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

Conducting Signals

Activity from *Brain Chemistry: Teacher's Guide*

by

Nancy P. Moreno, Ph.D., and Barbara Z. Tharp, M.S.

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Authors: Nancy P. Moreno, Ph.D., and Barbara Z. Tharp, M.S.
Editors: James P. Denk, Paula H. Cutler and Martha S. Young
Design: Martha S. Young
Illustrations: T Lewis and Martha S. Young

"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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Center for Educational Outreach, Baylor College of Medicine
One Baylor Plaza, BCM411, Houston, Texas 77030 | 713-798-8200 | 800-798-8244
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Conducting Signals

More than a century ago, biologists discovered that nerve impulses involved electricity. At first it was believed that electricity flowed through nerve cells much as it travels along a wire. However, further investigation revealed that only living nerve cells could conduct messages.

Eventually, biologists discovered that electrical impulses are transported along the cell membranes of neurons. Chemical changes along the length of the membrane cause an electrical charge to move as a single pulse from one end of the cell to the other. Thus, the movement of an electrical impulse along a nerve cell resembles a line of dominoes, in which each domino triggers the next one to fall. Once the signal reaches the end of the axon, it is passed to the next nerve cell either electrically or by a chemical messenger that crosses the gap, or **synapse**, between nerve cells.

Movements of sodium, one of the components of salt, help generate the electrical charge that travels along the neuron membrane. Potassium, chlorine and calcium also are involved. This activity helps students observe the relationship between certain substances dissolved in water and the conduction of an electrical signal.

Students will build a circuit that connects a bulb to a battery. Electricity, which is the movement of electrons (negative charge), will flow from the negative terminal to the positive terminal.

Students will use their setups to investigate whether distilled water conducts electricity and compare the results to those achieved with salt water and sugar water. Students also will test the conductivity of a sports drink. Pure water is a poor conductor of electricity. However, when salt is added, water conducts electricity very efficiently. Dissolved salt (NaCl) separates into negatively charged atoms (chloride ions, written as Cl-) and positively charged atoms (sodium ions, written as Na+). The current is carried by Cl- ions, which migrate toward a wire connected to the positive terminal of a battery.

Unit Links

LEGACY OF LOST CANYON
Story, Chapters 5-6; Science box, p. 23.

EXPLORATIONS
Did You Know?, p. 4; Sending Signals, p. 7.

OVERVIEW
Students create an electrical circuit and investigate how some dissolved substances conduct electricity.

CONCEPTS
- Nervous system messages are sent as electrical signals along the length of living nerve cells.
- Dissolved salts are important for electrical signals in cells.

SCIENCE & MATH SKILLS
Predicting, observing, comparing, recording observations and interpreting

TIME
Preparation: 20 minutes
Class: 45 minutes or more

MATERIALS
See p. 12.

Neuron Firing

The process of stimulating a neuron to send an impulse to one or more other neurons is called "firing." The trigger can be a sensory signal (light, heat, sound, etc.) or it can be received from other neurons.

A few kinds of nerves are coupled directly, so that an electrical signal traveling down one neuron passes unimpeded to the next one. This type of transmission from one neuron to another occurs very rapidly and usually is found in places in the nervous system where speed of conduction is important.

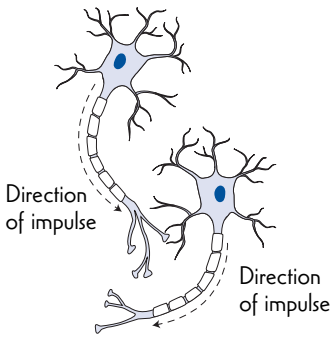
MATERIALS

- 60 mL of sports drink (see SETUP)
- black marker
- clear plastic cup, 9 oz
- graduated cylinder (mL)
- measuring spoon, 1/2 tsp
- wire stripper

Each group will need:

- 180 mL distilled water (see SETUP)
- 4 clear plastic cups, 9 oz
- 2 clear plastic cups, 2 oz
- 2 15-cm pieces of #22 gauge insulated wire (see SETUP)
- 2 strips of aluminum foil, 5 cm x 1 cm each
- 1/2 teaspoon of salt
- 1/2 teaspoon of sugar
- battery, 9 volt
- battery snap connector, 9 volt (see SETUP)
- 2 coffee stirrers
- mini light bulb
- mini light bulb socket
- copy of Sending the Signals student sheet

One Way Only



Signals are conducted electrically in one direction along the length of a neuron's axon and passed either electrically or chemically across the synaptic gap to the next neuron or series of neurons.

SETUP

Batteries, battery snap connectors, mini light bulbs, wires and light bulb sockets are provided in the Materials Kit (see p. vi).

For each group, prepare two 15-cm pieces of #22 gauge black insulated wire. Strip 2 cm of insulation off both ends of each wire to expose the copper wire inside. Strip 1 cm of insulation off both wires on the 9-volt battery connectors.

Cut or tear two strips of aluminum foil (about 5 cm x 1 cm each) per group.

Label each of three 9-oz cups as "water," "salt water" and "sugar water." Pour 60 mL of distilled water into each cup.

Label two 2-oz cups as "salt" and "sugar." Measure 1/2 teaspoon of salt into one cup and 1/2 teaspoon of sugar into the other cup.

If using powdered mix, prepare the sports drink according to package directions and have ready for open inquiry (see Items 10–11). Pour 60 mL of sports drink into a 9-oz cup for class discussion.

Place all materials needed for each group in a central location. Have students work in groups of four.

PROCEDURE

1. Remind students of the previous activity in which they learned about neurons. Ask, *Did you know that neurons rely on electricity to carry messages along the length of the axon? Can you think of other examples of ways that living things use electricity?* Students may offer examples such as electric eels.
2. Ask students, *Which substances in living things might be important for electrical signals in neurons?* Students may not have much prior knowledge of materials in cells. If necessary, remind students that living things consist mostly of water. In addition, a number of dissolved materials such as salts, sugars and other carbohydrates, and proteins are present in cells and other parts of living organisms.
3. Tell students that they will build an electrical circuit and use it to investigate which substances might be important for conducting electricity in cells. Have the Materials Managers from each group collect the materials (see SETUP).
4. Distribute the Sending Signals sheets. Have students follow the instructions on the sheet to build and test their circuits.
5. Ask, *Where is the source of energy for the bulb? Where is the electricity traveling?* Point out that electricity flows in only one direction (negative to positive). Relate this to neurons by

pointing out that tiny electrical impulses also travel in only one direction along the length of axons.

6. Tell students that they will use the circuit setups to conduct three tests using distilled (pure) water, a salt water solution and a sugar water solution. For each test, students will insert the foil wrapped tips of their circuits into a liquid and observe the bulb.
7. Have students create a table on the back of their student sheets or on a separate sheet of paper (see Sample Table, sidebar). They will need to leave enough room on their tables to record predictions, reasons for their predictions and results. Give students time to predict the outcomes of each test and justify their predictions.
8. Have students conduct each test and record the results.
9. Discuss students' outcomes: salt water conducted electricity; distilled water and sugar water did not conduct electricity. Ask, *Which of the two dissolved substances might be involved in electric signaling in neurons?* (salt)

   Note. To promote safety, make sure that students understand that tap and rain water also are good conductors of electric current. Point out that students never should use a hairdryer, radio or television near a bathtub or sink; and never should touch anything that runs on electricity with wet hands.
10. Continue by showing students the sports drink. Ask, *Why do people use these drinks?* Students may or may not know that the drinks are promoted as sources of body salts lost as sweat during exercise. Ask, *How might you be able to investigate whether the advertising claims are valid?* Challenge students to use their circuit setups to figure out a way to test whether the sports drink is a good source of lost salt.
11. You may want to give students time to plan and bring in other drinks to test the next day. Students should compare their findings to the information provided on the sports drink label. Have each group present its investigation and results to the class.

BRAIN JOGGING

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

- Salt is an important part of the diet for humans, but it has not been plentiful throughout history. What are some of the roles salt has played in human culture, civilization and politics?

Salt Bodies

In addition to its role in the nervous system, salt is important for muscle movement, digestion and the movement of fluids into and out of cells. Salt lost from the body in sweat and in urine must be replaced. Normal human blood contains about 0.9% salt.

Sample Table

	Prediction	Reason	Result
Distilled Water			
Salt Water			
Sugar Water			

Electric Signals

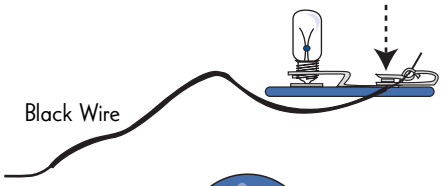
- Electricity flows in one direction (negative to positive).
- Chemicals, such as salt, that dissolve into positively and negatively charged atoms in water will conduct electricity.
- Chemicals, such as sugar, that remain intact when dissolved do not conduct electricity.
- Electricity in living cells depends on positively and negatively charged atoms (ions) dissolved in water.
- Electrical signals in neurons travel very quickly—up to several hundred miles per hour.
- Nerve impulses involve the opening and closing of tiny tunnels in the cell membrane. The movement of charged atoms (such as sodium), through the tunnels creates an electrical impulse.

Sending the Signals

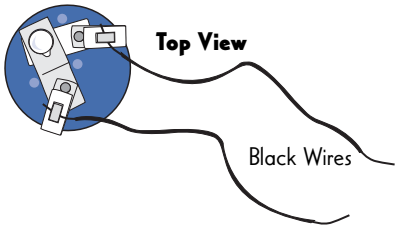
BUILDING A CIRCUIT

1. Screw the light bulb into the light bulb socket. The bottom of the bulb should touch the metal plate beneath the opening for the bulb.

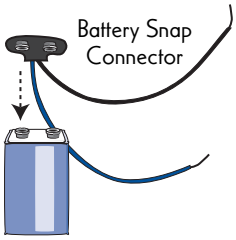
2. Press down and hold one clip of the light bulb socket. Thread the exposed end of one black wire into the center loop. Release the clip.



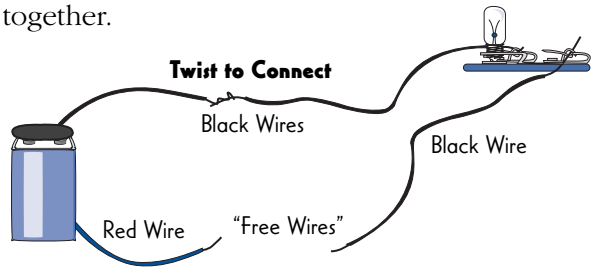
3. Repeat the process for the second piece of black wire and the other clip on the socket.



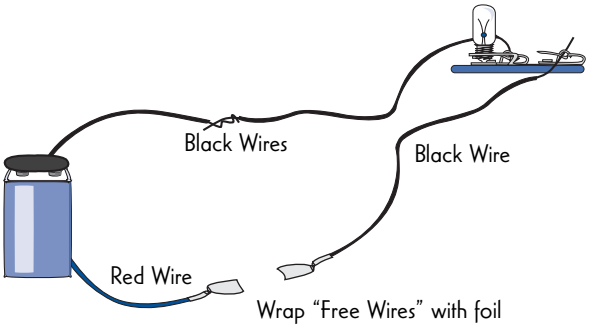
4. Push the battery snap connector onto the top of the battery until it snaps into place.



5. Connect the black wire on the battery connector to one of the black wires attached to the light bulb socket by twisting the exposed wires together.



6. Test the connection by briefly touching the ends of the "free wires" (red and black) together. (The bulb should burn brightly.)
7. Wrap the exposed ends of the "free" wires with the aluminum foil as shown below.



TESTING SOLUTIONS

1. **Which substances in cells help conduct electricity?** All cells contain water, some dissolved salts and sugar. You will investigate what happens when a tiny amount of electricity passes through **distilled water**, **salt water** and **sugar water**. You have three cups of distilled water. Pour the small cup of salt into the cup of water labeled "salt" and stir to dissolve it. Pour the small cup of sugar into the cup of water marked "sugar" and stir to dissolve it.
2. What do you think will happen when you put the foil-wrapped wires in each of the cups? Make a table on a separate sheet of paper to record your predictions for each substance. Give a reason for each of your predictions.
3. Test the liquid in each cup. Record the results for each liquid tested.
4. Based on your observations, which substances in cells would you say helped conduct electricity? Write a paragraph describing the steps you followed, your observations and your answers to this question.