

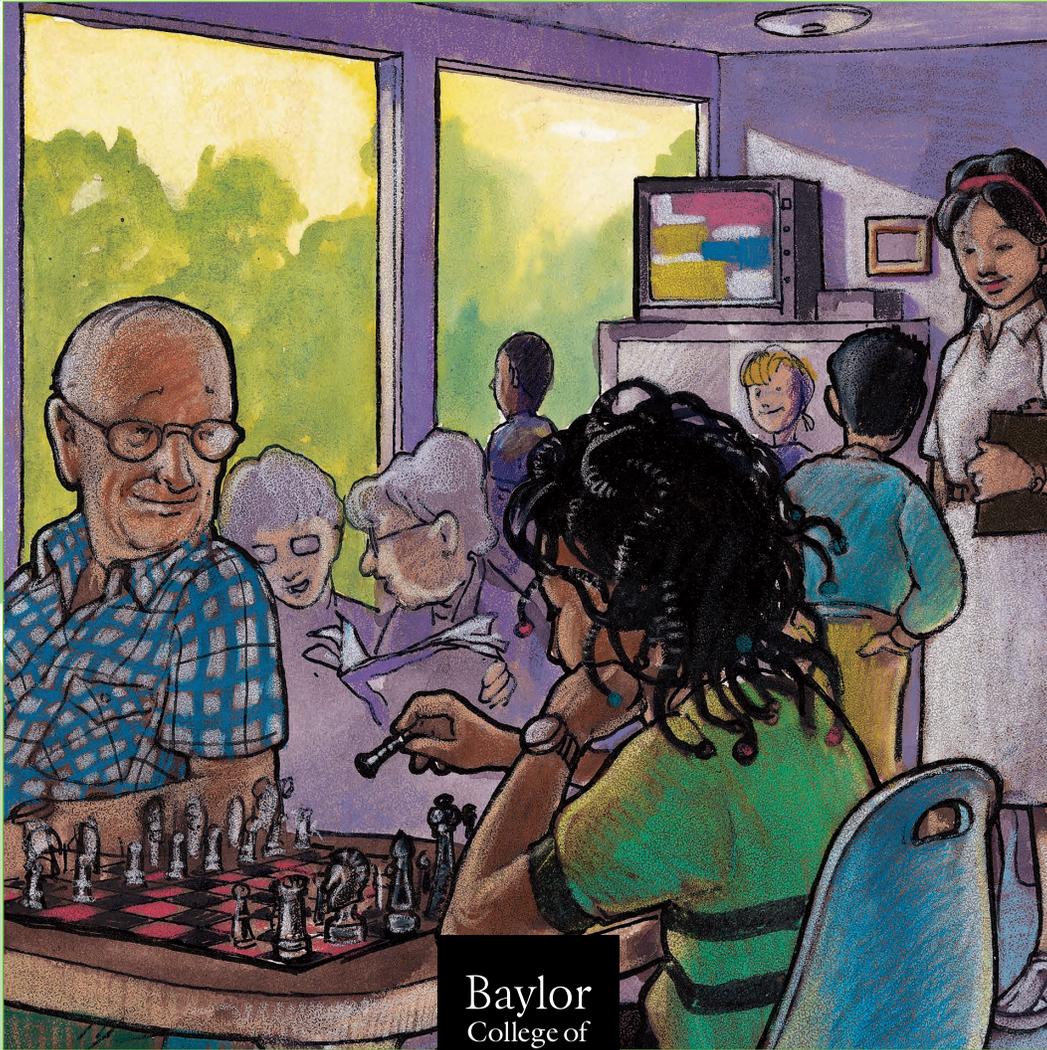


MEMORY AND LEARNING

Teacher's Guide

Written by

Nancy Moreno, Ph.D., Barbara Tharp, M.S., Judith Dresden, M.S., Katherine Taber, Ph.D., and Leslie Miller, Ph.D.



Baylor
College of
Medicine



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The logo for Baylor College of Medicine, consisting of a black square with the words "Baylor", "College of", and "Medicine" stacked vertically in a white, serif font.

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

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The activities described in this book are intended for school-age children under direct supervision of adults. The authors, Baylor College of Medicine and funding agencies 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.

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The logo for Baylor College of Medicine, featuring the text "Baylor College of Medicine" in a serif font, with "Baylor" on the top line, "College of" in the middle, and "Medicine" on the bottom line, all in white text on a black rectangular background.

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MEMORY AND LEARNING

This BrainLink® teacher's guide is designed to be used with the following other components of this unit.

- *Danger at Rocky River: A Memorable Misadventure*
- *Explorations*
- *The Reading Link*

If you and your students are interested in learning about the basic organization and functions of the brain, consider the BrainLink unit, *Brain Comparisons*.



ACKNOWLEDGMENTS

“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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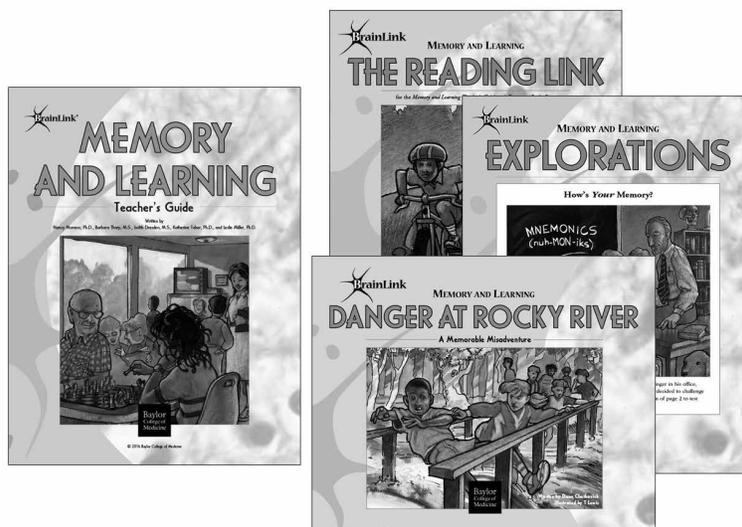
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ABOUT BRAINLINK®



The BrainLink® project's exciting activities, explorations and adventures “link” students, teachers and parents to advanced knowledge of the brain and nervous system and to vital science and health information. Prepared by teams of educators, scientists and health specialists, each BrainLink® unit focuses on a different aspect of the brain and the nervous system. The activity-based, discovery-oriented approach of the BrainLink materials is aligned with the National Science Education Standards and the National Health Education Standards.



The four components of each BrainLink® unit help students learn why their brains make them special.

- Each student storybook presents the escapades of the NeuroExplorers Club in an adventure that also teaches science and health concepts.
- *Explorations* is a colorful mini-magazine full of information, activities and fun things for children and adults to do in class or at home.
- *The Reading Link* provides language arts activities related to each BrainLink unit's storybook.
- Each BrainLink teacher's guide offers inquiry-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.

BrainLink® materials offer flexibility and versatility and are adaptable to a variety of grade levels and teaching and learning styles.

BRAINLINK UNITS

BioEd offers the following BrainLink teaching units to help you and your students learn more about the brain and central nervous system.

BRAIN COMPARISONS

(major structures of the brain in humans and other animals)

MEMORY AND LEARNING

(how the brain stores and retrieves information)

THE MOTOR SYSTEM

(reflexes, movements, and coordination between the brain and body)

THE SENSORY SYSTEM

(how the senses work, visual illusions, and how the brain processes sensory information)

BRAIN CHEMISTRY

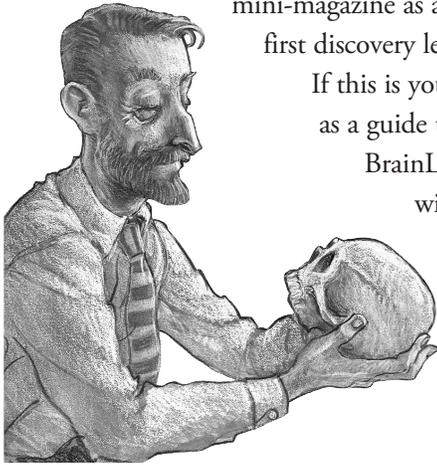
(the brain and neurons, chemical communication in the body, risk perception vs. reality, and how personal choices can affect brain function and performance)

For complete resources, visit www.bioedonline.org today!



WHERE DO I BEGIN?

The teachers guide to activities, adventures storybook, reading supplement mini-magazine and components of each BrainLink® unit are designed to be used together to introduce and reinforce important concepts for students. To begin a BrainLink unit, some teachers prefer to generate students' interest by reading part or all of the adventures story. Others use the cover of the mini-magazine as a way to create student enthusiasm and introduce the unit. Still others begin with the first discovery lesson in the teacher's guide.



If this is your first BrainLink unit, you may want to use the pacing chart on the following page as a guide to integrating three of the components of the unit into your schedule. When teaching BrainLink for 45–60 minutes daily, most teachers will complete an entire BrainLink unit with their students in two to three weeks. If you use BrainLink every other day or once per week, one unit will take from three to nine weeks to teach, depending on the amount of time you spend on each session.

Each BrainLink teacher's guide provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of all materials, estimates of time needed to conduct activities and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are provided. The final

activity in each guide is appropriate for assessing student mastery of concepts and may also be given as a pre-assessment prior to beginning the unit.

USING COOPERATIVE GROUPS IN THE CLASSROOM

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides an organized setting for group interaction and enables students to share ideas and to learn from one another. Through such interactions, students are more likely to take responsibility for their own learning. The use of cooperative groups provides necessary support for reluctant learners, models community settings where cooperation is necessary, and enables the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. There are materials to be managed, processes to be performed, results to be recorded and clean-up procedures to be followed. When students are “doing” science, each student must have a specific role, or chaos may follow.

The Teaming Up! model* provides an efficient system. Four “jobs” are delineated: Principal Investigator, Materials Manager, Reporter and Maintenance Director. Each job entails specific responsibilities. Students may wear job badges that describe their duties. Tasks are rotated within each group for different activities, so that each student has an opportunity to experience all roles. Teachers even may want to make class charts to coordinate job assignments within groups.

Once a cooperative model for learning has been established in the classroom, students are able to conduct science activities in an organized and effective manner. All students are aware of their responsibilities and are able to contribute to successful group efforts.

* Jones, R.M. 1990. *Teaming Up!* LaPorte, Texas:ITGROUP.

SAMPLE SEQUENCE



The components of this BrainLink® unit can be used together in many ways. If you have never used these materials before, the following outline might help you to coordinate the activities described in this book with the Memory and Learning unit’s adventure story, *Danger at Rocky River* and student magazine, *Explorations*.

Similar information also is provided for you in the “Unit Links” section of each activity in this book.



ACTIVITY	CONCEPTS	CLASS PERIODS TO COMPLETE	LINKS TO OTHER COMPONENTS OF UNIT	
			DANGER AT ROCKY RIVER	EXPLORATIONS
1. How Do We Learn?	There are several kinds of learning.	1	Story, Chapters 1–2 Science boxes, p. 2 and 4	“Memories,” p. 3
2. Strategies to Remember	Declarative memory handles people, facts and events.	3	Story, Chapters 3–4 Science box, p. 7	Cover activity “Matter of Fact!” p. 2 “Memory Power” p. 5
3. Practice Makes Memories	Procedural memory is our knowledge of how to do things.	1 or more	Story, Chapters 5–6 Science boxes, p. 10 and 14	“Matter of Fact!” p. 2 “Remember What You’ve Learned?” p. 8
4. Memorable Moments	Short-term and long-term are two stages of memory.	1–3	Story, Chapters 7–9 Science box, p. 16	“Matter of Fact!” p. 2 “Ruff Stuff” p. 6, “Careers for NeuroExplorers,” p. 7
5. A-Mazed	Learning is a complex process.	2	Story, Chapters 10–12 Science box, p. 22	“Matter of Fact!” p. 2 “Did You Know?” p. 4
6. Profiles in Learning	There are a variety of learning disorders.	1	Story, Chapters, 13–14 Science box, p. 28	“Mixed Signals” p. 6 “Brain Busters!” p. 7
7. What’s Your Story?	Summary and post-assessment activity	1	Story, Chapters 15–16 Science boxes, review all	“Brain Food” p. 4



UNIT MATERIALS

Suggested Objects for Activity 2

- Aluminum foil, 1-in. sq.
- Aluminum wire, 1-in. piece
- Brass screw
- Button, metal
- Button, plastic
- Coin, metal
- Coin, plastic
- Cork, large
- Cotton ball
- Cotton cloth, 1-in. sq.
- Crayon
- Cylinder, acrylic, 1 x 1-in.
- Fake fur material, 1-in. sq.
- Golf tee
- Marble
- Octagon “jewel”
- Piece of gravel
- Ping-pong ball
- Rubber band, #16
- Sandpaper, coarse, 1 sq. in.
- Sandpaper, fine, 1 sq. in.
- Sponge, square
- Steel ball
- Steel nut, 7/16-in.
- String, 3-in. piece
- Styrofoam ball
- Wax paper, 1-in. sq.
- White chalk
- Wire nail
- Wood cube bead
- Yarn, 3-in. piece

You will need the following materials and consumable supplies to teach this unit with 24 students working in six cooperative groups. See “Setup” sections within each activity for alternatives or specifics.

ACTIVITY 1 (p. 1)

Does not require special materials.

ACTIVITY 2 (p. 5)

- 60 or more small objects that can be discriminated by sight (see side bar, left, for suggested items)
- 6 paper towels (or napkins) to cover the trays
- 6 small trays (or plates)

ACTIVITY 3 (p. 9)

- 24 mirrors, small unbreakable
- 24 pencils

ACTIVITY 4 (p. 12)

- 6 “Memorable Moments” game boards with 6 sets of “Brain Flash” cards and “Experience” cards (see activity Setup)
- 18 blue game pieces
- 18 green game pieces
- 18 red game pieces
- 18 yellow game pieces
- 6 die (or numbered cubes)

ACTIVITY 5 (p. 23)

- 24 empty cereal boxes with one end sealed
- 24 sheets 8.5 x 11-in. white card stock
- 24 sheets 8.5 x 11-in. white paper
- 6 glitter pens (see activity “Setup”)
- 6 stopwatches

ACTIVITY 6 (p. 30)

Does not require special materials

ACTIVITY 7 (p. 38)

Does not require special materials.

How Do We Learn?

We learn continuously throughout our lives. Every day, new information enters our brains, is processed and is stored in a way that allows it to be found again and used. The “storerooms” in our brains hold memories of all the people we have known, experiences we have had, emotions we have felt, facts we have learned and skills we have mastered, as well as all of our vocabularies and knowledge of languages.

When information is retained in the brain in a way that allows it to be found and used later, we say it has been “learned.” Learning is closely related to memory. Once we have learned something, we can recall it



Unit Links

DANGER AT ROCKY RIVER
Story, Chapters 1-2
Science boxes, p. 2 and 4
(If using BrainLink for the first time, have students read “How the NeuroExplorers Club Began,” and “The NeuroExplorers,” p. iv-vi.)

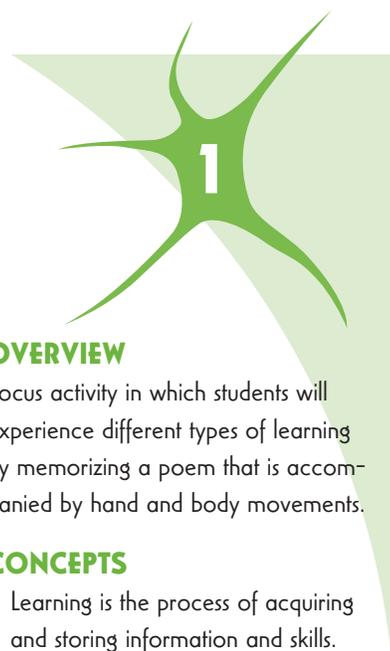
from memory, or “remember” it. In other words, learning is the process of acquiring information or skills. Memory refers to the recall of stored knowledge or skills.

Sometimes we make a conscious effort to learn something—when we play new music on the piano, for example. Other times, we learn things without any effort at all. Have you ever found yourself singing a jingle that you have heard on the radio or TV, but never tried to learn?

Even very simple animals are capable of some kinds of learning. They can, for example, adjust their responses to light or to being touched, based on past experience. In higher animals, including humans, most learning involves the formation of associations.

- Association is learning by making connections among sensations, ideas, memories and responses. If your cat or dog runs to the kitchen when you open the cupboard, it probably has learned to associate the sound of the door with being fed. Often, associative learning is combined with other ways of learning. For example, human babies learn language by imitating the adults and older children around them and by associating the sounds they make with different outcomes.
- Imitation is an important component of many kinds of learning, such as learning to speak, tie a shoelace or shoot a basketball.
- Repetition also is an important element of many learning processes.

We say phone numbers several times to ourselves to help us remember them. We repeat our baseball or tennis swings to improve the coordination of our movements. As young children, we even practiced walking until we became skilled!



OVERVIEW

Focus activity in which students will experience different types of learning by memorizing a poem that is accompanied by hand and body movements.

CONCEPTS

- Learning is the process of acquiring and storing information and skills.
- Memory is the recall of stored information.
- There are several types of learning.

SCIENCE & MATH SKILLS

Communicating and inferring

TIME

Preparation: 20 minutes

Class: 45 minutes

MATERIALS

Teacher

- Projector
- Overhead transparency of the student page

Per Student

- Copy of the “Memories” page



Habituation

Becoming used to a repeated stimulus (like a loud noise) is called habituation. For example, you might be startled or jump the first time someone blows a loud whistle. After a while, however, if the sound is repeated with no ill effects, you will stop jumping every time you hear it. On the other hand, if something painful accompanies the loud sound, your reaction to the whistle will be more exaggerated the next time you hear it. An increase in the response to a stimulus is called sensitization. This is a very basic kind of learning. Just like you, single neurons habituate to certain stimuli, in a process called adaptation. As a neuron adapts to a stimulus, it sends out fewer and fewer signals in response to a constant stimulus, just like you come to eventually ignore, or habituate to, the whistle blowing.

Learning does not happen only at school. No matter where we are, our brains continuously receive new information from the sensory system (eyes, ears, nose, tongue and skin). In fact, we learn many things without consciously trying. To observe this kind of learning (sometimes called latent learning), try moving a common object, such as the trash can, to a different spot in your classroom. How many times do your students go to the old place with their trash?

This focus activity allows students to experience learning through association, imitation and repetition by memorizing and performing a poem accompanied by hand movements.

SETUP

This activity should be conducted with the entire class.

PROCEDURE

1. To conduct a pre-assessment of students' knowledge about learning, memory and the brain, use the following questions as a basis for class discussion or as the subject for a paragraph written by students. More detailed versions of these questions appear as part of the post-assessment (see Activity 7, "What's Your Story?").
 - Think about some of your favorite memories. What is special about these memories to you? Choose one of these memories to think about in more detail.
 - What senses were involved in the memory (seeing, smelling, tasting, etc.)?
 - Was any kind of learning involved with this memory?
 - Why did you remember it?
 - What parts of your brain might have been used to form and keep this memory?
2. Before beginning the activity, prepare yourself by reading and practicing the poem, "Memories." Use the illustrations and instructions for hand motions beneath each line of the poem on the student page as a guide. The suggested motions should become easy to remember after a few tries. Feel free to modify the motions for your class.
3. Talk about memory and learning with the class. Ask students for ideas about what memory is and how it is useful. Ask, *What does it mean to learn or remember something? How are memory and learning related?*
4. The poem presents one way to think about learning and memory. Introduce it to your students in one or more of the following ways.
 - Read the poem aloud, without hand motions.
 - Project an overhead transparency of the poem on a screen.
 - Give each student a copy of the poem.

- 
5. Read or recite the poem for the class, using the hand motions. Then let your students join you in reciting the poem and performing the movements. Try it several times. Possible variations include the following.
 - Break the class into small groups. Let the groups practice. Then bring the class back together to perform the poem with movements.
 - Divide the class into three or six groups, with each group assigned to learn one verse or two lines of the poem. Bring the entire class together to perform the poem.
 6. Discuss how students learned the poem by imitation (watching the teacher), repetition (saying and/or doing something over and over, practicing or rehearsing) and association (connecting the words with the motions).
 7. Repeat the poem and the motions later in the day and/or for the next few days. Then ask, *Do you remember most of the words and motions of the poem, “Memories”?* *Have you learned the entire poem?* Talk about how learning has been taking place. Ask, *What helped you learn the poem?*

BRAIN JOGGING

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

- Would it be possible to spend an entire day without learning a single thing? Without using your memory?
- What are some things you have learned by watching and doing the same thing as someone else? By practicing?
- Do animals remember? What types of things might animals remember?

Classical Conditioning

Classical conditioning, described by Ivan Pavlov, is one kind of learning by association. Pavlov, who studied digestion in dogs, observed that the mere sight of food would cause them to salivate. He trained dogs to stand quietly in harnesses until, after the sound of a bell, he fed them meat powder. He observed when the dogs salivated. At first, the dogs salivated only when they received the meat powder. After repeating the experiment a few times, however, Pavlov found that the dogs would salivate when the bell rang, before they received the meat powder. They had learned, or been conditioned, to react to the bell just as they responded to the presence of food.

Instinct

Some kinds of knowledge already are “wired” into the nervous system at birth, like a baby’s knowing how to smile at his or her mother or a bird’s knowing how to build a nest. This is known as instinct.

MEMORIES



Your memory is a backpack

Touch upper back with hands

Where you keep all your notes.

Writing motion, one hand writing on other



All the ones you want to keep,

Pull hands into chest, holding something

And even those you don't!

Make pushing away motion



It takes them and it files them

Gathering motion, pulling toward waist

In pockets made for you.

Bring hands down and into pockets (pants, jacket or imaginary)



They all have special places,

Touch hands to top of head

Some for longer, it is true.

Spread arms far apart



There's a place for short-term memories

Quickly and lightly touch sides of head with hands

Of what happened just today,

Point index fingers down in front of body



But lots of long-term space, as well,

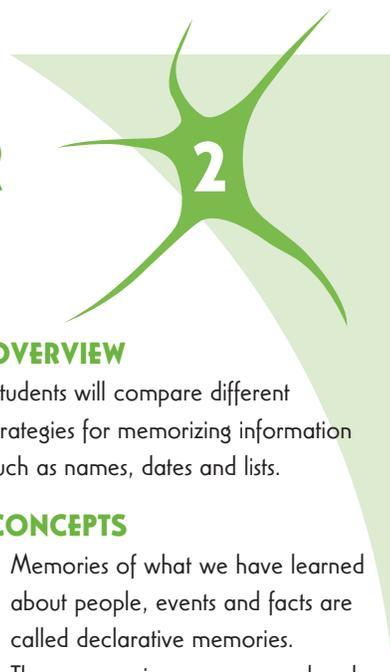
Extend arms outward, indicating a large space

For things that need to stay!

With both hands, push "memories" into head, nodding as if saying, "yes"



STRATEGIES TO REMEMBER



2

Our “memory banks” hold records of our past, including our experiences and what we have learned about people, places, events and facts. These types of memories, which can be recalled by conscious thought and can be described in words, are called declarative, or explicit,

memories. Declarative memories, such as, “Yesterday, I ate an apple” or “Nine times eight equals 72” can be called up and stated, or “declared.” Declarative memories are processed and stored in pathways in the cerebral cortex.

Not all of our memories can be expressed by language. Some memories, such as remembering how to ride a bicycle or play a musical instrument, involve skills that are acquired and recalled without conscious thought.

These types of memories, which involve how to do things, are known

as procedural memories. Procedural memories are processed and stored separately from declarative memories in the brain. Activity 3, “Practice Makes Memories,” highlights procedural memories.

There are many ways to improve performance in certain kinds of declarative memory tasks. Known as mnemonics, these strategies make it easier to remember names, dates or lists. A few mnemonic techniques are listed below.

- Rhythm and rhyme form the basis of many simple memory boosters. For example, a tricky grammatical rule is easy to remember when stated as: “I before E except after C.”
- Acronyms and phrases provide hints that help us remember long strings of names or lists. The acronym, “ROY G. BIV,” helps students remember the colors of the spectrum (red, orange, yellow, green, blue, indigo and violet). The first letters of the words in the phrase, “My Very Energetic Mother Just Served Us Nuts,” makes it easier to remember the names and order of the planets in our solar system (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune).
- Mental images can be useful for recalling names and lists. To remember the name of someone you have just met, construct a mental image that links the person’s appearance to his or her name. For example, picturing Mrs. Green in a green dress may make it easier to remember her name.

OVERVIEW

Students will compare different strategies for memorizing information such as names, dates and lists.

CONCEPTS

- Memories of what we have learned about people, events and facts are called declarative memories.
- These memories are processed and stored in the cerebrum.

SCIENCE & MATH SKILLS

Observing, comparing, computing, summarizing and graphing

TIME

Preparation: 15 minutes

Class: 45 minutes to conduct experiment; 45 minutes for calculations and graphing; 45 minutes for follow-up graphing activity

MATERIALS

Teacher

- 6 sheets of paper towels or napkins to cover items on trays or plates
- 6 small trays or plates
- Small objects, such as buttons, toys, pencils, etc., to create trays for student groups (see “Suggested Objects,” sidebar, p. 6)

Per Student Group

- Covered tray or plate containing 10 items (for younger students), or more items (for older students)

Per Student

- Pencil
- Sheet of white paper



DANGER AT ROCKY RIVER

Story, Chapters 3-4
Science box, p. 7

EXPLORATIONS

Cover activity, “Matter of Fact!”
p. 2, “Memory Power” p. 5

Suggested Objects

- Aluminum foil, 1-in. sq.
- Aluminum wire, 1-in. piece
- Brass screw
- Button, metal
- Button, plastic
- Coin, metal
- Coin, plastic
- Cork, large
- Cotton ball
- Cotton cloth, 1-in. sq.
- Crayon
- Cylinder, acrylic, 1 x 1-in.
- Fake fur material, 1-in. sq.
- Golf tee
- Marble
- Octagon “jewel”
- Piece of gravel
- Ping-pong ball
- Rubber band, #16
- Sandpaper, coarse, 1 sq. in.
- Sandpaper, fine, 1 sq. in.
- Sponge, square
- Steel ball
- Steel nut, 7/16-in.
- String, 3-in. piece
- Styrofoam ball
- Wax paper, 1-in. sq.
- White chalk
- Wire nail
- Wood cube bead
- Yarn, 3-in. piece

- Grouping unrelated items into categories or lists helps break strings of information into bits that are easier to remember. Now famous psychology experiments on memory suggest we can only remember about 7–9 items at a time. Phone numbers are easier to recall as one three-digit and one four-digit number than as one series of seven numbers. Items are even easier to remember when organized into meaningful groups.

SETUP

This activity is best conducted with the students in groups of four, followed by a class discussion of observations and results. If time is limited, assign a different memory strategy to each group instead of having all of the groups complete each of the trials.

Place 10 or more small objects on a tray or plate for each group of students. Each tray should have a different assortment of items. Hide the contents of the trays by covering them with napkins or paper towels.

PROCEDURE

Trial 1: No Memory Aid

1. Distribute a covered tray or plate to each group. Each student should have a pencil and a sheet of paper. Explain to the students that they will be learning something new and creating memories.
2. Have a student in each group uncover the tray. Instruct students to study the trays individually for five minutes, without talking or touching the objects. After five minutes, have the students cover the trays. Immediately ask if they think they have created a memory of the items on their trays. Have each student list as many of the objects as he or she can remember.

Note. You may find that more or less time is appropriate for your students. However, the time allowed for each trial should be the same.

3. Have each student count items that he or she remembered. Have younger students add their values and record the total number of items remembered by the members of the group. Older students should compute the average number of items remembered in their group and/or class.

Trial 2: Grouping

1. Rotate the trays around the classroom, so that each group has a different set of objects to observe. This time, ask the members of each group, working together, to sort their objects in any way that is meaningful to them and might help them to remember the objects. Give them five minutes to complete the task.

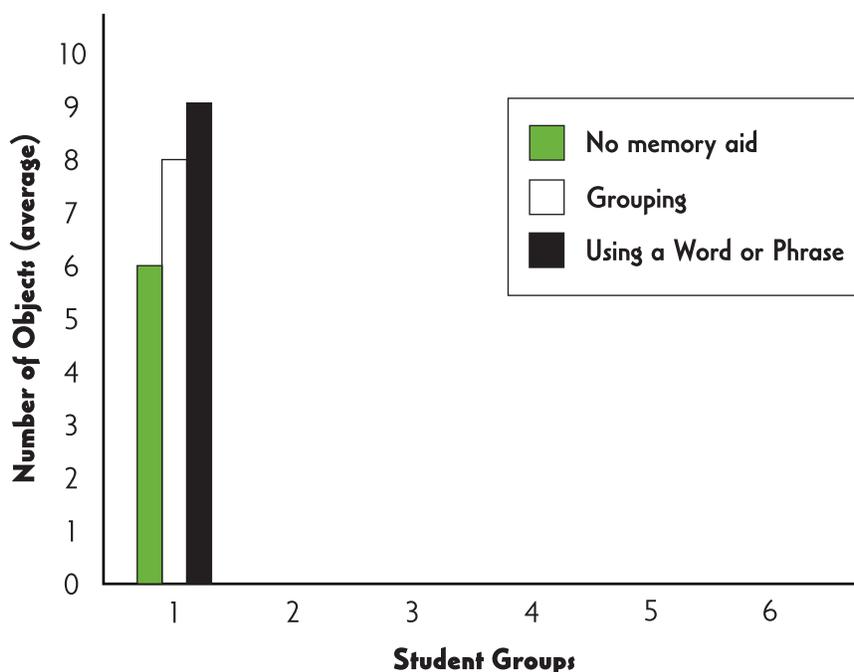
- Have students cover the trays and, again, ask them to list as many items as they can remember on their sheets of paper. Ask, *Were you able to remember fewer or more items this time than when you simply observed the objects on the tray?* Have the groups tabulate their results as before.

Trial 3: Using a Word or Phrase

- Rotate the trays around the classroom one more time. Tell the groups to construct an acronym or a funny sentence based on the first letters of each of the objects. Students may touch or arrange objects as they work together. Allow the groups five minutes to work. Then tell them to cover the trays and list the objects on their sheets of paper. Ask, *Were you able to remember fewer or more items than you were during the last trial? How useful was the word or phrase in helping you to remember the objects on the tray?*
- Have the groups tabulate their results and record group and/or class averages or totals. Let the groups share their acronyms and phrases with the rest of the class.

Tabulating Results

- Have the groups make final tabulations of their results and compute group and/or class averages or totals. Older students should compare the results of the three trials as a bar graph.



Are Memories Accurate?

Have you ever disagreed with a friend about your recollections of a past event or statement? We often think of our memories as being infallible, like video recordings. But in reality, our declarative memories are constructed from pieces of what we saw, heard, felt and experienced at the time. Once they are stored, memories can be altered by attitudes, wishful thinking and even suggestions by others. Therefore, later recall of memories is not an exact copy of the stored information. Instead, the brain uses stored clues about a past event to reconstruct it again in the present.

Forgetting

Were it not for forgetting, our brains would be cluttered with too much useless information. Forgetting is the process by which stored information is lost over time. Amnesia is an inability to create new memories or an inability to recall old ones.

Gray Matter

The outermost layers of the cerebrum, known as the cerebral cortex, contain the cell bodies of neurons important for thinking, planning, memory, movement and the senses. Tissue in the nervous system that contains many cell bodies often is called gray matter. Gray matter also is found in the central portion of the spinal cord, as well as other areas of the brain.

2. Ask students, *Which method was most effective in helping you to remember the objects? Did some of you find one strategy to be more effective than the other? What does this tell us about ways in which we learn and remember? Which method might help you remember the items for the longest period of time? Are there any real-life applications of these memory tools?*
3. Explain to students that they have been using one kind of memory—the memory of “what” (objects, facts, people and events). This kind of memory is handled by the cerebral cortex in the brain. Ask students to name other examples of their “what,” or declarative, memories (people they know, places they have been, etc.).
4. Many games and puzzles rely on information stored as declarative memory. Challenge your students to create their own “Brain-nastics” games. OR Have them think of other games they play at home or at school that use information from their memories of “who, what, where and when.”

Follow-up

1. After a few days, ask the students to record the items they remember from the three different trays. Have students calculate totals per group, or averages, and graph as before.
2. Students should discuss the later graphs and compare them with the first graphs. Ask students, *Are there differences? Why might there be differences? Can any conclusions be drawn regarding different memory techniques?*

BRAIN JOGGING

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

- Our experiences are not always recorded accurately in declarative memory. Our memories of events can be influenced by emotions and by things that happen later. Can you think of times when your memory of an event or object was not accurate or did not agree with someone else’s?
- Remind students about something that happened recently in your classroom. Let everyone in the class write down a description of that event, including as many details as possible. Do all of the descriptions agree? What do you think might have caused differences among the descriptions?

PRACTICE MAKES MEMORIES

When we are very young, we learn basic skills like walking and reaching to grasp objects. Later, we master more complicated movements, such as writing, playing sports or dancing. With practice, our performance of these tasks improves. Such learned movements are stored as motor programs in the cerebellum. Your students may already have learned about programs for movements in the activity “Practice Makes Perfect,” in the Motor System unit.



Unit Links

DANGER AT ROCKY RIVER
Story, Chapters 5-6
Science boxes, p. 10 and 14

EXPLORATIONS
“Matter of Fact!” p. 2, “Remember What You’ve Learned?” p. 8

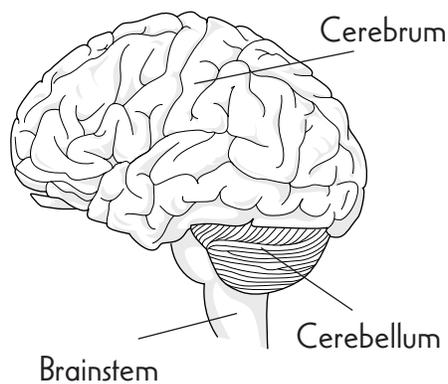
Memories of how to do things are processed and stored in the brain independently of memories about facts, names, places and events. This type of “how-to” memory, called procedural memory, often is difficult to describe in words. (For example, try explaining how to ride a bicycle to someone.) Procedural memories are not restricted to motor programs. Routines, such as shaving after a shower every day, also

are believed to be stored in the cerebellum. However, it also is known that damage to a part of the cerebral cortex called parietal cortex disrupts our ability to carry out practiced routines, such as getting dressed, for example.

Repetition, or learning by doing something over and over, often is important for making procedural memories. The following activity demonstrates procedural memory formation by challenging students to learn a new physical skill and to improve it through practice.

SETUP

This activity is best conducted with students working individually or in pairs (to take turns with mirrors), followed by a whole class discussion of observations and results.



3

OVERVIEW

Students experience how a new motor skill improves with practice.

CONCEPTS

- Procedural memory is our memory of how to do things.
- The cerebellum is important for storing procedural memories.
- Repetition is important in forming procedural memories.

SCIENCE & MATH SKILLS

Observing, comparing observations and drawing conclusions

TIME

Preparation: 5 minutes

Class: 30 minutes; second optional session of 30 minutes

MATERIALS

Per Student

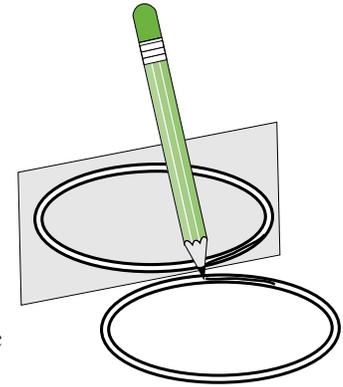
- Pencil
- Small unbreakable mirror
- Copy of the “Mirror Work” page

Implicit Memory

Procedural memories fall within a broader category of memories that do not require conscious thought and are difficult to express in words. Other forms of implicit memory include habituation (becoming used to a non-harmful stimulus, such as traffic noise) and sensitization (an increased response to a sharp pain or other disagreeable stimulus).

PROCEDURE

1. Give each student a copy of the “Mirror Work” student page and a small plastic mirror.
2. Direct each student to hold his or her mirror so that the reflection of one of the shapes on the “Mirror Work” page can easily be seen.
3. Instruct students to draw a line between the border lines of each shape as accurately as possible, while looking **ONLY** in the mirror. Students may choose the sequence in which they draw the lines on the rest of the shapes.
4. Have the students compare their first efforts with their last. Ask, *Did it become easier to draw the lines after a few times? Why do you think it became easier? Have you learned a new skill?*
5. If time permits, allow students to practice their mirror-drawing skills over several days. Have them test their skills again. Ask, *Was the mirror-drawing easier this time than the first time you tried it? What kind of memory have you formed?*



BRAIN JOGGING

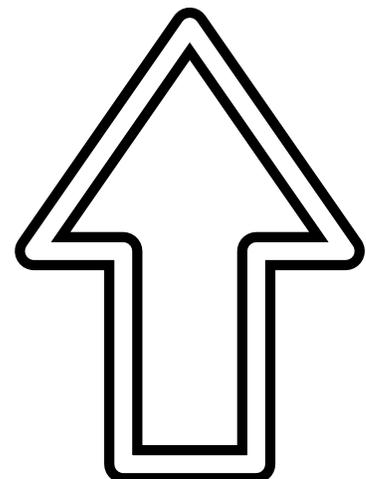
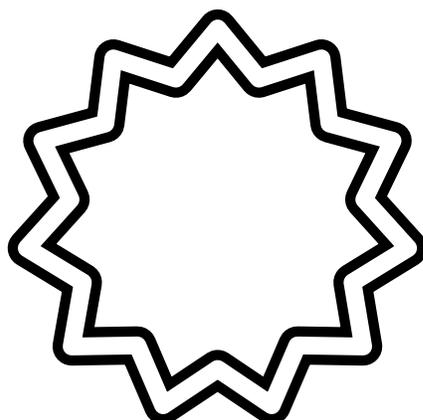
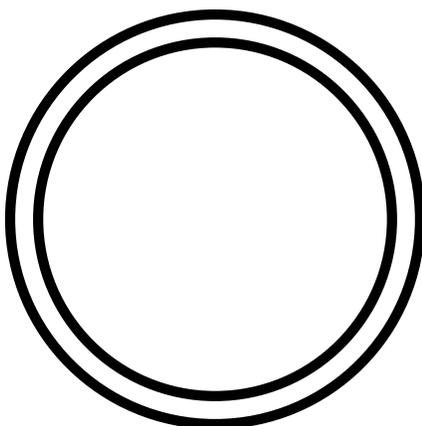
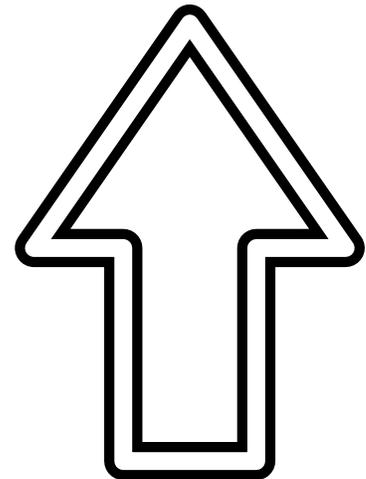
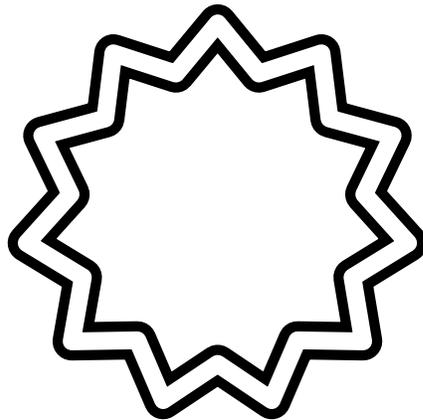
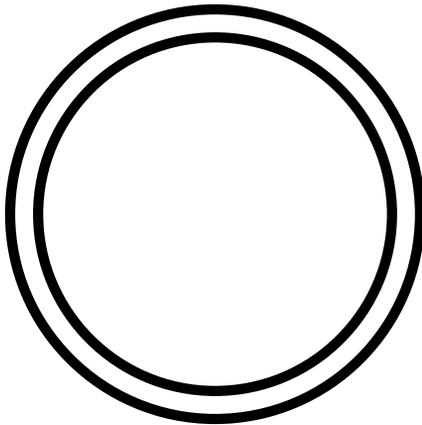
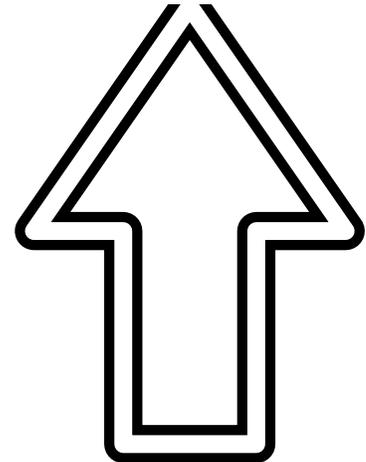
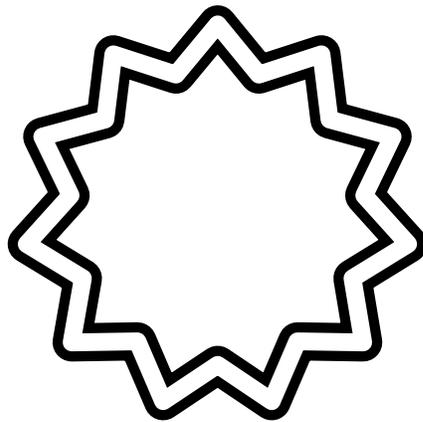
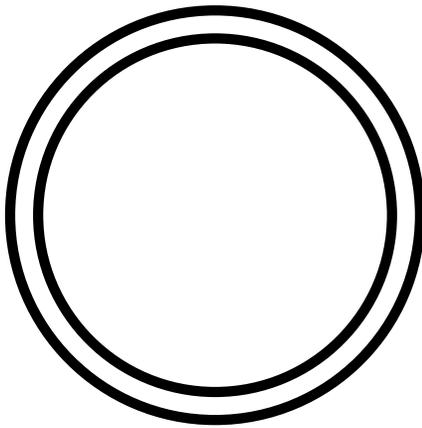
Here are more ideas for you and your students to explore.

- Name some everyday activities that rely on procedural “how-to” memories.
- What would happen if we were not able to learn and improve our physical skills by practicing? Think of several examples.
- B.J., one of the NeuroExplorers, is an avid drummer. Do you think she had to practice to become skilled? How do you think Kyle developed his abilities to play video games?

MIRROR WORK



1. Hold your mirror so that the reflection of one of the shapes can be seen easily.
2. Keep your eyes only on the mirror image as you draw a line in the white space between the outer black lines of the shape. Repeat for each of the shapes below.



4

OVERVIEW

Students learn about the transfer of knowledge from short- to long-term memory as they play a board game illustrating basic memory processes.

CONCEPTS

- Short-term memories last only a few minutes; long-term memories last from a few hours to a lifetime.
- There are different pathways in the brain for processing memories.
- The hippocampus is important for forming long-term memories.

SCIENCE & MATH SKILLS

Problem-solving, counting and communicating

TIME

Preparation: 20 minutes

Class: 20 minutes to color game boards and review rules;

30 minutes to play game at least twice; 20 minutes to discuss game process.

MATERIALS

Per Student Group

- 1 game board, 1 set of Brain Flash cards and 1 set of Experience cards (included in kit, or see SETUP)
- 12 game pieces (3 each of four different colors, i. e., 1 set of 3 pieces per student)
- 1 die or numbered cube

Per Student

- Copy of student pages

MEMORABLE MOMENTS

For many years, scientists looked for a single place in the brain where memories might be stored. Now they believe that such an area does not exist. Instead, memories are stored as changes in connections between neurons in many different parts of the brain. These changes involve either the growth of new nerve connections (new synapses) or the strengthening of existing ones.

Several areas of the brain have been identified as important for learning and memory. The role of the cerebellum in storing memories of how to do things (procedural memories) is highlighted in Activity 3. Other types of memories, especially those of people, facts and events, are stored in the cerebrum. This type of memory, highlighted in Activity 2, is called declarative memory because it can be recalled and communicated in words. Areas deep inside the brain help process many kinds of memories—not only recollections of facts, but also of emotions—and make them permanent.

Learning and memory depend on information from the senses. All sensory input (even input from muscles) is held briefly in the brain. For example, for approximately one tenth of a second, we have total photographic recall of everything we have just seen!

Part of the information that comes into the brain is transferred to *short-term memory*, where it can be held for up to several minutes. Some things in short-term memory are moved to *long-term memory*, especially when they are rehearsed or practiced. Visual information and some of our experiences (especially if they are traumatic, exciting or significant in other ways) also are stored in long-term memory even when they are not repeated. Long-term memories can last for a few hours up to an entire lifetime.

An amazing case history in neuroscience showed that declarative memories (our memories of facts, events and people) and procedural memories (our memories of how to do things) are processed independently in different areas of the brain. This case (see “The Remarkable Case of H.M.,” p. 14), helped doctors to identify one brain structure important in converting some short-term memories to long-term ones.

Study of the cases of H.M.* and others led neuroscientists to conclude that the hippocampus (plural: hippocampi) is critical for the transfer of



DANGER AT ROCKY RIVER

Story, Chapters 7-9
Science box, p. 16

EXPLORATIONS

“Matter of Fact!” p. 2, “Ruff Stuff,” p. 6, “Careers for NeuroExplorers,” p. 7

Alzheimer's Disease

First described in 1906 by Alois Alzheimer, Alzheimer's is a disorder that causes the gradual loss of brain cells. Areas of the brain that control memory and thinking skills usually are affected first by this progressive disorder.

Sensations and Memory

It is widely believed that memories are stored in the regions of the brain involved in processing the senses involved in creating the memory. For example, visual memories are stored in the visual cortex (part of the cerebral cortex where vision information is first processed). Auditory memories are stored in the auditory cortex (hearing part of the cerebral cortex). The hippocampus is important for processing most of the declarative memories stored in these other brain regions.

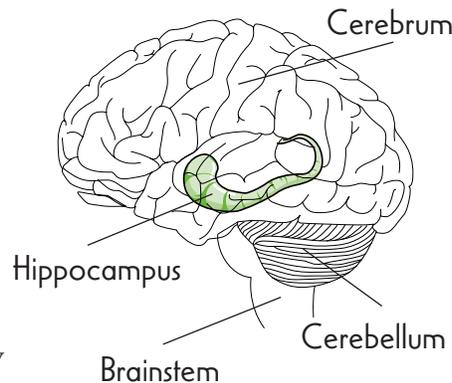
Working Memory

A special short-term memory store allows us to hold things in mind long enough to solve problems and carry out tasks. Working memory, for example, helps us search efficiently for a lost item by keeping track of where we have already looked.

many kinds of information from short-term to long-term memory. One sea horse-shaped hippocampus is located deep within each half of the cerebrum. Memories are completely intact even with only a single functional hippocampus, but both hippocampi were removed from H.M. Without hippocampi, many kinds of memories never become stored in long-term memory. Damage to the hippocampi is one of the early effects of Alzheimer's disease. It leads to losses in the ability to form new lasting memories of people, places and events.

Not all memories are processed through the hippocampi. The cerebellum is responsible for storing memories of movements and procedures. This is why H.M.'s ability to learn new motor skills and to improve them over time was not impaired. One activity H.M. was able to learn to do very well was "mirror" writing, as in Activity 3.

The "Memorable Moments" game in this activity helps students learn about the formation of short- and long-term memories. It shows the involvement of the hippocampi in processing memories, illustrates the path of memories formed by vivid or significant experiences, and demonstrates the role of repetition in forming some kinds of memories.



SETUP

Photocopy the instructions, game board and cards (see p. 15–19), making enough sets for six groups of students.

Have students play the game in groups of four. After the game has been played, conduct a discussion with the entire class about how memories are processed.

PROCEDURE

1. Tell the story of H.M. to your students. Challenge them to imagine life without the ability to form many kinds of long-term memories. Stress the role of the hippocampi in processing memories of "who,

* Every effort is made to protect the privacy of patients whose cases are documented in scholarly medical reports. For this reason, patients are never identified by name. Initials (usually not the correct ones) are used instead. The case of H. M., originally published by B. Milner in 1966, has been described extensively in numerous neuroscience reference texts. For further reading, see: Thompson, R. 1993. *The Brain: A Neuroscience Primer*. W. H. Freeman & Company, New York.

The Remarkable Case of H.M.

H.M. was a patient who underwent drastic brain surgery to treat severe epilepsy. Although the epilepsy was controlled, H.M.'s memory was dramatically affected by the procedure. He no longer was able to form long-term memories from many kinds of new information, particularly relating to people, events and facts. He could not remember his own experiences, except for those that occurred before the surgery.

Other aspects of H.M.'s memory were not impaired. In addition to memories of his life, his vocabulary, and facts he had learned before surgery, he still was able to retain information for a few minutes in short-term memory. He also was able to learn and remember new motor skills. Neuroscientists working with H.M. concluded that the structures removed from H.M.'s brain, the hippocampi, were responsible for converting information from short- to long-term in declarative memory, but not for storing it. Other research showed that long-term memories of this kind are stored in various areas of the cerebral cortex.

what, where and when” for long-term storage in the cerebral cortex.

2. Distribute the “Rules of Play” and “Memorable Moments” game boards and materials among the groups of students.
3. Have students play the game in groups of four, following the “Rules of Play.” Older students may be able to read and follow the instructions independently. Younger students will need to have the rules explained to them.
4. After all students have had an opportunity to play the game one or more times, initiate a discussion on the differences between short- and long-term memory. Ask the students, *Can you think of kinds of information that usually are held in short-term memory and then are lost? How about kinds of information that we remember for a long time? Can we make long-term memories if the hippocampi don't do their job?*
5. Use a transparency of the “Brain Diagram” (p. 22) to point out the locations of the hippocampus, the cerebral cortex and the cerebellum.

BRAIN JOGGING

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

- Think of five things that often are held in short-term memory without being transferred to long-term memory.
- What has been the most difficult memory to get into your long-term memory? What did you do to get it there?

RULES OF PLAY



Object of the Game

The first player to place all of his or her game pieces into Long-term Memory wins.

1. Each player will need three game pieces of the same color or shape. Place all the game pieces in the Home space. Put the Experience cards and Brain Flash cards on the spaces indicated for each on the game board.
2. To determine which player goes first, each player will roll the die once. The player who rolls the highest number plays first. Players take turns rolling the die, moving clockwise from the first player.
3. To move a game piece from Home to the Experience space, a player must roll a 1, 3 or 5.
4. Once a game piece is placed on the Experience space, the player immediately should pick an Experience card. The card will tell the player which path to follow and how many spaces to move. OR the card may direct the player to roll the die to see how many spaces to move. After his or her turn, the player should place the Experience card at the bottom of the pile of Experience cards. A player's turn ends after he or she has completed the instructions on the Experience card.
5. Once a game piece is started along a path, rolling the die or following instructions on a card will determine the number of spaces that a player may move the piece during a turn. Only one game piece may be moved at a time. The number shown on the die may not be split among two or more game pieces on the board.
6. If a player rolls a 1, 3 or 5, he or she may choose between moving another game piece out of Home and selecting an Experience card OR moving a game piece that is already on a path.
7. Two or more game pieces may occupy the same space on the board.
8. When a player lands on a Brain Flash space, (neuron with a lightning bolt), the player to his or her left picks a Brain Flash card and reads it to the player. Instructions given on the cards should be followed as directed. If the card has a question on it, the player on the Brain Flash space must try to answer it. If the correct answer is given, he or she receives an extra turn. If an incorrect answer is given, the player's turn is over. Each Brain Flash card should be placed on the bottom of the pile after use.
9. Players must roll the exact number of spaces needed to enter Long-Term Memory. Once a game piece has been placed in Long-Term Memory, it cannot be removed.





BRAIN FLASH CARDS

BRAIN FLASH

Which part of the brain handles memories of well-learned movements?

Answer: Cerebellum

BRAIN FLASH

Choose one of your game pieces already on a path and move it back 1 space.

BRAIN FLASH

Where does most thinking and learning happen in the brain?

Answer: Cerebrum or cerebral cortex

BRAIN FLASH

Choose one of your game pieces already on a path and move it back 5 spaces

BRAIN FLASH

What kind of memory lasts from several hours to a lifetime?

Answer: Long-term memory

BRAIN FLASH

Choose one of your game pieces already on a path and move it back 3 spaces.

BRAIN FLASH

What kind of memory doesn't last very long?

Answer: Short-term memory

BRAIN FLASH

Choose another player's game piece already on a path and move it forward 5 spaces.

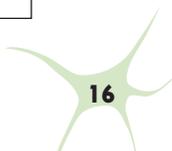
BRAIN FLASH

What is another name for a nerve cell?

Answer: Neuron

BRAIN FLASH

Choose another player's game piece and move it back 1 space.



BRAIN FLASH CARDS



BRAIN FLASH

What are the wrinkles on the brain called?

Answer: Gyri

BRAIN FLASH

Choose one of your game pieces already on a path and move it forward 4 spaces.

BRAIN FLASH

Which branch of science studies the nervous system?

Answer: Neuroscience

BRAIN FLASH

Choose one of your game pieces already on a path and move it forward 5 spaces.

BRAIN FLASH

What types of memories store information about facts and events?

Answer: Declarative

BRAIN FLASH

Choose one of your game pieces already on a path and move it forward 6 spaces.

BRAIN FLASH

What is the seahorse-shaped part of the brain that is important for memory?

Answer: Hippocampus

BRAIN FLASH

Choose one of your game pieces already on a path and move it forward 2 spaces.

BRAIN FLASH

What is the command center of the body?

Answer: Brain

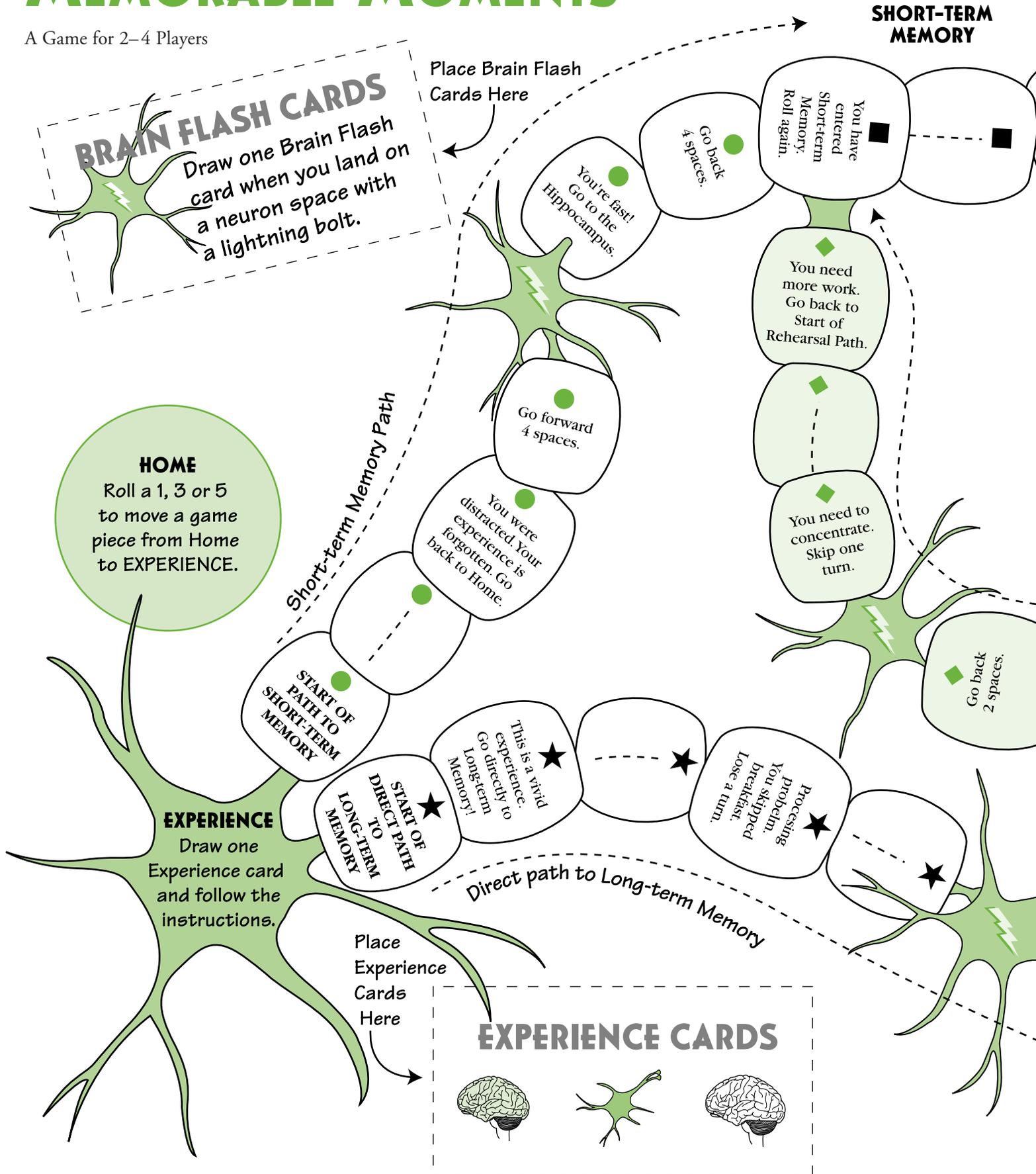
BRAIN FLASH

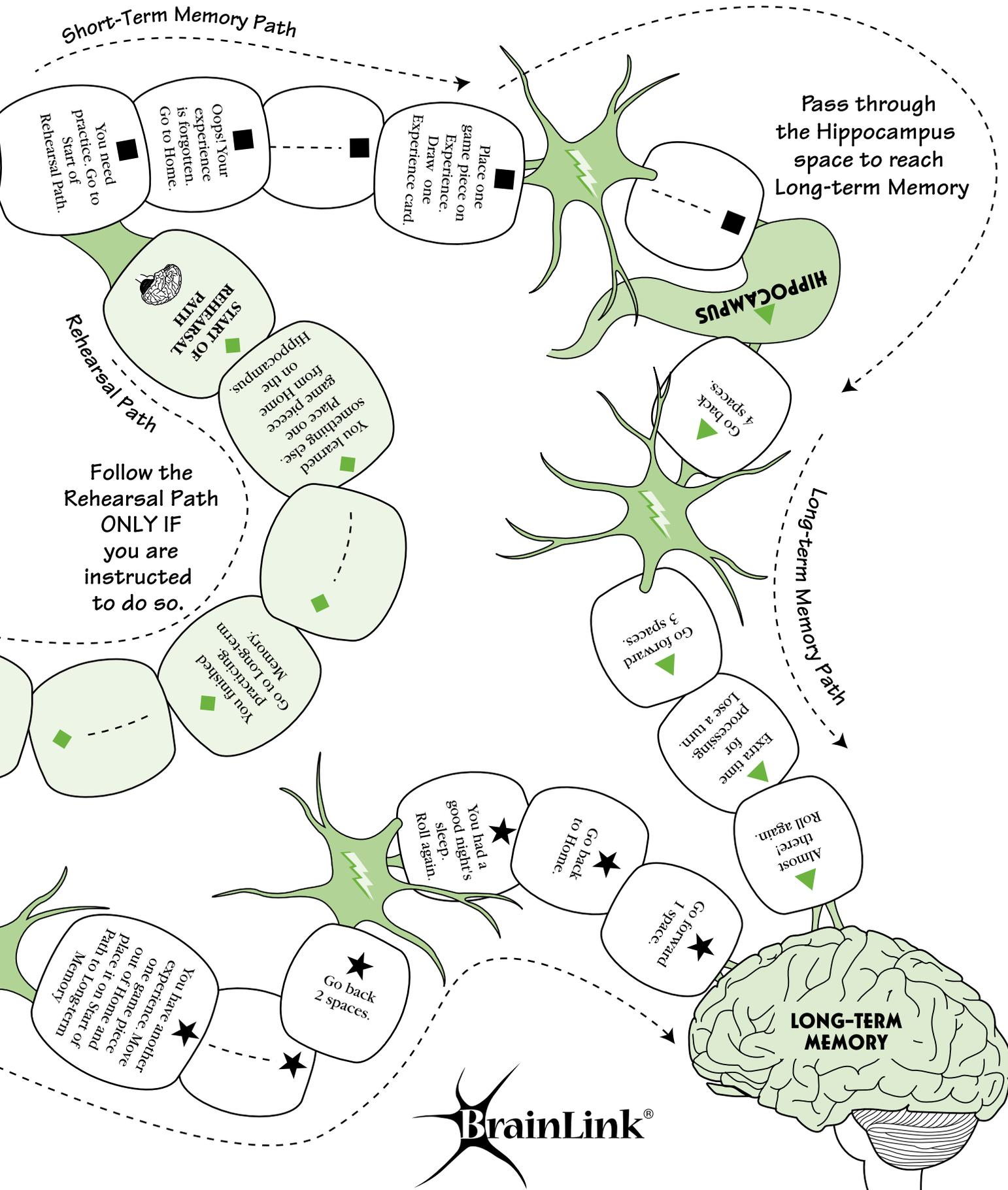
What do you call tricks to help you remember facts or lists?

Answer: Mnemonics

MEMORABLE MOMENTS

A Game for 2-4 Players







EXPERIENCE CARDS



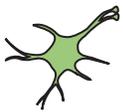
EXPERIENCE

You see a painting.
Roll to follow the
Direct Path to Long-term Memory.



EXPERIENCE

You watch a program on TV.
Roll again to follow the
Short-term Memory Path.



EXPERIENCE

You hear a new word.
Roll to follow the
Short-term Memory Path.



EXPERIENCE

You are learning to ride a bike
and need to practice. Go to the
Start of Rehearsal Path space.



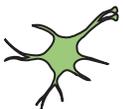
EXPERIENCE

You are studying the multiplication tables.
Go to the
Start of Rehearsal Path space.



EXPERIENCE

You hear someone's name for the
first time. Roll to follow the
Short-term Memory Path.



EXPERIENCE

You eat a scrambled egg for breakfast.
Roll to follow the
Short-term Memory Path.



EXPERIENCE

You visit the Grand Canyon.
Move 6 spaces along the
Direct Path to Long-term Memory.



EXPERIENCE

You graduate from elementary school.
Move 6 spaces along the
Direct Path to Long-term Memory.



EXPERIENCE

You read a book about dinosaurs.
Move 5 spaces along the
Short-term Memory Path.

EXPERIENCE CARDS



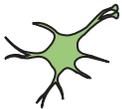
EXPERIENCE

You see a very beautiful sunset.
Move 1 space along the
Direct Path to Long-term Memory.



EXPERIENCE

Loud music interrupted
your thinking.
Return 1 game piece to Home.



EXPERIENCE

You look up the phone number
to order pizza. Roll to follow the
Short-term Memory Path.



EXPERIENCE

You start learning a foreign language.
Take 1 of your game pieces
out of Home and place it on the
Start of Rehearsal Path space.



EXPERIENCE

You need to learn the
names of the planets. Go to the
Start of Rehearsal Path space.



EXPERIENCE

You are embarrassed because you
forgot your homework.
Move 3 spaces along the
Direct Path to Long-term Memory.



EXPERIENCE

You hit your head hard when you fell.
You lose your memory for a short time.
Return all game pieces to Home
except those in Long-term Memory.



EXPERIENCE

You want to learn a new joke. Take one game
piece out of Home and place it on the
Start of Rehearsal Path space.



EXPERIENCE

Something very embarrassing happens
to you. Move 4 spaces along the
Direct Path to Long-term Memory.

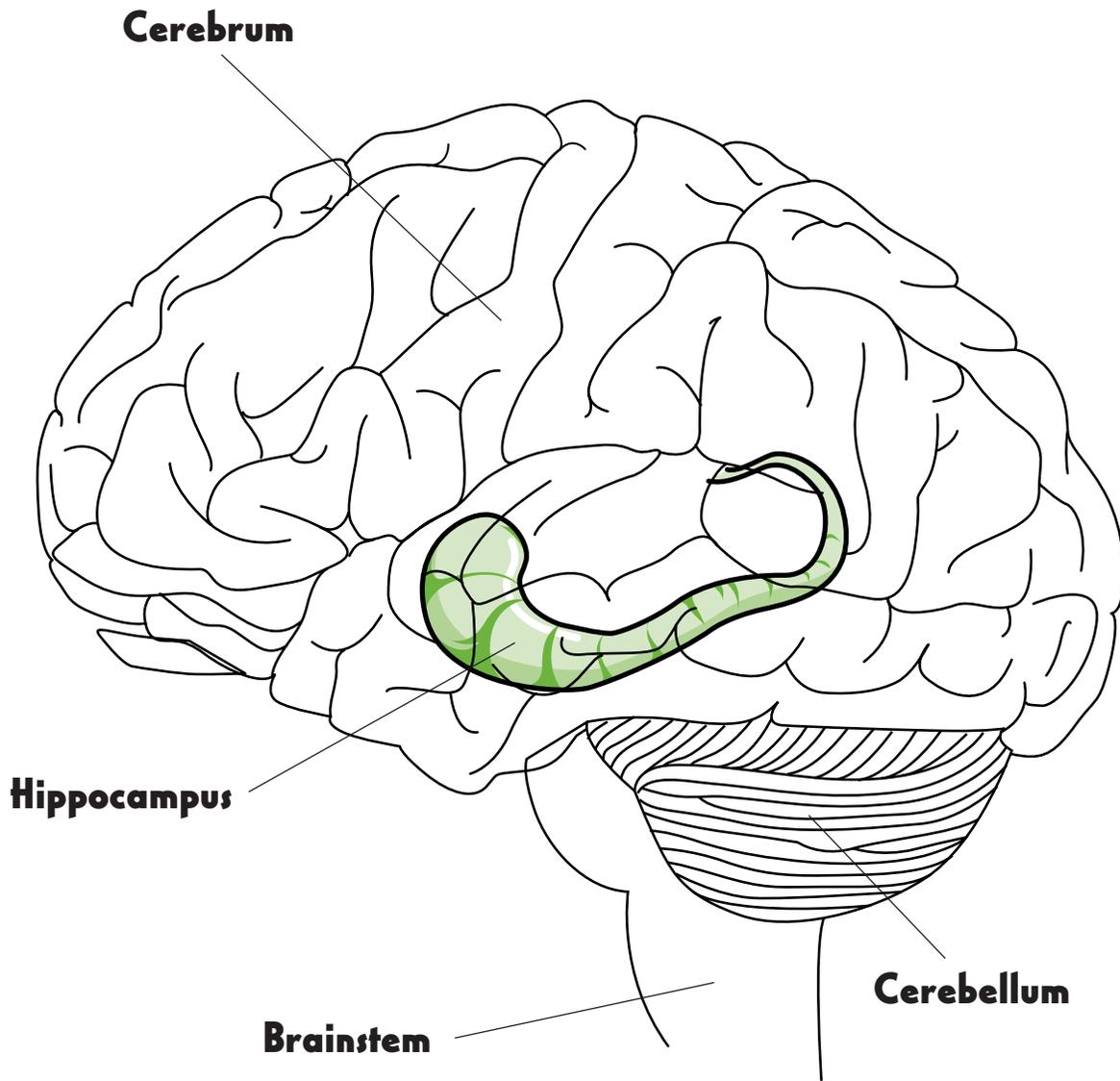


EXPERIENCE

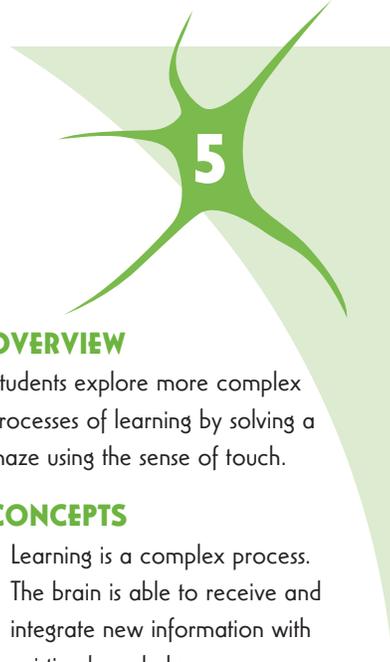
You are too tired to concentrate.
If you have a game piece on the
Rehearsal Path, put it back on Home.



BRAIN DIAGRAM



A-MAZED



5

The brain continuously uses knowledge already stored in memory to evaluate new situations and to make decisions. Remarkably, it is able to combine stored information with new sensory input to refine existing knowledge. For example, on the first day of school, new students might know how to reach their classrooms, but not the cafeteria. By the second day, they also



DANGER AT ROCKY RIVER

Story, Chapters 10–12
Science box, p. 22

EXPLORATIONS

“Matter of Fact!” p. 2
“Did You Know?” p. 4

will know how to walk to the cafeteria, but may not have explored the school well enough to locate the library. After a few weeks, however, most students will have a good picture of the layout of the school in their “minds’ eyes,” and would be able to draw a map of the school. Each day, new information has been added to the mental image of the school stored in their brains.

Usually, several distinct parts of the brain work together to receive and integrate new information. In this activity, students will solve mazes using

touch information received through their fingertips. At first, they will not be able to envision how the maze is configured. After a few tries, however, they will be able to picture the correct path through the maze clearly in their minds. This example of trial and error learning involves several different stages of information processing, some of which may occur almost simultaneously in separate regions of the brain.

A simplified description of the processing that occurs in the brain is given on the facing page. Building a mental map from touch and joint position information is a complex task. The brain must put together different kinds and pieces of information about the maze pattern in space. Then it must create an image in the “mind’s eye” from the combined information. Although very few studies have been done examining the changes in brain activity during this type of information processing, present evidence indicates that the creation of the mental image requires actual activation of parts of the vision area of the cerebral cortex. It is amazing that the brain can perform this type of complex operation, and even more amazing that we do this type of processing all the time, without even being aware of what we are doing!

SETUP

Photocopy the maze patterns (6 of each, p. 26–29) on white card stock .

OVERVIEW

Students explore more complex processes of learning by solving a maze using the sense of touch.

CONCEPTS

- Learning is a complex process.
- The brain is able to receive and integrate new information with existing knowledge.

SCIENCE & MATH SKILLS

Measuring variables, comparing measurements, predicting, charting and drawing conclusions

TIME

Preparation: 20 minutes

Class: 30 minutes to create mazes;
30 minutes to test mazes

MATERIALS (See Setup)

Teacher

- 24 sheets of 8.5-in. x 11-in. white cardstock

Per Student Group of Four

- 4 different maze patterns photocopied on white cardstock
- 4 glitter pens (or glitter or sand and white glue)
- 4 pencils
- 4 sheets of paper (for recording trials)

Per Student Team of Two

- Empty cereal box with one end sealed
- Stopwatch (or clock with a second hand)

Four patterns are provided (p. 26–28) to be distributed evenly throughout the class. Have students work in groups of four to share materials as they make the mazes. Have them work in pairs to experiment with the mazes.

As an alternative, you may use bottled white glue and glitter or sand instead of glitter glue pens. Have students “draw” thin lines of glue over the lines on the mazes, then sprinkle the glitter or sand on the wet glue (over newspaper). You also may photocopy the mazes on white paper, then glue each maze to a heavier sheet of paper.

PROCEDURE

Preparing the Mazes

1. Distribute different maze patterns to each group of students.
2. Ask the students to solve their mazes with a pencil. Ask, *Was it difficult to find your way through the maze?* Now have the students try to solve the mazes with their eyes closed. Ask, *Could you solve it this time? What is the problem? What information is needed? How could you get the needed information?* Guide students toward a discussion of the role of other (non-visual) senses in providing information. In this case, the sense of touch can help them solve the maze with their eyes closed. Explain that they will use touch to explore the mazes.
3. Direct the students to draw over all the lines of the mazes using their glitter pens. They should include the square at the beginning of the maze and the triangle at the end of it. Let the mazes dry.

	Trials	Time (seconds)
Student 1	1	
	2	
	3	

	Trials	Time (seconds)
Student 2	1	
	2	
	3	

Testing the Mazes

1. Explain to the students that they will solve the mazes using only the sense of touch. Discuss the difficulties that might be encountered when the maze cannot be seen. Ask, *Do you think that you will become “better” or faster at completing the maze with practice? What might happen to account for a change in “maze-solving speed”?*
2. Arrange the students in teams of two. Distribute cereal boxes and stopwatches. Have one student in each team place his or her maze inside a cereal box with the starting square on the maze at the CLOSED end of the box. Direct the other student within each pair to place his/her hand inside the box and feel for the starting square. Once the square is located, the student should begin to trace the maze with one finger, while the other student records the time it takes the first student to complete the trip through the maze (find the ending triangle). Results should be recorded on a simple table (for example, see sidebar, left). Repeat the same trial at least two more times.
3. Students should switch roles (and mazes) and repeat the experiment. Have older students graph the results.

4. Have the students look at the results. Ask, *Did the maze become easier to solve? Did you learn which branches led to “dead ends”? Did you become faster at moving through the maze? What could account for the difference?*
5. Challenge the students to think about the paths that they followed to complete the mazes successfully. Ask, *Can you “see” the maze pattern in your “mind’s eye”?*
6. Leaving the mazes in the boxes so that they cannot be seen, have students draw their maze paths as they remember them on clean sheets of paper. Then remove the mazes from the boxes and have students compare their drawings to the actual mazes. Ask, *What type of sensory information did you use to solve the maze? How close is your drawing to the real path?*
7. With the entire class, share the background information found at the beginning of this activity (see p. 23), as appropriate for your grade level. It is important to note that there are many processes going on in the brain to make the leap from tactile exploration of the maze to ease in remembering the path in your “mind’s eye.” You might ask questions such as, *Which parts of the brain are involved in processing touch information? Cerebral cortex? Cerebrum? Motor cortex? What does this tell us about the location of learning and memory in the brain?*

BRAIN JOGGING

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

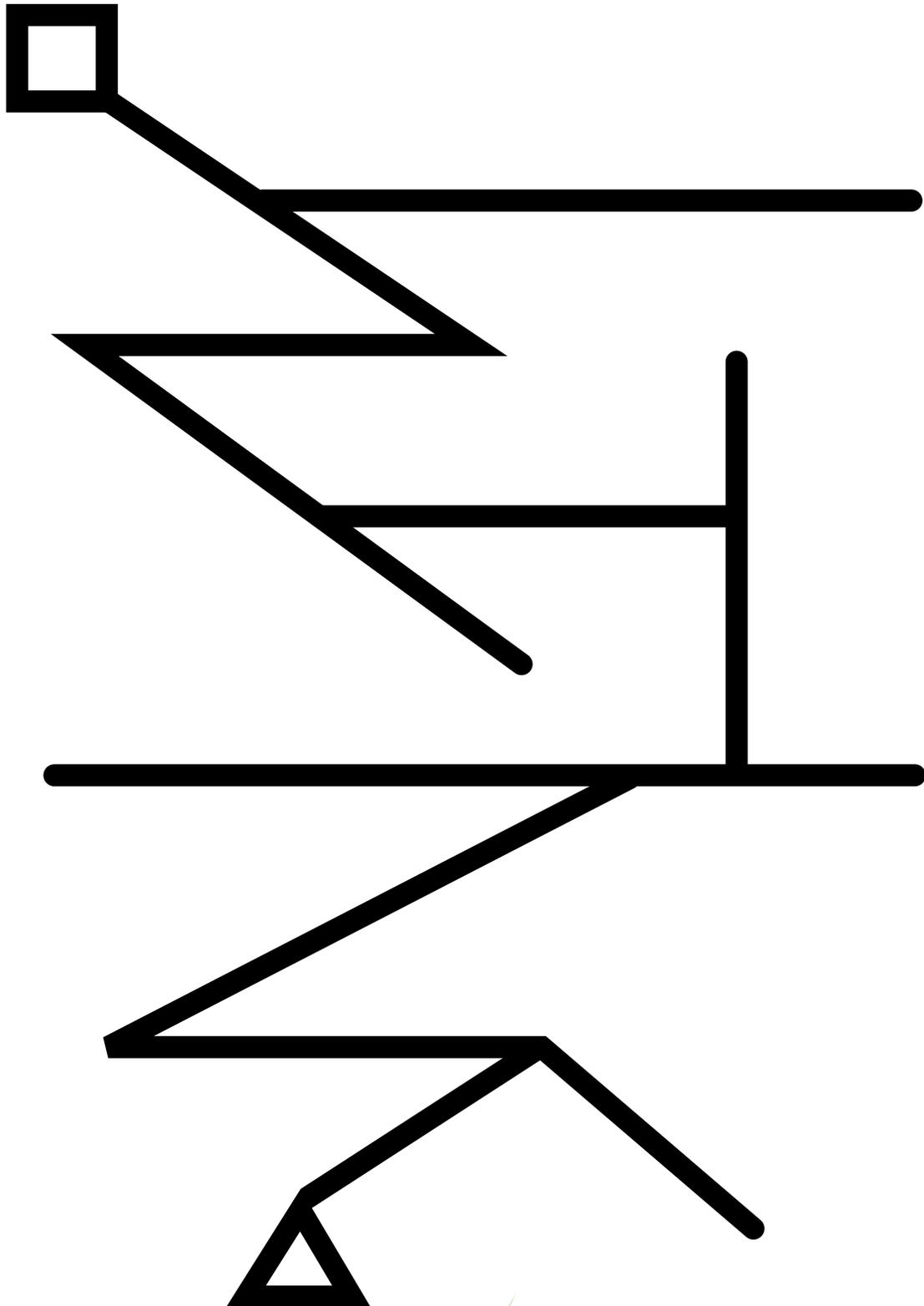
- What are some other activities in which you have to “see” with your “mind’s eye”?
- What other senses do you use for learning?
- Learning to solve the mazes in this activity is one example of learning by trial and error (or association, see Activity 1). How might the ability to learn through experience be important for the survival of any animal?
- How might someone who cannot see or hear use another sense to enable his or her brain to learn about what is going on around him or her?

Creating a Mental Image from Touch Information

1. Touch information from the fingertips is sent to the cerebral cortex.
2. Information about the finger’s joint position is sent to the cerebral cortex.
3. Each type of sensory information is processed separately.
4. Touch and joint position information are combined.
5. Combined information is transformed into information about arrangement and position (spatial information).
6. A mental image of the spatial information is created.
7. The mental image is stored in memory.
8. With each additional exploration of the maze, the mental image is compared with new information about the maze.
9. The mental image stored in memory is adjusted with each exploration until a complete image of the maze is formed in memory in the cerebral cortex.
10. If solving the maze becomes completely automatic through practice, then a program for the necessary movements also is stored in the cerebellum.



MAZE PATTERN 3



PROFILES IN LEARNING

OVERVIEW

Students read four essays about successful people who have overcome a variety of learning difficulties. References are provided to stimulate further exploration of learning disabilities.

CONCEPTS

- Dyslexia is a common learning disorder.
- Many successful people have learning disorders.

SCIENCE & MATH SKILLS

Communicating, applying prior knowledge to new situations and using reference materials

TIME

Preparation: 10 minutes

Class: 45 minutes

MATERIALS (See Setup)

Per Student Group

- Copies of student pages

About 10–15 percent of people in the United States have learning disabilities involving language. Of these, dyslexia is the most common cause of reading, writing and spelling difficulties.

Children with dyslexia have difficulty learning to read and spell despite normal eyesight and hearing, appropriate education and normal intelligence. Dyslexia usually affects reading and spelling, but can take a variety of forms, sometimes causing difficulty with mathematics, recognizing sounds in words, putting thoughts into words orally or on paper, or even organizing materials. A person with dyslexia may have any combination of these problems. In addition, some studies indicate that characteristics of attention deficit/hyperactive disorder (ADHD), a behavioral disorder, also can be observed in as many as 50 percent of those diagnosed with a learning or reading disorders. However, even though ADHD and dyslexia may occur together, one is not the cause of the other.

Letters and figures sometimes look different to a person with dyslexia than to other people. The letters may appear scrambled, or some words or letters may be reversed. A simple example of reading and writing problems caused by dyslexia is given in the Explorations component of this unit. Language difficulties experienced by dyslexic children appear to be related to problems in decoding single words and with processing phonemes—the smallest sound units of speech. Researchers suspect that brain areas that control language play critical roles in this disorder. Others are finding that dyslexia is a developmental disorder in which the ability to see and hear language is impaired due to differences originating in the cerebellum.

Dyslexia creates different learning patterns in the brain, so persons with this problem must be taught in different ways. With appropriate diagnosis, special instruction and support from teachers, family and others, children with dyslexia can succeed in school and beyond. Additional information can be acquired from the resources listed at the end of this activity, from local schools or from organizations specializing in learning disorders.



DANGER AT ROCKY RIVER

Story, Chapters 13–14
Science box, p. 28.

EXPLORATIONS

“Mixed Signals” p. 6
“Brain Busters!” p. 7

Photographing the Brain

High tech imaging methods allow scientists to photograph the brain in action. These techniques help scientists learn which areas of the brain are involved with different learning disabilities. For example, researchers have linked dyslexia to systems in the brain for vision, language and speech sound processing.

SETUP

This activity may begin with a class discussion, followed by reading of the biographical essays, or vice versa. With younger students, you may want to read the individual biographies to the class and then conduct a discussion. Otherwise, individuals or groups can be given reading assignments and then asked to find further information either about the persons or about dyslexia and other forms of learning disabilities from the library or from the suggested source organizations.

PROCEDURE

1. Lead a class discussion about differences in learning styles and patterns. For example, some of us find it easy to spell, and some of us have to work very hard at it. Some are better at math and some excel at reading or writing. Different learning patterns are normal. However, some people's brains work very differently, which makes it much harder for them to learn to read and spell words, even though they may be very intelligent. Someone who specializes in learning disabilities can find out how to help these people learn more easily.
2. Continue the discussion by telling the class that some children have a kind of learning difficulty called dyslexia. Ask students if they have heard of dyslexia. Write the word on the board (dyslexia: diz-LEK-see-uh), and practice pronouncing it. Let students share any experiences that they or someone they know may have had with this kind of difficulty and look for common characteristics. See if they can come up with a definition for dyslexia, which can be revisited AFTER the students have read the Profiles in Learning.

OR

Without talking about dyslexia, tell the members of the class that they are going to read (or hear) some stories about people who have had difficulties in learning.

3. Depending on the age of the students, either distribute the Profiles in Learning student pages or read the essays to the class. You may prefer to read or tell one essay per day to younger children. Older students may be divided into four groups, giving a different selection to each group.
4. Have individual students tell the class about the selections that were read. If groups read different selections, have a student from each group present his or her group's story to the class. As the stories are told, list them on the board. Or, let a student list facts about dyslexia and ways to cope with and work around such a problem.

Resources

For more information, look for these organizations on the Internet or at your library.

- Association of Children and Adults with Learning Disabilities
- Council for Exceptional Children, Division of Learning Disabilities
- The International Dyslexia Association (formerly the Orton Dyslexia Society)
- National Institute of Child Health and Human Development, National Institutes of Health

Also contact local schools and organizations specialized in learning disorders.

5. Distribute and discuss the “Famous People Who Had Difficulty” student sheet. This sheet contains the names of persons reported or believed to have had difficulties learning in school.
6. Encourage students to learn more about dyslexia or about other learning disabilities by contacting local or national organizations or by visiting the library.

BRAIN JOGGING

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

- Write a short story or diary entry from the point of view of a person who has difficulty in school because he or she learns in different ways from other students.
- What do all of the people whose profiles you read have in common, besides dyslexia?

References for Profiles in Learning Essays

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- Lampton, Christopher. *Thomas Alva Edison*. New York: Franklin Watts, 1988.
- Persico, Joseph. *The Imperial Rockefeller: A Biography of Nelson A. Rockefeller*. New York: Simon & Schuster, 1982.
- Steger, Will, with Paul Scherke. *North to the Pole*. New York: Times Books, 1987.
- Thompson, Lloyd J. “Language Disabilities in Men of Eminence.” *Bulletin of The Orton Society*, Vol. XIX, 1969.
- Wenzel, Dorothy. *Ann Bancroft: On Top of the World*. Minneapolis: Dillon Press, 1990.

A VICE PRESIDENT'S STORY



On December 19, 1974, Nelson Rockefeller became Vice President of the United States. Being in public office was nothing new to Mr. Rockefeller. He had been Governor of New York for 15 years, having been elected four times to that office.

Some said that Nelson Rockefeller's success in reaching such high positions was helped by being born into a very wealthy family. His grandfather, John D. Rockefeller, was once the richest man in the world. But there was something else that kept Nelson striving to reach his goals. It was something he learned as a boy, as he struggled to cope with a "learning disability" called dyslexia (diz-LEK-see-uh).

Dyslexia is a difference in brain functioning that can make it difficult for people with average or above-average intelligence to read, write or spell. When Nelson was in school, people didn't know about dyslexia. Although he was outgoing and had the makings of success, Nelson was a poor student. Neither he nor anyone else could understand why he had such trouble reading or why he confused words and mixed up numbers.

In an interview when he was 68 years old, Nelson Rockefeller told about his difficulties in school: "I saw words backwards. Or I repeated them backwards. Even today, if I just glance at something, I still get mixed up... I have no confidence in reading.... I can't see a

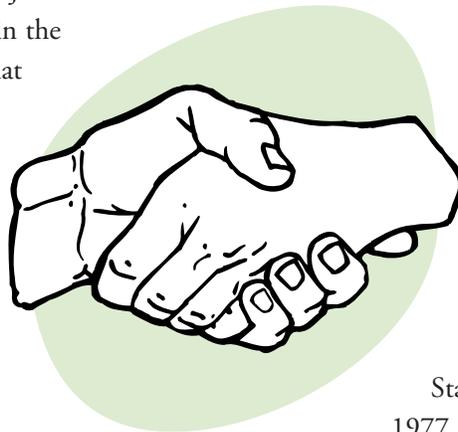
whole word. I have to go through it syllable by syllable."

Rockefeller nearly failed ninth grade and was in the bottom third of his high school class. When he realized that he might not be accepted into college in spite of all his money, Nelson learned that "I had to be determined and I had to discipline myself in order to overcome it... to be an achiever. You have

to have a strong sense of courage to overcome something like this." With all his advantages, Rockefeller might have been tempted to give up and take an easy way out. Instead, he worked hard with tutors, and eventually, he was able to go to college.

During his career, Rockefeller served under six of the seven United States presidents between 1940 and 1977. He was an outstanding politician and leader, even though, as his long-time secretary said, "He was terrible at dictating letters and speeches. He fragmented sentences...."

A speech writer of Rockefeller's wrote in a book about him, "Rockefeller overcame, or at least learned to deal with, his dyslexia. As he grew older, Nelson came to believe that his determination had turned his handicap to advantage." As Nelson Rockefeller put it: "Accept the fact you have a problem. Don't try to hide it. Refuse to feel sorry for yourself. You have a challenge. Never quit!"





TURNING ON THE LIGHT

Thomas Alva Edison was a brilliant and famous American inventor. It is hard to imagine that he had trouble learning.

But at one time, he said, “I remember I used never to be able to get along at school. I was always at the foot of the class. I used to feel that the teachers did not sympathize with me, and that my father thought I was stupid. I almost decided that I must be a dunce.”

When he was eight years old, Thomas Edison heard his teacher say that his mind was “addled” (mixed up or confused). It is clear, from the stories told by his teachers, his family and by Edison himself, that he had real learning difficulties. He may have had what is now known as dyslexia (diz-LEK-see-uh). Young Thomas was upset because he had so much trouble learning, and so was his mother. She was a teacher, and she found it hard to believe what Thomas’ teacher had said about her son.

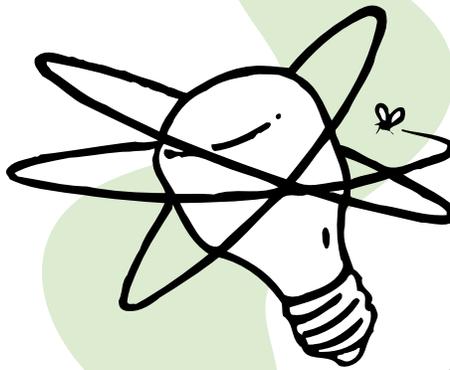
Mrs. Edison removed her son from school and decided to teach him herself. She encouraged him by reading to him and helping him find new ways to learn. When he was nine, she gave him a book about science experiments and he tried out every experiment in the book. His mother gave him other books that also interested him. It became clear to her that Thomas’ brain worked differently from other children’s, so his mother helped him to learn in different ways.”My mother was the making of me,” he once said.

While his mother helped him to follow his interests and worked with him every day, she was unable to help him overcome some of his learning difficulties. People wrote in his biographies that he never learned to spell and that his grammar was terrible. But Edison’s difficulties did not stop him. He stuck with things until

he figured them out. That is how he invented the light bulb. He tested more than 3,000 different materials until he finally found one, carbonized cotton thread, that could carry an electric current without burning up. “The electric light has caused me the greatest amount of study and has required the most elaborate experiments... [but] I was never, myself, discouraged,” he explained.

In addition to the light bulb, Edison created the phonograph, the electric generator, the electric locomotive, the mimeograph and the alkaline storage battery. Over his lifetime, he was granted more than 1,000 patents for his inventions. He was a pioneer in the electric power industry—without which we wouldn’t have radio, television or computers today.

In spite of having to overcome learning difficulties as a child, Thomas Edison changed the world. Maybe those difficulties even helped him want to keep plugging away at things until he figured out how to make them work. Think about it the next time you turn on a light!



POLAR EXPLORER



The wind howled, and they could hardly see through the blowing snow as they skied over solid ice. Each member of the group pulled a 200-pound sled full of supplies. Their faces were frozen, and they were exhausted. Their legs and arms ached. They had pulled their sleds over an ice drift that was ten feet high. The four adventurers were determined to reach the South Pole. They skied on into the wind, over the vast icecap of the Antarctic continent.

On January 14, 1993, the American Women's Expedition reached its goal. The team had skied for 67 days in the constant daylight of the antarctic summer, in -30°F temperatures. This courageous group had covered 660 miles to become the first women ever to reach the South Pole on foot. They used no dogs or motorized vehicles, because they didn't want to harm the environment. Ann Bancroft headed the expedition. She was their leader, their coach and their inspiration.

But this was not the first challenge Ann Bancroft had tackled. She already had become the first woman to reach the North Pole by dogsled, as part of another expedition in 1986. Now she had become the first woman to reach both the North and South Poles across the ice. Success was not new to her, for she always worked very hard to do her best.

When Ann was in elementary school, she tried hard to do well, but she did not always succeed. In fact, her grades were very low. Neither she nor anyone else could

understand why it was so hard for her to read and spell. She became discouraged, and the only parts of school she liked were recess and gym class.

In the seventh grade, Ann took some special tests and was told that she had dyslexia (diz-LEK-see-uh). As she later described this problem, "When I tried to read,

signals on the nerve paths to my brain got mixed up, so letters and numbers seemed scrambled."

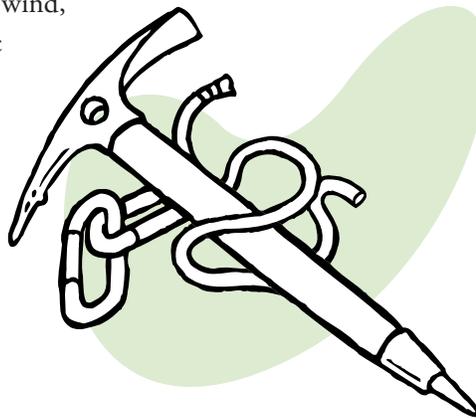
Having a name for her difficulty didn't make it easier, but she kept trying to find ways to succeed.

In high school, Ann became an excellent athlete. She played basketball and was a runner on the girls' track team. She loved camping and hiking in the summer. School still was hard for her, but she finished high school and decided to go to college. It always was a struggle,

but she wouldn't give up, because she wanted to become a teacher. Finally, she graduated from the University of Oregon.

Ann Bancroft had done the impossible. She, who had thought she couldn't learn, was a teacher! She taught physical education and special education in her home state of Minnesota. She also was an expert mountain-climber and reached the top of Mt. McKinley, the highest peak in North America.

Now, in the icy glare at the South Pole, Ann knew again what it was like to face a very hard task, and to keep at it until you succeed!





DOCTORING HIMSELF

M eet Dr. Garth O. Vaz, Medical Director of the Gonzales Community Health Center in Gonzales, Texas. On any day of the week, you might find him examining a patient’s swollen ankle or listening as a patient describes the pain in her lower back. Dr. Vaz is one of only a handful of doctors in a small town. He works day and night, and he wouldn’t have it any other way. Being a doctor is something Garth Vaz had wanted for most of his life — and it was a long time coming.

When he was a boy on the island of Jamaica, Garth had difficulty in school. He was good at math, but he could not seem to learn to read or write. In those days in Jamaica, students got a “flogging” (were hit with a stick or paddle) when they failed. Garth didn’t like the floggings, and he left school in the ninth grade.

In 1967, when he was 20 years old, Garth Vaz came to the United States looking for a better life. He worked, he joined the Army, and he finally passed a test that was equal to a high school diploma. He dreamed of going on with more education. If only he could find the money, he would even go to medical school. What a dream!

He had a long way to go. He entered the University of Florida, but college courses were difficult for Garth, and he had to drop out. By this time he had a family to support. But in the back of his mind, he still longed to become a doctor.

Finally, Garth got a college degree and entered medical school at the University of Florida. In one of his classes, he heard about a “learning disability” called

dyslexia (diz-LEK-see-uh)—a difference in brain functioning that can cause problems with reading and writing. As the professor described this difficulty, Garth Vaz recognized it as his own. Until then, he had thought his trouble was due to problems with his eyes as a child.

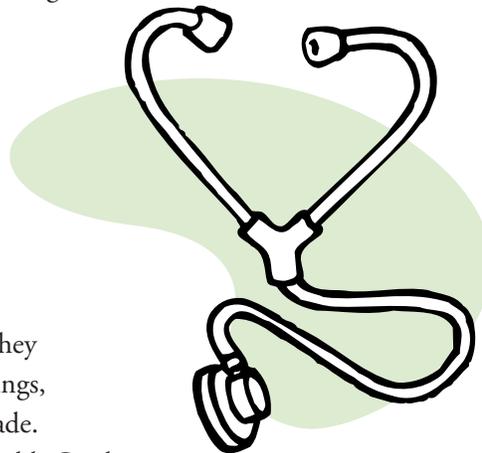
Garth still had trouble in medical school. He failed a class that required a lot of writing on medical charts, and he sometimes had trouble reading the questions with tricky wording. He had to leave and take another job.

But Garth Vaz would not give up. He took remedial courses and finally re-entered medical school. In December 1988, Garth Vaz’s dream came true. He received his medical degree!

Through a physically handicapped friend, Garth had learned about laws that protect people with disabilities, so that they can achieve their highest potential. These laws allowed him extra time on exams and a person to read the tests to him. This helped him to pass the exam to become certified in family practice medicine.

Dr. Vaz loves his work, but he will always feel challenged, just to keep up with the latest discoveries in medicine. When asked how he manages to stay on top of it all, he replied, “I always had a big fear of getting behind in my studies, so I got in the habit of staying ahead with my reading. This habit serves me well now.”

Dr. Vaz gives this advice to others with dyslexia: “Pursue your goal. Don’t let the idea of dyslexia stop you. Recognize your disability as a positive.”



WHO'S WHO WITH LEARNING DIFFICULTIES



Hans Christian Andersen

Writer

Ann Bancroft

Polar Explorer

Ludwig van Beethoven

Musician and Composer

Wernher von Braun

Rocket Engineer

Erin Brokovich

Community Activist

Cher

Actress and Singer

Winston Churchill

Prime Minister of England and
Nobel Prize Winner for Literature

Walt Disney

Animation Artist and Motion Picture Executive

Thomas Edison

Inventor

Albert Einstein

Theoretical Physicist and
Nobel Prize Winner

Henry Ford

Automobile Manufacturer

Benjamin Franklin

Public Official, Writer, Scientist and Printer

Galileo Galilei

Astronomer and Physicist

Whoopi Goldberg

Actress and Comedienne

Danny Glover

Actor

Earvin "Magic" Johnson, Jr.

Professional Basketball Player and Businessman

John Kennedy

President, United States of America

John Lennon

Musician and Composer

Edward James Olmos

Actor

Louis Pasteur

Chemist

Pablo Picasso

Artist

George Patton, Jr.

General, United States Army

Nelson Rockefeller

Vice President, United States of America

Nolan Ryan

Professional Baseball Player

Jules Verne

Science Fiction Writer



WHAT'S YOUR STORY?

OVERVIEW

Students review and apply concepts learned in this unit by recalling and telling about a favorite memory and analyzing the processes of learning and memory involved.

CONCEPTS

- Declarative memory is our recollection of what we have learned about people, facts and events.
- Procedural memory is our remembrance of how to do things.
- Different parts of the brain are involved in the processes of memory and learning.
- The collective memory of a culture is known as its oral tradition.

SCIENCE & MATH SKILLS

Applying prior knowledge to a new situation

TIME

Preparation: 5 minutes

Class: 45 minutes

MATERIALS (See Setup)

Per Student

- Copy of both student pages

The brain's ability to learn and remember directs all of our activities, every day of our lives. Who we are, both as individuals and as a species, is shaped to a large degree by the remarkable properties of our brains, which enable us to retain and utilize information both from within our bodies and from the world around us.

Learning is the process of acquiring information or skills. We can learn in many ways, including by association, imitation and repetition. We even “soak things in” without trying to learn them.

Memory refers to the expression or recall of stored information or skills. There are at least two major types of memories—facts, names, places and events. This is called declarative memory. The other is our “how to” memory—our memory of procedures and routines, or how to do things, like walking, throwing a ball or tying a shoe. This is called procedural memory.

Memories are stored as changes in the synapses, or connections, among neurons in different places in the brain. The exact storage points of memories are not known. However, we do know that some of the important structures for learning and memory are the cerebral cortex (for declarative memories, or “what”) and the cerebellum (for procedural memories, or “how”).

The hippocampus is another part of the brain that is important to memory. One hippocampus is located on each side of the brain, within the temporal lobes (side parts of the cerebrum). This seahorse-shaped group of cells is crucial for the formation of long-term memories about facts, experiences, people and places—our declarative memories.

Memories last for varying lengths of time. We remember some things for only a few seconds or minutes before they are forgotten. These are short-term memories. Other things, especially those which are repeated or are important to us, become stored as long-term memories. Long-term memories can last for a few hours to an entire lifetime.

People, especially those in the same family or community, often tell each other stories about things they remember or have heard from the past. Long before history was written down with dates and places, storytellers related the lore passed down from their ancestors so that it was preserved



DANGER AT ROCKY RIVER

Story, Chapters 15-16
Science boxes: Review all.

EXPLORATIONS

“Brain Food” p. 4

Inborn or Acquired Differences

The processes of memory and learning can be affected by differences in brain functioning, either inborn or acquired. Dyslexia and Alzheimer's disease are two examples of disorders that alter the abilities to learn and remember to varying degrees.

from generation to generation. This way of passing on the collective memory of a culture is referred to as oral tradition. Historical information sometimes is gathered and preserved more formally today through recorded interviews with participants about past events and ways of life. The preservation of people's memories, when they tell their "stories" to interviewers, is known as oral history.

Even though we might see pictures, videos or other records of things that happened in the past, nothing compares to hearing stories of what occurred in the words of someone who was there. It brings the past to life and links us closer to it and to persons remembering it. Although everyone remembers things differently, each account is valuable; different versions of the same event, all put together, can give a more complete and vivid picture of the past. Just writing down or recording our own memories now and looking at them later can let us re-experience events in our own lives and learn more about ourselves and our world.

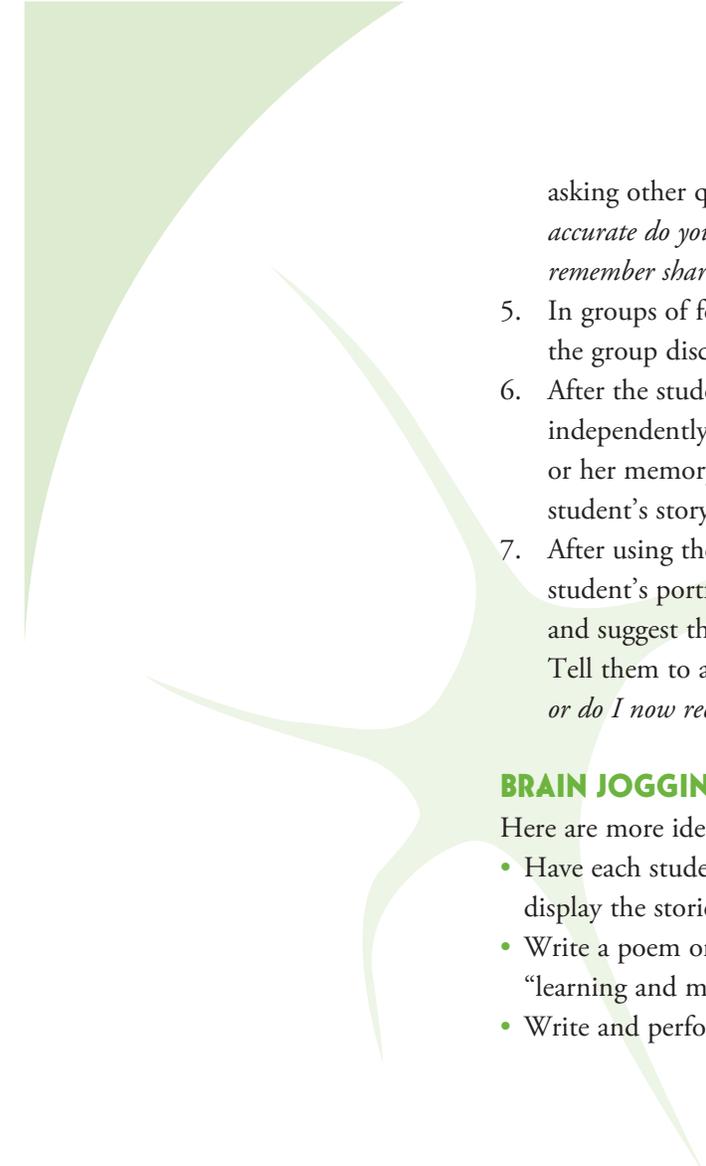
SETUP

After introducing the concepts of oral tradition and oral history, have students work individually and in small groups to create their stories.

PROCEDURE

1. Explain to students that stories can be an important way of teaching, learning and remembering. For centuries, people have used stories to share and preserve the history and beliefs of their cultures, to learn about themselves and to give meaning to their lives. Tell students that they are going to be storytellers, sharing one of their own memories.
2. Ask each student to list five (three for younger children) of his or her favorite memories. Also ask for examples from the class and discuss why these memories had become part of their long-term memories.
3. Direct the students to think about and choose one of their memories to tell as a story to other members of a small group. Encourage them to include as many details as possible. Suggest beginning with phrases such as: I remember the first time..., the scariest time..., the funniest time..., when I learned to..., etc.
4. Tell the class that, as each student finishes his or her story, the group is to discuss possible answers to the questions on the "My Memory" student sheet. Project a transparency of the page, distribute copies of it or write the questions on the board. Talk about types of answers that would be appropriate for each question.

You may want to encourage your students to think further by



asking other questions such as, *How old are your memories? How accurate do you think they are, and why? Do family members or friends remember shared events differently?*

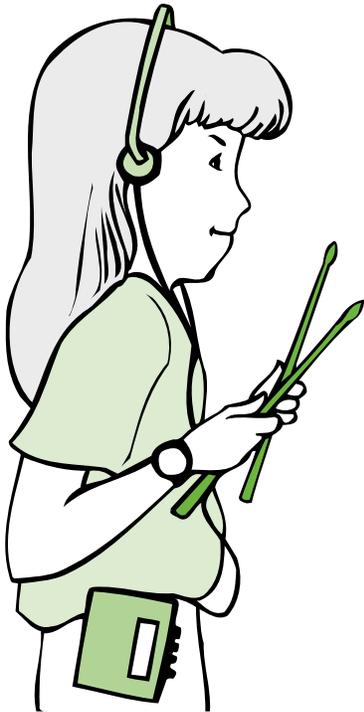
5. In groups of four, let each student share his or her memory story, with the group discussing answers to the memory questions for each story.
6. After the students have shared their stories, have each student independently complete the “I Remember...” student sheet about his or her memory story. The sheet will contain a short summary of each student’s story and answers to the questions about the memory.
7. After using the student sheets for assessment, save them in each student’s portfolio. Look at them again at the end of the school year, and suggest that the students save them to look at several years later. Tell them to ask themselves later, *Do I still remember this the same way, or do I now recall it differently? Why might that be?*

BRAIN JOGGING

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

- Have each student make a drawing to illustrate his or her story and display the stories and finished artwork.
- Write a poem or song involving something you have learned about “learning and memory.”
- Write and perform a play about the different ways in which we learn.

MY MEMORY



Ways of Learning

Association
Repetition
Imitation

Types of Memory

How (procedural)
What (declarative)
Short-term memory
Long-term memory

Parts of the Brain Involved with Memory

Cerebellum
Cerebral cortex
Hippocampus



Questions to Ask and Answer About Your Memory

1. Which kind of memory was it (“how” or “what”)?
2. Which senses were involved in making the memory (vision, hearing, taste, smell, touch)?
3. Which type of learning was involved (association, imitation, repetition, etc.)?
4. What helped it to be kept in long-term memory? (surprising, exciting, scary, funny, practiced until learned, etc.)?
5. Which parts of the brain were used in forming and keeping this memory?





I REMEMBER...

This is a summary of my story.

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1. Which kind of memory was it (“how” or “what”)?

 2. Which senses were involved in making the memory (vision, hearing, taste, smell, touch)?

 3. Which type of learning was involved (association, imitation, repetition, etc.)?

 4. What helped it to be kept in long-term memory? (surprising, exciting, scary, funny, practiced until learned, etc.)?

 5. Which parts of the brain were used in forming and keeping this memory?



GLOSSARY



Alzheimer's disease - a disease, found especially in older adults, that damages or destroys cells of the central nervous system so that people can no longer remember or think normally

association - broad category of learning that involves forming mental connections among sensations, ideas, memories and movements

brain - control center of the nervous system, located within the skull and attached to the spinal cord; command center of the body

brainstem or brain stem - structure that connects the rest of the brain to the spinal cord and controls basic survival activities such as breathing, heartbeat, body temperature and digestion

central nervous system - the part of the nervous system in vertebrates that consists of the brain and spinal cord

cerebellum - part of the brain located directly above the brainstem that controls the sense of balance and helps the muscles work together for learning and coordination of rote movements

cerebral cortex - the outermost component of the brain's cerebrum; controls our most advanced abilities, such as speech and reasoning

cerebrum - large rounded outer layer of the brain where thinking and learning occur, sensory input is received and voluntary movement begins

classical conditioning - type of learning by association in which a neutral stimulus (for example, a sound) is paired with a second stimulus that causes a response (for example, presence of food, leading to salivation)

declarative memory - knowledge or memory of past experiences, facts, people and events; stored in the cerebral cortex

dyslexia - learning disorder caused by differences in brain function; can take many forms including difficulty with writing, reading, spelling, mathematics, speaking, listening or remembering what is seen or heard

epilepsy - condition caused by sudden changes in the activity of neurons in the brain; affects a person's awareness and action, often with jerking movements of the body and limbs, for short periods of time

gyri - outward folds on the surface of the cerebral cortex

habituation - type of learning characterized by a decrease in the response to a stimulus; to be accustomed to something through continued exposure

hippocampus - a seahorse-shaped area of neurons in each temporal lobe of the brain; participates in the processing and formation of long-term memories (hippocampi, plural)

imitation - type of learning that involves observing someone else and copying his or her activity

learning - gaining knowledge or skills by instruction, study or experience; storage of information in the brain in a way that allows it to be recalled and applied

learning disability - any kind of disorder that makes it difficult to learn and process new information, especially relating to performance in school

long-term memory - more or less permanent storage of information and skills in memory; long-term memories can persist for a few hours up to an entire lifetime

memory - recall of knowledge or skills; information that people or animals have stored in their brains over time

nerve cell - neuron; a cell of the nervous system that conducts a signal from one part of the body to another

nerve - a bundle of nerve fibers and associated cells

nervous system - brain, spinal cord and nerves in the body

neuron - a cell of the nervous system that conducts a signal from one part of the body to another

neuroscience - branch of science related to study of the nervous system

oral history - documentation of past events through story telling from generation to generation



procedural memory - knowledge of “how” to do things, stored in the cerebellum

repetition - element of many learning processes that involves doing something over and over

sensitization - type of learning in which continued exposure to a stimulus leads to an increase in the response

sense - 1) function of the body by which one is made aware of the world outside, as sight, hearing, touch, smell or taste, or of conditions inside the body, as pain or hunger; 2) a feeling or awareness; 3) to become aware of

sensory - relating or pertaining to the senses

sensory neuron - type of nervous system cell that transmits impulses from a sense organ or receptor toward the central nervous system

short-term memory - an early stage in the processing of information in the brain, during which information is held for a short period of time (several minutes or less); some of the information held in short-term memory is lost, other information is processed further so that eventually it is held in long-term memory





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