5

The Brain

LESSON PLANNING CALENDAR

Use this Lesson Planning Calendar to determine how much time to allot for each topic.

Schedule	Day One	Day Two	Day Three	Day Four
Traditional Period (50 minutes)	Studying the Brain Lower-Level Brain Structures	Lower-Level Brain Structures (continued)	The Cerebral Cortex	Differences Between the Brain's Two Hemispheres
Block Schedule (90 minutes)	Studying the Brain Lower-Level Brain Structures	The Cerebral Cortex Differences Between the Brain's Two Hemispheres		

ACTIVITY PLANNER FROM THE TEACHER'S RESOURCE MATERIALS

Use this Activity Planner to bring active learning to your daily lessons.

Topic	Activities
Studying the Brain	**Getting Started:** Critical Thinking Activity: Fact or Falsehood? (10 min.) **Building Vocabulary:** Greek and Latin Roots (10 min.) **Enrichment Lesson:** Lobotomies (15 min.) **Digital Connection:** *Scientific American Frontiers* (2nd ed.), Segment 6: "Image-Guided Surgery" (30 min.) **Digital Connection:** *Scientific American Frontiers* (2nd ed.), Segment 8: "Old Brain, New Tricks" (15 min.) **Digital Connection:** *Scientific American Frontiers* (2nd ed.), Segment 5: "Mind Reading" (30 min.)
Lower-Level Brain Structures	**Demonstration Activity:** Brain Puzzles, Models, and Molds (10 min.) **Application Activity:** A Portable Brain Model (20 min.) **Digital Connection:** DVD Series: *Journey to the Center of the Brain* (58 min.) **Digital Connection:** Videocassette Series: *The Brain: Our Universe Within* (50 min.) **Digital Connection:** *The Mind* (2nd ed.), Module 10: "Life Without Memory: The Case of Clive Wearing, Part 1" (14 min.) **Digital Connection:** *The Mind* (2nd ed.), Module 11: "Clive Wearing, Part 2: Living Without Memory" (33 min.) **Digital Connection:** DVD: *Inside Information—The Brain and How It Works* (58 min.) **Graphic Organizer:** The Brain (15 min.) **Digital Connection:** *The Mind* (2nd ed.), Module 6: "Brain Mechanisms of Pleasure and Addiction" (7 min.)
The Cerebral Cortex	**Digital Connection:** *The Brain* (2nd ed.), Module 25: "The Frontal Lobes and Behavior: The Story of Phineas Gage" (15 min.) **Digital Connection:** *The Brain* (2nd ed.), Module 7: "Brain Anomaly and Plasticity" (7 min.) **Digital Connection:** *Discovering Psychology:* "The Behaving Brain" (30 min.) **Digital Connection:** *The Brain* (2nd ed.), Module 1: "Organization and Evaluation of Brain Function" (8 min.) **Digital Connection:** *The Mind* (2nd ed.), Module 7: "The Frontal Lobes: Cognition and Awareness" (9 min.) **Application Activity:** The Sensory Homonculus (15 min.) **Digital Connection:** *The Mind* (2nd ed.), Module 18: "Effects of Mental and Physical Activity on Brain/Mind" (10 min.) **Enrichment Lesson:** Hemispherectomy (15 min.) **Digital Connection:** DVD Series: *The Brain: Our Universe Within* (90 min. each) **Digital Connection:** *Discovering Psychology:* "The Responsive Brain" (30 min.)
Differences Between the Brain's Two Hemispheres	**Digital Connection:** *The Brain* (2nd ed.), Module 6: "Language and Speech: Broca's and Wernicke's Areas" (15 min.) **Digital Connection:** *The Mind* (2nd ed.), Module 8: "Language Processing in the Brain" (15 min.) **Digital Connection:** *Scientific American Frontiers* (2nd ed.), Segment 7: "Severed Corpus Callosum" (15 min.) **Digital Connection:** *The Brain* (2nd ed.), Module 5: "The Divided Brain" (15 min.) **Cooperative Learning Activity:** Hemispheric Specialization (15 min.) **Critical Thinking Activity:** The Wagner Preference Inventory (15 min.) **Application Activity:** Handedness Questionnaire (15 min.) **Application Activity:** Behavioral Effects of the Split-Brain Operation (15 min.) **Enrichment Lesson:** The Right Brain Movement (15 min.) **Digital Connection:** *Mind Talk—The Brain's New Story* (58 min.) **Digital Connection:** DVD: *Left Brain, Right Brain* (56 min.) **Digital Connection:** Technology Application Activity: *PsychSim:* "Hemispheric Specialization" (20 min.) **Digital Connection:** Videocassette: *A Mind of Her Own* (15 min.) **Portfolio Project:** Connecting Neuroscience and the Brain

MODULE 5

The Brain

The human brain is perhaps the most fascinating, complicated, and powerful structure in the universe.

What is the most amazing thing in the universe? The answer is a matter of opinion, no doubt, but surely one of the leading candidates must be the brain. Think about it—oops, I guess that's already impossible without your brain! All art, music, and literature ever created began in a brain. The world's great (and not-so-great) architecture started in a brain. The principles of democracy, mathematics, and science began in a brain. You name it: If humans (or other animals) were behind it, the brain is what allowed it to happen. A brain can even think of itself in an effort to understand itself. Your liver can't do that.

The brain's complexity is, well, mind-boggling, but our discussion is limited to the basics. Vocabulary is the key. If you can master the words (most of which would already make perfect sense if you spoke Greek and Latin!), you will be well on your way to understanding your brain.

INTRODUCE THE MODULE

Getting Started TRM

Have students use **Critical Thinking Activity: Fact or Falsehood?** as a prereading strategy to find out what they already know about the brain. The activity, along with its results, will prime students to note terms and concepts in the text that confirm or dispel their preconceptions about this topic.

Building Vocabulary TRM

Have students work with partners to find and review Greek and Latin word roots (cited throughout the sections of the module) of some terms related to the brain. Then have pairs complete the activity on **Handout 5–3** in the Teacher's Resource Materials. This activity focuses on reading comprehension skills in addition to module vocabulary.

Resource Manager

Activities	TE	Web/Multimedia	TE	Film/Video	TE
Application	84, 86, 90, 91	Digital Connection	79, 85, 90, 92	*Scientific American Frontiers* (2nd ed.), Segment 8	78
Cooperative Learning	89	Technology Application	90, 92	*The Brain* (2nd ed.), Module 25	79, 85
Critical Thinking	77, 91, 92			*Scientific American Frontiers* (2nd ed.), Segment 6	79
Demonstration	84			*Scientific American Frontiers* (2nd ed.), Segment 5	80
Enrichment	79, 85, 89			*Journey to the Center of the Brain*	82
Graphic Organizer	81, 82, 83, 87, 93			Series: *The Brain: Our Universe Within*	82
Portfolio Project	92			*The Mind* (2nd ed.), Module 10	83
Vocabulary	77			*The Mind* (2nd ed.), Module 11	83
				Inside Information—The Brain and How It Works	84
				The Mind (2nd ed.), Module 6	84
				Discovering Psychology: "The Behaving Brain"	84

Film/Video references continue on page 78

5

TEACH

TEACHING TIP

Emphasize to students that the brain is interconnected in function. Even though research in this module will highlight the specialization of different parts of the brain and nervous system, these parts do not function in isolation. If one part of the brain or nervous system were to fail, the whole system may not function. Thus, the brain and nervous system are greater than the sum of their parts!

Beyond the Classroom TRM

Debate When Charlie refers to "newer" versus "older" parts of the brain, he is highlighting those parts that are shared with other mammals and are therefore the earliest parts of the brain that evolved. Have students debate the following questions:

- If humans and other mammals share so many parts of the brain, what distinguishes humans from all other mammals?
- Does explaining the brain from an evolutionary standpoint make you feel more or less different from other animals? Why?

At this point, you may want to use ***Scientific American Frontiers* (2nd ed.), Segment 8: "Old Brain, New Tricks."**

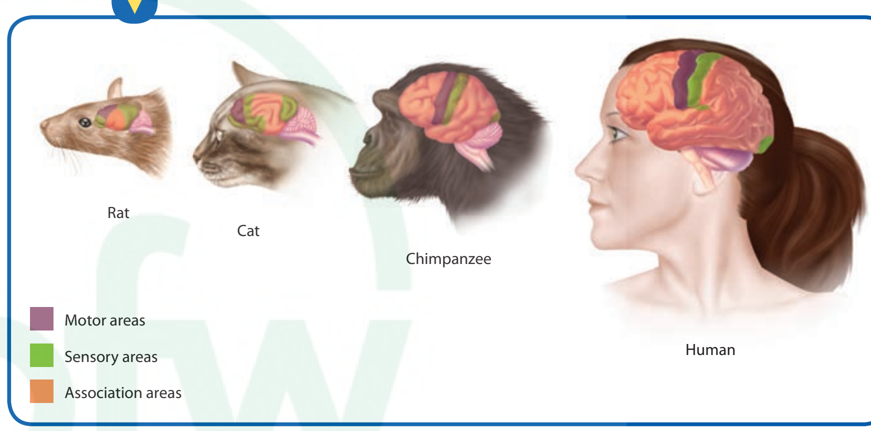
A Universe of Brains

One indication of our endless fascination with brains is the number of objects that use the shape of a human brain to attract attention. My students have brought me several dozen toys, advertisements, and cards that use the human brain. When do you suppose they'll bring me a hot air balloon?

The brains of most animals and all mammals share certain similarities (see **Figure 5.1**). Most animal brains, for example, have similar components because they share certain functions, such as digestion and respiration. The more complex the organism, the more complex and highly developed its brain. Complex organisms share basic components with less complex life forms. These parts of the brain developed first and tend to be in the inside, lower regions of the brain. The more complex parts of the brain that control uniquely human functions—things like judgment and sense of humor—are layered around and on top of the lower, more basic regions of the brain. In isolation, no one part of the brain would be capable of anything, but functioning together, the parts of the brain form an integrated whole with remarkable abilities. We will begin our discussion with the lower structures of the brain and then progress to those complex structures that truly make humans special. But first, let's take a look at how psychological scientists study the brain.

Figure 5.1
Brain Similarities in Different Mammals

Every mammal has a brain that can engage in similar functions, such as the ones noted here. The core areas of mammal brains are even more similar than the outer surfaces depicted here.



Resource Manager	
Film/Video	**TE**
The Brain (2nd ed.), Module 1	84
The Brain (2nd ed.), Module 7	85
The Mind (2nd ed.), Module 7	86
The Mind (2nd ed.), Module 18	87
Series: *The Brain*	88
Discovering Psychology: "The Responsive Brain"	88
Mind Talk—The Brain's New Story	89
Left Brain, Right Brain	89
The Brain (2nd ed.), Module 6	90
The Brain (2nd ed.), Module 8	90
A Mind of Her Own	91
The Brain (2nd ed.), Module 5	92
Scientific American Frontiers (2nd ed.), Segment 7	92

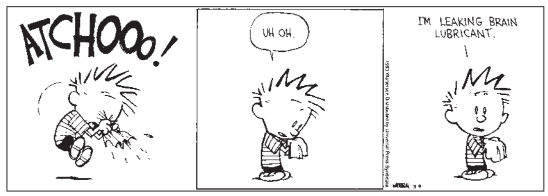
Studying the Brain

WHAT'S THE POINT?

5-1 What tools are available to psychological scientists for studying the brain?

case study A research technique in which one person is studied in depth in the hope of revealing universal principles.

Case Studies



In a **case study,** one person is studied in depth in the hope of revealing useful information. One of the most famous case studies in the history of psychology is that of Phineas Gage. Gage, a young man in his twenties, was working for the railroad in 1848 when he suffered a devastating brain injury. An explosion blew a pointed, 4-foot-long rod through Gage's cheek, just behind his eye, and straight out through the top of his skull (see **Figure 5.2**). Despite severe damage to his frontal lobe, Gage survived. In fact, he never even lost consciousness! The disruptive changes in his personality, however, have fascinated people ever since. Because the injury damaged the frontal lobe, where the judgment and the ability to make good decisions are located, Gage went from being a responsible worker to becoming an unreliable, irritable, dishonest man who could not hold his previous job. Despite living many more years, he was, in the words of a friend, "no longer Gage." Gage's injury and the annals of many other brain injuries over the years have allowed psychologists to speculate on the functions of the parts of the brain destroyed by the accidents. Each unfortunate injury allows psychologists to add another piece to the puzzle of how the brain operates.

Case studies have always been an important way to study the brain, but they are limited in the kind of information they provide because accidents are haphazard. And because case studies are based on a sample size of one, it is difficult to generalize the findings to other cases. How do we know everyone would respond as Gage did to similar circumstances? Only experiments

Figure 5.2
Phineas Gage
This case study is so compelling that it's still being researched more than 150 years after Gage's accident. On the left is a computer-generated image showing the probable path of the rod that passed through Gage's brain. On the right is a photograph taken after the accident. Gage is holding the rod.

TEACHING TIP TRM

The idea that we use only 10 percent of our brains is a myth that likely emerged as a result of early case study research in neuroscience. As brain research techniques evolved, scientists found that most of the brain is active at any given moment. Those areas thought to be unused were probably association areas.

To help students learn more, use **Enrichment Lesson: Lobotomies** and ***Scientific American Frontiers*** **(2nd ed.), Segment 6: "Image-Guided Surgery."**

ACTIVE LEARNING

Multicultural Connection

Ethical practices in medicine vary among countries. Assign small groups of students to research ethical guidelines for brain research on human research participants in one of the following regions or countries, comparing the guidelines to those in the United States: the European Union, Russia, China, Japan, Mexico, South America, South Africa, India, or Australia. Have students present their findings to the class, emphasizing responses to the following questions:

- How are these policies similar to and different from U.S. policy?
- Have the policies of this country/region positively or negatively affected patient health?

DIGITAL CONNECTION TRM

For a vivid reenactment of Phineas Gage's accident, use ***The Brain*** **(2nd ed.), Module 25: "The Frontal Lobes and Behavior: The Story of Phineas Gage."**

CROSS-CURRICULAR CONNECTION

Research Methods

How do other fields of science use case studies when experiments are not ethically or realistically possible? Have students gather some research articles from other fields of science that have used case studies so students can see what conclusions scientists have drawn about the use of case studies in this research.

5

Beyond the Classroom

Guest Speaker Invite a radiologist to class to discuss the different brain scans. Ask your guest if it is possible to bring brain scan examples to show your students and to describe how the scans are administered and interpreted.

Beyond the Classroom TRM

Discuss Help students relate to brain-imaging techniques by asking them to share their experiences if they've had any of the described scans. While most scans are done on other body parts, describing them can be enlightening for all students.

At this point, you may want to use ***Scientific American Frontiers* (2nd ed.), Segment 5: "Mind Reading."**

computerized axial tomography (CT or CAT) A series of X-ray photographs taken from different angles and combined by computer into a composite representation of a slice through the body.

magnetic resonance imaging (MRI) A technique that uses magnetic fields and radio waves to produce computer-generated images that distinguish among types of soft tissue; this allows us to see structures within the brain.

allow us to draw solid cause-and-effect conclusions. From a scientific point of view, our conclusions would be more sound if we could systematically damage specific brain regions in experiments on humans. You are probably already considering the ethical difficulties with this—at the least, it would be difficult to secure volunteers! So, given the ethical limits to gathering experimental evidence on the brain, case studies can provide important but somewhat limited information. Luckily, ever-improving technology gives us another line of evidence.

Scanning Techniques

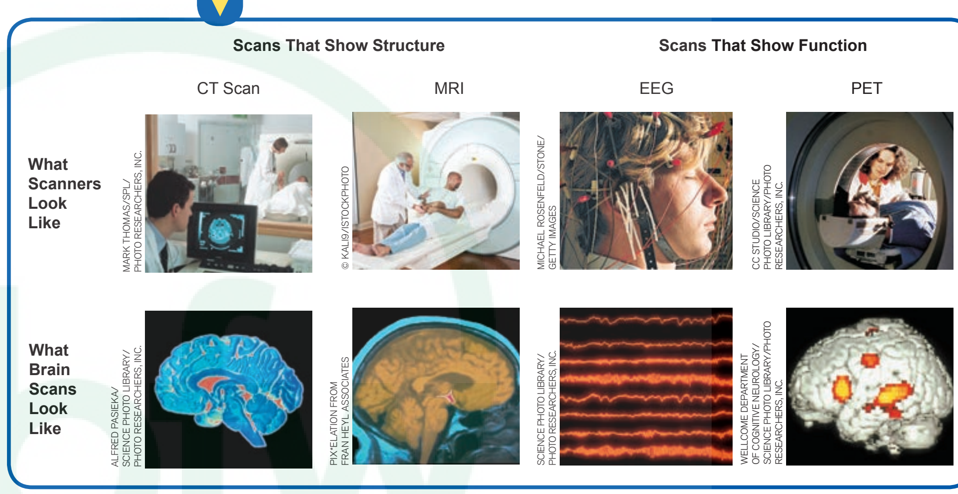
With remarkable technological advances, various scanning techniques provide a window through which researchers can study healthy, functioning brains in living people. These techniques have revolutionized brain research and the diagnosis and treatment of brain problems. Brain scans provide information in two different categories: brain structure and brain function (see **Figure 5.3**).

To study brain *structure,* researchers mostly use two kinds of scans: computerized axial tomography and magnetic resonance imaging. **Computerized axial tomography** (usually referred to as **CT or CAT**) is a series of X-rays taken from different angles and combined by computer into a composite representation of a slice through the body. **Magnetic resonance imaging (MRI)** uses magnetic fields and radio waves to produce computer-generated images that distinguish among different types of soft tissue. This allows us to see different structures within the brain. These scans are ideal for examining what the specific parts of the brain (and other parts of the body as well) actually look like. For example, CT scans and MRI images can find a tumor or locate brain damage following a stroke.

To study brain *function,* researchers mostly use the electroencephalogram, the positron emission tomography scan, and a newer technology based on

Figure 5.3
Modern Scanning Techniques

These machines may look scary, but they provide a window into the brain for both research and treatment of disorders.



magnetic resonance imaging called functional MRI (fMRI). These three types of scans allow researchers to see what the brain is doing at a given point in time. An **electroencephalogram (EEG)** is an amplified recording of the waves of electrical activity that sweep across the brain's surface. These electrical waves are measured by electrodes placed on the scalp. EEGs are often the tool of choice for diagnosing sleep disorders and seizure disorders. A **positron emission tomography (PET) scan** is a visual display of brain activity. Researchers inject a radioactive form of glucose (blood sugar) into a person, and the PET scan detects where it goes in the brain while the person performs a given task. PET and fMRI scans track the flow of blood to help identify which parts of the brain are active during a particular task. Such scans have taught us, for example, that the occipital lobes are responsible for visual processing and that facial recognition occurs in the temporal lobes.

Phineas Gage remains famous for his tragic contribution to psychological knowledge. We are fortunate that new scanning techniques have made it possible to learn more about the brain with less human suffering. Consider what new "windows to the brain" will open up during your lifetime! Perhaps you will help develop one of them.

electroencephalogram (EEG) An amplified recording of the waves of electrical activity that sweep across the brain's surface; these waves, measured by electrodes placed on the scalp, are helpful in evaluating brain function.

positron emission tomography (PET) scan A visual display of brain activity.

brainstem The oldest part and central core of the brain; it begins where the spinal cord swells as it enters the skull and is responsible for automatic survival functions.

PAUSE NOW OR MOVE ON

Turn to page 92 to review and apply what you've learned.

Lower-Level Brain Structures

WHAT'S THE POINT?

5-2 What kinds of behaviors and thoughts are controlled by the innermost parts of our brain, the lower-level brain structures?

The innermost structures of your brain are similar to the brains of all mammals. They are at the core because they evolved first. The newer regions are layered on top, much as paint builds up on the walls of older houses. In this section, we examine some of the innermost structures, called lower-level brain structures. They include the brainstem, the thalamus, the cerebellum, and the limbic system.

The Brainstem

No structural point marks where the brain and the spinal cord meet. You can either think of the brain as a rose that has blossomed on top of a stem or think of the spinal cord as a tail that extends down from the brain. Your choice! The **brainstem** is the oldest part and central core of

ACTIVE LEARNING

Research

Have students explore statistics regarding survival and recovery rates from spinal cord injuries.

- Do mortality and recovery rates differ for injuries closer to the brainstem?
- How do people with spinal cord injuries feel about life and their injuries? What are their general levels of well-being?
- How have recent advances in spinal cord research changed the prognosis of spinal cord injuries? How have people like the late Christopher Reeve helped with this research?

FYI

Studies in cats have showed that stimulating the **reticular formation** caused them to perk up their ears as if they had heard something. When the area was cut, the cats lapsed into an unrecoverable coma. Studies like this indicate that the reticular formation helps us pay attention to novel stimuli in the environment.

Differentiation TRM

Graphic Organizer Students can use **Graphic Organizer: The Brain** to preview content for this module.

- **Independent learners** can fill out the organizer on their own or follow along in class during discussion and lecture.
- **Cooperative learners** can use the textbook as a resource and work in groups to find the answers that fit in the blanks.
- **Exceptional learners** can fill in the blanks independently, with a tutor, or during class discussion and lecture.

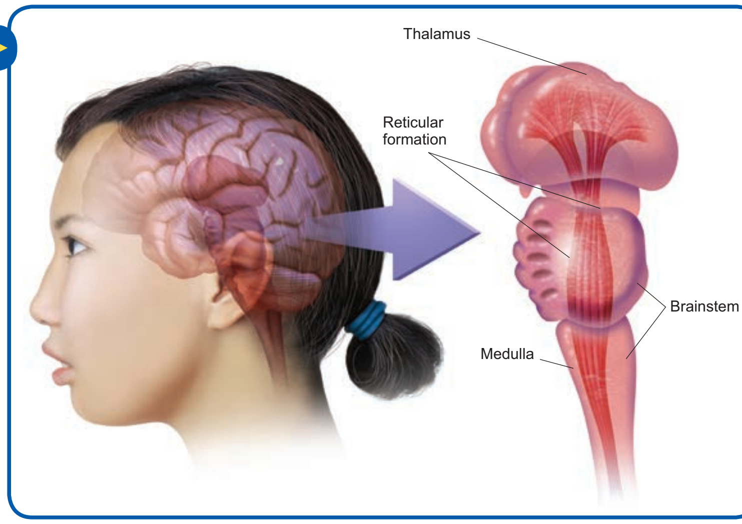
FYI TRM

- All sensory information—except for smell—is routed through the thalamus, which sends the information to the appropriate cortex for processing.
- Smell, an "old" sense on the evolutionary scale, travels to the olfactory cortex and then to the thalamus for processing.
- It seems that our brains adapted other senses after smell, causing them to be processed differently.

At this point, you may want to watch ***Journey to the Center of the Brain*** and ***The Brain: Our Universe Within.***

Figure 5.4
The Brainstem and the Thalamus

The brainstem is a swelling at the top of the spinal cord. The medulla and reticular formation support fundamental processes like breathing and wakefulness. The thalamus, perched on top, routes sensory information to the proper regions of the brain.



medulla [muh-DUL-uh] Located at the base of the brainstem, it controls basic life-support functions like heartbeat and breathing.

reticular formation A nerve network in the brainstem that plays an important role in controlling wakefulness and arousal.

the brain. It begins where the spinal cord swells as it enters the skull (see **Figure 5.4**).

Located at the base of the brainstem, the **medulla** controls basic life-support functions such as heartbeat, breathing, circulation, and swallowing. Don't hurt yours—damage in this region would almost certainly lead to death.

Another part of the brainstem is the **reticular formation,** a nerve network that plays an important role in controlling wakefulness and arousal. The reticular formation follows the back of the spinal cord as it rises into the brain. Damage to this region would cause a coma.

Ever notice how easily smell triggers memories? Smell information bypasses the thalamus and is routed directly to memory and emotion centers in the brain. This may be why the smell of your grandparents' house or a hospital ward can unleash a flood of emotions, sometimes positive and sometimes negative.

The Thalamus

The **thalamus,** Greek for "inner chamber," is located at the top of the brainstem in the middle of the brain. The thalamus is the brain's sensory switchboard, and it directs messages to the sensory receiving areas in the cortex. Have you ever seen a photograph of an old-fashioned telephone switchboard, with an operator plugging in cords to route calls to the proper phone? Such is the role of the thalamus. The incoming fibers of all your senses (except smell) funnel into the thalamus, which then distributes the sensory information to the proper regions of the brain for processing.

The Cerebellum

The **cerebellum,** Latin for "little brain" (and it does look a bit like an extra minibrain), is attached to the rear of the brainstem. In conjunction with other brain regions, your cerebellum controls voluntary movements and balance

CROSS-CURRICULAR CONNECTION TRM

Anatomy and Physiology

Team up with your school's biology teacher to create a lesson on brain parts and functions. Feel free to explore parts of the brain that aren't included in the text. The biology teacher can present lessons about the specific parts and functions, and you can offer lessons that explore how these parts affect behavior. You may wish to use **Graphic Organizer: The Brain** in this cross-curricular lesson.

If possible, have students use *A Colorful Introduction to the Anatomy of the Human Brain: A Brain and Psychology Coloring Book* to review what they have learned.

Source: Pinel, J. P. J., & Edwards, M. E. (1998). *A colorful introduction to the anatomy of the human brain: A brain and psychology coloring book.* Needham Heights, MA: Allyn & Bacon.

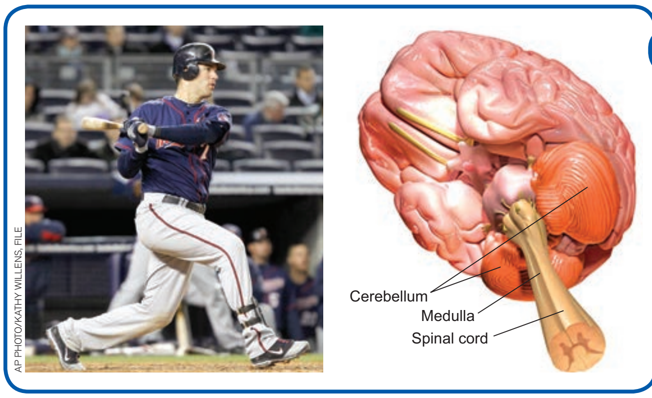


Figure 5.5
The Cerebellum

The cerebellum is obvious as it juts out from the bottom rear of the brain. Its primary role is coordination and balance. Joe Mauer would be unable to make contact with a baseball if his cerebellum weren't working properly.

(see **Figure 5.5**). Research has shown the cerebellum plays a role in governing emotions, hearing, and touch (Bower & Parsons, 2003). The cerebellum also controls memories for knowing how to use your body for things like walking or playing the guitar. The cerebellum makes it possible to smoothly engage in tasks such as running or writing. If your cerebellum were damaged, you could still decide to move your feet, but you would lose much of the coordination and balance required for dancing well. You could move your hands, but you would lose the dexterity required to play the guitar.

thalamus [THAL-uh-muss] The brain's sensory switchboard, located on top of the brainstem; it directs messages to the sensory receiving areas in the cortex.

cerebellum [sehr-uh-BELL-um] The "little brain" attached to the rear of the brainstem; it helps coordinate voluntary movements and balance.

limbic system A ring of structures at the border of the brainstem and cerebral cortex; it helps regulate important functions such as memory, fear, aggression, hunger, and thirst, and it includes the hypothalamus, the hippocampus, and the amygdala.

The Limbic System

As you can see from **Figure 5.6,** the **limbic system** (Latin for "border"), is a ring of structures at the border of the brainstem (the older core regions) and the cerebral cortex (the more recently developed surface regions). The limbic system helps regulate important functions such as memory, fear, aggression, hunger, and thirst. The limbic system includes the hypothalamus, the hippocampus, and the amygdala.

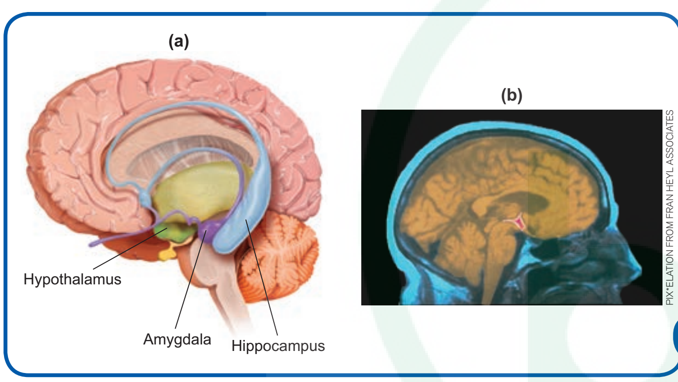


Figure 5.6
The Limbic System

(a) The limbic system is a ring of structures (including the hippocampus, amygdala, and hypothalamus) surrounding the thalamus and forming a border between the brainstem (the older core regions) and the cerebral cortex (the more recently developed surface regions). (b) The hypothalamus is tiny, but it plays a huge role in regulating responses ranging from thirst to pleasure. The hypothalamus is the red-colored region in this MRI brain scan.

Differentiation

Research indicates that part of the cerebellum's function is to tell the brain what to expect from the body's own movements. In this way, the brain can ignore expected pressure on the soles of the feet while walking and attend to more important sensations such as stubbing a toe.

Sarah-Jayne Blakemore and her colleagues at University College, London, addressed the interesting question "Why can't we tickle ourselves?" The researchers had six volunteers lie in a brain-scanning machine with their eyes closed. A plastic rod with a piece of soft foam tickled the participants' left palms. The volunteers were either tickling themselves or were being tickled.

The Blakemore team concluded that during self-tickling, the cerebellum tells the somatosensory cortex, "It's just you. Don't get excited." The brain knows what to expect and dampens the tickling sensation.

Source: Blakemore, S., Wolpert, D., & Frith, C. (1998). Central cancellation of self-produced tickle sensation. *Nature Neuroscience, 1,* 635–640.

TEACHING TIP TRM

Help students understand that the limbic system is a collection of structures in the midbrain. Often, students will not understand that the limbic system is made up of the hypothalamus, hippocampus, and amygdala.

At this point, you may want to use the video resources ***The Mind* (2nd ed.), Module 10: "Life Without Memory: The Case of Clive Wearing, Part 1"** and ***The Mind* (2nd ed.), Module 11: "Clive Wearing, Part 2: Living Without Memory."**

Check for Understanding TRM

Have students use **Graphic Organizer: The Brain** described in the Teacher's Resource Materials to label each brain part and describe its function on a blank organizer or as a quiz.

5

Beyond the Classroom TRM

Apply Studies in rats have shown that the **hypothalamus** can be divided into two sections: the lateral side (LH), which controls hunger, and the ventromedial side (VMH), which controls satiety. In these studies, stimulation to the LH produced behaviors that led to seeking out food and lesions to the VMH caused rats to overeat until they became obese. You can use **Application Activity: A Portable Brain Model** and **Demonstration Activity: Brain Puzzles, Models, and Molds** to point out the location of the hypothalamus.

TEACHING TIP TRM

Help students remember the function of the **hypothalamus** by reminding them that it controls the function of the **pituitary gland,** studied in Module 4. As the "master gland," the pituitary gland directs hormonal system functions. If our hormones regulate everything from hunger to stress reactions to sex, then the hypothalamus really does control the body!

At this point, you may want to watch ***Inside Information—The Brain and How It Works*** and ***The Mind*** **(2nd ed.), Module 6: "Brain Mechanisms of Pleasure and Addiction."**

FYI TRM

The **hippocampus** is the only known brain structure that can be completely removed without causing any physical problems. But while physical function is not lost, damage or removal of the hippocampus destroys the ability to form new memories. People suffering from this live constantly in the present. Like the main character in the film *Memento*, they cannot remember anything for longer than a few minutes. Imagine what the world would be like with only a short-term memory!

At this point, you may want to watch ***Discovering Psychology*****: "The Behaving Brain"** and ***The Brain*** **(2nd ed.), Module 1: "Organization and Evaluation of Brain Function."**

hypothalamus [hi-po-THAL-uh-muss] A neural structure lying below the thalamus; it helps regulate many of the body's maintenance activities, such as eating, drinking, and body temperature, and is linked to emotion.

hippocampus A neural center located in the limbic system that wraps around the back of the thalamus; it helps process new memories for permanent storage.

amygdala [uh-MIG-duh-la] An almond-shaped neural cluster in the limbic system that controls emotional responses, such as fear and anger.

Of the many structures in the limbic system, perhaps the most important is the **hypothalamus,** a neural structure lying beneath the front of the thalamus (*hypo* means "beneath"). The hypothalamus helps regulate many of your body's maintenance functions, including hunger and thirst, the fight-or-flight reaction to stress, and body temperature. The hypothalamus also plays a large role in the experience of emotion, pleasure, and sexual function. Cell for cell, it would be hard to identify a more crucial brain part.

Two other vital structures in the limbic system are the hippocampus and the amygdala. The **hippocampus,** which looks vaguely like a seahorse (you guessed it—*hippo* is Greek for "horse"), is a neural center that wraps around the back of the thalamus and helps process new memories for permanent storage. The **amygdala** (from the Greek for "almond") is an almond-shaped structure in the limbic system. The amygdala controls many of your emotional responses, especially emotions like fear and anger.

PAUSE NOW OR MOVE ON

Turn to page 92 to review and apply what you've learned.

The Cerebral Cortex

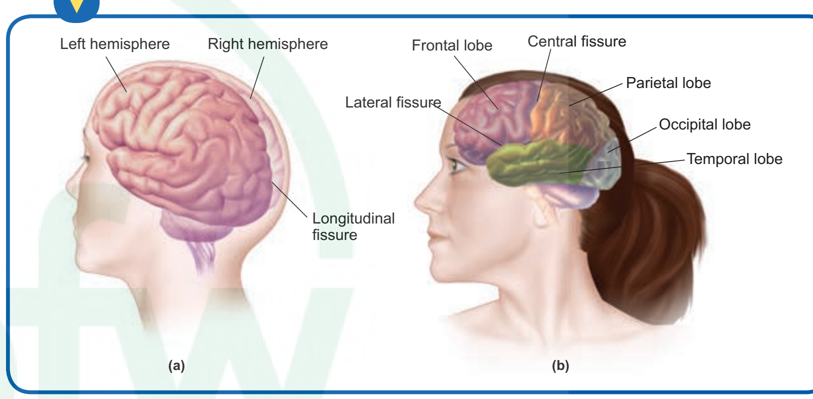
WHAT'S THE POINT?

5-3 What are the regions of the outer surface of the brain, the cerebral cortex, and what are the functions of these regions?

Close your eyes and conjure up an image of a brain. What did you see? Probably not the lower-level structures we have been discussing, right? More likely, you thought of the brain's wrinkled outer surface—the **cerebral cortex** (see **Figure 5.7**), an intricate fabric of interconnected neurons that make up the

Figure 5.7
Basic Landmarks of the Cerebral Cortex

The cerebral cortex is the wrinkled outer surface of the brain. It is divided by fissures into two hemispheres (a) and four major lobes (b).



body's ultimate control and information-processing center. The cerebral cortex covers the brain's lower-level structures, just as a glove covers your hand. The word *cortex* derives from the Latin word for "bark," an appropriate name given the tree bark–like appearance of the brain's outer surface. The wrinkles of the cerebral cortex allow more brain tissue to be packed into a confined space, like a sleeping bag into its stuff sack. Thanks to this efficient use of space, an estimated 20 to 23 billion neurons can exist in a layer of brain tissue only one-eighth of an inch thick (de Courten-Myers, 2002). Even more amazing, there are several times as many glial cells sharing this space with the neurons. These glial cells assist and support the neurons, much as paramedics assist and support the work of physicians (Miller, 2005).

Major Divisions of the Cortex

The most dramatic feature of the cortex is the **longitudinal fissure,** the crevice that divides the cerebral cortex into two halves called *hemispheres* (see Figure 5.7a). If you were to poke your pencil down this fissure (not that you should try this, mind you), you would eventually meet resistance at the **corpus callosum,** a large band of neural tissue that connects the two brain hemispheres and allows them to communicate with each other. The corpus callosum is clearly visible in **Figure 5.8.**

If you look back at Figure 5.7a (and use your imagination), you may note that the brain resembles a side view of a boxing glove. If you make your way around the boxing glove, you can see that additional fissures—a lateral fissure and a central fissure—create major divisions of tissue on each side. These divisions create four brain lobes—frontal, parietal, occipital, and temporal (see Figure 5.7b). Lying just behind the forehead, the **frontal lobes** (left hemisphere and right hemisphere) enable your most advanced cognitive (thinking) abilities, such as judgment and planning. The frontal lobes' rational abilities literally lie atop, and connect with, the more primitive limbic region where the roots of emotion are found. This means that both emotion and reason are going to influence the decisions you make. The frontal lobes include the motor cortex (discussed later).

cerebral [seh-REE-bruhl] cortex The intricate fabric of interconnected neurons that form the body's ultimate control and information-processing center.

longitudinal fissure The long crevice that divides the cerebral cortex into the left and right hemispheres.

corpus callosum [KOR-pus kah-LOW-sum] The large band of neural tissue that connects the two brain hemispheres and allows them to communicate with each other.

frontal lobes The portion of the cerebral cortex lying just behind the forehead that is involved in planning and judgment; it includes the motor cortex.

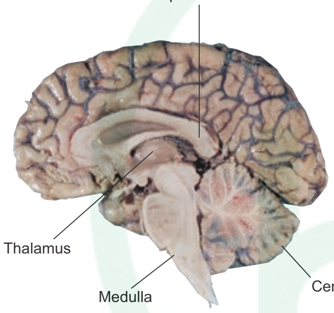


Figure 5.8
The Corpus Callosum

The corpus callosum is clearly visible in this photograph of a brain, made by cutting straight down through the longitudinal fissure. You can also see other structures we have discussed: the thalamus, the medulla, and the cerebellum.

ACTIVE LEARNING TRM

Brain Surgery: Hemispherectomies

Have students research hemispherectomies, procedures in which an entire hemisphere of the brain is removed. **Ask:**

- Why was such a drastic procedure performed, and what was the expected result?
- What amazing recovery stories resulted from these procedures?

Students can learn more about brain surgery by viewing ***The Brain*** **(2nd ed.), Module 7: "Brain Anomaly and Plasticity"** and from **Enrichment Lesson: Hemispherectomy.**

Differentiation TRM

Frontal lobotomies were first performed in the 1940s to treat aggressive schizophrenics. In the most common procedure—the "ice-pick lobotomy"—a surgeon would sweep a pick back and forth, severing the connections of the prefrontal cortex with the rest of the brain. Pose the following questions to your students regarding lobotomies:

- Based on your knowledge of the brain, why did this surgery seem to work?
- Why do you think this surgery was used on "hard-to-handle" patients?
- What ethical guidelines today would prevent the use of lobotomies?

To help students learn more, use **Enrichment Lesson: Lobotomies.**

ACTIVE LEARNING

The Wrinkly Cortex

Explain to students that the deeply convoluted surface of the brain is strongly linked to intelligence. Because of its wrinkled appearance in humans, only about a third of it is visible on the surface.

1. Illustrate the surface area of the cortex by taping together two 11 × 17 sheets of paper (large-size copy paper).
2. Tell students the following: "This sheet represents the approximate surface area of that thin sheet of neural tissue that we call the cerebral cortex. How can we fit it inside a skull small enough, along with the rest of the fetus, to be delivered through the mother's birth canal?"

(Students should guess that nature's answer is to crumple it up.)

DIGITAL CONNECTION TRM

Use ***The Brain*** **(2nd ed.), Module 25: "The Frontal Lobes and Behavior: The Story of Phineas Gage"** to reinforce the relationship of the amygdala and the limbic system with the cerebral cortex and the frontal lobe. Without communication among these brain regions, people lack the judgment to control emotional reactions.

FYI TRM

Two major fissures on the sides of the brain outline the boundaries of different lobes.

- The **lateral fissure** marks the upper limits of the temporal lobes and the bottom limits of the frontal lobes.
- The **central fissure** marks the boundary between the frontal and parietal lobes. On the frontal lobe side of the central fissure lies the motor cortex. On the parietal side of the fissure lies the sensory cortex.

At this point, you may want to use ***The Mind*** **(2nd ed.), Module 7: "The Frontal Lobes: Cognition and Awareness."**

TEACHING TIP TRM

Students can remember the different lobes by associating function with location.

- The **frontal lobe** controls thinking and judgment. Have students tap their foreheads as they think through a difficult decision.
- The **temporal lobe** controls hearing and is located just beside the ears.
- The **occipital lobe** controls vision. Have students recall an instance when they were hit in the back of the head. When this happens, people typically "see stars" because their visual system is momentarily impaired.
- The **parietal lobe** controls touch and sensory processing. Have students scratch the tops of their heads as if they are washing their hair. This will help them remember that touch is controlled by that part of the "head."

At this point, you may want to use **Application Activity: The Sensory Homunculus.**

Beyond the Classroom

Vocabulary Have students work in groups to find Greek and Latin roots for other parts of the brain not defined in the text, such as the medulla, reticular formation, corpus callosum, longitudinal fissure, frontal lobes, parietal lobes, occipital lobes, and temporal lobes.

parietal [puh-RYE-uh-tuhl] lobes The portion of the cerebral cortex lying at the top of the head and toward the rear; it includes the somatosensory cortex and general association areas used for processing information.

occipital [ahk-SIP-uh-tuhl] lobes The portion of the cerebral cortex lying at the back of the head; it includes the primary visual processing areas of the brain.

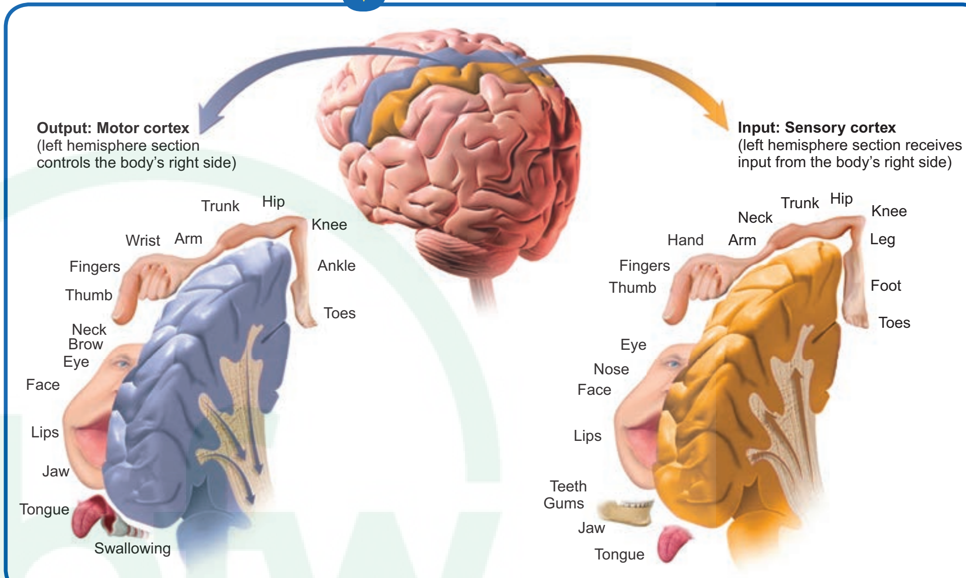
Behind the frontal lobes, at the top of the head and toward the rear, are the **parietal lobes.** The parietal lobes include the somatosensory cortex (discussed later), but they are largely designated as *association areas*—regions available for the general processing of information, including much mathematical reasoning and integration of memory. At the rear of the cerebral cortex are the **occipital lobes,** the primary visual processing areas of the brain. You may not have eyes in the back of your head, but you do see with the back of your brain. Finally, the thumb region of the boxing glove, lying roughly above the ears, holds the **temporal lobes,** which include the auditory (sound) processing areas of the brain.

Movement and Feeling

Have you ever wondered how your brain tells your body parts to move? What happens in your brain to let you walk, raise your hand, or wiggle your ears? Is there a specific spot where these things happen? The answer is *Yes.* The **motor cortex** is a strip of tissue on the rear edge of the frontal lobes that controls voluntary movements of your body parts (see **Figure 5.9**). Different points on the motor cortex control different parts of your body, but they do so in a curious cross-wired pattern. Thus, the motor cortex in your right hemisphere takes care of movement on the *left* side of your

Figure 5.9
The Motor Cortex and the Somatosensory Cortex

On both sides of the central fissure, two strips of brain tissue handle information flowing from your senses to your body parts. The motor cortex is part of the frontal lobes, and the somatosensory cortex is part of the parietal lobes. The figure drawn on the expanded version of each strip roughly represents the amount of brain tissue devoted to particular body parts.



ROB VAN NOSTRAND

When Does One Point Become Two?

Your sensitivity to touch increases as you move down the inside of your forearm toward your wrist and the palm of your hand. To test this yourself, unfold a paper clip so the two tips are about half an inch apart. Then drag the two-pointed clip slowly and gently down a friend's arm while he has his eyes closed. If all goes well, your friend will report that the two tips of the paper clip feel like one point when they are higher on his arm. The two tips will begin to feel like two points lower on the arm as you approach the wrist again. This happens because the wrist and hand have more brain tissue on the somatosensory cortex, and thus more sensitivity, than does the upper arm.

body, and the motor cortex in your left hemisphere controls movement on the *right* side of your body.

Another odd thing about the motor cortex is that the bigger parts of your body don't have the largest amount of brain area. Instead, the parts of the body that are capable of more intricate movements (like the hands and the face) demand more brain tissue than body parts for which intricate movement is not possible (like the arm and the ankle). If you were to draw a body along the motor cortex so that the body parts were proportionate to the amount of brain tissue, you would have a distorted drawing indeed, like the one in Figure 5.9.

Just behind the motor cortex, a similar strip of tissue stretches along the front edge of the parietal lobes. This is the **somatosensory cortex,** a brain area that registers and processes body sensations. This term sounds more difficult than it really is. If you remember that *soma* is Greek for "body," you'll remember that this strip of cortex is where your body senses register. For example, when you feel a tickle under your nose or the pain of a stubbed toe, your brain will register that stimulation in the somatosensory cortex. As you can see in Figure 5.9, the somatosensory cortex allots more brain tissue to parts of your body that are more sensitive to touch (like your fingertips) than to those that are less sensitive (like your arms).

Brain Plasticity

The brain has an extraordinary ability to compensate for damage or injury. While damage to the brain is always serious, under some circumstances, especially in young people, the cerebral cortex can actually "reprogram" itself to compensate for a problem. For example, if a tumor in one brain

temporal lobes The portion of the cerebral cortex lying roughly above the ears; it includes the auditory (hearing) areas of the brain.

motor cortex A strip of brain tissue at the rear of the frontal lobes that controls voluntary movements.

somatosensory cortex A strip of brain tissue at the front of the parietal lobes that registers and processes body sensations.

Differentiation

When **Albert Einstein** died in 1955, his family (based on Einstein's wishes) donated his brain to researchers for scientific study. Among the more interesting findings include these:

- The overall size of Einstein's brain was average, but the **inferior parietal lobe,** where visual-spatial cognition, mathematical thought, and movement imagery are controlled, was 15 percent wider than normal. Einstein's insights were often the result of visual images that he translated into mathematics. For example, he based his theory of relativity on what he thought it would be like to ride through space on a beam of light.
- The **Sylvian fissure** (a groove that runs through brain tissue) was shorter than average. This meant the brain cells were packed more closely together, permitting more interconnections and cross-referencing of information.
- Critics observe that while Einstein's brain may be different, the cause-and-effect relationship is unanswered, noting that differences may result from strenuous mental exercise, not inherent genius.

Sources: Lemonick, M. D. (1999, June 28). Was Einstein's brain built for brilliance? *Time,* p. 54.

Witelson, S. F., Kigar, D. L., & Harvey, T. (1999). The exceptional brain of Albert Einstein. *The Lancet, 353,* 2149–2153.

Beyond the Classroom TRM

Writing Have students tap into their creativity by writing short stories that use different parts of the brain as characters. Each story character should be a brain part whose function relates to the character's actions, feelings, or motives. Review the stories to make sure that the characters accurately reflect the brain part they represent. Invite volunteers to read their work aloud or make the stories available for other students to read. As students create or share their stories, encourage them to refer to **Graphic Organizer: The Brain.**

At this point, you may want to use ***The Mind* (2nd ed.), Module 18: "Effects of Mental and Physical Activity on Brain/Mind."**

TEACHING TIP

Students may wonder why the brain's ability to transfer function is called *plasticity*. Have students think about how flexible plastic is compared to other solid objects. Plastic can be molded, taking whatever shape the mold is. The brain also adapts to its environment, molding its function in response to the circumstances it experiences.

Beyond the Classroom

Debate Some wonder what benefit focusing on positive neuroscience would offer. Have students discuss how "positive" brains may function differently from "negative" brains. Make connections with later modules on cognition and abnormal psychology when discussing mood-congruent memories and the cognitive processes underlying depression.

FYI TRM

Roger Sperry (1913–1994) won the 1981 Nobel Prize for Physiology or Medicine for his work on split-brain research. After receiving a degree in English from Oberlin College, he moved on to doctoral work in zoology and postdoctoral work under Karl Lashley at the Yerkes Primate Laboratory.

At this point, you may want to watch ***The Brain*** **and** ***Discovering Psychology:*** **"The Responsive Brain."**

plasticity The brain's ability to change, especially during childhood, by reorganizing after damage or experience.

hemisphere starts to disrupt language ability, language function may transfer to the other hemisphere (Thiel et al., 2006). This remarkable ability is called **plasticity.**

The brain's plasticity is what makes some forms of therapy effective. There was a stroke victim who lost much of the ability to use his arm. His therapists did not allow him to use his good arm. By forcing him to use the damaged arm, he gradually regained function as his brain adjusted to the forced usage. Eventually, he was able to write and play tennis with the arm (Doidge, 2007). (See Thinking About Positive Psychology: The Positive Neuroscience Project to learn about other innovative brain research.)

Thinking About POSITIVE PSYCHOLOGY

The Positive Neuroscience Project

While considerable research in neuroscience has focused on disease, dysfunction, and the harmful effects of stress and trauma, very little is known about the neural mechanisms of human flourishing. Creating this network of future leaders in positive neuroscience will change that.

—Martin Seligman

Written into a multimillion-dollar grant proposal, those words helped the University of Pennsylvania's Positive Psychology Center obtain the support necessary to fund a number of research projects collectively called the Positive Neuroscience Project (www.posneuroscience.org). The projects selected to receive funding all study how the brain enables human flourishing.

Program director Denise Clegg (2009) notes that to qualify for grant money, proposed research ideas need to fall into one of the following categories (adapted from www.posneuroscience.org/research-awards.html):

1. *Virtue, strength, and positive emotion:* What are the neural bases of cognition that enable virtues such as persistence, honesty, compassion, love, curiosity, courage, and creativity?
2. *Exceptional abilities:* What is special about the brains of exceptional individuals? Can we learn from them?
3. *Meaning and positive purpose:* How does the brain enable us to find meaning and achieve goals?
4. *Decisions, values, and free will:* How does the brain enable decisions based on values, and how can decision making be improved?
5. *Beliefs and meditation:* How do religious and spiritual practices affect neural function and behavior?

The wide range of topics being studied is impressive, ranging from attempting to understand the neurological differences between highly nurturing and less nurturing fathers to exploring the brains of people who flourish in the face of stress that would cripple others. Other studies seek to find the neural link between stressful events and the ability to bounce back from stress, and still others attempt to locate where positive emotions originate in the brain.

This exciting research is just getting under way. Those wishing to get updates as studies are published can write to info@posneuroscience.org.

PAUSE NOW OR MOVE ON

Turn to page 93 to review and apply what you've learned.

Differences Between the Brain's Two Hemispheres

WHAT'S THE POINT?

5-4 Are the left hemisphere and the right hemisphere responsible for different thoughts and behaviors?

Have you ever heard people speak of the "right brain" and the "left brain" or even describe someone as being "left-brained" or "right-brained"? Like many popular ideas, this pop psychology notion is partly right and partly wrong. In truth, you have only one brain, not two. Yes, your single brain *is* divided into two hemispheres, and some functions differ significantly between the two halves. But the two sides of your brain are allies, not enemies. They communicate constantly via the corpus callosum, and to accomplish most tasks you must use both the right side and the left side of your brain.

Language and Spatial Abilities

Language is the best example of a clear-cut difference in the functions of your brain's two hemispheres. In most people, language functions are located primarily in the left hemisphere. A small percentage of the population seems to be "wired" for language in the right hemisphere, but nobody is quite sure why.

Two particularly important language regions of the left hemisphere are Broca's area and Wernicke's area (see **Figure 5.10**):

- **Broca's area,** located in the left frontal lobe, directs the muscle movements involved in *expressive language* (speech). Damage to Broca's area, which often happens to victims of strokes, results in difficulty with spoken language. The stroke victim can form ideas but cannot turn those ideas into coherent speech.
- **Wernicke's area,** located in the left temporal lobe, is involved with *receptive language* (your ability to understand what someone else says). Damage to Wernicke's area might leave a person able to hear words but unable to comprehend the meaning of sentences created with the words. She would be able to recognize the individual parts of a computer (monitor, mouse, keyboard, and so on) but not understand that these parts, together, create a computer.

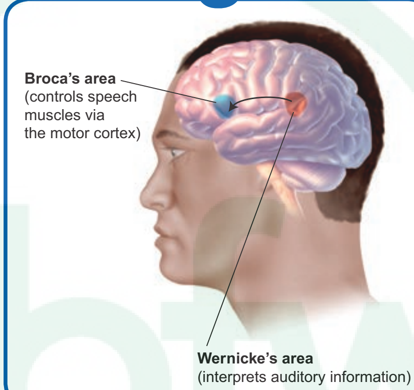
The right hemisphere, however, is not just a bystander. It houses most of your brain's *spatial* abilities. The word spatial relates to your ability to perceive or organize things in a given space, such as judging distance, understanding geometric objects, or packing a car's trunk. The right hemisphere also provides the insight to help us make

Broca's area A brain area of the left frontal lobe that directs the muscle movements involved in speech.

Wernicke's [VER-nik-ees] area A brain area of the left temporal lobe involved in language comprehension and expression.

Figure 5.10
Broca's Area and Wernicke's Area

These two language areas are found only in the left hemisphere in most people.



Beyond the Classroom TRM

Research Have students research programs that claim to educate people on "both sides of the brain." **Ask:**

- What techniques do they use to accomplish their goals?
- How have these programs used scientific research well? How have they misinterpreted the research?
- What concerns about education today do these programs try to address?

To help students learn more, use **Enrichment Lesson: The Right Brain Movement** and watch ***Mind Talk—The Brain's New Story.***

TEACHING TIP

Help students remember the functions of **Broca's area** by relating the story of its discovery. Paul Broca was a French doctor in the late eighteenth century. In working with a patient named "Tan" (that syllable was the only thing the patient could utter), Broca theorized that the damaged region in the frontal left hemisphere was responsible for spoken language, which was confirmed about a century later when CT scans of Tan's preserved brain revealed the damaged area.

Beyond the Classroom TRM

Debate Ask students whether they ever had a teacher try to gear his or her class toward educating the "whole brain." Have students debate whether such practices were helpful. The debate should focus on whether the positive effects of "right-brain techniques" may be the result of a **placebo** or **Hawthorne effect.** Before beginning, students should choose to defend the affirmative or the negative viewpoint.

At this point, you may want to watch ***Left Brain, Right Brain.***

Active Learning TRM

Hemispheric Specialization
Have students use **Cooperative Learning Activity: Hemispheric Specialization** to show how language can interfere with their ability to balance a dowel in either hand. Language tends to interfere with the left more than the right, showing specialization of the left for language, which reinforces Sperry and Gazzaniga's research.

FYI

- Most left-handed people process language in the left hemisphere.
- Other lefties fall into two groups: Some have all language abilities in the right hemisphere, while others show a mixed pattern. Nobody has tracked these exceptions enough to know where their language abilities lie.

Differentiation TRM

Jerre Levy, one of Roger Sperry's collaborators, emphasizes the following points in challenging what she calls the "two-brain" myth.

- There is no activity to which only one hemisphere makes a contribution. When a person reads a story, the right hemisphere may help decode the visual information, while the left hemisphere plays a role in understanding syntax.
- Logic is not confined to the left hemisphere. Patients with right-hemisphere damage show more major problems in this area than do patients with left-hemisphere damage.
- There is no evidence that creativity or intuition is exclusive to the right hemisphere. For example, both hemispheres are equally skilled in discriminating musical chords.
- It is impossible to educate one hemisphere at a time. The right hemisphere is educated as fully as the left in a literature class; the left hemisphere is educated as much as the right in an art class.

At this point, you may want to use **Technology Application Activity: *PsychSim:* "Hemispheric Specialization."**

Digital Connection TRM

Several videos from the series *The Brain* and *The Mind* touch on subjects related to hemispheric differences:

- ***The Brain*** **(2nd ed.), Module 6: "Language and Speech: Broca's and Wernicke's Areas"**
- ***The Mind*** **(2nd ed.), Module 8: "Language Processing in the Brain"**

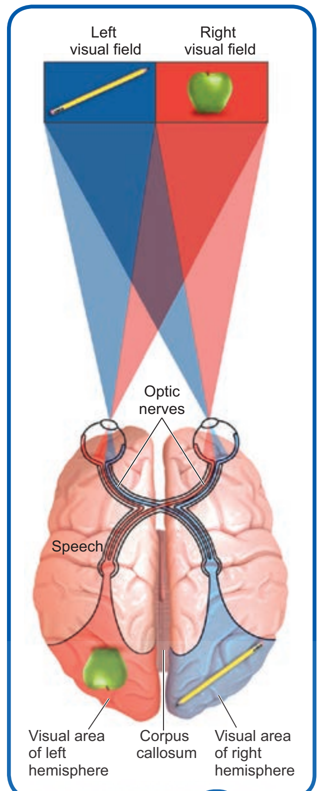


Figure 5.11
The Flow of Visual Information

Both eyes receive information from both visual fields, but all information from the left visual field ends up in the right hemisphere. The right visual field is processed in the left hemisphere. When the corpus callosum is cut, the two hemispheres cannot share information.

connections among words. What word goes with painting, ring, and nail? Our right hemisphere finds the answer: *finger.* For a small handful of people with surgically severed corpus callosums, however, the differing roles of the two hemispheres are much more dramatic.

The Split Brain

What would happen if the two halves of your brain were separated? Could you still function as a normal person? Why would anyone even consider such a dramatic procedure?

The last question is the easiest to answer. In the 1960s, scientists were working on ways to treat severe epilepsy, a brain disorder in which a person has uncontrollable seizures. In an attempt to prevent these seizures from spreading from one side of the brain to the other, surgeons performed a "split-brain" operation in which they cut the corpus callosum. The operation was successful—seizures no longer plagued the patients whose brains were split—but there were side effects.

Cutting the corpus callosum prevents the two hemispheres of the brain from communicating with each other. Surprisingly, psychologists Roger Sperry and Michael Gazzaniga (1983, 1988) found that the surgery left patients' personality and intellect unchanged. However, it altered perception—and corresponding behaviors—in some interesting ways. To understand why these changes occurred, we need to take a closer look at the roles of the two hemispheres.

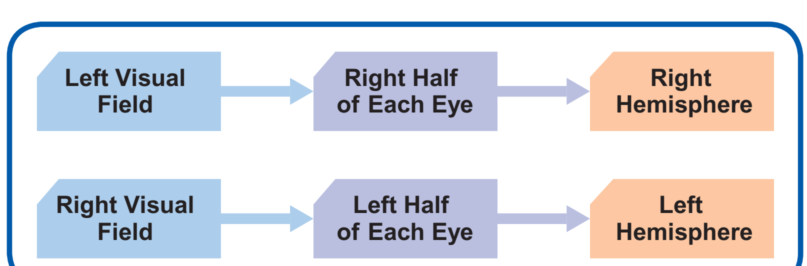
As you can see in **Figure 5.11,** we normally route visual information efficiently from the eyes to the brain. The important thing to notice is that information from your left visual field (the area to the left of your nose) falls on the right side of the retina at the back of each of your two eyes. In an intact brain, this design includes distributing the information across the corpus callosum so that the visual information is available to both hemispheres.

So, what happens when the information is *not* shared between the two hemispheres? In cleverly designed experiments, Gazzaniga and Sperry asked split-brain patients to focus on a spot at the center of a screen while images were projected to either the left or the right visual field (Gazzaniga, 1983). The results demonstrated some interesting gaps in perception among people whose corpus callosum had been severed. Here are two examples:

1. When the picture of an item was projected to the *left visual field,* the patient was unable to identify the object verbally. Why? Because information from the left visual field is processed in the right hemisphere, but the speech center is located in the left hemisphere. There is no way to move the information from the right to the left hemisphere if the corpus callosum has been cut.
2. Look at the situation in **Figure 5.12.** In this case, the split-brain patient focuses on the dot while the HE is projected to the left visual field and ART is projected to the right visual field. The results are perfectly predictable, based on our understanding of the way the brain is organized. The patient will respond ART when asked what was seen, but to her own surprise will

Reteach

Remind students that visual information directed to each side of the brain comes from visual fields, not from each eye. The left eye doesn't send information to the right hemisphere and vice versa. Rather, the right halves of each eye send information to the right hemisphere and the left halves of each eye send information to the left hemisphere.



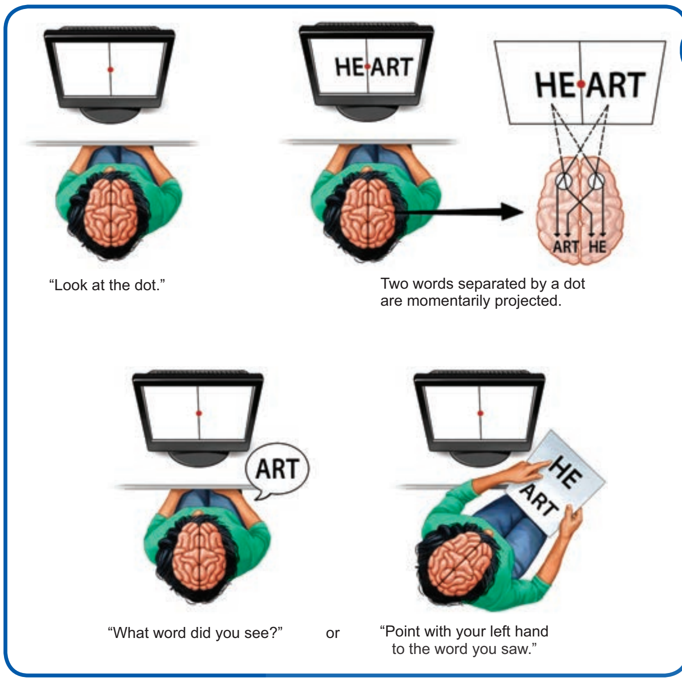


Figure 5.12
Wonders of the Split Brain

This split-brain patient *says* she sees only the word ART because the speech center can receive information only from the left hemisphere, which processes the right visual field. Her left hand *points* to HE because it's controlled by the right hemisphere. The right hemisphere can process information only from the left visual field.

point to the word HE when asked to use her left hand to identify what she saw. What would the person do if asked to use her right hand to select the word she saw? That's right—she would point to ART. And, of course, a person with an intact corpus callosum would see the whole word, HEART.

These results are pretty strange—a bizarre but literal case of the left hand not knowing what the right hand is doing. Why, then, did the researchers conclude that the side effects of the surgery were minimal? Remember that to find these results, Sperry and Gazzaniga set up a procedure that required participants to focus on a dot at the center of the visual field. In real life, split-brain patients would be constantly moving their heads and eyes from side to side. Both visual fields would continually detect significant amounts of information and would make that information available to both brain hemispheres, despite the severed corpus callosum.

This is not to say the split-brain procedure has no lingering aftereffects. People who have had this surgery know that the left and right sides of the body seem at times to be under the command of different masters (because they are). When there is a conflict between the two hemispheres, the left brain usually tries to make sense of it all (Gazzaniga, 1988). Thus, if the right hemisphere of the brain implements a behavior, like walking, the left hemisphere will try to explain the reason ("I'm going to get a Coke"). It must be unnerving to have a brain at odds with itself, but these strange events would not significantly reduce a person's ability to function, and they usually would not be obvious to other people.

Beyond the Classroom TRM

Apply Split-brain patients do not experience problems in daily life because the surgery does not sever the **optic chiasm,** the site where nerves connecting the eyes and brain cross, leading to cross-hemispheric processing. Split-brain patients receive visual information from both visual fields, so abnormalities are only noticeable in specialized laboratory conditions. Help students visualize the split-brain with **Application Activity: Behavioral Effects of the Split-Brain Operation.**

Differentiation TRM

Michael Gazzaniga reports the case of V.J., a left-handed, divided-brain woman whose case challenges notions of where language resides. When a word was presented to her left visual field (and processed by the right hemisphere), she could write it but not say it. When a word was presented to her right visual field (processed by the left hemisphere), she could say it but not write it. This was the first clear scientific evidence that in some people, capacities for spoken and written language may lie in different hemispheres. Linguist Steven Pinker thinks the case presents evidence that reading and writing evolved separately from spoken language and may be wired into the brain's "spare areas."

At this point, you may want to watch ***A Mind of Her Own.***

Beyond the Classroom

Critical Thinking People often wonder why many young people risk serious brain injury by engaging in reckless behavior (drug use, fast driving, drinking, smoking, and so forth). Engage students in a class discussion of this question. Guide the discussion toward the potential impact that unintentional brain damage has on physical, mental, and social health.

Active Learning TRM

Handedness and Hemisphere Dominance

Students will enjoy finding out if hand preference and hemispheric dominance are related. Using **Critical Thinking Activity: The Wagner Preference Inventory** and **Application Activity: Handedness Questionnaire,** students can determine which hand they prefer and which hemisphere is dominant and then relate the two pieces of information. Discuss with students why they may or may not have seen a relationship and what their results say about the workings of the brain.

Digital Connection TRM

Reinforce the descriptions of Michael Gazzaniga's experiments with split-brain patients by viewing ***Scientific American Frontiers* (2nd ed.), Segment 7: "Severed Corpus Callosum"** and ***The Brain* (2nd ed.), Module 5: "The Divided Brain."**

Beyond the Classroom

Research Consider these possibilities for hands-on activities related to brain research:

- Invite a neurologist from a local medical school or hospital to be a guest speaker.
- Visit a neuroscience research lab at a university or medical center.
- Inquire about or arrange a "shadowing" program or internship in neuroscience for interested students.
- Invite a forensic psychologist or medical examiner to speak to your class about how he or she examines the brain to determine the cause of death.

Beyond the Classroom

Guest Speaker Invite a neurosurgeon who performs split-brain surgeries to class to discuss the medical uses of this procedure and the effects on epileptic patients. Have students ask the following questions:

- Why would this procedure be used?
- What side effects are noticeable at first? Do they wear off over time?
- What are the long-term effects of this surgery?

ASSESS

Check for Understanding TRM

Review and confirm concepts about the brain, using **Critical Thinking Activity: Fact or Falsehood?** Suggest that students take turns reading items from the handout to partners, who should answer with "true" or "false." Together, student pairs can check responses with information in the text.

This unique attempt to control epileptic seizures yielded important information about the role of the brain's two hemispheres. The information has since been verified with modern brain-scanning techniques that were not available in the 1960s. Maybe the most important lesson of this research relates to the vital communication that travels between the hemispheres via the corpus callosum. Our left and right hemispheres form one, integrated brain. A recent book on the great myths of popular psychology reminds us that those trying to sell us products to develop one side of the brain or the other are more interested in our bank accounts than in science (Lilienfeld et al., 2010).

PAUSE NOW OR MOVE ON

Turn to page 93 to review and apply what you've learned.

SUMMARY AND FORMATIVE ASSESSMENT

MODULE 5

Thinking About the Brain

Studying the Brain

WHAT'S THE POINT?

5-1 What tools are available to psychological scientists for studying the brain?

- Case studies of brain injuries were the only method available before more current technological advances.
- Brain-scanning techniques can reveal a range of information about brain structure and function.
  - CT and MRI scans provide detailed images of brain structures.
  - EEGs reveal brain waves, an indication of brain activity levels.
  - PET and fMRI scans can provide information about activity levels of different regions of the brain.

Apply What You Know

1. The in-depth examination of the results of Phineas Gage's brain injury is an example of a(n) __________.
2. Which of the following tools is most likely to be used by a researcher who needs to measure activity levels in the brain?

   a. EEG c. CT
   b. MRI d. PET

Lower-Level Brain Structures

WHAT'S THE POINT?

5-2 What kinds of behaviors and thoughts are controlled by the innermost parts of our brain, the lower-level brain structures?

- The innermost parts of our brain, the lower-level brain structures, control basic life-support functions, such as breathing, wakefulness, muscle coordination, and routing sensory messages.
- The limbic system is key to our emotional experiences and memory system.

Apply What You Know

3. Damage to the brain's __________ would be life-threatening.

Portfolio Project TRM

Connecting Neuroscience and the Brain

To show their understanding of neuroscience and the brain, ask students to create a portfolio of activities and writing based on Modules 4 and 5. The portfolio may include the following:

- **Technology Application Activity: Neuroscience and Behavior on the Internet** (found in Module 4 TRM)
- A research paper on a topic you have reviewed and OK'd
- A poster presentation on the brain, nervous system, or hormonal system*
- A public awareness campaign for peers*
- An experimental project in which students work with local university professors or clinicians who specialize in brain research or neuroscience

Use **Handout 5–6** as a general rubric for evaluating portfolio projects. Tailor the rubric to your specific needs.

*Students can create these projects individually or in small groups.

a. hippocampus
b. cerebellum
c. medulla
d. amygdala

4. The brain's _________ helps process new memories.

The Cerebral Cortex

WHAT'S THE POINT?

5-3 What are the regions of the outer surface of the brain, the cerebral cortex, and what are the functions of these regions?

- The four lobes of the cerebral cortex perform many functions, but the primary ones can be summarized as follows: The (left and right) frontal lobes control judgment and planning, the parietal lobes control general processing of information, the temporal lobes process auditory signals, and the occipital lobes process visual signals.
- Two of the most important specialized cortexes of the cerebral cortex are the motor cortex and the somatosensory cortex.

Apply What You Know

5. Describe where the brain processes movement and body sensations.
6. The large band of neural tissue that connects the two brain hemispheres is the _________.

Differences Between the Brain's Two Hemispheres

WHAT'S THE POINT?

5-4 Are the left hemisphere and the right hemisphere responsible for different thoughts and behaviors?

- Two regions in the left hemisphere, Broca's and Wernicke's areas, coordinate to allow speech.
- The right hemisphere seems to be more responsible for some spatial reasoning and word-association tasks.

Apply What You Know

7. One method of examining differences between the two hemispheres is to study patients
   a. with split corpus callosums.
   b. who were born with no brainstem.
   c. who developed both a left and a right frontal lobe.
   d. with a limbic system that includes both a hippocampus and an amygdala.
8. _________ area controls expressive speech and _________ area controls receptive speech.

KEY TERMS

case study, p. 79
computerized axial tomography (CT or CAT), p. 80
magnetic resonance imaging (MRI), p. 80
electroencephalogram (EEG), p. 81
positron emission tomography (PET) scan, p. 81
brainstem, p. 81
medulla [muh-DUL-uh], p. 82
reticular formation, p. 82
thalamus [THAL-uh-muss], p. 82
cerebellum [sehr-uh-BELL-um], p. 82
limbic system, p. 83
hypothalamus [hi-po-THAL-uh-muss], p. 84
hippocampus, p. 84
amygdala [uh-MIG-duh-la], p. 84
cerebral [seh-REE-bruhl] cortex, p. 84
longitudinal fissure, p. 85
corpus callosum [KOR-pus kah-LOW-sum], p. 85
frontal lobes, p. 85
parietal [puh-RYE-uh-tuhl] lobes, p. 86
occipital [ahk-SIP-uh-tuhl] lobes, p. 86
temporal lobes, p. 86
motor cortex, p. 86
somatosensory cortex, p. 87
plasticity, p. 88
Broca's area, p. 89
Wernicke's [VER-nik-ees] area, p. 89

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CLOSE

Reteach TRM

Summarize Provide students with blank copies of **Graphic Organizer: The Brain.** Have students fill out this organizer as a full class activity, calling on volunteers to name brain parts and describe the function of each. If some items remain confusing for students, have them use their text to check for the correct response.

Using the Test Bank

The **Test Bank** that accompanies this textbook offers a wide variety of questions in different formats and levels of complexity. Use the software to construct whole tests or to integrate standardized questions into teacher-made tests.

Answers Studying the Brain: Apply What You Know

1. case study
2. (d)

Answers Lower-Level Brain Structures: Apply What You Know

3. (c)
4. hippocampus

Answers The Cerebral Cortex: Apply What You Know

5. The brain processes movement in the motor cortex and body sensations in the somatosensory cortex.
6. longitudinal fissure

Answers Differences Between the Brain's Two Hemispheres: Apply What You Know

7. (a)
8. Broca's/Wernicke's