BioEd[SM]

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

BrainLink

Message in a Neuron

Activity from *Brain Chemistry: Teacher's Guide*

by

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

For more information on this and other educational programs, contact the Center for Educational Outreach at 713-798-8200, 800-798-8244, or visit www.CCITonline.org/ceo.

BCM
Baylor College of Medicine

ISBN: 1-89278-041-X

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
ISBN: 0-89278-0444-0

BioEd℠

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

The activities described in this book are intended for school-age children under direct supervision of adults. The authors, Baylor College of Medicine and the publisher cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text.

Development of BrainLink® educational materials was supported, in part, by funds from the National Institutes of Health, National Center for Research Resources, Science Education Partnership Award grant number R25 RR13454. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of Baylor College of Medicine, the sponsoring agency, or the publisher.

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

ACKNOWLEDGMENTS

The BrainLink project at Baylor College of Medicine has benefited from the vision and expertise of scientists and educators in a wide range of specialties. Our heartfelt appreciation goes to James Patrick, Ph.D., Vice President and Dean of Research, and Head, Division of Neuroscience; Stanley Appel, M.D., Professor and Chairman of Neurology; and William Thomson, Ph.D., Professor of Family and Community Medicine at Baylor College of Medicine, who have lent their support and expertise to the project. We also express our gratitude to Marsha Lakes Matyas, Ph.D., Education Officer of the American Physiological Society, who led field tests of this unit in the Washington, DC area.

Members of the original BrainLink steering committee provided much valued vision and inspiration that shaped the project's initial direction and design: Terry Contant, Ph.D.; Barbara Foots, M.S.; Anne Hayman, Ph.D.; Judith Livingston, M.Ed.; Christina Meyers, Ph.D.; Kathleen Philbin, Ph.D.; Carolyn Sumners, Ed.D.; and Katherine Taber, Ph.D. We also acknowledge the invaluable contributions of Leslie Miller, Ph.D., and Judith Dresden, M.S., who originally led the BrainLink project.

Several colleagues helped to guide the production of this book. In particular, we wish to thank Michael Levy and Sara Copeland Shalin of the Division of Neurosciences, Baylor College of Medicine; David Heller, B.S., Middle School Education, Carolina Biological Supply Company; and Eric Chudler, Ph.D., University of Washington.

Special thanks go to the National Institutes of Health, National Center for Research Resources, Science Education Partnership Award Program for its support of the BrainLink project.

We are especially grateful to the many classroom teachers in the Houston area who eagerly participated in the field tests of these materials and provided invaluable feedback.

Center for Educational Outreach, Baylor College of Medicine
One Baylor Plaza, BCM411, Houston, Texas 77030 | 713-798-8200 | 800-798-8244
www.BioEdOnline.org | www.CCITonline.org/ceo

BCM
Baylor College *of* Medicine

Message in a Neuron

Each of the billions of neurons in the brain and nervous system communicate with other cells. Some neurons receive and transmit thousands of messages. Others connect with only a few cells. As noted earlier, nervous system signals travel along the cell membranes of individual neurons, but what happens at the ends of neurons? How does a signal move across the synapse (gap) to other neurons? The answers to these questions involve highly efficient mechanisms that allow signals to be transmitted from neuron to neuron.

In almost all cases, nervous system signals travel in only one direction along a neuron. Signals are received on dendrites or on the cell body and trigger an electrical impulse that moves along the axon. At the end of the axon (or **axon terminal**) of a neuron, the impulse triggers the release of chemical messengers, called **neurotransmitters**, from special pockets known as **vesicles**. Neurotransmitters released from the vesicles leave the cell and physically move through the narrow watery space between neurons. The space between neurons is about 20 nanometers (one nanometer equals 0.000,000,1 centimeters). Once on the other side of the gap, the neurotransmitters attach to special **receptor** molecules on a dendrite or on the cell body of the receiving neuron. The joining of the neurotransmitters to their specific receptor sites can promote the generation of a new electrical impulse (the neuron "fires") OR the neurotransmitters can have an inhibitory effect, making it harder for the neuron to fire.

Biologists have identified more than 100 different neurotransmitters. Each has a different three-dimensional shape, which fits only a certain kind of receptor site. The relationship between a neurotransmitter and its receptor is similar to that of a key and a lock.

The story does not end, however, with the binding of the chemical messengers to receptors on the next neuron. If the messengers remained in place, no new signals could be received. Thus, a mechanism to destroy the messenger also must exist. Usually, other chemicals within the receiving neuron break the

Unit Links

LEGACY OF LOST CANYON

Story, Chapter 7; Science boxes, pp. 20, 22 and 24.

EXPLORATIONS

Mind & Body Connections, p. 5.

OVERVIEW

Students play a simple card game to learn the sequence of events in the transmission of nervous system signals.

CONCEPTS

- Nervous system signals are transmitted electrically along individual neurons.
- Neurons are separated from each other by a tiny gap.
- Chemical messengers called neurotransmitters cross the gap between neurons.
- Neurotransmitters fit into special receptor sites on receiving neurons.

SCIENCE & MATH SKILLS

Sequencing, communicating, applying knowledge and identifying patterns

TIME

Preparation: 10 minutes
Class: 45 minutes

MATERIALS

- 24 sheets of white card stock, 8 1/2 x 11 in.
- 6 bags, resealable plastic (approx. 4 x 6 in.)
- transparency of Transmitters & Receivers student sheet (p. 10)
- overhead projector

Each student will need:

- prepared copy of Locks & Keys Cards (see SETUP) and copy of Rules of Play student sheets
- pair of scissors

What are Neuro-transmitters?

Researchers define a substance as a neurotransmitter when it meets the following criteria.

- The substance can be found inside the neuron that is believed to release the neurotransmitter.
- The substance is released in response to an electrical signal in the cell membrane.
- Specific receptors for the substance can be found on the receiving neuron.

neurotransmitters into smaller molecules, which diffuse back into the synaptic gap.

A few kinds of neurons do not communicate through neurotransmitters. Instead, an electrical charge passes directly from neuron to neuron. This type of signaling, in which the communicating neurons are very close together, is uncommon in the nervous systems and brains of mammals. Unlike chemical messengers, electrical communication across a synapse does not allow different kinds of messages to be sent.

SETUP

Make four photocopies (per group) of the Locks & Keys Cards student page using white cardstock. Have students conduct this activity in groups of 4.

PROCEDURE

Learning About Chemical Messengers

1. Remind students of the activity they recently completed by asking, *What happened when you tested whether salt water would conduct electricity?* Students should remember that salt dissolved in water carried the electrical current from one foil strip to the other, thus completing the circuit.
2. Tell students that rapid movements of dissolved substances like those in salt also make it possible for neurons to transmit electrical signals along the lengths of their axons. In the case of neurons, a single pulse of electricity is transmitted along the axon rather than a current.

   Note. You may want to set up a row of dominoes to demonstrate how toppling one domino will set off an impulse that topples each domino in sequence, and correlate this action to the movement of an electrical impulse along a cell membrane.
3. Project a transparency of the Transmitters & Receivers student sheet (p. 10). Point to the top neuron and ask, *Where would signals be received on this neuron?* (dendrites or cell body). *If a signal travels along this neuron, where will it go?* (signal will travel the length of the axon).
4. Point to the gap between the two neurons and ask, *What happens when the signal reaches the end of the axon? How could the message get to the next cell?* Allow students to discuss different scenarios. List their suggestions on the board. (You may want to group their suggestions into two broad categories: one representing scenarios related to electrical

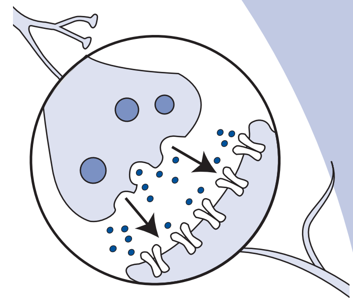
transmission and the other related to possible kinds of chemical transmissions.)

5. Use questions to help students evaluate their list of possible ways for signals to cross the synapse from one neuron to the next. Ask, *Which of these choices would allow for rapid communication?* (electrical-type communications). *Which might allow neurons to send and receive different messages?* (systems that use different messengers, such as chemicals).
6. Point out that in a few cases, neurons in the human nervous system transmit messages electrically to other neurons. However, in most cases, special chemical messengers (neurotransmitters) are released and travel across the gap to the next neuron, where they fit into special slots called receptors.
7. Distribute photocopies of the Locks & Keys Cards and Rules of Play pages (see SETUP) to each group of students. Have students cut out the cards and arrange one set of cards in a logical sequence using the text at the bottom of each card as a guide. Discuss the sequence of events shown in the cards with the class. Point out that even though the cards depict a sequence in which a neurotransmitter promotes the firing of another neuron, neurotransmitters also can communicate a "stop" message, which makes it harder for the next neuron to fire.
8. Make a list on the board of the transmission sequence in neuron communication: 1) Dendrites; 2) Neuron Fires!; 3) Axon; 4) Neurotransmitters; 5) Synapse; 6) Receptor; 7) New Message; and 8) Recycle. List the sequence in order (top to bottom), but do not number the list.

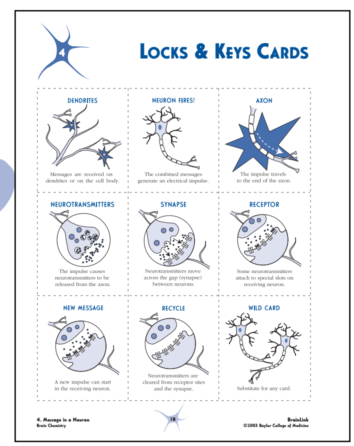
Playing the Game

1. Leave the list of steps on the board to help students as they play the game. Depending on the ages and prior knowledge of your students, you may want to erase the sequence after students have played a few rounds of Locks & Keys.
2. Explain to students the Locks & Keys Rules of Play, which are similar to the card game "Go Fish."
3. Have students play the game for two or more rounds, or until they are comfortable with the sequence of events depicted on the cards.
4. Have students place cards in the clear plastic bags for storage.

Chemical Communication

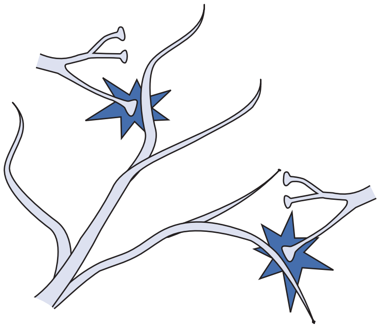


In most cases, communication across the **synapse** (tiny gap between neurons) occurs chemically instead of electrically. Chemical messengers, called neurotransmitters, can either promote or inhibit the firing of neurons.



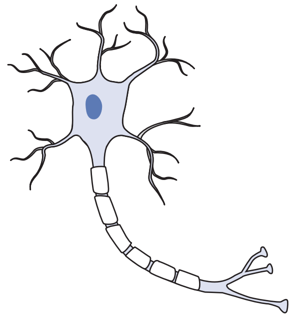
Locks & Keys Cards

DENDRITES



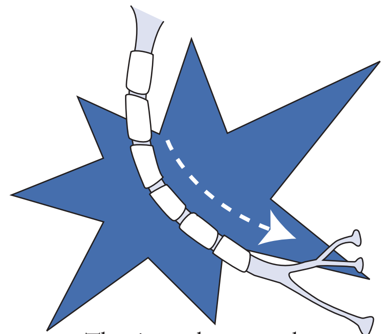
Messages are received on dendrites or on the cell body.

NEURON FIRES!



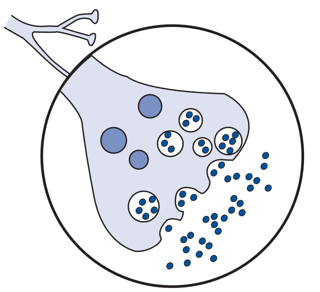
The combined messages generate an electrical impulse.

AXON



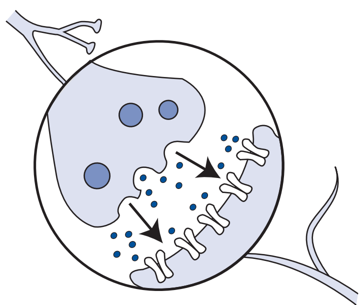
The impulse travels to the end of the axon.

NEUROTRANSMITTERS



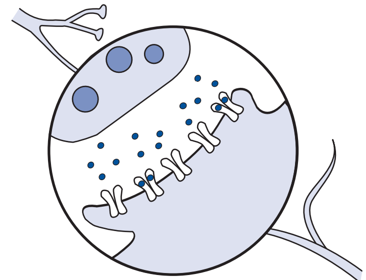
The impulse causes neurotransmitters to be released from the axon.

SYNAPSE



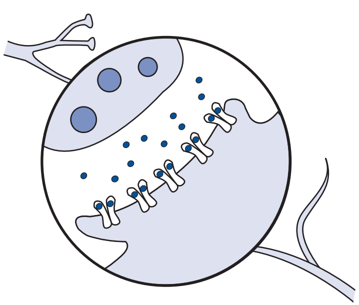
Neurotransmitters move across the gap (synapse) between neurons.

RECEPTOR



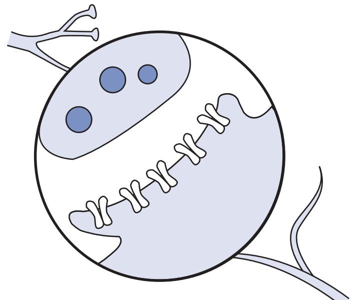
Some neurotransmitters attach to special slots on receiving neuron.

NEW MESSAGE



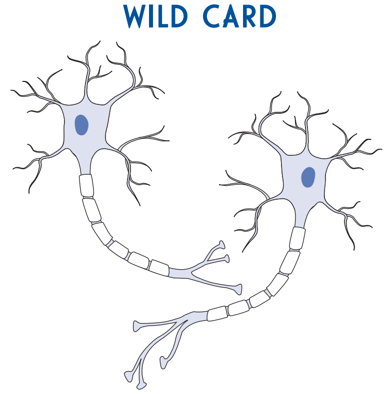
A new impulse can start in the receiving neuron.

RECYCLE



Neurotransmitters are cleared from receptor sites and the synapse.

WILD CARD



Substitute for any card.

Locks & Keys Rules of Play

- Each student is dealt five cards. The remaining cards are placed in a pile in the center of the table. Play proceeds to the left.

- Players take turns trying to obtain at least three cards in a neurotransmission sequence (run). For example:
  Axon
  Neurotransmitters
  Synapse

- A run may contain the last and first elements of a sequence. For example:
  Recycle
  Dendrites
  Neuron Fires!

- Each player begins his or her turn by asking any player for a card by name. For example, "Max, do you have any Axons?"

- If Max has one or more Axon cards, he gives all of them to the asking player, who then receives another turn to ask any player for another card. If Max does not have any Axon cards, he replies, "Locked Up!" and the asking player draws one card from the pile. Wild Cards may not be requested or given.

- If the requested card (not a Wild Card) is drawn from the pile, the asking player receives another turn. Otherwise, the player to the left begins his or her turn.

- Sets of three or more cards in sequence may be laid down at any time during a player's turn, including after a card has been drawn from the pile. Players may add cards to their existing runs, but only during their turns. For example, if a player draws a Neuron Fires! card from the pile, he or she may add it to the run beginning with the Axon card that he or she already had laid down.

- Only one Wild Card may be included in any run (regardless of the number of cards in the run). Once a Wild Card has been used in a run, it may not be moved to another position.

- If a player has no cards in his or her hand at the end of a turn, he or she draws another card from the pile and waits until his or her next turn.

- The game proceeds until all cards have been drawn from the center pile, and no player can lay down or add to any more runs.

- **SCORING.** A player's score consists of the number of cards in the runs he or she laid down minus the number of cards still held in his or her hand.