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Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine

BrainLink

Crossing the Gap

Activity from *Brain Chemistry: Teacher's Guide*

by

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"The brain is the last and grandest biological frontier, the most complex thing we have yet discovered in our universe. It contains hundreds of billions of cells interlinked through trillions of connections. The brain boggles the mind."

James D. Watson
from Discovering the Brain
National Academy Press, 1992

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Crossing the Gap

OVERVIEW

Students conduct a simulation to demonstrate how multiple incoming signals influence the action of neurons.

CONCEPTS

- Messages can either stimulate the next neuron to send a signal or inhibit that neuron from sending a signal.
- Certain chemicals change the way signals are sent and received.

SCIENCE & MATH SKILLS

Predicting, comparing and contrasting, recording observations and interpreting results

TIME

Preparation: 10 minutes
Class: 30–45 minutes

MATERIALS

- transparency of Transmitters & Receivers student sheet
- overhead projector

Each group will need:

- one die
- set of Brain Chemical cards (see SETUP)

Each student will need:

- copy of Fire Those Neurons! student sheet

Most neurons in the brain communicate with each other by releasing chemical messengers called neurotransmitters. Neurotransmitters cross the gaps between neurons or between neurons and other cells, such as muscle, and match up with specific receptors. Chemical signaling between neurons allows different kinds of messages to be sent. For example, not all chemical messengers stimulate neurons to fire. Some messengers make it harder for an electrical impulse to be generated in the receiving neuron. Since one neuron can share synapses with thousands of other neurons, the combined effects of different messages ultimately determine whether a signal will be triggered or not.

Unit Links

LEGACY OF LOST CANYON

Story, Chapter 8; Science boxes, pp. 20 and 23.

EXPLORATIONS

Think About It, p. 8.

Many **drugs** have powerful effects on the nervous system because they act on neurons' receptors. Some drugs trick the receptor because they are shaped like the neurotransmitter that is supposed to attach to the receptor. Once attached, however, the drugs can produce very different results. Curare, for example, is a deadly poison used by South American Indians. It causes death from paralysis, because it binds to receptors on muscle cells but doesn't stimulate the muscles to contract. Since the receptors are blocked, the real chemical messenger for muscle contraction (acetylcholine) can no longer bind to the site, leading to paralysis.

Drugs also can interfere with communication between neurons by preventing the manufacture of neurotransmitters within cells, by preventing release of chemical messengers or by blocking reception of the messengers. Some drugs cause excessive firing of neurons by stimulating massive releases of neurotransmitters, by mimicking the effects of chemical messengers, or by preventing the normal breakdown and recycling of chemical messengers.

This activity will help students learn about the relationships between chemical messengers, receptors and the actions of common chemicals in alcoholic beverages, cigarettes and illicit substances on brain functions.

SETUP

If making your own Brain Chemical cards, make six photocopies of the student page on white cardstock. Cut out the cards to make six sets of the four different cards. Each group should receive one set of cards. Have students conduct this activity in groups of 4.

PROCEDURE

1. Review the steps in nervous system communication that students learned while playing Locks & Keys (Activity 4). Tell students that they will be simulating what happens when chemical messengers, or neurotransmitters, go from one neuron to the next. Point out that most neurons can receive messages from many other neurons. Some of these messages "stimulate" or cause firing, other messages "inhibit" or prevent firing. Neurons "decide" to fire or not depending on the kinds of messages they receive.
2. Distribute a copy of Fire Those Neurons! to each group of students.
3. Students will take turns rolling a die twice. The first roll will determine how many incoming signals excite the neuron to fire. The second roll will determine how many signals inhibit firing (or have students use two different colored die and roll them together). During each trial, students should subtract the second number from the first. If the outcome is zero or a positive number, the neuron will "fire" or pass the message. If the outcome is a negative number, the neuron will not fire.
4. Conduct a class discussion of the results of the model thus far. Ask, *Did it matter how many "stimulating" messages were present for firing as long as the number was greater than the "stopping" or "inhibiting" messages?* Point out that the firing of a neuron is like turning on a light switch—either an impulse is created or it is not.
5. Tell students that they will be conducting another round of the simulation. This time, however, give each student a Brain Chemical card that will provide additional instructions for each trial. As they progress through the simulation, students will discover that the drugs have changed the patterns of neuron firing.
6. After students have completed the second round, ask, *Did you receive different results this time? Did the neurons fire more or*

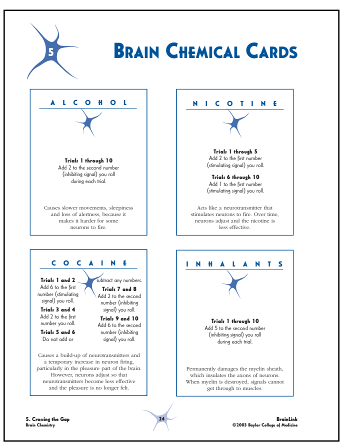
Drugs and the Nervous System

Research on how drugs affect neurons has led to improved medicines and to better understanding about how drugs of abuse act on the nervous system.

- **Fluoxetine** (Prozac) blocks the reuptake of the neurotransmitter serotonin and keeps it active in brain circuits related to emotional states. Fluoxetine and similar drugs are used to treat depression.
- **L-Dopa**, an important drug for treating the muscle tremors of Parkinson's disease, supplies raw material for the neurotransmitter dopamine.
- **Marijuana** contains a substance (THC) that connects to receptors on neurons in parts of the brain that influence pleasure, memory, thought, concentration, sensory and time perception, and coordinated movement.
- **MDMA**, known as "Ecstasy," increases the activity levels of serotonin and other neurotransmitters in the brain. MDMA is linked to long-term damage of parts of the brain critical for thought, memory and pleasure.
- **Morphine** and **Heroin** mimic chemical messengers that trigger brain pathways responsible for pleasure and blocking pain. With regular heroin use, tolerance develops. This means that the abuser must use more of the drug to achieve the same affect—eventually leading to addiction.

Brain Disorders and Drug Treatment

Disorders such as depression, anxiety and schizophrenia often are treated with medicines that affect one or more steps in the synthesis, release or breakdown of certain neurotransmitters. In fact, learning how these drugs work has provided insight into the mechanisms in the brain underlying these diseases.



less often? Did the responses of the neurons change over time? Help students conclude that each of the chemicals on the Brain Chemical cards changes the way neurotransmitters work. In addition, at least two of the examples (cocaine and inhalants), cause changes in neurons. Revisit the neuron diagram (Transmitters & Receivers student sheet, p. 10) to find the places affected by these chemicals.

7. Conduct a class discussion to help students correlate the effects of drugs on the nervous system to physical or behavioral changes that can be observed or felt. Detailed information about the substances listed on the Brain Chemical Cards are given below. For additional information on other substances, read Drugs and the Nervous System (see sidebar, p. 21).

ALCOHOL depresses the central nervous system (brain and spinal cord). It causes slowed movements, loss of balance and sleepiness by enhancing the activities of several neurotransmitters that inhibit neuron firing. Alcohol affects neurons in many parts of the brain, which explains why it has numerous effects on thinking and movement. Even one drink may cause poor judgment and unrealistic estimations of risk.

COCAINE is a strong central nervous system stimulant that interferes with the reuptake of dopamine, a neurotransmitter associated with pleasure and movement. Dopamine is released as part of the brain's reward system and is involved in the "high" that characterizes cocaine consumption.

INHALANTS damage or destroy the myelin sheath that insulates nerve axons. Without myelin, nervous system signals to muscles are disrupted. This loss leads to tremors and muscle spasms. In addition, inhalants can cause irregular heart rhythms leading to heart failure and even death or can cause death by filling the lungs with poisonous substances instead of oxygen.

NICOTINE stimulates the activity of neurons in many parts of the brain and nervous system. It causes increases in blood pressure and heart rate, faster respiration, narrowing of arteries and stimulation of the central nervous system. It also stimulates the release of a neurotransmitter (dopamine) in parts of the brain related to addiction and pleasure (limbic system).

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Encourage students to learn more about how different chemicals affect the brain by conducting research in the library on the Internet. A good place to start is the National Institute on Drug Abuse at http://www.nih.nida.gov.

Fire Those Neurons!

Can chemicals change neuron communication? You will investigate this question by simulating how a neuron processes many incoming messages. Messages can signal a neuron to fire (a stimulating signal) or make it harder for a neuron to fire (an inhibiting signal).

ROUND 1

1. Roll the die 2 times. The first number you roll will tell you how many incoming messages stimulate the neuron to signal other neurons. The second number you roll will tell you how many incoming messages tell the neuron not to fire. Subtract the second number from the first. If the answer is zero or a positive number, your neuron is activated and it fires (sends a message to other neurons). If the answer is a negative number, then the neuron does not fire.
2. After 10 trials, count the number of times the neuron was activated and fired. Write the number in the box.

TRIAL	Number of Stimulating Signals	Number of Inhibiting Signals	RESULT
1	–	=	
2	–	=	
3	–	=	
4	–	=	
5	–	=	
6	–	=	
7	–	=	
8	–	=	
9	–	=	
10	–	=	

ROUND 2

1. You have been given a Brain Chemical card with additional instructions. Read the card and predict whether the brain chemical described on your card will increase or decrease neuron firing. Record your prediction on the back of this sheet.
2. Roll the die as you did for Round 1, but make additions or subtractions to the numbers you roll, as directed by the instructions on the card.
3. After 10 trials, count the number of times that the neuron was activated and fired. Write the number in the box.

TRIAL	Number of Stimulating Signals	Number of Inhibiting Signals	RESULT
1	–	=	
2	–	=	
3	–	=	
4	–	=	
5	–	=	
6	–	=	
7	–	=	
8	–	=	
9	–	=	
10	–	=	

How were the Rounds similar? How were they different? To what do you attribute the differences? Were there any changes in the pattern of neuron firing from Trial 1 to Trial 10? Write your answers on the back of this sheet.

Brain Chemical Cards

ALCOHOL

Trials 1 through 10
Add 2 to the second number (inhibiting signal) you roll during each trial.

Causes slower movements, sleepiness and loss of alertness, because it makes it harder for some neurons to fire.

NICOTINE

Trials 1 through 5
Add 2 to the first number (stimulating signal) you roll.

Trials 6 through 10
Add 1 to the first number (stimulating signal) you roll.

Acts like a neurotransmitter that stimulates neurons to fire. Over time, neurons adjust and the nicotine is less effective.

COCAINE

Trials 1 and 2
Add 6 to the first number (stimulating signal) you roll.

Trials 3 and 4
Add 2 to the first number you roll.

Trials 5 and 6
Do not add or subtract any numbers.

Trials 7 and 8
Add 2 to the second number (inhibiting signal) you roll.

Trials 9 and 10
Add 6 to the second number (inhibiting signal) you roll.

Causes a build-up of neurotransmitters and a temporary increase in neuron firing, particularly in the pleasure part of the brain. However, neurons adjust so that neurotransmitters become less effective and the pleasure is no longer felt.

INHALANTS

Trials 1 through 10
Add 5 to the second number (inhibiting signal) you roll during each trial.

Permanently damages the myelin sheath, which insulates the axons of neurons. When myelin is destroyed, signals cannot get through to muscles.