BRAIN

THE WORLD INSIDE YOUR HEAD

Teacher's Activity Guide

Acknowledgments

Made possible by Pfizer Inc

Produced by Clear Channel Exhibitions

Concept and text by Word Craft, Monterey, CA

Illustrations by Kerry Ferguson, San Antonio, TX

Design by Rose Davis, GraphicsToo, San Antonio, TX

Introduction

Welcome to *Brain: The World Inside Your Head*, a traveling exhibit made possible by Pfizer Inc and developed by Clear Channel Exhibitionsin collaboration with the National Institute of Mental Health,the National Institute on Drug Abuse and the National Institute of Neurological Disorders and Stroke.

Brain: The World Inside Your Head introduces you and your students to an extraordinary organ—the brain. In the exhibit, you'll investigate neurons, synapses and the brain-body connection. You'll also meet people with extraordinary brains, such as Albert Einstein, and explore the mystery of the origin of the mind. You'll learn more about brain disorders and how drugs affect the brain. Then you'll conclude your investigation with an exploration of one of the biggest mysteries of all—the purpose of dreams.

The purpose of this Teacher's Activity Guide is to enhance your class' visit to *Brain: The World Inside Your Head*. We've divided this Guide into two main sections: pre-visit activities and post-visit projects. The pre-visit activities focus on the many ways that your brain gets you through the day—at home, at school and at play. The post-visit projects will help your students explore selected topics further and pull together all they've learned.

These activities are multidisciplinary, encompassing lessons in science, math, language arts, performing arts and art. The activities can be integrated easily into your curriculum to enhance and enliven your current lesson plans. Because science is the exhibit's focus, the activities in this Guide cover the following National Science Education Standards:

- Grades K – 4 Content Standard C: The characteristics of organisms; and Content Standard F: Personal health

- Grades 5 – 8 Content Standard C: Structure and function in living systems and Regulation and behavior; and Content Standard F: Personal health

- Grades 9 – 12 Content Standard C: Behavior of organisms; and Content Standard F: Personal and community health.

At the back of the Guide you'll find a glossary and list of reading materials and references, which may be helpful when exploring the brain.

We hope you enjoy this adventure of discovery!

Table of Contents

Pre-Visit Activities

AT HOME

This group of activities will help your students explore how their brains work at home—while they're doing chores, looking at family photos, playing games or simply sleeping.

First Memory

Subjects: life sciences, language arts
Grades: 2 - 12
Concepts: describing, comparing, communicating
Duration: two 15- to 20-minute sessions

OBJECTIVES

Students will discover that...

- two people may have different memories of the same event because of the way the brain stores and retrieves memories.
- each time they retrieve a memory it gets transformed as the brain adds, changes or deletes different aspects.

BACKGROUND INFORMATION

Have you ever looked through a photo album with your parents or friends, and, after describing a memory, had your parent/friend reply, “That’s not how it happened”? How can two people, who were at the same place at the same time, have two different memories of the same event?

One reason has to do with personality. When two people observe and remember the same event, each person remembers only the parts that are the most important to him or her.

The other reason is that the brain doesn’t store memories as an exact copy of an event, like a videotape. Instead, it scatters bits and pieces of the memory throughout the cortex—the wavy outer layer of the brain. Each time a person accesses a memory, the brain has to decide if each bit actually belongs, then arrange those that do into proper context. Sometimes facts gets added, tweaked or lost in the process. The more times a person recalls a memory, the more it gets changed.

Finally, most people cannot remember events before age three. That’s because parts of the brain that are responsible for storing memories aren’t yet mature.

In this activity students will recall their very first memory. Then they’ll compare their version to that of someone who was there. Chances are, the two versions will differ.

ACTIVITY

<u>Materials</u>
paper and pencil

QUESTIONS TO BEGIN

- How far back can you remember?
- What’s your very first memory?
- How old are you in your very first memory?

PROCEDURE

1. Have students close their eyes and think of their very first memory.

2. Have each student write down his or her memory in as much detail as possible (younger students can share their memories orally).

3. As a homework assignment, have each student ask someone who was part of the memory to write down or describe their version of the same event. If that person doesn't remember the event at all, the student should note that.

4. In class the next day, have students read or describe both versions of the memory and point out the differences.

5. Close with a discussion of how the brain stores a memory by scattering it throughout the cortex and recalls it by putting the bits together.

QUESTIONS TO CLOSE

- Did you and the other person remember exactly the same thing?
- What parts of the memory did both of you agree on?
- What parts of the memory did both of you disagree on?
- What might account for the differences?

Sources

Arms, Karen and Pamela A. Camp. *Biology.* 4th ed., Fort Worth, TX: Saunders College Publishing, 1995.
Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.
Johnson, George. "What Happens When the Brain Can't Remember." *New York Times,* Sunday July 7, 1996. p. E10.
Schacter, Kenneth A., Kenneth A. Norman and Wilma Koustaal. The cognitive neuroscience of constructive memory. *Annual Reviews Psychology* 49 (1: 1998): 289-318.

Blotto!

Subjects: life sciences
Grades: K - 12
Concepts: observing, comparing, describing
Duration: two 30- to 45-minute class sessions

OBJECTIVE

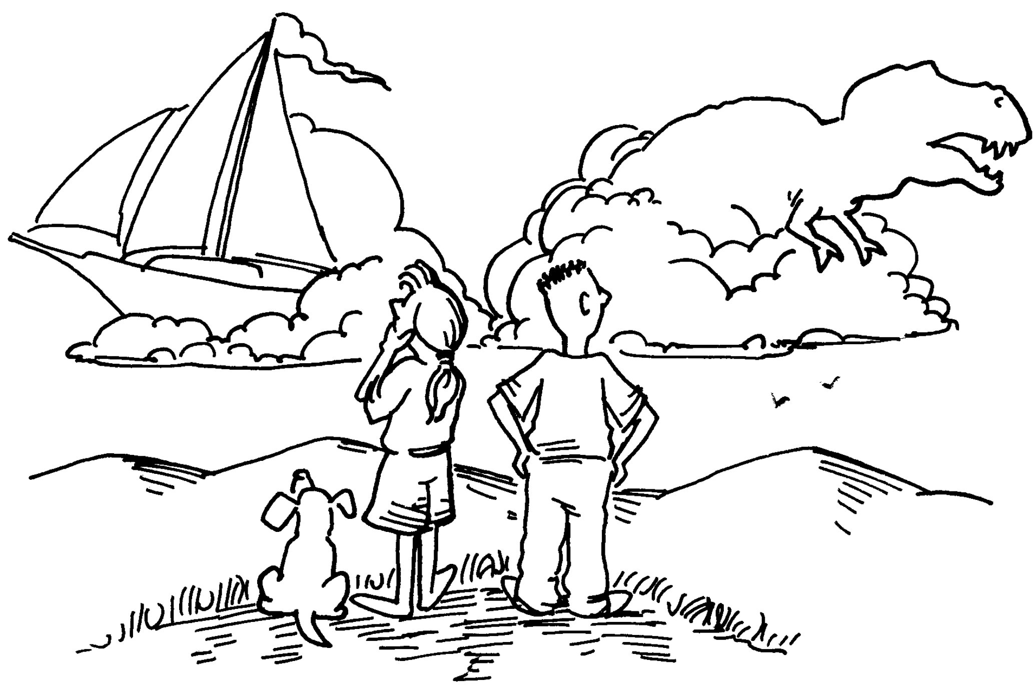
Students will discover that...

- their brains help them interpret and understand what their eyes see.

BACKGROUND INFORMATION

Have you ever looked for animal shapes in the clouds passing overhead? Have you and a friend ever seen two different animals in the same cloud? How can that be? To "see" a shape in a cloud, your brain has to interpret, or make sense of, the image your eyes perceive. How your brain interprets the information depends in part on your personality.

Using a similar concept, psychologists can test your personality. Instead of using clouds, however, they ask people to state what they see in inkblots. The name of the test is the Rorschach (say, roar-shock) Test, named after the Swiss psychiatrist Hermann Rorschach who invented it in 1921.



Rorschach got his idea for using inkblots to evaluate personalities when he was working in a psychiatric hospital. He noticed that some adolescent patients gave different answers from others to a game called Blotto. In this game, people stated the image they saw in a particular design.

Since Rorschach's time this psychiatric test has been refined. Three different standardized tests are in use today. The inkblots and the meanings of their different interpretations are closely guarded by psychiatrists. (You wouldn't want someone cheating on the test, would you?)

In this activity, your students will make "inkblots" and interpret them. Then they'll compare their interpretations to those of their classmates.

ACTIVITY

Materials

- thick white paper, 1 sheet per student
- paint brushes or teaspoons
- black poster paint
- pencils
- clothesline and clothespins

QUESTIONS TO BEGIN

- Have you ever looked for shapes in the clouds passing overhead?
- What kinds of things did you see in the clouds?
- Were they really in the clouds or did you imagine they were there?

PROCEDURE

1. Start by making the inkblots: give each student a sheet of thick white paper. (If you choose to use pre-made inkblot cards, skip to step 5.)
2. Using a paintbrush or spoon, have each student drizzle 1 to 2 teaspoons of black poster paint onto the middle of the paper. Apply sparingly; you can always add more. Fold the paper (lengthwise or crosswise; it doesn't matter). Rub the folded paper so that the paint smears around, being sure to smooth out all lumps.
3. Have students unfold the paper. Let the inkblots sit on a flat surface until dry.
4. When the inkblots are dry, number each with a unique number.
5. Set the inkblots out around the room or hang them on a clothesline with clothespins for display.
6. Have students visit each inkblot and write down its number and the very first thing they see in it. (You might ask younger students what the inkblot reminds them of.)
7. When all students have written down something for each inkblot, have them take their seats. As you hold up each inkblot, have students share what they interpreted the inkblots to be. Keep a tally of the results for each one.

QUESTIONS TO CLOSE

- Did everybody see the same thing in each inkblot?
- Why did different people see different objects in the same inkblot?
- Did some inkblots have more variation of responses than others?

Sources

Rorschach Inkblot Test [web site]. Available from http://www.rorschach.org
Somatic Inkblot Series Center. *Historical Development of Inkblot Technique* [website]. Available from http://www.somaticinkblots.com/sisManual/ch2_historical.CFM
Trager, James. *The People's Chronology.* New York: Henry Holt and Co., 1992.

A-maze-ing!

Subjects: life sciences
Grades: 2 - 8
Concepts: observing, reasoning
Duration: one 30-minute class session

OBJECTIVES

Students will discover that...

- when the eyes see something, the brain tries to make sense of, or interpret, it.
- optical illusions mislead the brain as it tries to interpret what the eyes see.

BACKGROUND INFORMATION

Your brain is constantly interpreting, or making sense of, what you see. When you first learned to read, for example, your brain learned to make sense of the letters that your eyes perceived. Whenever your eyes see any image that can be interpreted in more than one way, the brain must choose how to interpret it. To make a choice, it usually relies on past experience. Sometimes your brain gets confused about how to interpret what your eyes see. This is what happens with an optical illusion.

In these activities, your students will experience optical illusions.

ACTIVITY 1—MIRROR MAZE

Materials

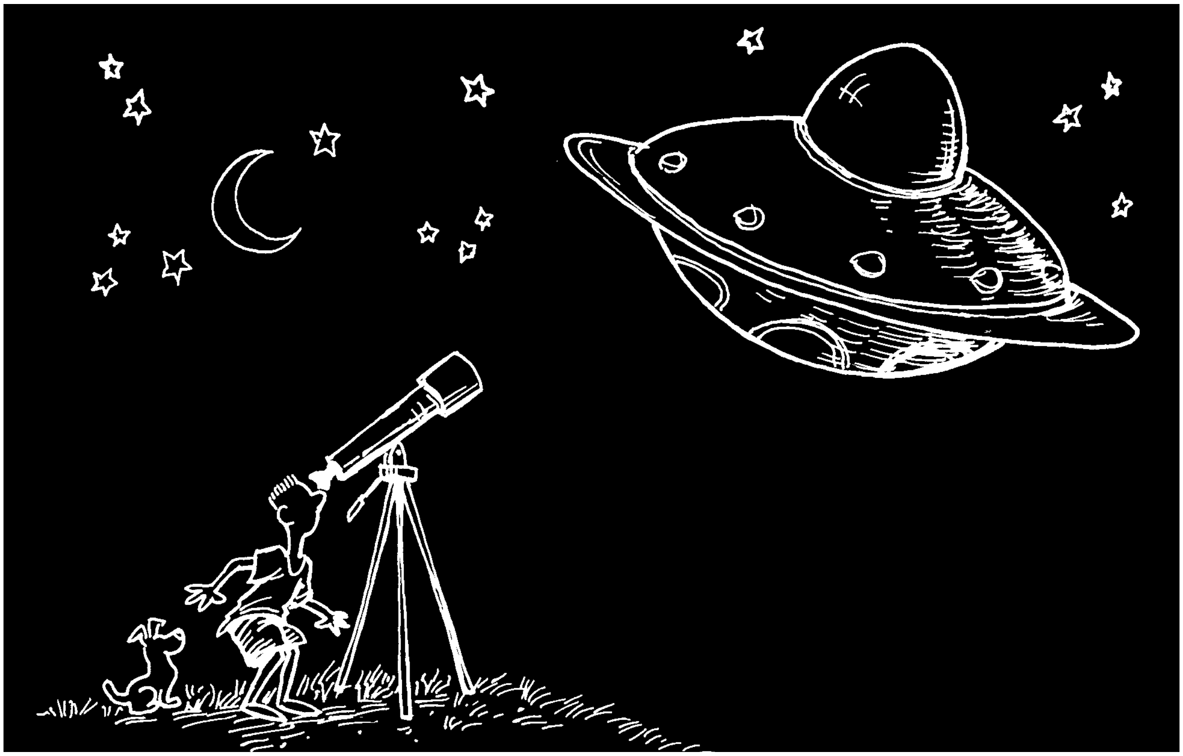
- a baseball cap for each student (students can provide their own)
- 1 small mirror per cap; mirrors should fit on the underside of the cap's brim
- masking tape
- 1 copy of the maze for each student (see below)
- a pencil for each student

QUESTIONS TO BEGIN

- Have you ever looked at words on a piece of paper while holding it up to a mirror? What did you see?
- If you tried to write your name on a piece of paper while holding it up to a mirror, what would happen? (Assume you were looking into the mirror while writing your name.)

PROCEDURE

1. Arrange students into teams of three or four. Give each team member some tape and a mirror.
2. Have students tape a mirror to the underside of each baseball cap's brim.
3. Give each student a maze and pencil.
4. Instruct students to put on a cap, look up into the mirror so that they see the maze, then try to complete the maze from start to finish.



5. Have students share their results and describe their experiences to members of their team.

6. If there's time, have students practice writing their names or drawing a picture on the back of the maze while looking in the mirror.

QUESTIONS TO CLOSE

- Did your hand do what you expected when you tried to draw or write?
- Did the experiment get easier with practice?
- Do you think you could learn to write in a mirror image, where everything is reversed?

ACTIVITY 2—TRY YOUR EYE

Materials

- photocopies of Illusions 1, 2 and 3, one for each student
- one ruler for each team

QUESTIONS TO BEGIN

- What is an optical illusion?
- Have you ever seen an optical illusion? Can you describe it?

PROCEDURE

1. Have students form teams of three or four.
2. Give a ruler and a copy of the Illusions to each team.

3. Have students look at Illusion 1. Ask them, “Are the stairs on the floor or ceiling?” Can they tell that the image can be seen from two different perspectives? (If students can’t see the stairs on the ceiling, have them spin the page so it’s upside-down.)

4. Next, have students look at Illusion 2. Ask them, “Which horizontal line is longer?” Have them compare the lines with the ruler.

5. Have students look at the lines in Illusion 3. Ask them, “Are the lines straight or wavy?” Have them check their answers using the ruler.

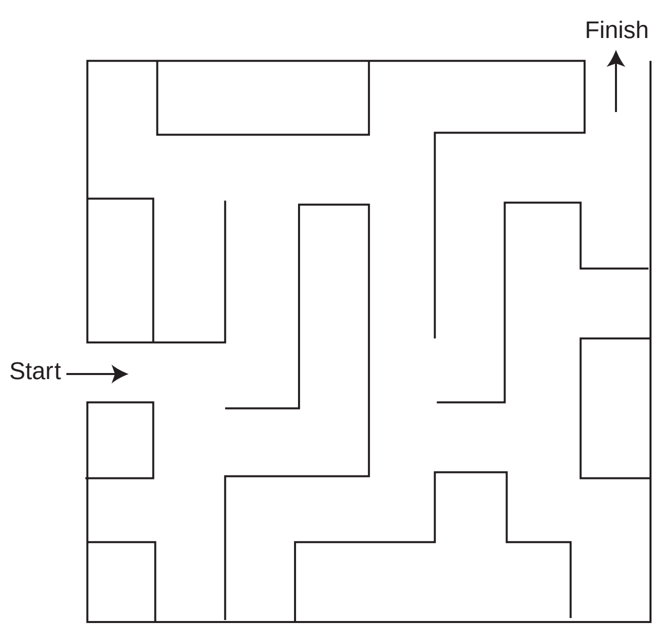
QUESTIONS TO CLOSE

- Was it hard to see that the stairs in Illusion 1 were both on the floor and on the ceiling?
- Why do you think the upper line in Illusion 2 looked longer?
- After you discovered that the wavy lines in Illusion 3 were actually straight, did the lines still appear wavy?
- Did everyone in your group perceive the illusions the same way, or did some interpret them differently?

Adapted from
Ontario Science Centre. Scienceworks: 65 experiments that introduce the fun and wonder of science. Reading, MA: Addison-Wesley Publishing Co., Inc., 1986.
Murphy, Pat, Ellen Klages and Linda Shore. *The Science Explorer Out and About.* 1st ed., New York, NY: Henry Holt and Company, 1997.

Sources
Bower, Bruce. “Rethinking the Mind.” Science News, October 17, 1992, p. 265.
Carter, Rita. Mapping the Mind. Berkeley: University of California Press, 1998.

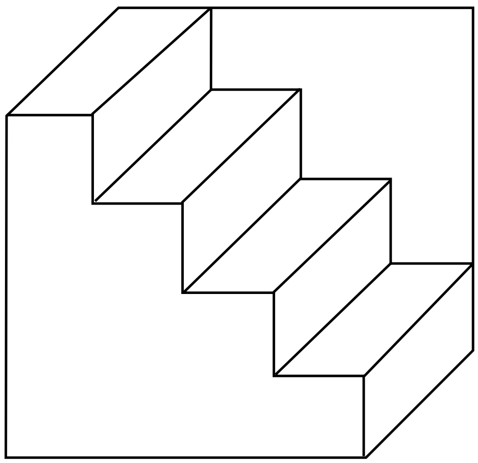
A-maze-ing! Maze

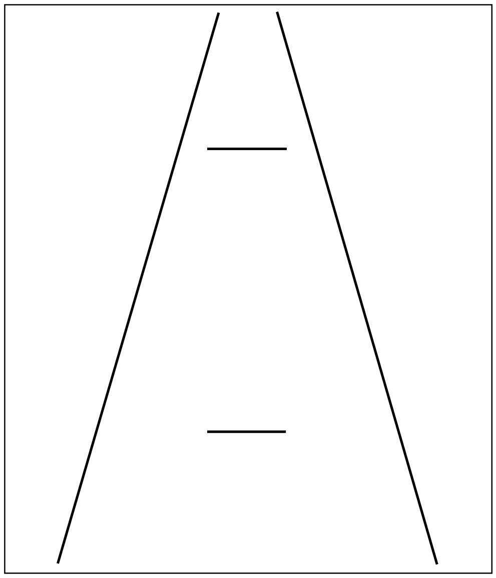


A-maze-ing!
Illusions

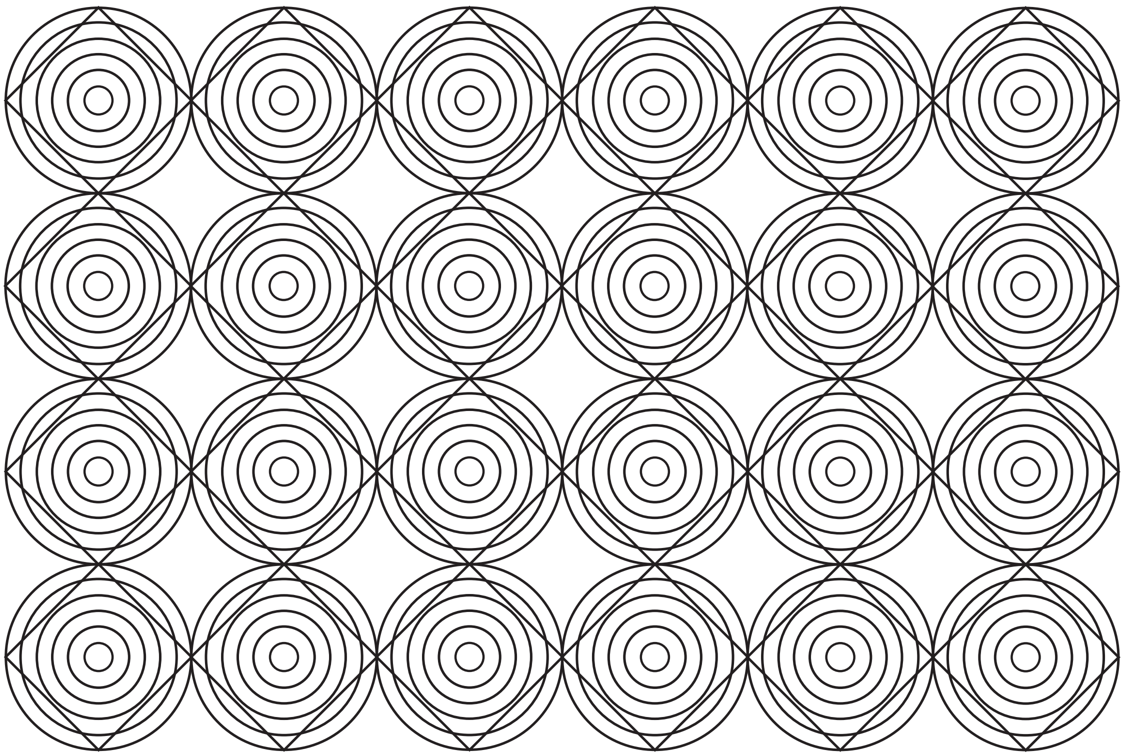
Illusion #2

Illusion #1





Illusion #3



Spying on Sleep

Subjects: life sciences, mathematics, language arts
Grades: 5 - 12
Concepts: data collecting, reasoning, communicating, calculating, graphing
Duration: one 30-minute session to start, several 10-minute sessions for making journal entries and one 30-minute wrap-up session

OBJECTIVES

Students will discover that...

- sleep is the brain's way of rejuvenating itself.
- the sleep they get at night directly affects how they feel during the day.
- they don't always get the same amount or quality of sleep every night.

BACKGROUND INFORMATION

All human brains need sleep. Sleep has many functions, some of which scientists don't fully understand. They do know that while asleep the brain makes vital proteins, such as those that maintain and repair brain cells, at a faster rate than while awake. Sleep also helps store energy efficiently. If you go too long without sleep, you'll lose your coordination and fast reactions, and you may stumble on words or slur your speech. How much sleep do you need every night? That depends—everyone's different.

In this activity students will keep a Sleep Journal to determine their regular sleep patterns. They'll record their time to bed, estimated time to fall asleep, the time they woke up, and the time they actually got out of bed. They'll also rate their energy levels when they woke up. They'll note sleep events, such as waking in the night, dozing after the alarm went off, or waking up just before the alarm sounded, along with any daytime observations, such as extra drowsiness. After seven days they'll compare their sleep entries with those of the other students in the class.

ACTIVITY

Materials

- 4 sheets of notebook paper per student
- 2 sheets of colored construction paper per student
- stapler
- 1 copy of the Morning Energy-Level Scale per student
- glue or tape
- crayons and/or markers for decorating sleep journals
- 1 copy of the Sleep Journal Questions per student
- pencils or pens

QUESTIONS TO BEGIN

- Do you think you need a lot of sleep or a little sleep?
- How many hours of sleep do you get each night, on average?
- If you went without sleep, do you think you'd be able to remember things as well as you could with a good night's sleep? Would you be able to think as clearly?

PROCEDURE

1. Begin by making the Sleep Journals: younger students can sandwich four pieces of notebook paper between two pieces of colored paper and staple along the left edge; older students can use notebooks.

2. Hand out copies of the Morning Energy-Level Scale (see below) and have students glue or tape it to the inside cover of their journals.

3. Down the left side of each journal page, have students write the following headings: Date, Wake-up Time, Time Out of Bed, Time to Bed, Estimated Time to Fall Asleep, Total Hours of Sleep, Morning Energy-Level Rating, and Notes. Be sure they leave a space for writing next to each heading; the Notes section should have extra room.

4. Explain that for the next week, the students will keep track of their sleep patterns. Each day they are to fill in each category. In the Notes section they are to write down anything else regarding their sleeping patterns: if they woke up at night, how many times they hit the snooze button on the alarm, if they woke up before the alarm, if they overslept, what their mood was, etc.

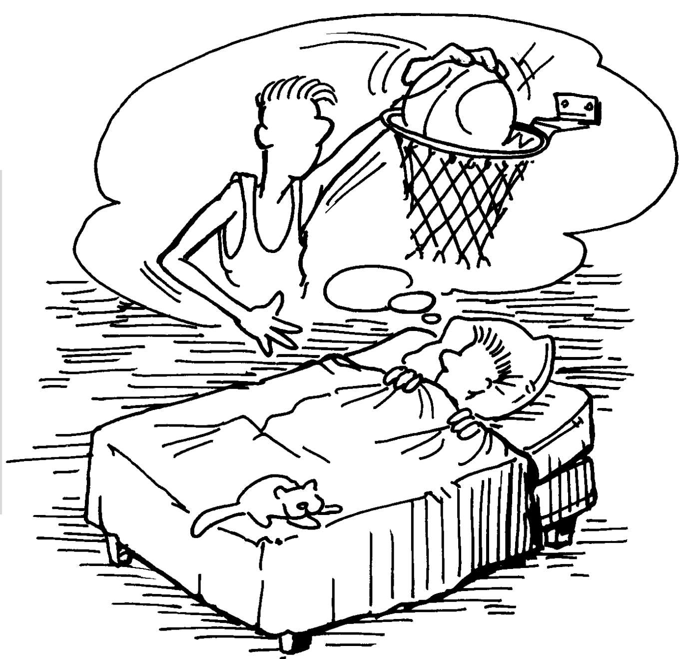
5. Instruct them that tonight they will write down the information about going to bed on the page with today's date (page 1). Tomorrow morning they are to record their waking information on page 2. Then, tomorrow night they will complete page 2, etc., for 7 days.

6. At the end of 7 days (counting weekends) gather the class together to evaluate the data.

7. Hand out copies of the Sleep Journal Questions (see below). Explain that students are to study the data in their journals to answer to the questions. Then have them write up their responses and turn them in.

MORNING ENERGY-LEVEL SCALE

5 = woke up before the alarm and jumped out of bed
4 = woke up with the alarm
3 = woke up with the alarm, but laid in bed awhile
2 = hit the snooze button several times (or parent came in several times), but eventually woke up
1 = overslept or slept in



SLEEP JOURNAL QUESTIONS

1. Did you go to bed the same time every night and wake up the same time every morning?

2. Make a bar graph (histogram) of the number of hours you slept each night. Label the X-axis Night 1, Night 2, Night 3, etc. The Y-axis will show the number of hours of sleep and should be labeled starting with 0 and ending with the most hours you slept on a single night. Did you sleep the same amount every night or did it vary?

3. Calculate the average number of hours you slept a night (add the number of hours you slept each night and divide by the number of nights).

4. Were there any nights when you got at least an hour less than your average amount of sleep? If so, check your energy-level rating for that day and write it down.

5. Check the Notes section for the day after you had a short night's sleep. Were you extra sleepy that day? Were you grumpy? Did you find it hard to concentrate or remember things?

6. Check your journal for a night when you had more than your average amount of sleep. What was your energy-level rating the next morning? Was it what you would expect? Why or why not?

7. Were there any nights when you had a hard time falling asleep? If so, how long did you estimate it took you to fall asleep? Did you note why you couldn't fall asleep? If you did, write down the reason.

8. Write a page describing your sleep patterns and your recommendations on how much sleep you need and why.

QUESTIONS TO CLOSE

- Discuss students' responses to the Sleep Journal Questions.

Sources
Arms, Karen and Pamela A. Camp. *Biology.* 4th ed., Fort Worth, TX: Saunders College Publishing, 1995.
Greenfield, Susan A. *The Human Brain: A guided tour.* New York, NY: Basic Books, 1997.
Sapolsky, Robert. "Wild Dreams." *Discover*, April 2001. pp. 37-43.
Whitfield, Philip, ed. *The Human Body Explained.* New York: Henry Holt and Company, 1995.

Deciphering Dreams

Subjects: life sciences, language arts
Grades: 6 - 12
Concepts: data collecting, describing, communicating, reasoning
Duration: one 30-minute session to start, several 10-minute sessions for making journal entries, and one 30- to 45-minute wrap-up session

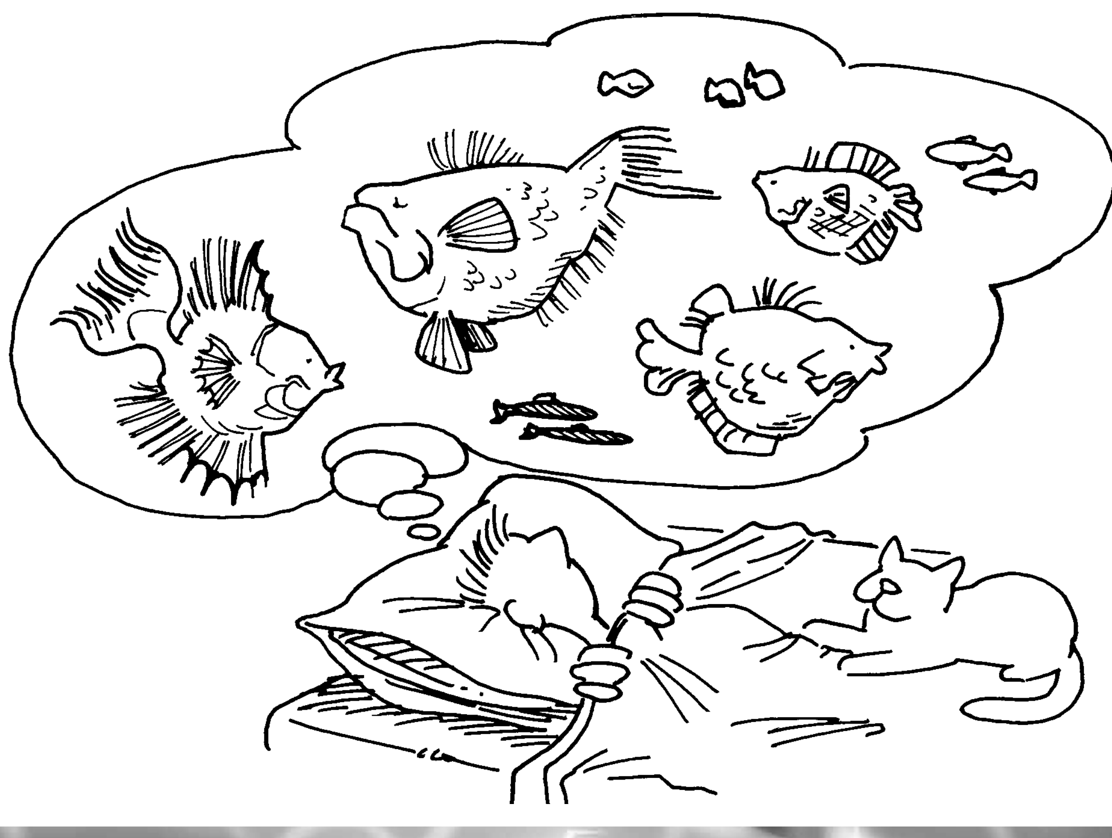
OBJECTIVE

Students will discover that...

- dreams are the brain's way of analyzing and setting into memory the events of the previous day or days.

BACKGROUND INFORMATION

Scientists don't fully understand why we dream. One theory says that dreams help us store the day's events into longer-term memory. This theory is called consolidation theory. The theory is based on the idea that the brain stores memories as groups of neurons that fire together in the same pattern every time. And, every time a group of neurons fires, scientists believe, the connections strengthen and consolidate into one functional memory group. The stronger the connection, the stronger the memory.



Where does dreaming fit in? Dreaming, or more specifically REM sleep, helps consolidate memories. REM stands for rapid eye movement. It's the stage of sleep where the eyes dart rapidly back and forth, and when most dreaming happens. During REM sleep, groups of neurons that comprise memories fire and re-fire, strengthening connections and thus strengthening memories.

Dreaming is your brain's way of sorting out important tidbits of information, filing them into long-term storage, and discarding the rest. It also helps you store new information. When people learn a new task, they are better able to repeat that task the next day if they have a good night's sleep. If they're deprived of REM sleep, however, they don't do nearly as well.

In this activity students will explore the consolidation theory of dreaming. By keeping a dream journal, they'll examine the connections between their dreams and events of the day or days past.

ACTIVITY

Materials

- 1 journal per student
- pencils or pens

QUESTIONS TO BEGIN

- How many of you remember your dreams?
- Do you remember all of your dreams?
- What purpose do you suppose dreams serve?

PROCEDURE

1. Explain that for the next week, when they wake up every morning, the students are to record the date and their dreams for the previous night in as much detail as possible. Once they have recorded their dreams they are then to write down anything from the past couple of days that were included in their dreams. For example, a student who dreamed about going to the circus may want to note the story about clowns that she had read the day before.
2. At the end of the week, ask students to share a dream and how it related to daytime events.
3. Finish this activity with students writing a summary or conclusion page about the connection between dreams and daily events.

QUESTIONS TO CLOSE

- Were you able to connect dream events with events in your daily life?
- Did you have some dreams that seemed to have no connections with daily life?
- Do you think you remembered every dream you had?
- Why is a good night's sleep important before a big test or a competition?

Sources

Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.
Whitfield, Philip, ed. *The Human Body Explained.* New York: Henry Holt and Company, 1995.

Pre-Visit Activities

AT SCHOOL

This group of activities will help your students explore how their brains work at school—while they're learning new information, storing it into long-term (or short-term) memory, retrieving it for tests, and applying what they've learned. They may even learn a few memory tricks.

Reading the Brain

Subjects: life sciences, language arts
Grades: 3 - 12
Concepts: reading, communicating
Duration: one 30-minute class session

OBJECTIVES

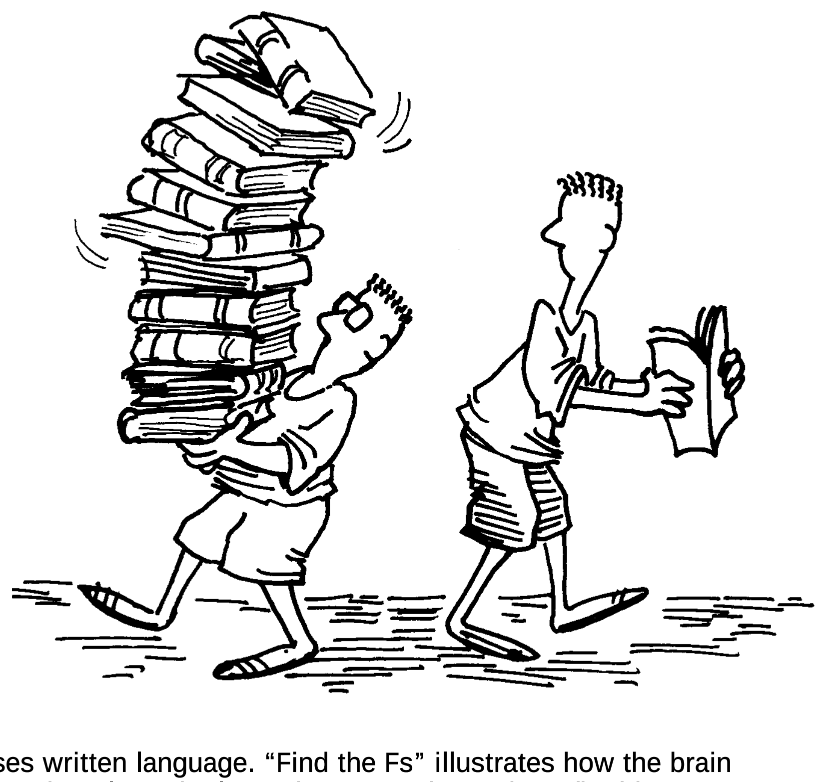
Students will discover that...

- while reading, the brain processes short, familiar words as a whole and decodes longer words letter-by-letter.
- while reading sentences, the brain processes a familiar group of words as a single phrase.

BACKGROUND INFORMATION

As children grow, they develop speech naturally. This is not true of reading. Children have to be taught to read.

People don't read all words in the same way. At first, when a child is learning to read, he or she links letters to their sounds to decipher words. In time, the child learns to recognize certain words, especially short ones, on sight. The brain stores small words, such as "of," as a unit, while longer words require decoding. The brain also stores common groups of words, such as "in the," as a whole phrase. Words or phrases the brain sees as whole units are called sight words or sight phrases. If something is missing or odd in one of these sight words or phrases, the brain compensates for the problem based on the context of surrounding letters or words.



In this activity your students will learn ways that the brain processes written language. "Find the Fs" illustrates how the brain interprets some words by decoding them letter-by-letter, but recognizes others (in this case the word "of") as whole units. The activity "I Love Paris" demonstrates how the brain recognizes common phrases as a whole. And the sentence "The cat sat on the mat" illustrates how the brain interprets confusing information by filling in the correct letters based on context.

ACTIVITY

Materials

- copies of the sentences (see below)

QUESTIONS TO BEGIN

- When you read, do you look at individual letters, individual words, groups of words or a combination of all three?
- What do you do when you're reading and you come across a new word?

PROCEDURE

1. Hand out copies of "Find the Fs." Instruct students to silently read the sentence and count the number of Fs it contains.

2. Ask the class: how many found four Fs? five? six? For those that didn't find all six, suggest they look for the word "of" (there are two) or have them read the sentence backwards.

3. Discuss the fact that the brain sees short words like "of" as whole units, while it looks at large or less familiar words letter-by-letter.

4. Hand out copies of "I Love Paris" and give the students a moment to silently read the sentence in the triangle. Call on two or three students and ask them what the sentence says. Does the rest of the class agree?

5. Explain that people miss repeated words, like the second "the" in this sentence, because the brain sees certain word patterns, such as "in the," as a whole phrase rather than as two separate words.

6. Hand out copies of "The cat sat on the mat" and have students read it silently. Ask two or three students what the sentence says. They should be able to read it, although all the "As" and the "Hs" have the same shape.

7. Explain that when you see something that can be interpreted two different ways, the brain automatically chooses the view that makes the most sense, based on the letters or words around it.

QUESTIONS TO CLOSE

- Were you surprised to find that there were six Fs in the first sentence? How about the repeated word "the" in the second sentence?
- Did you notice that in the sentence "The cat sat on the mat" the letters H and A had the same shape? Did you have trouble reading the sentence?

Adapted from
Gardner, Martin. *Entertaining Science Experiments with Everyday Objects*. New York: Dover Publishers, Inc., 1981.
Murphy, Pat, Ellen Klages, Pearl Tesler, Linda Shore and The Exploratorium. *The Brain Explorer: Puzzles, riddles, illusions and other mental adventures.* San Francisco: The Exploratorium and Henry Holt & Co., L.L.C., 1999.

Sources
Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.
How Children Learn to Read Words [web site]. Available from http://www.auburn.edu/~murraba/insight.html

Reading the Brain

Sentences

FINISHED FILES ARE THE RE-
SULT OF YEARS OF SCIENTIF-
IC STUDY COMBINED WITH
THE EXPERIENCE OF YEARS

I

LOVE

PARIS IN THE

THE SPRINGTIME

THE CAT SAT ON THE MAT

False Memories

Subjects: life sciences, language arts
Grades: 6 - 12
Concepts: comparing, communicating, reasoning
Duration: one 30-minute class session

OBJECTIVE

Students will discover that...

- making associations helps the brain store and access memory.

BACKGROUND INFORMATION

Many people use associations when they need to remember a word list. For instance, they may think "cake" if a grocery list includes milk, eggs and sugar. But sometimes this technique can backfire. You could come home with milk, eggs, sugar and flour. If you did, your brain tricked you into remembering something that wasn't there. Flour, in this case, would be a false memory.

Associations help your brain remember because the brain stores memories as a network of neurons (nerve cells). When a particular event happens, several neurons "fire," that is, each carries an impulse. Then, each time you recall the memory, the neurons fire again, strengthening their connections and triggering neighboring cells to fire. Before long, a whole network of neurons fires together. A memory is made. Because of the neural network, there are many paths to that memory. But sometimes the brain gets fooled and remembers something that isn't in the memory. Usually that happens when the false memory is closely related to the true memory.

In this activity your students will learn how the brain can trick them into remembering things that were never there. Each of the following lists contains words that are related to two key words, neither of which are on the list. When you ask your students to recall whether or not certain words were on one of the lists, chances are they'll incorrectly say the key words were.

ACTIVITY

Materials

- 1 copy of Lists A1 and A2
- 1 copy of Lists B1 and B2 for every two students
- 1 copy of Lists C1 and C2 for every two students
- blackboard and chalk

QUESTIONS TO BEGIN

- When you have to remember a list of items, like a shopping list, do you have any tricks that help you remember it?

PROCEDURE

1. Tell the class you're going to read a list of words out loud. They need to pay close attention because in a few minutes they're going to have to remember whether certain words were on the list.
2. Read List A1 slowly, saying one word about every 1.5 seconds.
3. When you're done, tell them you're about to read another list of words. They are to raise a hand when you say a word that was on the first list. (If students might respond based on other students' responses, have them lay their heads on their desks so they can't see the show of hands.)
4. Slowly read each word from List A2. Count the number of students who thought each word was on the original list and record results on the board.
5. Have students raise their heads (if applicable) and review the results.

List A1

smooth	summit	ready	glacier	climber
hill	tough	coarse	rugged	range
valley	sandpaper	peak	sand	steep
bumpy	top	plain	goat	ground
road	molehill	uneven	boards	gravel
climb	jagged	riders	bike	ski

List A2	on list A1?
smooth	yes
mountain	no
riders	yes
tumble	no
snow	no
rough	no

6. Now have students form teams of two. Give one member of each team a copy of Lists B1 and B2 and the other a copy of Lists C1 and C2. Let them take turns testing each other's memories by following steps 2 through 4 above.

List B1

thread	sewing	swim	haystack	brook
pin	Mississippi	prick	thorn	fish
water	boat	thimble	creek	cloth
stream	tide	flow	hurt	knitting
eye	sharp	run	injection	bridge
lake	point	barge	syringe	winding

List B2 — on list B1?

List B2	on list B1?
thimble	yes
needle	no
bridge	yes
rapids	no
river	no
shot	no

List C1

web	fright	crawl	bite	ugly
insect	bitter	tarantula	soda	cake
sour	fly	poison	creepy	feelers
candy	good	tooth	animal	small
sugar	taste	nice	chocolate	tart
bug	arachnid	honey	heart	pie

List C2 — on list C1?

List C2	on list C1?
candy	yes
sweet	no
widow	no
tooth	yes
spider	no
bread	no

QUESTIONS TO CLOSE

- How many of you remembered hearing a word that wasn't on the list read out loud?
- Why do you suppose you falsely remembered words?
- What might this say about how your brain helps you remember things?

Adapted from

Murphy, Pat, Ellen Klages, Pearl Tesler, Linda Shore and The Exploratorium. *The Brain Explorer: Puzzles, riddles, illusions and other mental adventures.* San Francisco: The Exploratorium and Henry Holt & Co., L.L.C., 1999.

Roediger, Harry L. III and Kathleen B. McDermott. Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology* 21 (4: 1995): 803-814.

Sources

Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.

Richardson, Sarah. "When Memories Lie." *Discover,* January 1997, p. 50.

Schacter, Kenneth A., Kenneth A. Norman and Wilma Koustaal. The cognitive neuroscience of constructive memory. *Annual Reviews Psychology* 49 (1: 1998): 289-318.

Whitfield, Philip, ed. *The Human Body Explained.* New York: Henry Holt and Company, 1995.

Super Memory

Subjects: life sciences, language arts, mathematics
Grades: 3 - 12
Concepts: comparing, organizing, memorizing, reasoning, describing
Duration: one 30- to 45-minute class session

OBJECTIVES

Students will discover that...

- they can use tricks to help their brains remember better.
- memory works best when ideas are linked together.

BACKGROUND INFORMATION

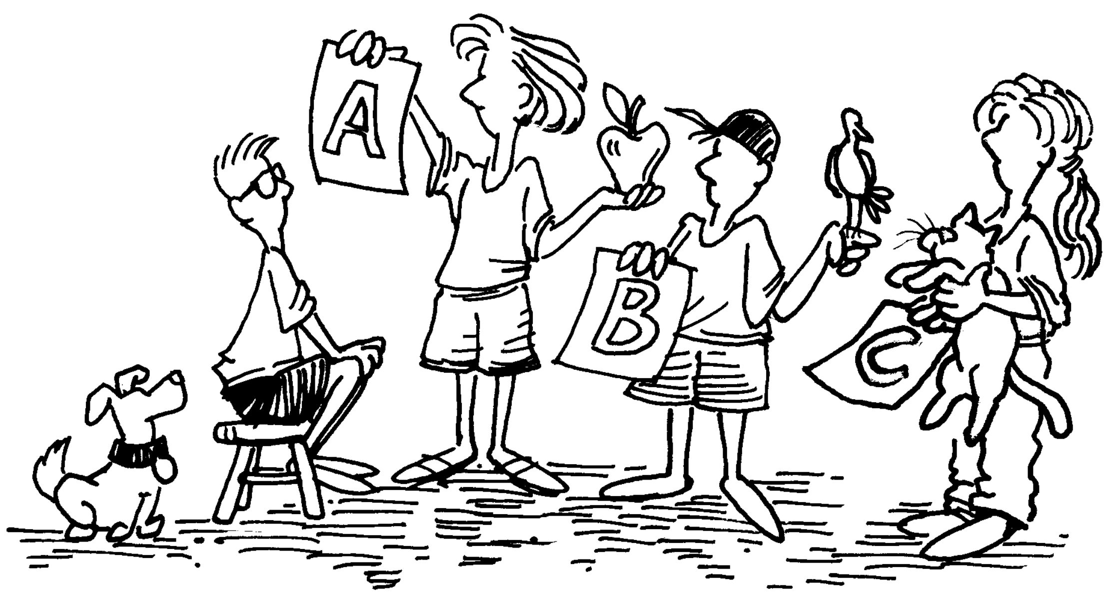
A well-known trick for memorizing lists is to associate items on the list with other ideas. The goal is to maximize the number of pathways to the memory. Such a trick is called a mnemonic (say, new-mon-ick) device.

Mnemonics work by forming many paths to a single memory. For example, you can take the first letter of each word in a list you need to remember and make a sentence out of words with those letters. Let's say you need to remember the first five presidents of the United States:

Washington, Adams, Jefferson, Madison, Monroe.

To help you remember, make a sentence out of the first letters of their names:

When Adam Jumped, Mary Mooed.



This mnemonic is extra helpful because it has two added clues: “Adam” helps you remember the second president, John Adams; and “Mary” comes before “mooed” to help you remember Madison comes before Monroe.

You can also try making up a story about a list of words. For example, let’s say you have to remember four things—an apple, a pie pan, a dog and a jump rope. You could make up a story like this:

> A woman was going to bake an apple pie. While she looked for her pie pan, her dog ate one of the apples. When she discovered an apple missing, she tied the dog to a tree with a jump rope.

Mnemonics can help you remember numbers, too, such as phone numbers, the combination to a gym locker or a number series.

Imagine that you have to memorize a friend’s phone number: 426-2580. You can remember the prefix, 426, by making a math equation out of it: 4 + 2 = 6. Or, it may simply be the same prefix that’s in your phone number. The second half, 2580, is easy to remember, too. Look at a telephone and you’ll see these four numbers form a straight line down the center of the key pad.

Another phone-number trick is to make words out of the numbers. Each number on the telephone key pad (except 0 and 1) has three letters associated with it (2 = A, B, C; 3 = D, E, F, etc.). If you want to remember 692-7426, just remember it spells out MY BRAIN. If a number has a 1 or 0 in it, you can use the letter ‘L’ for one and ‘O’ for zero, and just remember you made that change.

Another number mnemonic is to group lots of little numbers together to make a few big numbers. You can turn the number 1 4 9 2 1 9 8 0 1 9 0 1 into just three dates — 1492, 1980 and 1901.

These activities will show students how they can develop super memories by using mnemonic devices.

ACTIVITY 1

Materials

- 20 small, common objects per station
- 1 towel per station
- timer
- pencil and paper for each student

QUESTIONS TO BEGIN

- If someone gave you a list of ten things to remember, could you remember them all?

PROCEDURE

1. Set up the memory stations, each with a unique collection of 20 objects covered with a towel. Make as many stations as you need so that groups of students working around them can see all the objects.

2. Explain that below each towel is a collection of 20 everyday objects. Students will have two minutes to study the objects and another two minutes to make a list of all the objects they can remember.

3. Have students stand by a station of his or her choice; there should be about the same number of students at each. When all are ready, remove the towels, start the timers and have students study the objects for 2 minutes. At the end of 2 minutes replace the towels.

4. Set timers for another 2 minutes and have each student write down every object he or she can remember. Make sure students work individually.

5. After 2 minutes, ask students how many objects they could recall.

6. When all are finished, have students move to a different station. Repeat Steps 3 through 6, but this time have students remember the objects by making up a story about them.

7. Compare results with the first try.

QUESTIONS TO CLOSE

- Did you remember more objects the first time or the second time?
- Did making up a story help you remember the objects? Why or why not?

ACTIVITY 2

Materials

- pens or pencils and paper
- something to cover up the writing on the blackboard
- timer

ADVANCE PREPARATION

1. Make up a list of imaginary phone numbers and write each number on a separate strip of paper. Make sure the numbers include some type of pattern, similar to the phone number in the Background Information.

QUESTIONS TO BEGIN

- Do you have a hard time remembering numbers?
- How might you make remembering numbers easier?

PROCEDURE

1. Begin by sharing the mnemonic devices in the Background Information. As you do, diagram on the blackboard a phone key pad, showing the numbered buttons and the letters that are printed on each.

2. Hand each person an imaginary phone number.

3. Give students 2 minutes to invent a mnemonic for their phone number. Have them write the mnemonic on a piece of paper, then cover it up.

4. Call on individual students and ask each to recite the phone number they memorized. Write the number on the board and have the students share the mnemonic devices they used.

5. Write the following 8 digits on the blackboard: 9 3 6 3 2 2 6 8.

6. Give students 2 minutes to invent a mnemonic to remember the series. Students should work individually. Have them write down their mnemonic on a piece of paper and cover it up.

7. Cover the digits on the blackboard.

8. Distract the students for a minute by calling on two or three and asking each how many brothers and sisters they have.

9. Now have students write down the 8 digits on the board from memory.

10. Reveal the digits and have students check their answers. Ask, “How many of you got it right?” Ask those who did to share their mnemonic.

QUESTIONS TO CLOSE

- Which method do you prefer—turning numbers into letters, grouping numbers or making associations between numbers? Why?

Adapted from

Murphy, Pat, Ellen Klages, Pearl Tesler, Linda Shore, and The Exploratorium. *The Brain Explorer: Puzzles, riddles, illusions and other mental adventures.* San Francisco: The Exploratorium and Henry Holt & Co., L.L.C., 1999.

Sources

Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.

Schacter, Kenneth A., Kenneth A. Norman and Wilma Koustaal. The cognitive neuroscience of constructive memory. *Annual Reviews Psychology* 49 (1: 1998): 289-318.

Recital Recipe

Subjects: life sciences, language arts, performing arts
Grades: 3 - 12
Concepts: memorizing, communicating, comparing, reasoning
Duration: one 30- to 40-minute session to start, several 5-minute practice sessions and one 20- to 30-minute wrap-up session

OBJECTIVES

Students will discover that...

- short-term memory and long-term memory are two different ways of remembering.
- repetition helps the brain turn short-term memories into long-term ones.

BACKGROUND INFORMATION

You have different types of memory based on how long you want to retain a fact or recollection. Short-term memory is just like it sounds: it operates on the short term, usually a couple of hours or less. You use short-term memory when remembering a shopping list, cramming for a test or trying to remember a series of numbers. Long-term memory operates for periods longer than several hours and can last a lifetime. It lets you learn from experience and learn new, more complex concepts based on what you already know.

Scientists think that when you memorize something, the memory is stored in your cortex (the outer, wavy part of your brain) as a new and unique set of nerve-cell connections. The nerve cells of a particular memory work as a unit—when one fires, they all fire. At first the connections between a memory's nerve cells are weak. But each time you recall a memory, the connections between nerve cells strengthen. Thus, the connections between nerve cells are stronger in long-term memory than in short-term memory. Additional genetic and chemical changes in nerve cells help cement the long-term memory in place.

In this activity students will learn the difference between short-term and long-term memory. They will start by memorizing two short poems and reciting both within the hour. Then, over the next week, each student will recite one of the poems at least once a day, and not give the other any more thought. At the end of the week, they'll recite both and see what happens.

ACTIVITY

Materials

- assortment of books with short poems
- pencil and paper for each student

QUESTIONS TO BEGIN

- If you memorize two poems at the same time, which will you remember better—the one you practiced once or the one you practiced over and over? Why? Do you have any idea what happens in your brain?

PROCEDURE

1. In the morning, tell the class that they will be choosing two short poems to recite at the end of the day. Give the class about a half hour to look through books of poems and to choose two they would like to memorize. The two poems should be about the same length and difficulty. Have students take 15 to 20 more minutes to copy down each poem and memorize it.

2. Throughout the day, take one or two five-minute breaks during which the students refresh their memories. At the end of the day have pairs of students recite both poems to each other from memory.

3. When the recitals are over, have each student choose one of the poems to commit to long-term memory. Tell them they can look at the poem they chose as much as necessary, but they can't look at, recite or even think about the poem they didn't choose.

4. Each day for the next week, allow five minutes for each student to rehearse the poem he or she chose to remember.

5. At the end of the week, have student pairs re-join and take turns reciting the practiced and unpracticed poems.

QUESTIONS TO CLOSE

- Were you able to recite both poems at the end of the week?
- What happened when you recited the poem you didn't practice?
- Why might it be better to review test material over a period of several days than to cram all at once right before the test?

Sources
Arms, Karen and Pamela A. Camp. *Biology.* 4th ed., Fort Worth, TX: Saunders College Publishing, 1995.
Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.
Whitfield, Philip, ed. *The Human Body Explained.* New York: Henry Holt and Company, 1995.

Pre-Visit Activities

AT PLAY

This group of activities will help your students explore how their brains work at play—when they're catching balls, skipping in time, running like the wind, or anticipating an opponent's next move.

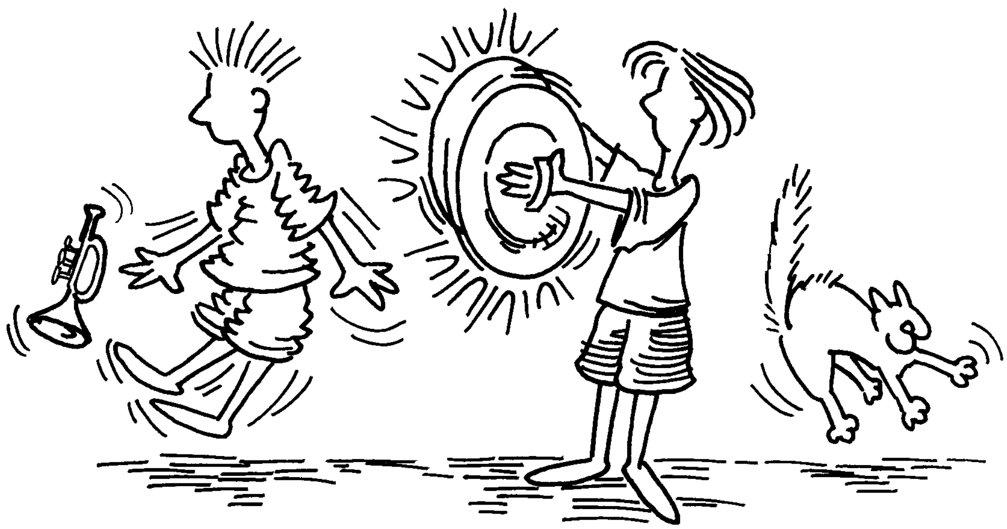
Reflexes

Subjects: life sciences
Grades: K - 12
Concepts: predicting, collecting data, comparing, observing, reasoning
Duration: one 45-minute class session

OBJECTIVES
Students will discover that...

- a reflex is a response to a stimulus that doesn't require brainwork.
- a reflex is fast.

BACKGROUND INFORMATION
Imagine you're playing or working in your yard and pick up a wooden stick. The stick jabs you with a splinter. Without thinking, you drop the stick. What happened?



You had a simple reflex response. When the nerves in your finger sensed the splinter, an impulse traveled along a sensory neuron (a nerve cell that senses sensations) to your spinal cord. There, the impulse passed to a motor neuron (a nerve cell that initiates movement), which carried the impulse back to the muscles in your fingers. The impulse made the muscles contract, and your fingers let go of the stick. At no time did the impulse travel to your brain for processing in order to make your fingers respond. Eventually your brain did receive an impulse. The sensory neuron carrying the original impulse also sent an auxiliary impulse to the brain. When it got there, your brain probably made you say "Ouch!" But by the time your brain registered the splinter, your fingers had already dropped the stick.

That's the beauty of a reflex—it's fast. And you don't even have to pay attention. Reflexes are no faster when you're paying attention than when you're not.

In this activity your students will learn about their bodies' reflexes. They will experiment with a physician's reflex hammer, make predictions about what will happen under varying conditions and compare results. They will also observe the photopupil reflex by shining a light on the eye and watching the pupil contract. They will conclude by testing the blink reflex, in which the eyes blink when a cotton ball is tossed at the face.

ACTIVITY 1—SLAM! (GRADES K - 12)

Materials

- a book
- chalkboard and chalk

QUESTIONS TO BEGIN

(see Procedure)

PROCEDURE

1. Begin by introducing the splinter scenario in the Background Information. When you get to the part that explains what a reflex is, discretely slide a book from the table so it lands on the floor with a loud slam.

2. Query the students for their responses: How many jumped, how many moved their heads, how many screamed, how many blinked their eyes, how many put their hands up? Tally the results on the board.

3. Explain that these are all reflexes to a stimulus—in this case, the loud noise that the book made.

4. Now that they're familiar with reflexes, explain that they will be doing a series of one or more experiments to explore reflexes.

ACTIVITY 2—KNEE TAP (GRADES 4 - 12)

Materials

- reflex hammers (optional)

PROCEDURE

1. Place students into teams. Distribute the reflex hammers and demonstrate the correct way to use one: gently tap the bottom edge of a seated student's kneecap (patella) with the small end of the hammer. (If you don't have the hammers, use the side of your hand. Do NOT use a carpenter's hammer.)

2. Have students take turns testing their patellar (knee) reflexes. Tell students to relax the legs and watch the hammer strike below the knee.

3. Explain that they will now repeat the reflex test, but this time they will not watch the hammer. Have them make a prediction: will the reflex response be faster, slower or the same speed when they don't watch? Once students make a prediction, have them test it.

ACTIVITY 3—PUPIL TEST (GRADES 3 - 12)

Materials

- a darkened room

PROCEDURE

1. Have students pair up and face each other. Explain that you will be turning out the lights in the room for 30 seconds. When you turn the lights back on, each student is to look into his or her partner's eyes and watch what happens.
2. Turn out the lights in the room.
3. After 30 seconds, turn the lights on while students watch each other's eyes.

ACTIVITY 4—BLINK TEST (GRADES 3 - 9)

Materials

- cotton balls
- pieces of clear Plexiglas or classroom windows

PROCEDURE

1. Hand out the clear Plexiglas sheets to pairs of students. (If you're using classroom windows instead, skip to Step 2.)
2. Have pairs decide who's Student A and who's Student B.
3. Have Student A hold the acrylic sheet up in front of his or her face. (Or have one student of each pair stand on either side of a window, with Student A's face close to the glass.)
4. Have Student B toss a cotton ball at Student A's face. Did Student A blink?

QUESTIONS TO CLOSE

- Was your patellar reflex faster when you were looking than when you weren't? Or was there no difference? What might account for the results of the Knee Tap experiment?
- What happened to your partner's pupil when the lights came back on? What advantage might the pupil reflex have?
- Did you blink when your partner tossed the cotton ball at your face? Why is this reflex important?
- Why are reflexes important?

Adapted from

Gunstream, Stanley E. *Explorations in Basic Biology.* 8th ed. Upper Saddle River, NJ: Prentice Hall, 1996.

University of Washington. *Neuroscience for Kids* [web site]. Available from http://faculty.washington.edu/chudler/chreflex.html

VanCleave, Janice Pratt. *Biology for Every Kid: 101 easy experiments that really work.* New York: John Wiley & Sons, Inc., 1990.

Sources

Arms, Karen and Pamela A. Camp. *Biology.* 4th ed., Fort Worth, TX: Saunders College Publishing, 1995.

Hot or Cold?

Subjects: life sciences, mathematics
Grades: 2 - 12
Concepts: measuring, comparing, reasoning, describing, communicating, predicting
Duration: one 30- to 45-minute class session

OBJECTIVES

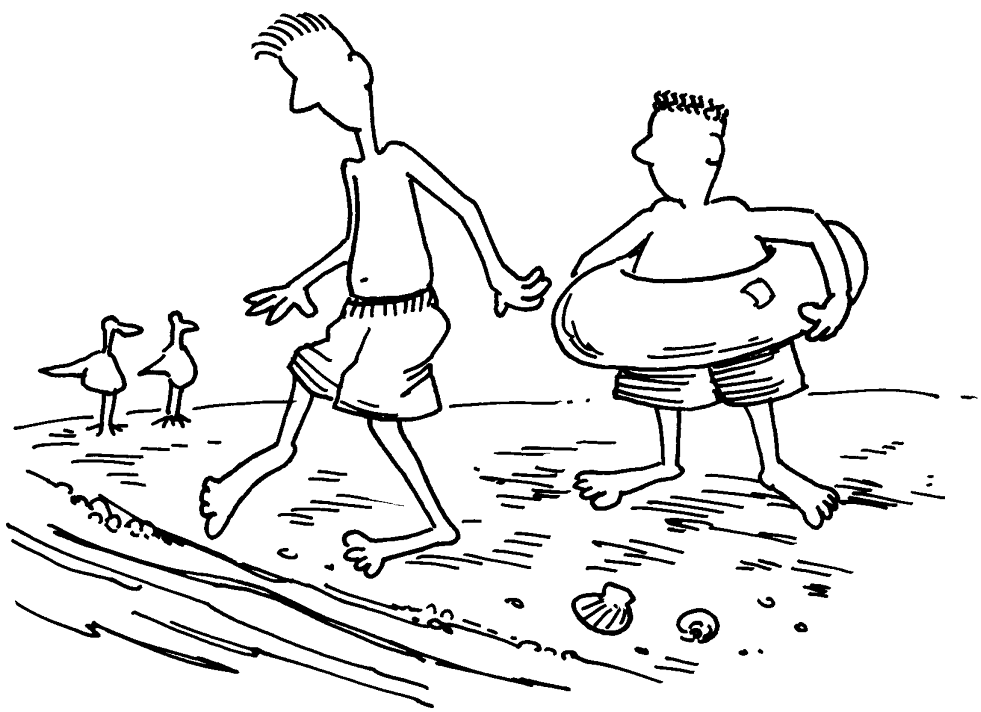
Students will discover that...

- warm can feel hot or cold.
- temperature sensors (called thermoreceptors) in the skin feel changes in temperature.
- they need their brains to help them interpret temperature signals from the skin's thermoreceptors.

BACKGROUND INFORMATION

Have you ever been outside and had an adult rush out and make you put on a jacket because, "It's freezing out here"? But you didn't think it was cold at all?

Hot and cold are relative, depending on how your brain receives impulses from neurons (nerve cells) in the skin. For example, warm water can feel especially hot if your neurons are used to feeling cold. In addition, when more neurons in your skin get stimulated, the brain interprets their added impulses to mean that cold is colder or hot is hotter. You can feel this happen when you test the temperature of a swimming pool with your toe and decide it's just right. But when you take the full-body plunge… Brrrrrrr!



Your skin contains different types of sensing receptors. The type of receptor that senses hot or cold is a neuron called a thermoreceptor. This type of sensor cannot detect exact temperature, but is great at detecting changes in temperature. Your brain then decides what's truly hot and what's cold.

In this activity your students will explore the brain's interpretation of impulses from thermoreceptors in the skin. When a student soaks a hand in cold water, then puts it into room-temperature water, the room-temperature water feels warm. And, when a student soaks a hand in warm water, then puts it into room-temperature water, the room-temperature water feels cold. Students will also discover that water seems less cold when felt with a fingertip's few thermoreceptors than it seems when felt with a hand's many thermoreceptors.

ACTIVITY

Materials

- a hot plate
- 3 large (4-quart or 4-liter) pans
- a clock with a second hand
- immersion thermometers
- towels for drying hands

and for each team

- 3 bowls
- water
- ice
- paper and pencils

ADVANCE PREPARATION

1. Fill a large pan with water and heat it on a hot plate to about 90 degrees Fahrenheit or 32 degrees Celsius (this will be the "warm" water).
2. Fill another large pan with ice and water.
3. Set a third pan out and let it adjust to room temperature.

QUESTIONS TO BEGIN

- Can you tell the difference between warm and cold? Are you sure?

PROCEDURE

1. Arrange students into teams of two to four. Have each team decide who will be the recorder, responsible for data collection, and give that person a piece of paper and pencil.
2. Have students fill one bowl with warm water, one with room-temperature water and one with ice water (but no ice). Or fill the bowls yourself and hand them to each team.
3. Have the recorder measure the water temperature in each bowl and record the results. Then have the recorder arrange the bowls of water on the counter so that the warm water is in the middle. (If you keep the temperatures secret from the other students until the end, their reports of what they feel will be more accurate during the experiment.)

4. Ask students: If you feel the cold water with one finger, will it feel warmer, cooler or the same when you feel it with an entire hand? Have team recorders write (or have teams state) their predictions.

5. Have students take turns dunking one finger in the cold water, feeling the temperature, then removing the finger from the water and immersing his or her entire hand. Does the water suddenly feel colder, warmer or the same? Have the recorder record (or have teams state) the results.

6. Ask students: if you soak your hand in cold water, then put that hand in room-temperature water, will the room-temperature water feel cold, warm or hot? What about if you soak a hand in the warm water first then put it in room-temperature water? Have the recorder write (or have teams state) their predictions.

7. Let students take turns simultaneously soaking one hand in the warm water and one in the cold water for 30 seconds. At the end of 30 seconds, have that person put both hands in the room-temperature water and state what he or she feels in each hand. If you're using recorders, have them write the results.

8. At the end of the experiment, have the recorder reveal the temperatures of each bowl to team members.

QUESTIONS TO CLOSE

- Does water temperature feel the same to one finger as it does to your entire hand? Which has the stronger sensation? Why?
- After one hand had been soaking in cold water and the other in warm water, did the room-temperature water feel the same to both hands? What do you think makes the water feel warmer or colder than it really is?

Adapted from
Gunstream, Stanley E. *Explorations in Basic Biology.* 8th ed. Upper Saddle River, NJ: Prentice Hall, 1999.
Ontario Science Centre. *Scienceworks: 65 experiments that introduce the fun and wonder of science.* Reading, MA: Addison-Wesley Publishing Co., Inc., 1986.
Wiese, Jim. *Head to Toe Science.* New York: John Wiley & Sons, Inc., 2000.

Sources
Audesirk, Teresa and Gerald Audesirk. *Biology: Life on Earth.* 5th ed. Upper Saddle River, NJ: Prentice Hall, 1999.

Quick! Catch!

Subjects: life sciences, mathematics
Grades: 2 - 12
Concepts: measuring, comparing, data collecting, calculating, graphing
Duration: one 45-to 60-minute class session and several subsequent 15-minute sessions

OBJECTIVE

Students will discover that...

- reaction times vary from person to person and from moment to moment.

BACKGROUND INFORMATION

How fast can you react to a surprising situation? A fast reaction time can help you win that football game, correct a bad landing on a snowboard jump, avoid a traffic accident, or catch the can of soda your friend almost knocked over. What controls your reaction time? Your nervous system. Some types of reactions are reflexes, in which your body's nervous system reacts without the help of your brain (see Reflexes activity). Other reactions require you to think. In these reactions, neurons (nerve cells) in the part of your brain called the cerebral cortex process incoming information and send out impulses or instructions to your body.

In this activity students will see how their reaction times measure up by testing how far a measuring stick falls before they catch it, then recording reaction times. Reaction time is the time required for an electrical impulse to travel from the brain, down the spinal column and into the muscles. When a student sees the measuring stick begin to fall, his or her brain sends a message down the spinal column. There the message jumps to neurons that run along the arm and into the fingers. The fingers clamp down and catch the stick.

ACTIVITY

Materials

- for each student team
- a measuring stick (yardstick or meter stick)
- paper and pencil to record reaction times

QUESTIONS TO BEGIN

- Do you have fast reactions or slow reactions?
- Do you always have the same reaction time from one moment to another?

PROCEDURE

1. Divide the class into teams of three students. Have Student A sit in a chair and extend a hand with the thumb and forefinger extended like pinchers.

2. Have Student B stand next to Student A and hold the yardstick vertically so that the zero end is just above Student A's thumb and forefinger.

3. Student B releases the yardstick at a random time and Student A catches it between thumb and forefinger as quickly as possible. Have Student C record the distance the stick fell before being caught. Repeat twice.

4. Have the three students switch jobs so that all get a chance to do every job.

5. Use the table or equations below to convert distance to reaction time.

For students in grades 8 - 12

6. Have each student calculate the average of his or her three reaction times, then use the table below to turn inches or centimeters into seconds.

7. Write each person's average reaction time on the board and have students graph the results.

8. Ask the students, Will your reaction times be the same every day? If not, will they go up, go down or vary from day to day? Have them write down their predictions.

9. Repeat steps 1 through 6 for the next few days and record results daily.

10 At the end of a few days, have each student graph his or her average daily reaction times.

Distance	Time (seconds)	Distance	Time (seconds)
2 inches (5 cm)	0.101	12 inches (30 cm)	0.247
4 inches (10 cm)	0.143	15 inches (38 cm)	0.279
6 inches (15 cm)	0.175	30 inches (76 cm)	0.394
8 inches (20 cm)	0.202	48 inches (122 cm)	0.50
10 inches (25 cm)	0.226		

If you used inches, use this formula

$$t = \frac{\sqrt{(2y)}}{19.6}$$

where y = distance the yardstick fell and
t = reaction time

If you used centimeters, use this formula

$$t = \frac{\sqrt{(2y)}}{31.3}$$

QUESTIONS TO CLOSE

- Were your reaction times the same every time?
- Did your reaction times get faster with practice? Do you think that with more practice you could improve your reaction time?

Adapted from
Gunstream, Stanley E. *Explorations in Basic Biology.* 8th ed. Upper Saddle River, NJ: Prentice Hall, 1999.
University of Washington. *Neuroscience for Kids* [web site]. Available from
http://faculty.washington.edu/chudler/neurok.html
Wiese, Jim. *Head to Toe Science.* New York: John Wiley & Sons, Inc., 2000.

Post-Visit Projects

These projects will help your students coalesce all they've learned from *Brain: The World Inside Your Head*. You could also use these projects as assessment tools.

Brain Art

Subjects: life sciences, language arts, art
Grades: K - 2
Concepts: communicating, describing, reasoning
Duration: one 30- to 40-minute class session or several shorter sessions

OBJECTIVE

Students will discover that...

- they need their brains for many things.

BACKGROUND INFORMATION

For this project students will create and present a poster that shows what they've learned about the brain. To help them focus, give them a theme. You (or they) can choose from the list below, or make up another one. When the posters are finished, put them on display. Here are a couple of possible themes:

- I need my brain because   .
- The most important thing my brain does is   .
- Every day I use my brain to   .

ACTIVITY

Materials

- large sheets of white paper or poster board
- crayons

QUESTIONS TO BEGIN

- Can anyone name something for which you use your brain?
- What is the most important thing your brain does for you?

PROCEDURE

1. Instruct students that they are going to make a poster about how they use their brains. Introduce the theme if you've chosen one or have the class vote on a theme.

2. Write the theme on the board so that students can copy it onto their posters.

3. Explain that each student is to fill in the sentence blank and then draw a poster on the chosen theme.

4. Allow enough time for students to complete their posters, or plan for several short work sessions.

5. When the posters are complete, have each child present his or her poster to the class. Hang them on display in the room or around school.

QUESTIONS TO CLOSE

- Why did you choose to fill in the blank the way that you did?

Adapted from

University of Washington. *Neuroscience for Kids* [web site]. Available from http://faculty.washington.edu/chudler/neurok.html

Brain Fair

Subjects: life sciences, language arts, art
Grades: 3 - 5
Concepts: sorting, organizing, describing, communicating, reasoning
Duration: several 30- to 45-minute class sessions and two or more hours for the fair

OBJECTIVES

Students will discover that...

- they use their brains for a wide variety of things every day.
- the brain is a complex, effective organ.

BACKGROUND INFORMATION

If you think about it, the brain is like a fair—it's a busy, bustling place full of surprises. For this project students will demonstrate how the brain is like a fair in the most fun way imaginable—they'll put on a fair of their own. Students will dream up and build their own booths. There can be a brain teaser booth, an optical illusion booth, a word game booth, a dream analysis booth, etc. Whatever they choose to do, students must provide information on how the brain works during that particular activity. When the fair is ready to open, invite other classes to participate, or present it on Open House night.

ACTIVITY

Materials

- 1 table per booth
- streamers, crepe paper, balloons or other decorations
- posterboard
- paints, markers and/or crayons
- paper
- additional booth materials deemed necessary by student teams

QUESTIONS TO BEGIN

- When you go to a fair, what sorts of booths can you visit?
- What other kinds of activities are going on?
- If you were to host a Brain Fair, what types of booths would be there?
- What types of other activities might you include?

PROCEDURE

1. Begin by brainstorming a list of the booths and activities that could be included in the Brain Fair.

2. Ask students which booths or activities they'd be interested in creating and presenting at the fair. For ideas, they may rely on some of the pre-visit activities presented in this Guide. For

example, they may want to have an optical illusions booth (see A-maze-ing! activity) or a recital booth (see Recital Recipe activity).

3. Using the above information, outline the Brain Fair and help each student choose an activity. Encourage students to work in teams of two or three.

4. Allow about 30 minutes for students to work in their teams to plan their contributions to the fair. Tell them that at the end of the work session they should have: a name for their booth or performance, an outline of what a visitor to the booth will experience, and a list of materials and equipment they'll need to build each booth (booths can be made of decorated folding tables). They should also write down what their booth teaches about the brain.

5. Have teams begin making and collecting the materials they'll use in their booths.

6. Have teams make the booths: decorate the tables and use posterboard and paints or markers to make a sign announcing the booth's name.

7. Design, make and distribute flyers advertising the Brain Fair.

8. On the big day set up the booths, invite the rest of the school, friends and/or family.

9. Recruit parents, other teachers or school staff to be judges and hand out awards for best booth, most creative booth, most fun booth, etc.

QUESTIONS TO CLOSE

none

Adapted from
CRB Foundation Heritage Project. The Heritage Fairs Program [web site]. Available from http://www.abbotsford.net/heritagefair/school.htm

A Healthy Brain

Subjects: life sciences, mathematics, language arts
Grades: 6 - 8
Concepts: predicting, data collecting, comparing, classifying, reasoning, communicating
Duration: several 30- to 60-minute and 10- to 15-minute class sessions

OBJECTIVES

Students will discover that...

- caffeine is a drug that interferes with normal brain and body functions.
- quitting caffeine consumption causes withdrawal symptoms.

BACKGROUND INFORMATION

Think about all you've had to eat or drink today. Is chocolate, coffee, tea or soda on the list? All these things contain caffeine. Caffeine is a drug that changes the way your brain and body work. People like it because it makes them feel energetic and happy. But it also interferes with concentration and makes some people short-tempered. How does caffeine do all these things?

Caffeine is a stimulant that acts on your brain in several ways. First, it makes neurons (nerve cells) more active. In response, the adrenal glands produce adrenaline (also called epinephrine). Your heart races, your muscles tense, your airways open and blood vessels constrict. You're on the alert.

Because it's a stimulant, caffeine causes insomnia. Throughout the day, the activity of your nerve cells (with or without caffeine) produces a by-product called adenosine. In a caffeine-free brain, as adenosine builds up, it binds to neurons and slows them down. When adenosine build-up reaches certain levels, you get sleepy. But in a brain under the influence of caffeine, the caffeine binds to the neurons instead, blocking the action of adenosine. The result: there's no adenosine build-up and you can't go to sleep.

Caffeine also stimulates the brain to release another chemical called dopamine. Dopamine is a neurotransmitter—when released from one neuron it stimulates an adjacent neuron to fire. Caffeine causes neurons in a part of the brain called the "pleasure center" to release dopamine, bringing out feelings of pleasure and euphoria. This is why many people feel happy after drinking coffee.

Some scientists believe caffeine causes physical dependence because of its withdrawal symptoms. As caffeine levels drop, blood vessels dilate, causing headaches as excess blood flows into the brain. (Some headache relievers and cold medicines contain caffeine to reverse this process.) In addition, dopamine levels in the brain's pleasure center decrease, leaving behind feelings of depression or sluggishness. The neurons miss the stimulation that is no longer there and cravings begin. Fatigue or muscle pain may also set in.

For this project students will identify sources and quantities of caffeine in their diet. After giving up caffeine for a day, they'll note changes in how they feel. The project finishes with students researching caffeine's effect on the brain and body.

ACTIVITY

Materials

- paper and pencil
- reference books, Internet access and/or other research materials
- 1 copy of the caffeine tables per student (see below)
- 1 journal per student
- reward or prize for each student
- posterboards and markers (optional)

QUESTIONS TO BEGIN

- How many of you ingest caffeine, either in drinks or food?
- How many sodas do you drink a day? How much chocolate do you eat?
- Do you ingest a lot of caffeine, a little caffeine or no caffeine each day?

PROCEDURE

1. Hand out a copy of the caffeine content chart to each student. Review it for common sources of caffeine and the amounts of caffeine each contains.

2. For the next 3 days, have students keep track of everything they eat or drink that contains caffeine. Beside each item, have them write down the serving size and the amount of caffeine that item contains. Allow 10- to 15-minutes on days 2, 3 and 4 for students to calculate their previous day's caffeine intake.

3. At the end of the third day, have students form teams of 3 or 4. Explain that the next day (day 4) team members will conduct an experiment—they will go without caffeine for 24 hours, starting when they wake up. Have each student sign a team pledge that they will not cheat, and will help each other avoid caffeine. Explain that there will be a reward for all that complete the experiment.

4. During class on day 4, allow two 10- to 15-minute sessions (one in the morning and one in the afternoon) for students to note any symptoms they have from caffeine withdrawal.

5. On the morning of day 5, allow one more note-making session. Have students include how they felt when they resumed ingesting caffeine (if they did). When students are finished, ask

volunteers to share their notes.

6. Assign a research project: team members will work together to research the effects of caffeine on the brain and body. Allow two or three 30- to 45-minute class sessions for students to conduct their research.

7. Publish a class website or have each team prepare a poster about caffeine's effects on the brain and body.

Caffeine Content of Some Drinks and Foods

Item	Serving Size	Caffeine Content (mg)
Coffee—regular	7 oz.	100 - 175
Espresso	2 oz.	100
Tea	7 oz.	40 - 80
Jolt Cola	12 oz. can	71
Mountain Dew	12 oz. can	55 (0 in Canada)
Surge soda	12 oz. can	51
Cola (most brands)	12 oz. can	35 - 48
Chocolate brownie	2.5 oz.	16
Chocolate ice cream	4 oz.	5 - 10
Chocolate milk	7 oz.	2 - 7
Coffee—decaffeinated	7 oz.	2 - 5
Hot cocoa mix	1 packet	1 - 8
Chocolate bar (most brands)	1 bar	2 - 12
Chocolate chip cookie	1 oz.	3 - 5
Frozen chocolate pudding bar	1 bar	2
7-Up	12 oz. can	0
Root Beer (most brands)	12 oz. can	0
Sprite	12 oz. can	0

QUESTIONS TO CLOSE

- In general, what kinds of foods contain caffeine?
- How much caffeine do you ingest in a day? How can you avoid caffeine in your diet?
- How do you feel shortly after you eat or drink something that contains caffeine?
- What are caffeine's main effects on the brain?
- What happens when a person gives up caffeine?
- What would you say to someone who drinks sodas every day at breakfast, lunch and dinner?

Sources

Arms, Karen and Pamela S. Camp. *Biology.* 4th ed. Fort Worth: Saunders College Publishing, 1995.

Radio National and ABC Online. *The Health Report.* "Sleep; An interview with Dr. Robert McCarley, Professor of Psychiatry at Harvard University." [web site article]. Dec. 15, 1997. Available from http://www.abc.net.au/rn/talks/8.30/helthrpt/stories/s10677.htm

Marshall Brain's How Stuff Works. "Why does caffeine keep you awake?" [web site]. Available from http://www.howstuffworks.com/question531.htm

University of Washington. *Neuroscience for Kids* [web site]. Available from http://faculty.washington.edu/chudler/caff.html

Raloff, Janet. "Caffeine: The pain of going cold turkey." Science News, October 17, 1992, p. 265.

The Teenage Brain

Subjects: life sciences, mathematics, language arts
Grades: 9 - 12
Concepts: describing, organizing, data collecting, reasoning, communicating, comparing
Duration: several 45- to 60-minute class sessions

OBJECTIVES

Students will discover that...

- the teenage brain is unique because much of it is mature, but certain parts have not yet fully developed.
- many typical teenage behaviors and issues are directly related to the degree to which the brain has developed.

BACKGROUND INFORMATION

The human brain takes more than 20 years to fully mature. Thus, the teenage years represent the final stages of brain development in which many adult functions are in place, yet others are not. A teenager can communicate efficiently, forge connections between ideas, pay attention for extended periods of time, regulate his or her thoughts, think in the abstract, and distinguish right from wrong. Even so, the teenage brain is far from mature. Neurons in the frontal lobes, which help regulate emotion, self-control, impulse and judgment, are not fully myelinated. (Myelin is the fatty insulation that surrounds nerve cells allowing them to transmit impulses.) The temporal lobes, which also regulate emotional maturity, are still developing and myelinating. And the cerebral cortex, which controls intelligence, consciousness and self-awareness, isn't fully mature until an individual reaches his or her twenties. It is this mix of abilities and inabilities that creates that special person—the teenager.

Another thing that separates teens from younger children and adults is sleep schedules. Left on their own, teens will stay up late and sleep in. Recently, researchers have discovered the reason for this pattern, which they call sleep phase delay. It's the brain. Deep in the brain lies a structure called the pineal gland. The gland secretes a hormone called melatonin, which has been correlated with sleeping and waking patterns. As melatonin levels rise, sleepiness sets in. The brain makes melatonin all night, but as morning approaches, it ceases. Studies have shown that in teenagers, melatonin secretion sets in later at night than it does in younger children or adults. It also ceases later in the morning, making it hard for adolescents to wake up. In essence teens struggle to stay awake in morning classes because their brains think it's still nighttime.

For this project, students will research the unique state of the teenage brain. By learning more about the brain's development during the teenage years, they (and their parents) will gain insight into the confusing and difficult time called the teens. After using the Internet and print material as references they will make a scientific poster about their chosen topic. Like a professionally prepared poster, theirs will have an Introduction, Methods, Results and Discussion Section. It will also present data in graph or table form. Once the posters are complete, the students will share their work in a class poster session similar to that at a professional conference.

ACTIVITY

Materials

- reference books, library access or Internet access
- pen and paper or typewriter or word processor
- posterboard
- markers
- glue

QUESTIONS TO BEGIN

- Do you ever feel emotionally frustrated?
- Have you ever done anything impulsively, then thought, "That was a stupid thing to do"?
- Do you sometimes make bad decisions or otherwise use poor judgment?
- How many of you stay up late at night and sleep in on weekends to make up for lost sleep during the week?

PROCEDURE

1. Begin by explaining that all of the experiences addressed in the Questions to Begin are normal for most people and especially for teenagers, because of the teenage brain's stage of development.

2. Have students form teams of 2 or 3. Explain that team members will work together on a research project and will present their results during a class poster session. They can research the relationship between brain development and emotional issues, impulsiveness, judgment issues or sleep issues, or anything else that might interest them. They can use the Internet or a local public or university library (books and magazine databases) as resources. They may also choose to interview a physician or psychiatrist at a nearby hospital, medical clinic or county mental health department.

3. Have students present their information in a poster format. Each poster should include four sections:

a. Introduction: students explain the question/problem and any background information that their readers will need to understand.

b. Methods: students explain how they collected information—who they interviewed and where and when the interview took place, how they searched the Internet, which print materials were of greatest help, etc.

c. Results: students answer the question or explain the facts related to the problem posed in the Introduction. This section should also include supporting data or technical information and at least one graph or chart.

d. Discussion: students should explain the relevance of the results and how they relate to everyday situations. They should also demonstrate original thought.

4. Allow class time for students to conduct their research.

5. When students have finished their research, allow them at least one 45- to 60-minute class session to work on their posters.

6. When the posters are done, have team members organize their presentations and divide up presentation duties.

7. When posters are finished, host a poster presentation session for the class in which teams explain their posters to the rest of the class. You may also want to invite parents or other classes to attend.

QUESTIONS TO CLOSE

(see Procedure above)

Sources

Begley, Sharon. "Your Child's Brain." *Newsweek,* Feb. 19, 1996, pp. 55-62.

Greenfield, Susan A. *The Human Brain: A guided tour. New York,* NY: Basic Books, 1997.

National Academy Press. *Sleep Needs, Patterns and Difficulties of Adolescents: Summary of a Workshop (2000)* [web site article]. Available from http://books.nap.edu/catalog/9941.html

Glossary

anterior cortex	the front part of your brain behind your forehead; it seeks stimuli and helps focus attention
central nervous system	the part of the nervous system composed of the brain and the spinal cord
cerebellum	the part of the brain that coordinates body movements, reflexes, posture and equilibrium
cerebral cortex	the outer, wavy layer of tissue that covers much of the brain
corpus callosum	a broad band of tissue that connects the two halves of the brain
EEG	electroencephalogram; a machine that records the brain's electrical activity
hippocampus	a relatively small, seahorse-shaped section of the brain that plays a key role in learning and memory
impulse	an electrical or chemical message that travels along a nerve cell
interneuron	a type of nerve cell that links two other nerve cells
long-term memory	type of memory that lasts greater than an hour and can last a lifetime; stored in the cortex
mnemonic device	a device or trick that helps you remember something
motor neuron	a nerve cell that conducts impulses that control muscle contractions
nerve	a bundle of nerve cells outside the central nervous system
neuron	a nerve cell
parietal cortex	the part of the brain's outer layer that's toward the rear portion of the top of the head; helps you orient and focus
personality	individuality; the patterns and qualities of behavior that make a person unique
photopupil reflex	involuntary action of the eyes' pupils to close in response to sudden light
premotor cortex	a section of the brain toward the front that controls movement by creating (or not) the urge to move
reaction time	the time it takes for the impulse of a stimulus to reach the brain, for the brain to process the incoming information and to send a response stimulus to the body
reflex response	an involuntary, stereotyped response or reaction resulting from a stimulus
REM sleep	rapid eye movement; a stage of sleep in which the eyes move rapidly back and forth; the stage of sleep in which we dream
retrieval cue	a clue that helps a person access a certain memory
sensory neuron	a type of nerve cell that responds to a stimulus from the internal or external environment
short-term memory	type of memory that lasts for a few minutes to a few hours
spinal column	the backbone or vertebral column
spinal cord	the network of neurons that passes from the base of the brain through the center of the spinal column to the hips
stereotype response	a predictable response to a stimulus that happens the same way every time
stimulant	a substance that increases activity in the brain or spinal cord
stimulus	an agent that brings about a response in a cell or organism
thermoreceptor	a type of nerve cell that senses changes in temperature
touch receptor	a structure that responds to a touch stimulus
working memory	a form of very short-term memory that lasts for only a few minutes

Reading List & References

CHILDREN'S BOOKS AND ARTICLES

Elementary school

Dennison, Paul E. and Gail E. Dennison. *Brain Gym.* Ventura, CA: Edu Kinesthetics, 1994.

Jennings, Terry. *101 Amazing Optical Illusions: Fantastic visual tricks.* London: Sterling Publications, 1998.

Kay, Keith. *Little Giant Book of Optical Illusions.* London: Sterling Publications, 1997.

Murphy, Pat, Ellen Klages, Pearl Tesler, Linda Shore and The Exploratorium. *The Brain Explorer: Puzzles, riddles, illusions and other mental adventures.* San Francisco: The Exploratorium and Henry Holt & Co., L.L.C., 1999.

Odyssey, Adventures in Science. The March 2001 issue of this magazine is devoted entirely to the brain. Available from http://www.odysseymagazine.com

Sekel, Al. *The Art of Optical Illusions.* Hertfordshire: Carlton Books, 2000.

Simon, Seymour. *The Brain: Our Nervous System.* Apache Junction, AZ: Mulberry Books, 1999.

Middle school

Barmeier, Jim. *The Brain* (Lucent Overview Series). Farmington Hills, MI: Lucent Books, 1996.

Edwards, Betty. *Drawing on the Right Side of the Brain.* Revised and expanded ed. Los Angeles: J.P. Tarcher, 1999.

Jennings, Terry. *101 Amazing Optical Illusions: Fantastic visual tricks.* London: Sterling Publications, 1998.

Murphy, Pat, Ellen Klages, Pearl Tesler, Linda Shore, and The Exploratorium. *The Brain Explorer: Puzzles, riddles, illusions and other mental adventures.* San Francisco: The Exploratorium and Henry Holt & Co., L.L.C., 1999.

Odyssey, Adventures in Science. The March 2001 issue of this magazine is devoted entirely to the brain. Available from http://www.odysseymagazine.com

Sekel, Al. *The Art of Optical Illusions.* Hertfordshire: Carlton Books, 2000.

High school

Barmeier, Jim. *The Brain* (Lucent Overview Series). Farmington Hills, MI: Lucent Books, 1996.

Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.

Edwards, Betty. *Drawing on the Right Side of the Brain.* Revised and expanded edition. Los Angeles: J.P. Tarcher, 1999.

Greenfield, Susan A. *The Human Brain: A guided tour.* New York, NY: Basic Books, 1997.

Howard, Pierce J. *Owner's Manual for the Brain: Everyday Applications from mind-brain research.* 2nd ed. Marietta, GA: Bard Press, 2000.

Odyssey, Adventures in Science. The March 2001 issue of this magazine is devoted entirely to the brain. Available from http://www.odysseymagazine.com

Sekel, Al. *The Art of Optical Illusions.* Hertfordshire: Carlton Books, 2000.

Teacher's References

Carter, Rita. *Mapping the Mind.* Berkeley: University of California Press, 1998.

Dennison, Paul E. and Gail E. Dennison. *Brain Gym.* Teacher's edition. Ventura, CA: Edu Kinesthetics, 1994.

Greenfield, Susan A. *The Human Brain: A guided tour.* New York, NY: Basic Books, 1997.

Howard, Pierce J. *Owner's Manual for the Brain: Everyday Applications from Mind-Brain Research.* 2nd ed. Marietta, GA: Bard Press, 2000.

Murphy, Pat, Ellen Klages, Pearl Tesler, Linda Shore, and The Exploratorium. *The Brain Explorer: Puzzles, riddles, illusions and other mental adventures.* San Francisco: The Exploratorium and Henry Holt & Co., L.L.C., 1999.

National Academy of Sciences. *National Science Education Standards.* Washington, DC: National Academy Press, 1996.
Sekel, Al. *The Art of Optical Illusions.* Hertfordshire: Carlton Books, 2000.
U.S. Dept. of Health and Human Services and National Institute of Health and National Institute of Drug Abuse. *Mind Over Matter: The Brain's Response to Drugs Teacher's Guide.* NIH Publication No. 00-3592. 2000. Bethesda, Maryland. Available online at http:/www.nida.hih.gov or from the National Clearinghouse for Alcohol and Drug Abuse Information at 800-729-6686.
Wade, Nicholas. ed. *The Science Times Book of the Brain.* New York: The Lyons Press, 1998.

Web Sites

Centers for Disease Control
http://www.cdc.gov

Dana Foundation
http://www.dana.org

MEDLINEplus Health Info
http://www.medlineplus.gov

National Institutes of Health
http://www.nih.gov

National Institute of Mental Health
http://www.nimh.nih.gov

National Institute of Neurological Disorders and Stroke
http://www.ninds.nih.gov

National Institute on Drug Abuse
http://www.drugabuse.gov
http://www.165.112.78.61/MOM/TG/MOMTG-Index.html

National Science Resources Center
http://www.si.edu/nsrc

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html

Pfizer Inc
http://www.pfizer.com

Serendip Home
http://serendip.brynmawr.edu/home.html

Smithsonian Institution
http://www.si.edu

World Health Organization
http://www.who.int

Sources for Equipment & Supplies

Carolina Science and Math Catalog
800-334-5551 http://www.carolina.com

Edmund Scientific Catalog
800-728-6999 http://www.scientificsonline.com

Illusions in Art Cards: A Collection of Classic and Contemporary Visual Illusions in Art. Y & B Associates, Inc. 33 Primrose Lane, Hempstead, NY 11550.

MindWare: Brainy Toys for Kids of All Ages
800-999-0398 http://www.MINDWAREonline.com

NASCO Science Catalog
800-558-9595 http://www.nascofa.com