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Introductory Activity

Get To Know the Brain

**TIME** 30 minutes (including discussion)

**GRADE LEVEL** 4-12

**OBJECTIVE:** To explore the different things we do with our brain.

**MATERIALS:** Reproducible on page 24.

**BACKGROUND:** Whether we’re remembering a special day, figuring out change at the grocery store, or dancing to a favorite song, we’re using our brain. These quick activities show students how different parts of our brain help us perform different functions.

**WHAT TO DO:**
1. Ask the class if they’re ready to give their brains a quick workout. Then have them do each of the following, one after the other:
   a. Close your eyes and picture yourself having fun in a favorite place, like hanging out with friends, riding your bike, or performing on stage. Hold the image of this place in your mind for a few moments.
   b. Hold your hands together, with your palms facing each other. Tap your thumbs together, then your forefingers, your middle fingers, your ring fingers, then your pinkies.
   c. Pick a number between 1 and 10. Add your age. Subtract 7. What do you get?
   d. Pinch your arm. Squeeze hard, then stop.
   e. Think about your last birthday or another special event in the past year. Try to recall as many details as possible. What was the weather like that day? What were you feeling? Try to remember the sights, smells, sounds, and emotions, use different parts of the brain. For example, the smells you remember activate the olfactory cortex.
   f. When you remember a past event, you use, among other parts of your brain, the hippocampus buried inside your brain. The different senses you recall, like sights, smells, sounds, and emotions, use different parts of the brain. For example, the smells you remember activate the olfactory cortex.

**DISCUSSION:**
- Think of one of the first things you did this morning when you woke up. Did you hear an alarm? Remember something that happened the day before? What part of the brain did you use?
- Imagine a loud noise hurts your ears. Name two parts of the brain that have been activated.
- Which senses best help you remember a distant event from the past?

**THE HUMAN BRAIN**

Is a pinkish-gray mass covered with bumps and grooves. Although most people have the same patterns of bumps and grooves, no two brains are exactly alike!

What makes the human brain so special?

The answer lies in the specially developed cortex, the bumpy gray outer layer of the brain called the cerebral cortex. The cerebral cortex is the brain’s area for higher-level thinking, including reasoning and planning. Our bodies—and our lives—depend on a number of structures within and below the cerebral cortex. Some help us see and hear the world around us. Others are involved in learning and memory. Still others keep our heart pumping and lungs working. But while different parts of the brain are involved in different functions, all the parts are working together.

In fact, all the functions within our brain rely on complex networks of cells called neurons. All our thoughts and behaviors—both conscious and unconscious—are the result of communication among neurons. While messages pass along individual neurons by electrical signals, neurons communicate with each other mostly through tiny chemical messengers called neurotransmitters.

The following activities will help students learn about major structures in the brain, the different parts of a neuron, and how neurons communicate with each other.

**ACTIVITIES**

**Brain Twister:** In this favorite game with a new twist, students will explore the four lobes of the brain.

**Homemade Neurons:** Students will create their own 3-D models of a neuron.
**Brain Twister**

**TIME:** 45-50 minutes  
**GRADE LEVEL:** 4-5  
**OBJECTIVE:** To learn the names, locations, and major functions of the four lobes of the brain.

**MATERIALS:** For Brain Lobe Chart, Brain Twister Game Mat, and Brain Twister Spinner: Two pieces of large, white poster board, colored markers and/or paint in black, red, green, blue, and yellow, large white bed sheet, drinking straw, straight pin, large plastic cup.

Allow substantial time to create game materials. See directions below.

**BACKGROUND:** The cerebral cortex is the largest part of your brain. This folded gray mass sits on top of the rest of your brain. Thinking, vision, hearing, and speech are found here. The cerebral cortex is divided down the middle, into the right hemisphere and the left hemisphere. Each hemisphere can be divided into major sections called lobes. There are four lobes: frontal, temporal, parietal, and occipital. Each lobe helps us do different things. (See Brain Lobe Chart for major functions of each.)

**WHAT TO DO:**

**A. Prepare Game Materials**

1. Re-create the Brain Lobe Chart on a large piece of poster board. Next to each lobe name, place a circle using the suggested color. (Note: This color should correspond with the lobe on the Brain Twister Game Mat.)

2. Create a Brain Twister Game Mat:
   - On a large bed sheet, use markers or paint to create a simple line drawing showing the outside view of the brain. In each lobe region, paint about six or seven circles of the same color. These colors should correspond to the colors in the Chart. For example, the circles in the Occipital Lobe should be yellow.
   - Create a Brain Twister Spinner: Divide a square piece of white poster board into four sections. In the corners, write: Left Foot, Left Hand, Right Foot, and Right Hand. In each quadrant, add four small circles in blue, red, green, and yellow. All the circles on the spinner should form a circle around the center.

**B. Introduce the Brain**

1. Show students the Brain Lobe Chart and the Brain Twister game mat.

2. Describe the location, functions, and hemispheres of the cerebral cortex, the largest part of the brain. Explain that while there are other important structures underneath the cerebral cortex, this part of the brain is largely responsible for thought, reasoning, personality, and planning. It is also responsible for functions like hearing, vision, speech, and voluntary movement. (See Background.)

3. Explain that the cerebral cortex is divided into four major sections, called lobes: the frontal, parietal, and occipital.

4. Use the Brain Lobe Chart to review the locations and major functions of each lobe.

5. As a class, say the name of each lobe and ask students to touch the part of their skull where that lobe is located.

**C. Play the Game!**

1. Divide the class into groups of five and explain that each group will have a chance to play Brain Twister.

2. Explain that when a call is made, each player must put his or her appropriate hand or foot on one circle of the brain lobe that’s called out. Share the following rules:
   - If two or more players reach for the same circle, the teacher will decide which player got there first.
   - If a circle is taken, the other player(s) must find another circle of the same color.
   - Any player who falls or touches the mat with an elbow or knee is eliminated, changing places with the student at the spinner.

3. Ask the fifth student to turn the spinner and call out the body part and brain lobe where the arrow lands. The brain lobe will correlate to the specific color on which the arrow lands. For example, if the arrow falls on the blue circle in the “Left foot” quadrant, the call is: “Left foot, Temporal!”

4. Once the call is made, all the players try to put their appropriate hand or foot on an empty circle in the brain lobe that was called. Players should do this at the same time, so the challenge is to be the first to figure out where the lobe is located and place your hand or foot on a circle right away.

5. Continue the game until all the players have placed both hands and feet on lobes of the brain.

6. Try the game again, but have the teacher spin the spinner. Then call out a function of that lobe instead of calling out the name of the brain lobe. For example, if the arrow falls on the yellow circle in the “Right hand” quadrant, the call is: “Right hand, Vision!”

7. Allow other teams to take turns playing Brain Twister. As the other students are waiting their turn, have them work on one of the two extensions below.

**EXTENSIONS**

**Elementary/Middle School:** Have students create three-dimensional models of the brain using different colors of Play Dough or clay, or even colorful food like jellybeans. (See HOMEMADE NEURONS.)

Play Lobe Charades: Ask students to brainstorm some everyday actions associated with different lobes of the brain. For example, speaking and the frontal lobe, or hearing and the temporal lobe. Working in pairs, have students practice acting out some of the brain functions associated with one of the lobes. Then have them act out these functions for the class, without using any words. Challenge the class to figure out which lobe is associated with these actions.

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*Based on The Mind-Bending Game of Brain Twister by Macalester College, Saint Paul, Minnesota, and the “Brain Charades” activity on Neurosciences for Kids.*
To learn about the structure of a neuron
The brain is packed with over 100 billion nerve cells or neurons. Each neuron can connect with over 10,000 other neurons, which means there are trillions of connections between the neurons in a single brain! Communication through and between these tiny neurons is what makes the brain work. Each neuron has four basic parts: the cell body (also called the “soma”), the dendrites, the axon, and the axon terminals. Information passes through a neuron from the dendrite to the cell body, through the axon, and out the axon terminal to the next neuron’s dendrite. Neurons are constantly communicating with each other, but they never physically touch. Instead, messages are sent across tiny gaps called synapses, from one axon terminal to the next neuron’s dendrite. Messages travel through a neuron as electrical signals.

**Background:** The brain is packed with over 100 billion nerve cells or neurons. Each neuron can connect with over 10,000 other neurons, which means there are trillions of connections between the neurons in a single brain! Communication through and between these tiny neurons is what makes the brain work. Each neuron has four basic parts: the cell body (also called the “soma”), the dendrites, the axon, and the axon terminals. Information passes through a neuron from the dendrite to the cell body, through the axon, and out the axon terminal to the next neuron’s dendrite. Neurons are constantly communicating with each other, but they never physically touch. Instead, messages are sent across tiny gaps called synapses, from one axon terminal to the next neuron’s dendrite. Messages travel through a neuron as electrical signals, but messages pass between neurons mostly as chemical signals. When two neurons communicate, the axon terminal of one neuron changes that electrical signal into a chemical signal in the form of neurotransmitters, released into the synapse. These chemical messengers bind with receptors on the dendrites of the receiving neuron. But these dendrite receptors only accept a particular shape of neurotransmitter. The neurotransmitter must match the distinct shape of the dendrite receptor—just as a key fits into a lock. Neurotransmitters have unique functions, depending on their type and what part of the brain they’re activating.

**Background:**

**Objective:** To learn about the structure of a neuron by building a model, and to understand how neurons communicate.

**Materials:** Four colors of Play Doh or clay (enough for each student to have a golf-ball-size amount of each color), toothpicks (four for each student), Post-it® Notes (four for each student).

**Homemade Neurons**

**Time:** 25 minutes

**Grade Level:** 4-12

**What To Do:**

1. Have a class discussion about the structure and function of neurons. (See Background.)
2. Show students the diagram above and talk about the major parts of the neuron. Follow the imaginary path an electrical message or impulse takes through a neuron, talking about each part along the way.
3. Give each student four different colors of Play Doh or modeling clay. Challenge them to create their own neuron models, with each of the four colors representing the dendrites, the cell body, the axon, and the axon terminal.
4. Have students create four labels for each part by folding a Post-it® Note over a toothpick. Then have them stick their labels in the appropriate part of their model.

**The Brain’s Chemical Messengers**

There are many kinds of neurotransmitters at work in our brains. Different neurotransmitters control activity in different parts of our brain, which means they each have a unique function. However, a neurotransmitter’s effect depends on the receptor, so one type of neurotransmitter can have different effects depending on which part of the brain it activates. Binding of a neurotransmitter to a receptor will increase or decrease the likelihood that a new electrical signal will be produced. Scientists have identified many different kinds of neurotransmitters. Here’s a look at a few:

- **Acetylcholine** affects attention, learning, and memory. Low levels of acetylcholine are common in people with Alzheimer’s disease.
- **Dopamine** controls movement and coordination. People with Parkinson’s disease have extremely low levels and find it difficult to make smooth voluntary movements.
- **Endorphins** may be released when injury occurs. This neurotransmitter helps moderate pain and reduce stress.
- **Serotonin** affects mood, anxiety, and aggression. Its activity is enhanced by many drugs that alleviate depression.
5. Next, talk about how neurons work together, passing messages between them in the brain. Explain that neurons don’t actually touch. They send chemical messengers called neurotransmitters across a tiny gap called the synapse. (See Background.)

6. Ask students to work with a partner to show how information would flow between their two neuron models. Make sure they understand that neurotransmitters flow from the axon terminal of one neuron to a dendrite of the next. These parts should be close, but not touching, to show the synapse. (Please note that this is the most common type of synapse, but there are also synapses between a terminal and cell body (axosomatic synapses), and even between a terminal and another terminal (axoaxonic synapses).)

7. Discuss neurotransmitters and how they are accepted or rejected by receptors depending on their shape. Hand out four different kinds of small objects, such as pennies, jack, marbles, and paper clips, so that each student has one. Explain that each object represents a different type of neurotransmitter. Have students holding the same object work together to form connections between their neuron models. They should use the objects to create dendrite receptors that accept their assigned neurotransmitter. (They can do this by pressing the object into their clay dendrite, forming shapes that “fit” the neurotransmitter.) Finally, ask them to demonstrate their neuron connections by explaining how and in which direction the messages travel.

**DISCUSSION:**

- What did all the neuron models have in common? How were they different?
- Explain that just as no two neuron models are alike, neither are neurons within the brain. Talk about the three kinds of neurons:
  - **Sensory neurons** pick up information from the sense organs.
  - **Interneurons** are intermediate nerve cells that pass messages between various kinds of neurons, including sensory and motor ones.
  - **Motor neurons** tell muscles to move.

- When neurons communicate, how are neurotransmitters accepted or rejected? Talk about how the neurotransmitter must match the receptor, the distinct shape of the dendrite receptor.

**EXTENSIONS**

Discuss neurotransmitters and how they are accepted or rejected by receptors depending on their shape. The binding of a neurotransmitter to a receptor will increase or decrease the likelihood that a new electrical signal will be produced. Hand out one playing card to each student, explaining that each suit represents a different type of neurotransmitter or a dendrite receptor that will accept that neurotransmitter. Have students holding the same suit work together to form connections between their neuron models. Then ask them to show the direction the messages travel.

**High School:** Have students research the different types of neurotransmitters and their effects on the human brain. How can our brains be enhanced or moderated by drugs?

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**Senses and Perception**

In school, we’re usually taught that there are five senses: vision, hearing, taste, smell, and touch. But many neurologists believe there are at least nine senses, maybe more! Our sense of balance keeps us standing upright. And touch can be broken down into four different senses, each with its own dedicated nerves: pain, sensations of hot and cold, awareness of where parts of the body are located, and pressure on the skin.

When a cyclist hears a cheering crowd, sees the road zipping beneath her wheels, or feels the wind blowing across her face, her senses are getting information from the outside world. Our basic *senses* are sight, sound, smell, taste, and touch. They enable us to process information provided by *sensory stimuli*—messages from our external environment, the world outside our bodies. This external information (such as light, colors, and sound) is detected by sensory receptors, such as those in our eyes or skin. That information is transformed into electrical and chemical signals that carry the message through neuronal pathways to specific parts of the brain where the messages are interpreted. This process of interpretation is known as *perception*. Without perception, we couldn’t interpret all the lights, colors, sounds, and other sensations flooding our senses. For example, the sensory receptors of our eyes may detect visual images from our environment, but we actually see—interpret those images as meaningful information—in our brain. Perception is a process that we need to learn through our senses and experiences. We learn to recognize the sound of our parent’s voice or understand that an object in the distance looks smaller than one nearby.
To explore the sense of hearing and understand how we identify sounds.

• What parts of your body enabled you to hear these sounds?
• Were some sounds easier to identify? Why do you think that is?
• What were some of the sounds you heard?

**DISCUSSION:**

5. After you make the sound from several locations, remind them to keep their eyes closed while you try include: finger snapping, tearing a sheet of paper, dispenser, or banging a drum.

**WHAT TO DO:**

1. Explain to students that they are going to play a sound guessing game. Ask them to close their eyes and keep them closed throughout the activity.
2. Ask students to listen for a new sound. When their eyes are closed, ring the bell. When they think they know what the sound is, they should raise their hands.
3. Remind them to keep their eyes closed while they walk around the room, ringing the bell in different locations.
4. After you make the sound from several locations, ask students to put their hands down but keep their eyes closed.
5. Repeat this activity with other sounds. Other sounds to try include: finger snapping, tearing a sheet of paper, cutting in the air with scissors, pulling tape out of a dispenser, or banging a drum.
6. Put away any props you used and have students open their eyes.

**DISCUSSION:**

• What were some of the sounds you heard?
• Were some sounds easier to identify? Why do you think that is?
• What parts of your body enabled you to hear these sounds? Discuss the role of the brain in hearing, and how you actually hear and identify sounds in the temporal lobe of your brain. (See Background.)

• Was the sound always coming from the same place? How could you tell? Talk about how, in the process of learning to perceive sounds, we train our brains to recognize when sounds are moving away or towards us. Sounds get lower, or softer, as they move away, and louder as they move closer to us.

**BACKGROUND:**

We may detect sounds with our ears, but we really “hear” with our brains. How does this happen? First, a sound wave enters our ear, travels down the ear canal and sets off a series of vibrations in the eardrum and the cochlea. These vibrations create nerve impulses that travel along the **auditory nerve** to the brainstem and on to the **auditory cortex** of the temporal lobe. Here, the electrical signals that carried the sounds are processed and identified as actual sounds.

**WHAT TO DO:**

1. Give each student one cinnamon jellybean. Don’t reveal the flavor and ask students to just hold them in their hand or put them on their desk until everyone has one jellybean.
2. Ask students to plug their nose and then begin to eat the jellybean. Ask them what the jellybean tastes like and to write down their guess.
3. Then tell them to unplug their nose and ask what the bean tastes like now. Again, ask them to write down their guess.
4. Repeat this activity with cherry jellybeans.

**DISCUSSION:**

• Did holding your nose make any difference when you tried to identify the taste? How?
• Did the color of the jellybean affect how you thought it tasted?
• Why do you think your sense of taste is affected by your sense of smell?
• Smells often evoke memories and emotions. Ask students if they can think of any smells that they associate with memories, good or bad.

**BACKGROUND:**

Whether you’re eating spicy hot chili or sweet ice cream, your brain helps you detect these flavors. How does this happen? Tastebuds on your tongue hold **receptor cells**. Chemicals from your food activate these receptor cells, which send nerve impulses to taste areas in the cerebral cortex. But it takes more than your tastebuds to enjoy your favorite ice cream. In fact, taste and smell work together to help you experience and enjoy your food. (Cinnamon and cherry jellybeans work well, as they’re very distinctive flavors and they look very similar to one another.)

**WHAT TO DO:**

1. Ask students which parts of the body help them see. Talk about how the eye may collect visual information, light, but it’s the brain that allows us to process this information and form the images that we see. (See Background.)
2. Show students the optical illusion. Give them a chance to look at the image and ask: Which figure is larger?
3. Give students a chance to answer the question. Encourage them to explain why one figure appears larger than the other.
4. Reveal the answer to the optical illusion. You could have students use a ruler to confirm that the two figures are actually the same height.

**DISCUSSION:**

• Why do you think your brain had difficulty making sense of this image? What “clues” did our brains use to interpret the image that turned out to be misleading?

**BACKGROUND:**

Think you see with your eyes? Not exactly! Your eyes capture visual information, but you really see with your brain. Vision is a complicated process, so it’s not surprising that about a quarter of your brain is involved in processing vision. Just like the other sense organs, the eyes have special receptors. These visual receptors found in the retina turn light into electrical signals, which pass along the optic nerve, through a special relay region in the thalamus, to the **visual cortex** of the occipital lobe. In the visual cortex, the information is processed into the visual image we think of as sight.

But sometimes the brain can misread these visual signals—especially when you look at an optical illusion. This happens because your brain is used to organizing images into familiar patterns based on your past experiences and expectations. When your brain processes an optical illusion, it makes assumptions about the image based on these familiar patterns. So you may think you’re seeing something you really aren’t!
To understand that the brain sometimes senses and perceives in interpreting what we see or hear.

**BACKGROUND:** It’s one thing to see printed words on the page. Sometimes it’s quite another to understand them. Seeing the words is simply an act of identifying letters on a page as words. To understand what the words mean involves perception and comprehension. The brain must process the words and relate them to previous experience. In order to understand something that is being read or spoken, the reader or listener usually needs to know what the words relate to. In other words, they need a context for the words.

**WHAT TO DO:**
1. Ask students to take out a piece of paper and something to write with. Tell them you’d like them to try to sketch a picture of the scene that you’ll be describing.
2. Read aloud the following passage: If the balloons popped, the sound would not be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying since must buildings tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. There could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face-to-face contact, the least number of things could go wrong.
3. Ask several student volunteers to share their drawings.
4. Discuss what made this task so challenging. Ask if it would have helped if they had a picture.
5. Hand out copies of the reproducible on page 16. Ask a student to reread the paragraph as everyone looks at the illustration.

**DISCUSSION:**
- How did the picture help you understand the words?
- Explain that this test was developed in 1972 by two psychologists, John Bransford and Merieta K. Johnson. What do you think these psychologists were trying to teach?
- Describe what “context” means. How did the image provide a context for the words in the passage?
- When were you using your senses in this exercise? What role did perception play? Help students understand that their sense of hearing helped them hear the words and vision allowed them to see the words. Perception helped them interpret or understand the words and the picture.

**Confusing Colors**

**BACKGROUND:** Sometimes we ask the brain to process contradictory information. Imagine you’re asked to read the word “blue,” but the word is written in green. When the brain is asked to process this information, there is often a delay called the “Stroop Effect.” This phenomenon is named after J. Ridley Stroop, who discovered it in the 1930s. Scientists today have two theories for why the Stroop Effect happens: The first is about how fast the brain processes different kinds of information. The brain can process and name words faster than it can identify colors. The second theory suggests that this interference happens because identifying and naming colors requires more attention (and therefore more time) than reading words.

**MATERIALS:** A reproducible of the image on the right and accompanying text is available on page 16.

**DISCUSSION:**
- Which exercise took longer? Why?
- Which exercise was easier? Why?
- Ask students to hypothesize how these mixed messages affect the brain. Talk about the Stroop Effect. (See Background above.)

**WHAT TO DO:**
1. Give each student a color copy of the Stroop Effect Test on page 16. In this test, each word is shown in a color other than the one that corresponds to its name.
2. Ask a student volunteer to read the words and stress that they should ignore the colors. The student should read the words as fast as possible from left to right, starting with the top row. Have another student time how long it takes to name all the colors in order.
3. Ask the first student volunteer to read the list again. However, this time, ask the student to say the colors the words are written in as fast as possible, in the same order as above. Clarify that the student should not read the words, but just identify the color of each word. Again, have another student time how long it takes to read the words in order.
4. Divide the class into pairs. Have partners repeat the test above, as one student performs the test while the second student times how long it takes to name the colors, then read the words. Then switch roles so both students can try the test.

**DISCUSSION:**
- Which exercise took longer? Why?
- Which exercise was easier? Why?
- Ask students to hypothesize how these mixed messages affect the brain. Talk about the Stroop Effect. (See Background above.)

**EXTENSIONS**

Challenge students to research the Stroop Effect Test further. When and why do psychologists use this test? Which part of the brain is involved in selecting the right response? Try it upside down! Challenge someone to say the name of each color (not read the words). Then turn the test upside down and have the student name the color names again. Which was easier? Why do you think that is?

As fast as you can, use five markers and write the names of the color of the marker you are using. Then, use the same five markers, but this time write any color name but the correct one. (For example, if you have a blue marker, you can write any color name but “blue.”)


*Based on Colors, Colors! http://faculty.washington.edu/shalvis/words.html.
If the balloons popped, the sound would not be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying since most buildings tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face-to-face contact, the least number of things could go wrong.


In the view of the brain above. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain. (The basal ganglia and amygdala are not visible in the view of our inner brain.

There are at least several different kinds of memory, depending how long and what types of information are being stored in our brain.

Short-term or working memory lets us hold onto information as long as we’re focused on it. We may remember a friend’s question just long enough to reply, but could easily forget it moments later.

There are two kinds of long-term memory. The first kind helps us remember events, such as what we did during summer vacation (episodic memory), and names, such as the names of state capitals (declarative memory).

The second kind of long-term memory allows us to remember how to do things automatically—such as walk, ride a bike, or play the piano. It is called procedural memory. These skills and habits may seem like second nature to us, but in fact they required a lot of practice and repetition to learn.

These activities explore our short-term memory—and its limitations—as well as how we can enhance our long-term memory by strategies such as repetition, meaningful association, or cognitive activity.

ACTIVITIES

Eyewitness Game: Students will find out what they do—and don’t—remember when they're not paying attention.

Grades 4-12

Grocery Store Chaining: Students will play a game that demonstrates how repetition helps memory.

Grades 4-8

Now You See It, Now You Don’t: Students will test the limits of their memory and learn some new ways to make it stronger.

Grades 4-12

Mirror Image: Challenge students with an activity that shows how repetition helps form procedural memories.

Grades 6-12

Motor Learning Card Game: Students will test their reaction times and see how they change from one task to the next.

Grades 6-12
To understand how repetition and organizing information can enhance long-term memory.

BACKGROUND: New information is temporarily stored as short-term memory in our brains. Most of this information is soon forgotten, but some gets transferred to our long-term memory. How can we enhance our memory so that certain information gets stored in the brain over time? One way is by repetition. The more we do something, the stronger the communication between the neurons becomes. This, in turn, enhances our long-term memory. For example, you rarely forget your own phone number because you’ve repeated it so many times!

DISCUSSION:
• Compare the details that students remember about the first visitor. Which actions were remembered and which were not? Did students remember the details differently?
• Why were these details difficult to remember? Where was their attention focused when the first visitor entered the classroom? Talk about how the brain filters out most information at any given moment. (See Background.)
• Now compare the details that students remember about the second visitor. Were they able to remember much more? Why do they think that is?
• Discuss how eyewitness testimony can be “false” or manipulated.

WHAT TO DO:
1. Have students sit in a circle. Explain that you’re going to play a memory game called “Grocery Store,” in which the class creates and remembers a fictional shopping list. Explain that the items on the list will be in alphabetical order.
2. Begin the grocery list with an item that begins with “A” such as: “I went to the grocery store, and I bought some apples.”
3. Ask the person to your right to add another item to the shopping list, first repeating the other items already on the list in the order they were added. For example: “I went to the grocery store, and I bought some apples and bananas.”
4. Continue around the circle, asking each student to repeat the grocery list in order and add one more item to the list.
5. Keep playing until you’ve gone all the way around the circle, reached the end of the alphabet, or until someone forgets one of the items.

EXTENSIONS
• Did the items on the grocery list get easier or more difficult to remember? Why do you think that is?
• Do you think you could remember the items on the list a week from now? What if your class played the game, reciting the same items, every day?
• Talk about how information can be transferred from short-term to long-term memory. In this activity, what enhanced your long-term memory of the items on the grocery list?
• Discuss the importance of repetition in forming long-term memories. (See Background.)
• Would it have been more or less difficult to remember the items if they hadn’t been in alphabetical order? Talk about how arranging information in a familiar sequence makes the information easier to remember. (See Background.)
• What else could you have done to remember the grocery store items, without repeating the list? (For example, students could make up a story about the items on the list, giving each item meaning or a context.)

EXTENDERS
Elementary School: Have younger students play the grocery game by imagining a make-believe trip to the zoo and listing the different animals they see.
Middle School: Challenge older students to list the items in reverse order.

When I was a kid the brain was a telephone-switching network, then it became a digital computer, then it became a massively parallel digital computer. I’m sure there’s a book out there now for kids that says the brain is the World Wide Web, and everything’s crosslinked.

Rodney A. Brooks, roboticist

Brainy Quote
To understand the limits and strengths of memory and learning, imagine you're teaching a new visitor to the U.S. the names of the state capitals. The first time she hears the names, she may forget them within minutes. After all, they're just random words that enter her short-term memory. But what if you shared facts, pictures, and positive and negative stories about each capital? Or had her taste and smell foods and listen to music from each city? You might even compare certain capitals to cities she knows from her own country. Slowly, the capital names become part of her long-term memory. That's because you've added meaning to these previously meaningless words. You've enhanced her long-term memory by activating her senses and engaging her cognitive processes by thinking about and comparing the cities. You also added an emotional aspect to the different capitals. All of these experiences and associations help reinforce her memory of the capital names. We do this when we remember information. We make mental connections, or associations, that link the information with senses, ideas, memories, and emotions. Another way people remember information is by using mnemonics. A mnemonic is a short rhyme, phrase, word trick, or other strategy for making information easier to remember. One example is taking the first letter of each item and forming a real word. For example, HOMES is a memory trick for remembering the names of the five Great Lakes: Huron, Ontario, Michigan, Erie, and Superior.

**WHAT TO DO:**
1. Before students arrive, arrange 10 of the 20 items on the tray and cover them with the sheet or towel.
2. When students are seated, tell them that you need their full attention. Uncover the tray and ask them to look closely at, but not touch, the items.
3. After two minutes, cover the tray again and ask students to write down as many of the items as they can remember.
4. Show students the items again, but this time, ask them to touch and talk about the different items. What are they used for? Do certain items remind them of something? Which ones do they like? Do any seem to stand out as particularly interesting or different? Ask students to predict how this discussion will affect their ability to remember the items.
5. After two minutes, cover the tray again and ask students to write down as many of the items as they remember.
6. Explain that the ability to recall information depends on how well the information is stored in the first place. Discuss mnemonics, special techniques for memorizing information, such as rhymes, phrases, or mental associations. Ask students to share any tricks for memorizing a list of information. (See Background.)

**DISCUSSION:**
- Why do you think it was easier to remember the items on the tray after you had touched and talked about them?
- Discuss how making sensory, cognitive, and emotional connections helps enhance our long-term memory of information. (See Background.)

**BACKGROUND:** Imagine you're teaching a new visitor to the U.S. the names of the state capitals. The first time she hears the names, she may forget them within minutes. After all, they're just random words that enter her short-term memory. But what if you shared facts, pictures, and positive and negative stories about each capital? Or had her taste and smell foods and listen to music from each city? You might even compare certain capitals to cities she knows from her own country. Slowly, the capital names become part of her long-term memory. That's because you've added meaning to these previously meaningless words. You've enhanced her long-term memory by activating her senses and engaging her cognitive processes by thinking about and comparing the cities. You also added an emotional aspect to the different capitals. All of these experiences and associations help reinforce her memory of the capital names. We do this when we remember information. We make mental connections, or associations, that link the information with senses, ideas, memories, and emotions. Another way people remember information is by using mnemonics. A mnemonic is a short rhyme, phrase, word trick, or other strategy for making information easier to remember. One example is taking the first letter of each item and forming a real word. For example, HOMES is a memory trick for remembering the names of the five Great Lakes: Huron, Ontario, Michigan, Erie, and Superior.

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**Motor Learning Card Game**

**OBJECTIVE:** To develop an understanding of reaction time; to study the relationship between increasingly complex tasks and the time needed to process these tasks.

**MATERIALS:** For each pair of students: A deck of playing cards, clock or watch with second hand.

**BACKGROUND:** When your senses receive information—such as a bright light or loud noise—your nervous system must receive and integrate this message, then cause the body to respond. The time it takes this to happen is called reaction time. Perhaps the quickest reaction time in the human body can be seen in the reflex, a type of control system connecting stimulus to response. Reflexes can be built-in. The former is seen in the automatic response that happens when a doctor taps your knee and you kick, or if you quickly pull your hand away from a hot fire.

When you play cards, you may have a fast reaction time, but this is different from a simple reflex. The information from the card travels into the eyes, and then onto the visual cortex (in the occipital lobe). From there, it travels to the association cortex, where the visual information will be related to memory of where to place the card. This information travels to the motor cortex, where a signal then travels down through the spinal cord and to the muscles to control arm movement.

**WHAT TO DO:**

1. Introduce the term reaction time and explain what it means. Talk about how some reactions, or reflexes, are automatic and have very fast reaction times. Ask students to give examples of reflexes. (See Background.)

2. Next, explain that many actions may seem automatic—or require a very short reaction time—but are quite different from simple reflexes. Using the example of playing cards, talk about the path that information takes through different parts of the brain. (See Background.)

3. Explain that students are going to work in pairs and perform a series of tasks with playing cards. Each task will be more and more complex. Ask how they think the complexity of these tasks will affect their reaction times.

4. Divide the class into pairs and have them choose one as the Card Sorter and the other as the Recorder.

5. Give each pair a deck of cards and have them shuffle the deck well. Give students the following tasks. Each time, the Recorder should time and record the amount of time it takes the Card Sorter to complete the task. Ask students to shuffle the cards after each task:

   - **Task #1:** The Card Sorter deals the cards into two piles as quickly as possible.
   - **Task #2:** The Card Sorter places the cards into two piles based on color, one pile for red cards and a second pile for black cards. (If the student puts a card in the wrong pile, he or she should pick it up and continue sorting.)
   - **Task #3:** The Card Sorter deals the cards into four random piles.
   - **Task #4:** The Card Sorter places the cards into four piles based on the suit of the cards: one for hearts, diamonds, spades, and clubs.

   (Note: Some students will cut the deck in half in Task #2 above. Some will cut the deck into four piles in Task #3. This could engender class discussion about frontal lobe strategizing.)

6. Have students use the Recorder’s information to create a bar graph showing the time for each task.

**DISCUSSION:**

- Compare the bar graphs. Which tasks took the most time?
- Which of these tasks was most difficult? Did this task take more or less time?
- Talk about what made some tasks more difficult than others. How do you think your brain reacts to more and more difficult tasks?

**EXTENSION**

Have students perform one of the sorting tasks multiple times to observe the relationship between practice and the amount of time needed to finish a task.

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*Based on "Reaction Time and Neural Circuitry" in The Neuroscience Laboratory and Classroom Activities. National Association of Biology Teachers and the Society for Neuroscience."
When you picture yourself in a favorite place, you use your visual cortex in the back of your head.

When you tap your fingers together, you use the prefrontal cortex to plan the action and the motor cortex to send messages to your hand muscles.

When you feel pain, receptors in the skin send messages through the brain’s relay station, or thalamus, to the sensory cortex, where the pain’s location and intensity are perceived.

When you do simple math, you use the prefrontal cortex, one of the brain’s areas for cognitive functions.

When you identify sounds, you trigger the auditory cortex on either side of your brain. Note: the auditory cortex is not visible in this view of the brain.

The cerebellum coordinates the whole process and helps you time your precise hand movements.

When you remember a past event, you use, among other parts of your brain, the hippocampus buried inside your brain.

The different senses you recall, like sights, smells, sounds, and emotions, use different parts of the brain. The smells you remember activate the olfactory cortex.

The Dana Web site, www.dana.org, offers free resources and publications, accessible information and news about the brain, links to many other brain-related organizations, and special sections for kids and seniors.

SCIENCE STANDARDS AND BENCHMARKS

Please visit our Web site (www.wiredtowinthemovie.com) for information on National Science Education Standards covered in the guide. This guide also addresses the following Benchmarks for Science Literacy as specified by the American Association for the Advancement of Science:

**Grades 4-5**
- Nature of Science
- The Nature of Technology
- The Human Organism
- Human Society
- The Designed World
- Habits of Mind

**Grades 6-8**
- Nature of Science
- The Nature of Technology
- The Living Environment
- The Human Organism
- The Designed World
- Common Themes
- Habits of Mind

**Grades 9-12**
- Nature of Science
- The Nature of Technology
- The Living Environment
- The Human Organism
- Habits of Mind

RESOURCES

Visit our Web site (www.wiredtowinthemovie.com) for a full list of resources for educators and students, including links to Web sites. On the Wired to Win site, you and your students can explore interactive about brain science, read interviews with scientists and educators, and learn about the history of the Tour de France, cycling, and neuroscience. You can also go behind the scenes to discover how a large-screen movie is made.


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