BioEd℠

THE LEARNING BRAIN

# Brain Chemistry
# Teacher's Guide

## What Is a Neuron?


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## Source URLs

Page 1: Microscopic image of a hippocampal neuron by Robert S. McNeil © Baylor College of Medicine, http://www.neuralimages.org/.

Page 2. SEM image of purkinje neurons courtesy of The Gene Expression Nervous System Atlas (GENSAT) Project, NINDS Contracts N01NS02331 & HHSN271200723701C to The Rockefeller University (New York, NY), http://www.gensat.org/index.html/.

Page 3: Microscopic image of pyramidal neurons © BrainMaps.org, Creative Commons Attribution 3.0 License. http://brainmaps.org/.

## Overview

Students are introduced to how messages are sent and received by neurons, and they build a model neuron.

# What Is a Neuron?

The human brain is the most complex structure in the known universe. Consisting of close to 100 billion nerve cells (and many times that number of supporting cells), the brain is the center of our thoughts and emotions. It receives and processes information from the world around us, directs our movements and controls automatic functions of our bodies. Amazingly, virtually all functions of the brain and the rest of the nervous system are based on communication among nerve cells, also known as neurons.

### Unit Links

***Legacy of Lost Canyon***
Chapter 4
Science boxes, p. 11-12

***Brain Chemistry Explorations***
"Brain Busters!" p. 7
Neuron photograph, p. 2

In many ways, a neuron is like any other cell in the body. Each neuron is surrounded by a membrane, is filled with liquid (cytoplasm) and has a nucleus containing its genetic material. However, just as many other cells within the body are specialized to do a particular job, neurons are specialized to receive and transmit information. Even though they may differ in appearance, all neurons collect information from either the environment (information detected by the sensory system) or from other cells in the body. They transmit the information to other neurons and/or other kinds of cells (such as muscle).

A typical neuron has an enlarged area, the cell body, which contains the nucleus. Neurons typically also have two types of specialized extensions that project away from the cell body. The branches on which information is received are known as dendrites. Each neuron usually has many dendrites. Each neuron usually also has a longer taillike structure, or axon, which transmits information to other cells. Axons can be branched at their tips. The axons of many kinds of neurons are surrounded by a fatty, segmented covering called the myelin sheath. This covering acts as a kind of insulation and improves the ability of axons to carry nervous system signals rapidly.

Neurons communicate with one another through special junctions known as synapses. With the most common type of synapse, known as a chemical synapse, neurons do not actually touch. Rather, the end of the axon (or axon terminal) of one neuron is separated from the next neuron by a tiny gap called a synaptic cleft. Messages traveling from one neuron to the next must cross this gap and bind to the next neuron for the signal to continue along its path. Typically, a single neuron may be capable of

## Concepts

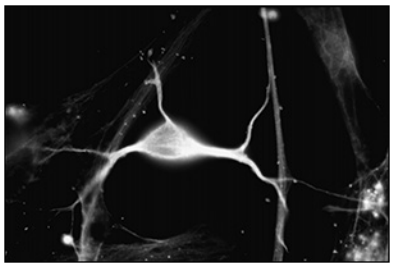
- Messages within the brain and the rest of the nervous system are sent very rapidly.
- Messages are conducted by cells called neurons.
- Neurons are specialized to receive and transmit messages.
- Neurons are connected in networks.

## Science & Math Skills

Predicting, inferring and modeling

## Time

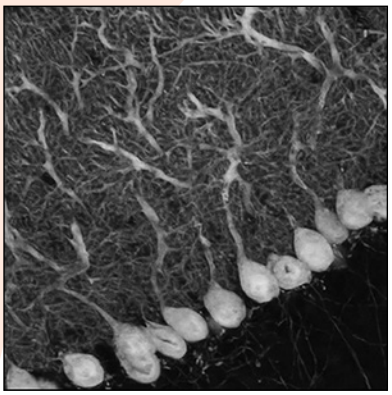
**Setup:** 10 minutes
**Activity:** 45 minutes



Microscopic image of a neuron from the hippocampus. Most neurons receive signals from many other neurons. The combined effects of these signals determine the response of the receiving neuron.

Microscopic image by Robert S. McNeil © Baylor College of Medicine.

## Purkinje Neurons



Purkinje cells are large neurons with branching, tree-like dendrites. These neurons form the sole output pathway of the cerebellar cortex, and they serve as an essential link in regulating the body's muscle tone and movement.

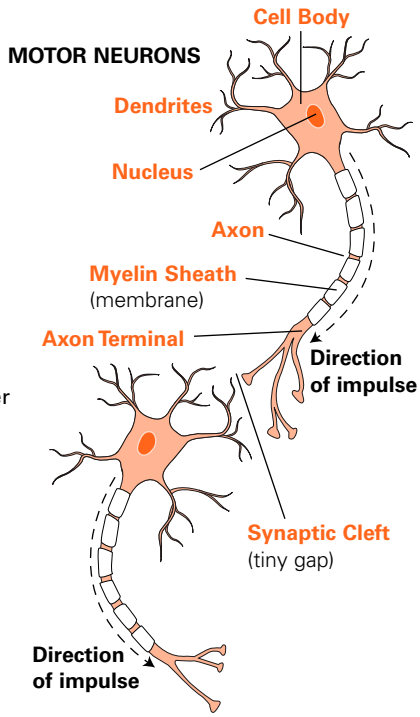
## Did You Know?

- New neurons are "born" throughout life and may play an important role in learning and memory. Scientists have discovered that the number of new neurons born in the brain is increased by physical exercise and decreased by factors such as stress and aging.
- In humans, axons can vary from only a fraction of an inch to more than 3 feet in length! The longest axons extend from the base of the spine all the way to the big toe of each foot.
- Neurons are accompanied and supported by other kinds of cells.

## Typical Structure of Neurons

A typical neuron has an enlarged cell body which contains the nucleus. Most neurons have branches, known as dendrites. Each neuron typically also has a longer tail-like fiber, or extension, called an axon. Information typically is received on the dendrites or on the cell body and is transmitted down the axon to other cells. (The myelin sheath, illustrated in the neurons to the right, has been enlarged for viewing its location on the axon.)

Neurons vary greatly in size and shape. Although neurons generally have only a single axon, they can have hundreds of dendrites.




receiving messages simultaneously on its dendrites and cell body from several thousand different neurons.

This activity provides students with a general introduction to neurons and to their role as message carriers within the body.

## MATERIALS

**Teacher (See Setup)**

- Document projector (or overhead projector and a transparency of "Transmitters & Receivers" page)

**Per Group of Students**

- Resealable plastic bag, approx. 12 in. x 15 in. (or gal size)
- Roll of masking tape, 0.75 in.

**Per Student**

- 4 pipe cleaners
- Modeling clay (or small styrofoam ball)
- Copy of "Transmitters & Receivers" page

## SETUP

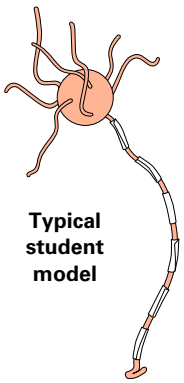
Organize materials in one plastic bag for each group and place in a central location. Conduct the initial portion of this activity with the entire class. Then have students work in groups of four.

## PROCEDURE

1. Begin by asking students how they react to touching something hot. Ask, *What happens when you accidentally touch a hot dish or iron?* Students might mention that they jerk their hands away quickly from the hot items. Ask, *Why might it be important for you to react quickly?*

2. Point out to students that components of the nervous system work together to conduct signals very rapidly. Reflex responses (which can be essential for survival) are especially fast, because the signal from sensors can be routed directly to muscles through the spinal cord without first passing through the brain.
3. Next ask students as a group to respond to some simple arithmetic questions. Ask, *What is two times four? Three times three? Three times nine? Ten times ten?* Follow by asking, *Did it take a long time for your brain to figure out the answers? Did it take long for your brain to send messages to your lips and tongue to form the words?* Reiterate that components of the brain and the rest of the nervous system work together very rapidly.
4. Project the "Transmitters & Receivers" page on the board. Mention that there are many different kinds of neurons (about 10,000!), but that all of them are designed to receive and transmit messages. Point out the "message-receiving" parts (dendrites and cell bodies) and "message transporting" parts (axons) on the two neurons. Mention the myelin sheath that surrounds the axons of some neurons and helps them conduct signals more rapidly (not unlike the insulation on an electrical wire).

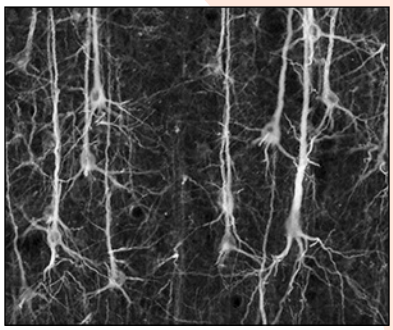
   You also may want students to look at the photograph of a neural network (sidebar, upper right). In the photograph, students can easily observe the cell bodies of neurons. They also can observe that axons and dendrites form complicated networks.
5. Distribute copies of the student sheet and have students complete it. Make sure students understand that messages flow in only one direction on each neuron.
6. Challenge students to use a variety of materials to create their own neurons (see "Typical Student Model," right). Use modeling clay or small styrofoam balls to create cell bodies, and pipe cleaners to create axons and dendrites. Remind students that, even though printed images give neurons (and other cells) a flat appearance, these structures actually have a variety of shapes in three dimensions.



**Typical student model**

7. Provide masking tape for students to create short myelin sheath segments on the axons of their neurons.
8. After students have made their neurons, ask them to identify on their models where incoming messages would be received from other neurons and from where their models would be able to transmit messages to other neurons.
9. Display the completed neuron models on a board or table. Or encourage students to work together to create networks of interconnected nerve cells using the neuron models they have created and display these constructions.

## Pyramidal Neurons



Pyramidal cells, like the ones shown above, are found in the cerebral cortex and other parts of the central nervous system. Pyramidal cells have a pyramid-shaped cell body and many dentritic branches.

## Extensions

- Obtain prepared slides of neurons and other cells in the nervous system from a commercial biological supply company. Or find photographs of neurons on the Internet. Help students find the cell bodies, dendrites and axons on the neurons. Students will observe that actual neurons are much more complex than their models, but still have the same basic parts.
- Try envisioning the following. If the cell body of a typical motor neuron (a neuron that sends messages to muscles) were the size a tennis ball, its dendrites would extend the length of a normal room and its axon would be about the size of a garden hose nearly 1/2-mile long.
- Neurons are not the only cells in the nervous system. They are assisted by other cells. Some types of cells even wrap around the axon to form the myelin sheath. Challenge students to use the Internet or library resources to find out more about these helpers, called glial cells.

# Transmitters & Receivers

**Neurons are special cells that pass messages throughout the body.**

1. Locate the cell body and the nucleus of each neuron.
2. Find the axons (long fibers) that lead from one neuron to the next.
3. Locate the dendrites (short branches) on the neurons.
4. Find the myelin sheath that wraps around each axon.
5. Locate the ends of each axon (or axon terminals). Notice the slightly rounded shapes.
6. Find the Synaptic Cleft (tiny gap between the neurons, across which messages must pass).
7. Label the parts of the neurons.
8. Notice the arrows on the drawing. What do you think they mean?

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9. A single neuron may receive messages from many other neurons at one time. Think about how messages are passed between neurons. Add another neuron to this image.