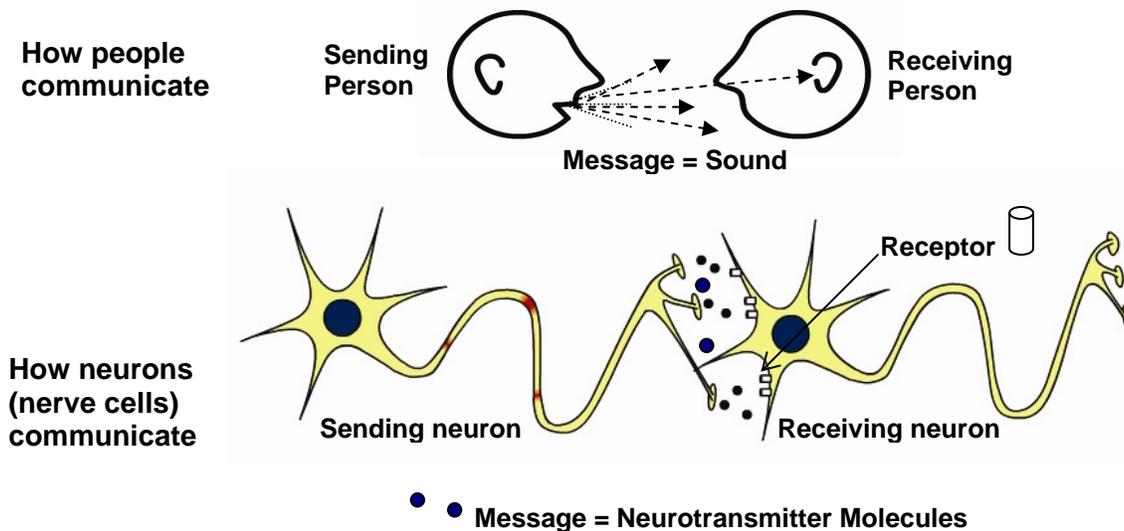
1. Explain to students that the activity they will be doing involves simulations of the events that occur at synapses - the gaps between neurons.
2. Distribute copies of the handout entitled “**Modeling Effects of Drugs on Neuron Communication**” to each student.
3. Read the information in the box at the beginning of the activity aloud to the class.
4. Distribute Model 1 to each team of students. Remind students that they should NOT open the models.
5. Ask students to read and follow the instructions for Model 1. If possible, do a class average for the number of receptors with beads for Model 1.
6. Share and discuss answers for Model 1.
7. Distribute Model 2 to each team of students.
8. Ask students to read and follow the instructions for Model 2. If possible, do a class average for the number of receptors with beads for Model 2.
9. Share and discuss answers for Model 2.
10. Distribute Model 3 to each team of students.
11. Ask students to read and follow the instructions for Model 3. If possible, do a class average for the number of receptors with beads for Model 3.
12. Share and discuss answers for Model 3.

## Activity 3

### Modeling Effects of Drugs on Neuron Communication

#### How do neurons communicate?

Your nervous system is made of nerve cells called neurons. Neurons do not touch each other. They are separated by a small gap called a **synapse**. To send a message, a **sending neuron** releases chemical message molecules called **neurotransmitters** into the synapse (gap). The neurotransmitters diffuse across the synapse and bind to **receptors** on the surface of a **receiving neuron**. When neurotransmitters bind to receptors, they trigger a nerve impulse (an electrical message) that travels along the receiving neuron.



1. What is the message that travels from a sending neuron to a receiving neuron?

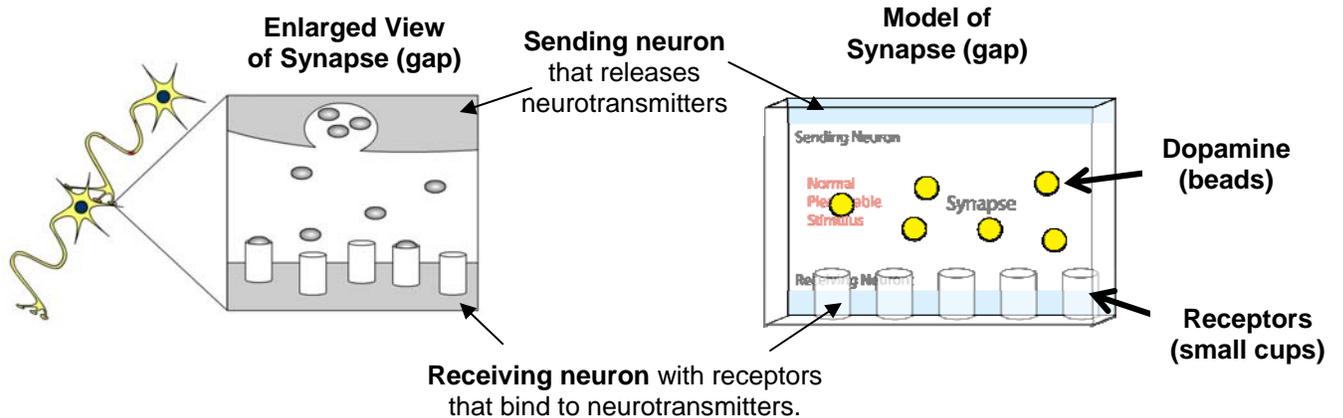
***Neurotransmitter molecules***

2. What part of a neuron is like the ears of a person who is listening to a sound message?

***The receptor***

## How do drugs interfere with neuron communication?

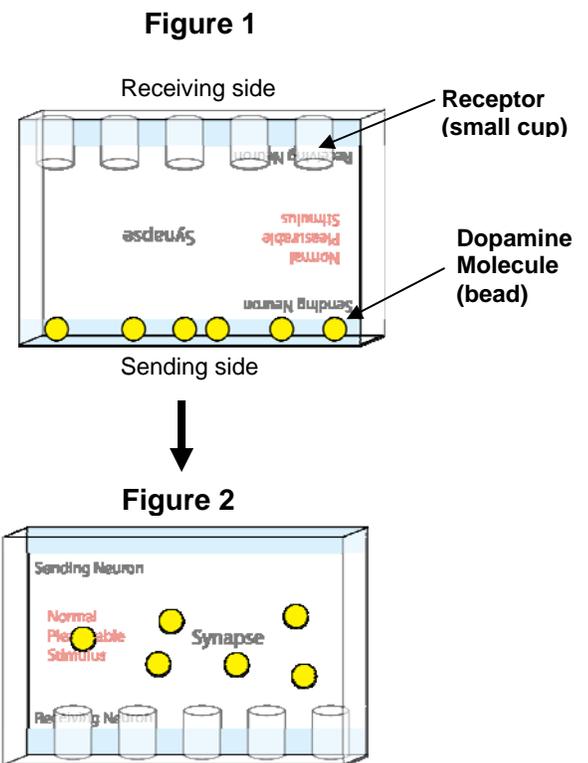
Drugs affect how neurons (nerve cells) in the brain communicate with each other by changing the chemical messages in the synapse. In this activity, you will observe models that illustrate communication between neurons that occurs at synapses.



### Model 1: Neuron communication with normal rewarding activity

First, you will look at the model labeled **Model 1: Normal Pleasurable Stimulus**. This model illustrates what happens in synapses when there is a normal rewarding (pleasant) activity such as eating or listening to music.

1. Set the model labeled **Normal Pleasurable Stimulus** so that the beads are on sending neuron side as shown in Figure 1.
2. Count the number of beads. The beads represent dopamine molecules. Record the number of beads in the Data Table. *The data table is on the last page of this handout.*
3. Notice that the other side of the model has small cups. These small cups represent receptors on the receiving neuron. Count the number of small cups (receptors) in the model. Record the number of cups in the Data Table.
4. When a nerve impulse reaches the sending end of the first neuron, dopamine molecules are released as shown in Figure 2. Model this by shaking and then quickly flipping the model over so that the beads move toward the end of the model with receptors.

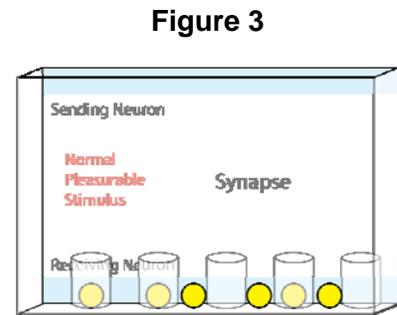


- When the beads reach the receiving end of the next neuron, some may enter the receptors (small cups) on this neuron as shown in Figure 3.

- Count the number of receptors (cups) that have dopamine molecules (beads) in them.
- Record the number of cups with beads in them on the Data Table in Trial 1.

- Repeat steps 4 and 5 to complete four additional trials.

- Calculate and record the average number of beads (dopamine) that entered the receptors.



### **Model 2: Neuron communication with first drug use.**

Next, you will observe the model labeled **Model 2 – First Drug Use**. This model illustrates what happens in synapses when a person uses drugs for the first time.

- Describe how the model labeled **First Drug Use** different from model labeled **Normal Pleasurable Stimulus**.

***There are more beads (dopamine molecules).***

- Use Model 2 to repeat the steps that you used with Model 1:
  - Count and record the number of dopamine molecules.
  - Count and record the number of receptors.
  - Shake and flip the model, then count and record the number of receptors that contain dopamine molecules.
  - Do five trials, then calculate the average for the five trials.
- Explain how this model illustrates why a person feels “high” with first drug use.

***The receiving cells are receiving more signals and are making more impulses.***

### **Model 3: Neuron communication after continued drug use.**

What do you do if you're listening to an iPod and the volume is too loud? You turn the volume down.

What does the brain do if continued drug use results in too much dopamine? To maintain homeostasis, brain neurons change to reduce the amount of dopamine stimulation.

Observe the model labeled **Model 3 - Continued Drug Use** that illustrates how neurons change when a person continues to use drugs.

1. Describe how the model labeled **Continued Drug Use** is different from the model labeled **First Drug Use**.

***There are fewer beads (dopamine) and fewer cups (receptors).***

2. Use Model 3 to repeat the steps that you used with Model 1.
  - Count and record the number of dopamine molecules.
  - Count and record the number of receptors.
  - Shake and flip the model, then count and record the number of receptors that contain dopamine molecules.
  - Do five trials, then calculate the average for the five trials.
3. Describe how Model 3 illustrates two changes that brain neurons make to adapt to abnormally high levels of dopamine associated with drug abuse.

***There are fewer dopamine receptors and fewer dopamine molecules.***

4. Explain how this model shows why a drug abuser becomes less able to enjoy normal pleasant activities such as eating or listening to music.

***The neurons in a drug abusers brain are not making enough impulses. OR The brain is sending fewer signals.***

### **Drug Tolerance**

When people abuse drugs they often find that they no longer respond to the drugs in the way they initially did. To feel “high” they need to use larger amounts of drugs and use drugs more frequently. This is called **drug tolerance**.

5. Explain how this model shows why a drug abuser develops drug tolerance - will need to use larger amounts of drugs and use drugs frequently to feel happy.

***It would take more drugs to increase the amount of dopamine that is released and the number of receptors that are bound to dopamine.***

6. Describe the changes in the neurons that lead to drug tolerance.

***The neurons have fewer receptors and they release less dopamine.***

**Data Table:**

**Neuron Communication**

	Number of Beads (Dopamine) in model	Number of Cups (Receptors) in model	Number of Receptors with Dopamine Bound					Average number of Receptors with bound Dopamine	Sensation experienced by person
			Trial 1	Trial 2	Trial 3	Trial 4	Trial 5		
<b>Model 1 Synapse with normal rewarding stimulus</b>	<b>10</b>	<b>8</b>						<i>Approx. 1 to 2.5</i>	<b>Happy</b>
<b>Model 2 Synapse with <u>first</u> drug use</b>	<b>20</b>	<b>8</b>						<i>Approx. 2.5 to 4</i>	<b>“High”</b>
<b>Model 3 Synapse after <u>continued</u> drug use</b>	<b>5</b>	<b>4</b>						<i>Approx. 0 to 1</i>	<b>Unhappy!</b>